Al Dur Phase II IWPP (Independent Water and Power Project) Kingdom of Bahrain

Environmental and Social Impact Assessment - Volume 2 – Main Text, Tables & Figures

Prepared for:

ACWA Power

February 2019

Document Information

Project Name	Al Dur Phase II IWPP, Kingdom of Bahrain
5Cs Project Number	1305/001/063
Document Title	Environmental and Social Impact Assessment Volume 2 – Main Text, Tables & Figures
Client	ACWA Power
5Cs Project Manager	Max Burrow
5Cs Project Director	Ken Wade

Document Control

Version	Version Date	Description	Author	Reviewer	Approver
Issue 1	06/12/2018	ESIA – Volume 2 – Draft 1	EFO	MKB/KRW	KRW
-	17/01/2019	ESIA – Volume 2 Draft 2	EFO	MKB/KRW	KRW
Issue 2	15/02/2019	ESIA- Volume 2 - FINAL	EFO	MKB/KRW	AJJB

1	Financial Capital
2	Social Capital
3	Natural Capital
4	Manufactured Capital
5	Human Capital

Regardless of location, mode of delivery or function, all organisations are dependent on *The 5 Capitals of Sustainable Development* to enable long term delivery of its products or services.

Sustainability is at the heart of everything that 5 Capitals achieves. Wherever we work, we strive to provide our clients with the means to maintain and enhance these stocks of capital assets.

Disclaimer

5 Capitals Environmental and Management Consulting
Principal office: PO Box 119899 Sheikh Zayed Road, Dubai, UAE
☎+971 4 343 5955 🖷+971 4 343 9366

CONTENTS

FIGURES

TABLES

List of Abbreviations

Abbreviation	Meaning
BOO	Build Own Operate
CCGT	Combined Cycle Gas Turbine
CEMS	Continuous Emissions Monitoring System
COD	Commercial Operation Date
ECOD	Early Commercial Operation Date
EER	Environmental Evaluation Report
EHS	Environment, Health & Safety
EP	Equator Principles
EPFI	Equator Principles Financial Institution
ESIA	Environmental & Social Impact Assessment
ESR	Environmental Scoping report
EWA	Electricity and Water Authority
GCC	Gulf Cooperation Council
GT	Gas Turbine
GTG	Gas Turbine Generator
GW	Giga Watt
HRSG	Heat Recovery Steam Generator
IFI	International Financial Institutions
IFC	International Finance Corporation
IWPP	Independent Water & Power Project
MENA	Middle East & North Africa
MIGD	Million Imperial Gallons per Day
MOF	Ministry of Finance
MW	Mega Watt
NOMAC	The First National Operations and Maintenance Company
PWPA	Power and Water Purchase Agreement
RO	Reverse Osmosis
SCE	Kingdom of Bahrain Supreme Council for Environment
SCOD	Scheduled Commercial Operation Date
ST	Steam Generator
SWRO	Seawater Reverse Osmosis
5 Capitals	5 Capitals Environmental & Management Consulting

1 INTRODUCTION

The Kingdom of Bahrain, Electricity and Water Authority (EWA) is the government proponent responsible for the development of a new Integrated Water and Power Project (IWPP) to meet the demand forecast for power & potable water supply within the country. EWA announced ACWA Power, Mitsui and Al Moayyed (the Project Sponsor Consortium) as the preferred bidder for the development, financing, design, engineering, construction, commissioning, ownership, operation and maintenance of the Al Dur Phase II Independent Water & Power Project (IWPP) (herein referred to as 'The Project' or 'Al Dur Phase II'). The Project will be developed on a Build Own and Operate (BOO) basis and will consist of a new Combined Cycle Gas Turbine (CCGT) natural gas fired power plant of 1,524 MW net power capacity and a Seawater Reverse Osmosis (SWRO) desalination plant of 50 MIGD net capacity. The Project is expected to operate for 20 years.

ACWA Power has appointed 5 Capitals Environmental & Management Consultancy (5 Capitals) on behalf of the Project Consortium to prepare this Environmental & Social Impact Assessment (ESIA) for the Project. The ESIA has been informed by the Environmental Scoping Reports (Ref Appendix A)prepared by 5 Capitals for the Lenders and Environment Arabia (the Bahrain Local Consultant) for SCE in accordance with Bahrain environmental regulations and this will be submitted to the Lenders.

The submission in Bahrain will be undertaken by a Category A registered consultant in Bahrain '*Environment Arabia Consultancy Services WLL*' who will oversee compliance with local regulations.

It is understood that ACWA Power will seek project finance from International Financial Institutions (IFIs) who are likely to be signatories of the Equator Principles (EP), a voluntary set of principles established to manage environmental and social investment risks, or have investment policies that are consistent with the IFC Performance Standards. As such, this ESIA has also been prepared in accordance with the expected environmental requirements of the prospective international Lenders thereby demonstrating alignment with the EP's, IFC Performance Standards and IFC EHS Guidelines. This includes consideration of potential 'social' impacts attributable to the Project, and the on-going management of these impacts & risks.

It should however be noted that for the purpose of this document the term ESIA is considered to be inclusive of the Environmental Impact Assessment (EIA) requirements of the Bahrain SCE as well as the Environmental & Social Impact Assessment requirements of the lenders. As such, references to the impact assessment of environmental and social parameters are termed as ESIA, unless there is specific reference to the EIA requirements of Bahrain SCE.

1.1 Objectives of the ESIA

The objectives of this ESIA in relation to this project include the following:

- Assessment of baseline conditions prior to the development of the project site through review of available data and conducting surveys;
- Assessment of the project's environmental & social impacts for the construction (including commissioning) operational and decommissioning phases;
- Review of compliance obligations, including applicable Bahraini regulations and international regulations & standards as well as international lender requirements.
- Determination of applicable mitigation and management measures to be implemented in order to avoid or minimise potential impacts; and
- Consideration of alternatives that can be used for the project leading to greater social and environmental gains.

1.2 Structure of the ESIA

In order to comply with the requirements for environmental & social assessment established by Bahrain SCE and international good practice, this report is presented in the following format developed by 5 Capitals:

- **Volume 1:** Non-Technical Summary
- **Volume 2:** Main Text, Tables & Figure
- **Volume 3:** Environmental Management and Monitoring Plan
- **Volume 4:** Appendices

Volume 1 provides a Non-Technical Summary of the ESIA, including the main outcomes, and conclusions.

Volume 2 comprises the main text of the ESIA and full impact assessment, with mitigation, management and monitoring measures identified. Volume 2 follows the following chapter structure:

1. Introduction
    - ESIA Objectives
    - ESIA Structure
    - Key Project Information
2. Project Information
    - Project Background and Rationale
    - Project Location
    - Land Use and Site Conditions
    - Project Description

- Project Construction Requirements
- Project Operational Requirements
- Project Alternatives

3. Regulatory Framework
   - National Regulation
   - Lenders Requirement
   - Environmental Standards
4. Approach to ESIA
   - ESIA Team
   - ESIA Process
   - Delineation of Study Boundary
   - ESIA Methodology
5. Air Quality (same structure for environmental aspects 6 to 9 & 14 to18)
   - Standards and Regulatory Requirement
   - Observations and Baseline Conditions
   - Receptors
   - Potential Impacts
   - Impact Significance, Mitigation and Management Measures and Residual Impacts
   - Monitoring.
6. Noise and Vibration
7. Marine Environment, Hydrodynamics, Water & Sediment Quality
8. Biodiversity (Terrestrial)
9. Geology, Soil and Groundwater
10. Solid and Liquid Waste Management (same structure for environmental aspects 11 to 13)
    - Standards and Regulatory Requirement
    - Observations and Baseline Conditions
    - Potential Impacts
    - Mitigation and Management Measures
    - Monitoring
11. Chemicals
12. Navigation
13. Tourism and Recreation
14. Traffic and Access
15. Socio Economics
16. Cultural Heritage and Archaeology
17. Landscape and Visual Quality
18. Health and Safety

19. Cumulative Impact Assessment
20. References

Volume 3 provides the Environmental Management and Monitoring Plan for effective implementation of the mitigation and management measures outlined in Volume 2 following impact assessment.

The Volume 3 will provide a framework for the development of the CEMP or Construction Environmental & Social Management System (CESMS), and the OEMP or Operational Environmental & Social Management System (OESMS) to be developed and implemented at a later stage.

The intention is for Volume 3 to be used by the EPC Contractor and O&M Company to develop the project specific environmental management plans, based on the specific findings and recommendations of the ESIA.

The CESMS and the OESMS will include responsibilities and procedures to ensure a systematic preventative to environmental and social management. It also will establish monitoring requirements to ensure adequate performance.

Volume 4 comprises Appendices, which are as follows:

- Appendix A - Environmental Scoping Reports
- Appendix B- Overall Project Layout
- Appendix C- Water Balance Diagram
- Appendix D-Detailed Construction Timeline
- Appendix E - SCE Response to Screening Form
- Appendix F – Stakeholder Responses
- Appendix G - Ambient Air Quality Instrument Calibration Certificate
- Appendix H- Ambient Air Quality Laboratory Results
- Appendix I – Air Dispersion Modeling Study
- Appendix J- Noise Meter Calibration Certificate
- Appendix K – Noise Baseline Survey Results
- Appendix L – Noise Modeling Study
- Appendix M – Marine Survey Al Dur September 2018
- Appendix N – Seawater Analysis July 2017 to January 2018
- Appendix O – Marine Hydrodynamic and Dispersion Modelling Study
- Appendix P – Soil and Groundwater Laboratory Results

1.3 Key Project Information

Table 1-1 Key Project Information

PROJECT TITLE	Al Dur IWPP Phase II
PROJECT PROPONENT/OWNER	Electricity and Water Authority (EWA), Bahrain
SPONSORS	ACWA Power, Mitsui & Co. and Al Moayyed Contracting Corp.
EPC CONTRACTOR	SEPCO III, Power China and Sidem
EQUIPMENT MANUFACTURER	Siemens (power block), Sidem & Veolia (water block)
O&M COMPANY	NOMAC
ENVIRONMENTAL CONSULTANT COMPANY NAME AND ADDRESS	Environment Arabia Consultancy Services WLL P.O. Box 10379, Manama Office 901, The Address Tower, Al Seef District Office: +973 1753 3259 Fax: +973 1753 3754
	5 Capitals Environmental & Management Consulting (5 Capitals) P.O. Box 119899, Sheikh Zayed Road, Dubai, UAE T: +971 (0) 4 343 5955 www.5capitals.com

5 Capitals is the Project Sponsors' environmental consultant overseeing the Environmental & Social assessment and management of the Al Dur IWPP Phase II project up to attainment of the necessary permits and project finance. An overview of 5 Capitals' credentials is presented herein and has previously been provided to Bahrain SCE in full.

It is a requirement of the SCE that an EIA is undertaken and submitted by a registered consultant in Bahrain, the Project has therefore appointed 'Environment Arabia' a Category A registered consultant in Bahrain to work together with 5 Capitals to oversee and ratify the EIA to be submitted in due course to the SCE.

A summary of the Project Sponsor credentials is presented in Figure 1-1 below..

Figure 1-1: Project Sponsor Highlights

Figure 1-2: Key Project Features

PPP Structure	Build, Own, and Operate (BOO) for an Independent Water and Power Plants and Gas connections Facilities. Net power capacity 1200 -1500 MW with potable water production of 50 MIGD
PWPA Term	**20 years** from Scheduled COD, i.e. 01 June 2022
Fuel	Natural gas supplied by Tatweer. Domestic gas in initial years of operation. Imported LNG is envisaged in future. **Natural Gas price** of 1.5 BHD/MMBTU (~ 4.0 $/ MMBTU) for Contract year 1 and 3.0 BHD/MMBTU (~ 8.0$/MMBTU) from contract years 2 to 20
Tariff	Tariff comprising capacity charge, variable charge, and fuel charge
Land Lease	Ministry of Finance (MOF) shall offer 30-year lease & a separate lease for temporary areas for construction period
Government Guarantee	MOF will guarantee Buyer's payment obligations as per PWPA terms
COD	1 Jul - 20 to Sep 2020, 1 Jun – 30 to Sep 2021: 4 GTs in simple cycle. 800 MW 1 Nov 2020 - 31 May 2022: 25 MIGD (one stream) SCOD on 01 June 2022 with 1500 MW Power and 50 MIGD Desalinated Water
Contractor	EPC Contractor : SEPCO III , Power China and Sidem. OEM : Siemens (power block) and Sidem, part of Veolia (water block) O&M Contractor: NOMAC (wholly owned subsidiary of ACWA Power)

2 Project Information

2.1 Project Background and Rationale

As stated in the Project RfP issued by EWA, the project is required, "To meet the forecast development in Bahrain, there is a requirement for additional power generation production of 1200-1500MW net and water production of 50MIGD net respectively. To meet these requirements, a new integrated power and water production facility is planned in Bahrain. The facility will be developed on BOO basis."

As such, the project was tendered by EWA as an independent development, with tender documents issued to a number of pre-qualified bidders in accordance with the following key scope requirements:

"The Project will comprise a gas-fired combined cycle power plant of approximately 1200-1500 MW net power capacity and a seawater desalination plant of 50 MIGD net desalination capacity. The Seawater Intake/Outfall Facilities were constructed during the development of Al Dur Phase I, and will be shared between Al Dur Phase I and Al Dur Phase II."

"The scope of works for the Project will cover the development, studies, design, engineering, financing, permitting, insurance, procurement, manufacturing, factory testing, transport to site, erection, construction, commissioning and performance testing including site investigation, site development and all related civil works, management and supervision, insurance and bonds during construction, as well as operation and maintenance."

"EWA will purchase the entire Demonstrated Net Power Capacity and the Demonstrated Net Water Capacity along with the Electrical Energy and the Potable Water associated therewith in accordance with the Phase II Power and Water Purchase Agreement (PWPA) from the Generator. The Term of the Phase II PWPA will commence on the date of execution thereof and terminate twenty (20) years from COD. The Scheduled Early Commercial Operation Date will be 01 June 2020 and the Scheduled Commercial Operation Date will be 01 June 2022."

2.2 Bahrain 2030 National Plan

A National Plan[1] has been produced for Bahrain with the goal to guide land use and economic growth in an organised and sequential way, creating an "intelligent island" that is the financial, business and banking capital of the Gulf Region. The National Plan is based on the delivery of ten key strategies:

1. **One Plan**: the concept that a focused, centralised and predictable vision is required with all future development conforming to this one National Plan.
2. **Market Economy**: realising the potential for economic growth, increased productivity and higher profit employment, in finance, tourism, niche manufacturing, education and health care. The National Plan identifies places for innovation, including Sitra Technology City and Muharraq new industry campuses.
3. **Environmental Resources**: encouraging all economic growth to take place in ways that enable the Kingdom's terrestrial and marine environments to be safeguarded and restored. This includes balancing new development with protected areas.
4. **Transportation**: delivery of a multimodal transport network providing safe, efficient and convenient access. This includes strategic routes, between Khalifa Bin Salman Port and the Saudi Arabia Causeway for example, for rapid international transportation of goods.
5. **Distinct Communities**: creating safe, vibrant places to live and work to meet the housing needs of the broadest range of Bahrainis. This includes protecting and enhancing historic districts by renovating and conserving their historic buildings and spaces.
6. **Public Waterfront**: the National Plan calls for a continuous waterfront from Budaiya to Juffair as part of a dramatic increase in publicly accessible waterfronts throughout the Kingdom

[1] 'Bahrain 2030: The National Plan' was produced by Skidmore, Owings and Merrill (SOM, 2007) for the National Planning Development Strategies (NPDS) team and Economic Development Board, Ministry of Municipalities and Agriculture.

7. **Protection of Cultural and Archaeological Heritage**: recognition of the value of Bahrain's national heritage through increased public awareness and enhanced public education.

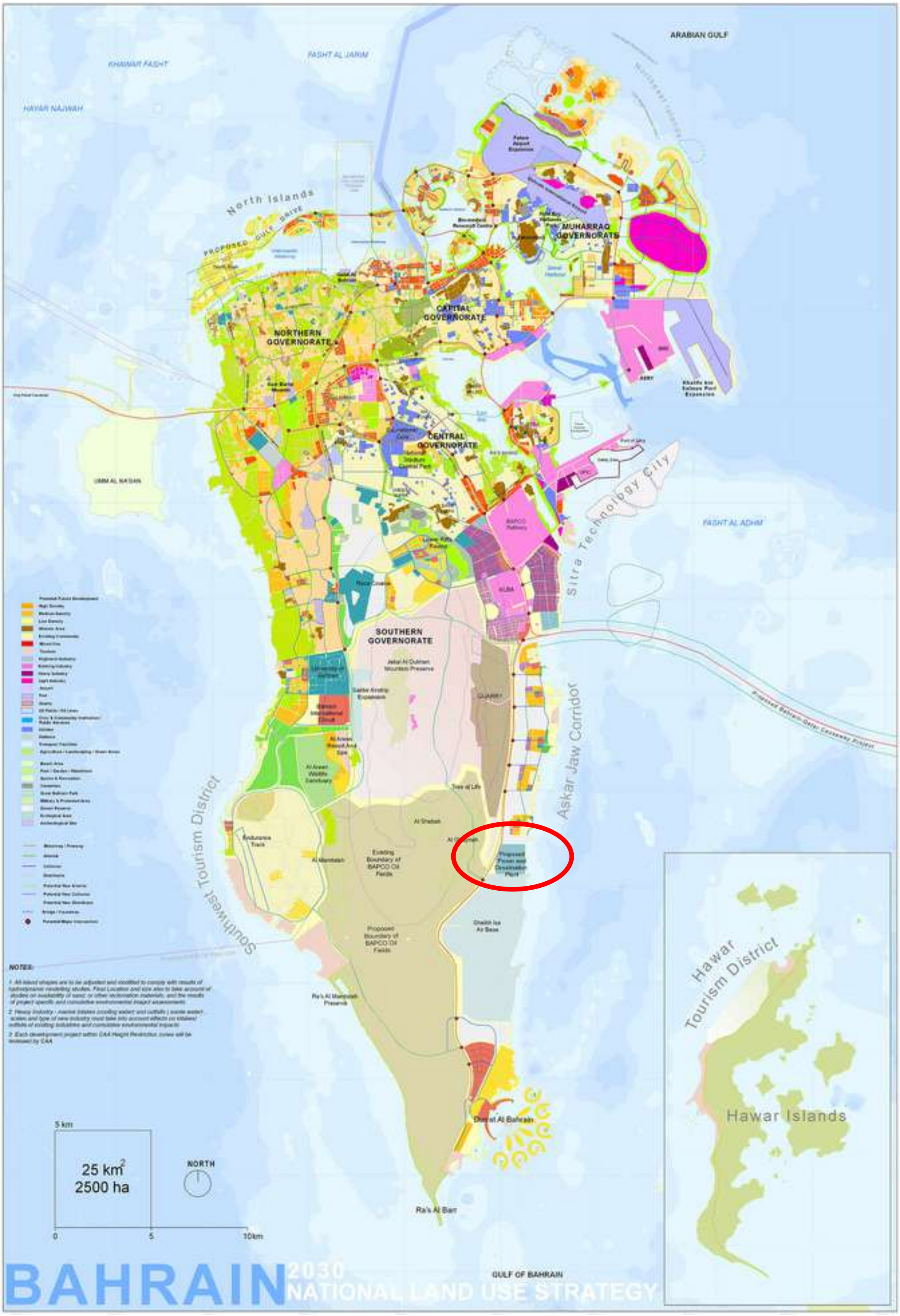
8. **Military Needs**: to consolidate land use by the military, developing a new campus at Sheikh Isa Air Base and considering the return of underutilised lands to civilian use. This may include for conservation or tourism purposes, for example at Hawar Islands.

9. **Green the Country**: to restore the tradition of Bahrain being the 'land of a million palms", including the enrichment of existing and new urban areas with parks, plazas and streetscape.

Within the second strategy of Bahrain National Plan 2030 outlined above is a sub- strategy for industrial development which is relevant to the Al Dur Phase 2. Industrial development is regarded as an integral factor in maintaining a robust market economy in Bahrain. To implement Bahrain's vision of attaining a further upscaled economy by 2030, an Industrial Strategy was developed within the Bahrain 2030 National Plan. This scheme proposes full-scale industrial development whilst at the same time planning to mitigate the impacts that may occur on other development aspects such as environment, tourism and property/residential developments.

The industrial strategy includes the clear demarcation of areas termed 'industrial corridors'. These areas have been strategically planned in a manner that will benefit specific industries through high quality investment; the proposed project lies within an area already demarcated for the Al Dur IWPP (refer to Figure below).

Figure 2-1: Location of Proposed Al Dur IWPP in Relation to Bahrain's 2030 Plan



2.3 Project Location

The proposed Project is located in Al Dur, in the Southern Governorate of Bahrain. The site is located immediately south of the existing Al Dur Phase I plant, adjacent to the Arabian Gulf coastline. The area of the Al Dur Phase II plot is approximately 192,500m^2.

The satellite image below presents the proposed location, footprint and boundaries of the proposed Project site, as well as Al Dur Phase I and existing facilities.

Figure 2-2 Proposed Project Location

Map Source: Google Earth

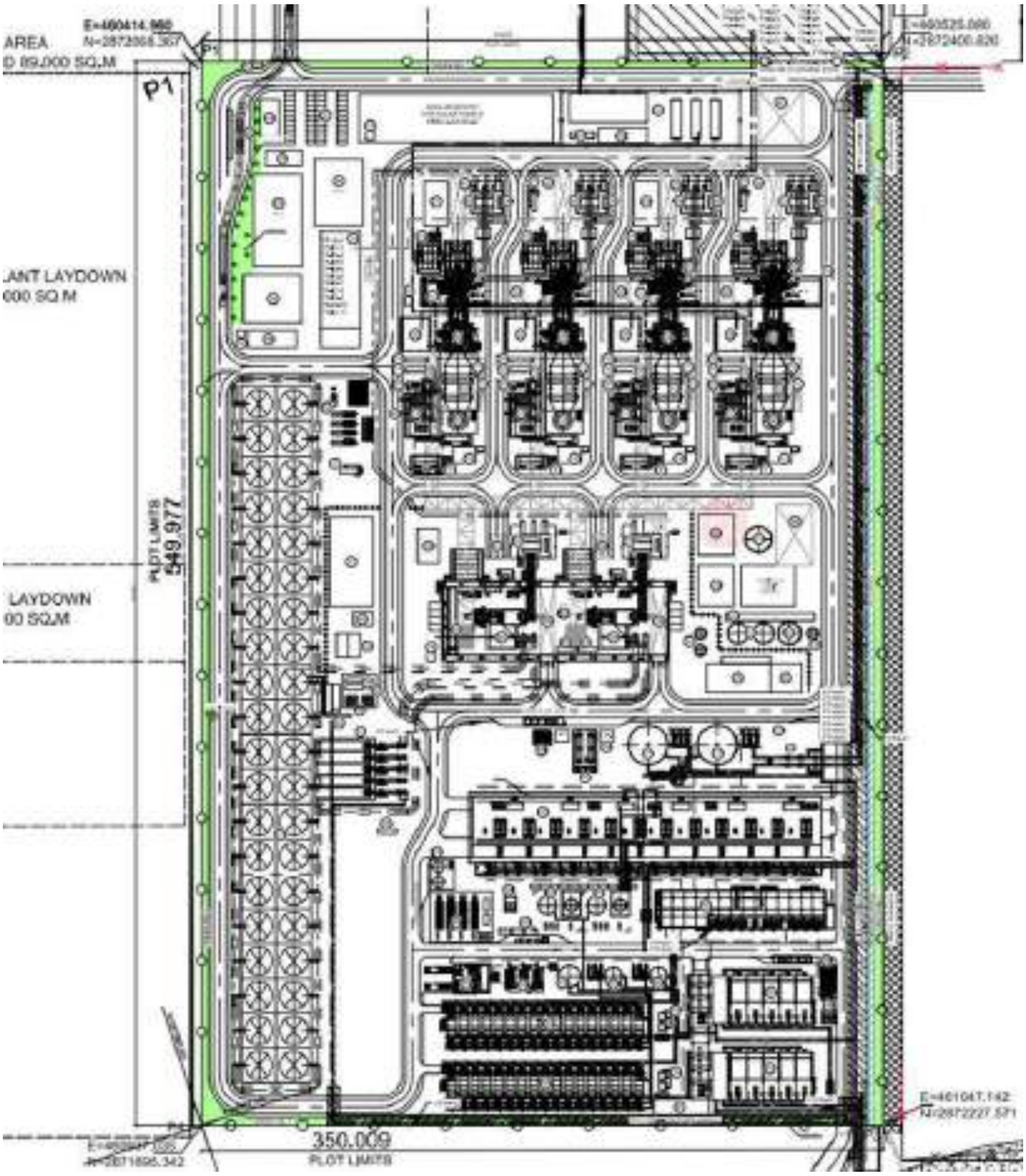
The proposed Project site coordinates are presented in the table below:

Table 2-1 Project Site Coordinates

ID	WGS 84 UTM ZONE 39R	
	EASTING	NORTHING
1	460414.960	2872068.367
2	460525.080	2872400.620
3	461047.142	2872227.571
4	460937.035	2871895.342

The Project layout is presented below. It should be noted that a detailed plan view layout of the Project is included in the Appendix B for reference regarding the proposed placement and locations of specific project features.

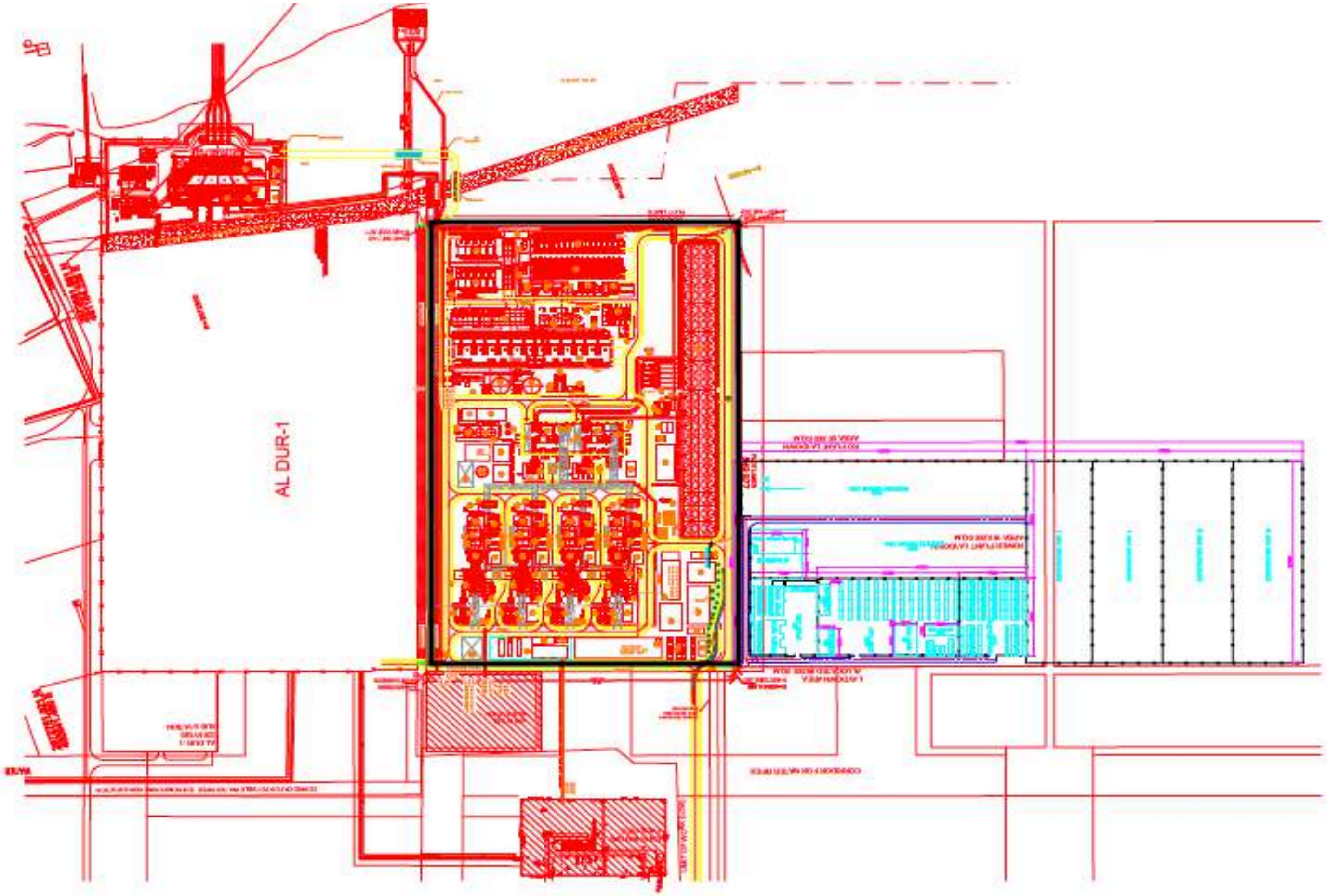
Figure 2-3: Project Layout



For context, an artistic impression is provided in the figure below (please note that the overall project layout where the Al Dur Phase 1 IWPP is shown is presented in the figure 2-5).

Figure 2-4: Artist's Impression of the Al Dur IWPP Phase 2 Project

Figure 2-5 Overall Project Layout (ref. Black Boundary Line for Al Dur IWPP Phase 2 Project)



2.3.1 Site Determination/ Selection

The Project site has been determined by EWA and is not subject to change based on strategic masterplan for this area. It is understood that this area was selected based on the following:

- Non-use of land (no economic or physical displacement involved).
- Available connection to the gas network, eliminating the need for additional works.
- Available intake and outfall, eliminating the need for offshore works.
- Fewer biological features of concern.
- Away from immediate residential or commercial areas.

2.4 Land Use and Site Condition

2.4.1 Land Ownership

The land is under the ownership of the Ministry of Finance (MOF). MOF will offer a 30-year lease & a separate lease for temporary areas for the construction phase.

2.4.2 Land Use

At present the Project is not subject to any formal or informal land uses, as was also evidenced during the initial site visit in October 2018 and as can be corroborated by the photograph below.

The image below provides an overview of the Project site and temporary construction working areas. The viewpoint is from the south of the temporary construction areas looking north-north-east with the Al Dur IWPP Phase 1 in the background.

Figure 2-6: Overview of Project Site

2.4.3 Site Condition

The project land is primarily empty and open with no restrictions concerning access, such as fences, or other boundary features. There is evidence that areas of the project site may have previously been used for certain activities due to some earthworks and grading as shown in the image below (some of which can also be seen in the right of the image above). Limited vegetation has re-established in this area at present and there is evidence of some recent vehicle movements.

Figure 2-7: Possible Previous Land Use Within the Project Site

It is possible that the land for the Al Dur IWPP Phase 2 project was previously used as the temporary construction area for the Al Dur IWPP Phase 1 Project. If this was the case, any previous temporary facilities have been fully demobilised and removed from the site. Visual and olfactory evidence of potential pollution sources were not identified during this visit.

2.4.4 Local Receptors & Sensitivities

The satellite image below presents the project location (in yellow) with notable receptors in the local area and range of project influences (particularly in terms of potential air quality impacts).

Figure 2-4 Potential Local Sensitive Receptors Relevant to the Project

Map Source: Google Earth

The receptors outlined above (with the exclusion of the Phase 2 Subcontractor Camp) have been presented in the table below with proximity to the proposed project indicated.

Table 2-2 Potential Local Sensitive Receptors Relevant to the Project

Receptor	Receptor Type	Location and Proximity to Project
Al Dur IWP	Industrial	Approximately 800m north of the Project boundary
Al Dur IWPP Phase 1	Industrial	Directly adjacent to the north of the Project boundary

Receptor	Receptor Type	Location and Proximity to Project
Al Dur IWPP Phase 2 Sub Contractor Camp	Residential	Approximately 200m south of the Project site boundary
Al Dur Residences	Residential	Approximately 400m south east of the Project boundary
King Hamad Highway	Infrastructure	Approximately 450m west of the Project boundary
Tourism Boat Jetty	Commercial	Approximately 800m north east of the Project boundary
Al Dur Development (Under Construction)	Commercial / Residential	Approximately 1.6km north of the Project boundary
Camp Areas	Residential	Approximately 1.8km north-west of the Project boundary
Royal Academy of Police	Institutional	Approximately 1.6km north- east of the Project
Air Base	Commercial	Approximately 2.2km south of the Project boundary
Jaww	Residential	Approximately 3km north of the Project boundary
Tree of Life	Recreational	Approximately 3.3km north-west of the Project

2.5 Project Description

The Project will be developed as an Independent Water and Power Project (IWPP) comprising of a natural gas combined cycle gas turbine with a net power capacity of 1,524MW and a seawater reverse osmosis desalination plant with a 50MIGD net capacity. The Project will be developed on a Build Own and Operate (BOO) basis.

The Project will make use of the existing seawater intake and outfall components, currently in use for the operation of the Al Dur Phase I. Hence, the scope of the Project will include the survey and assessment of the site on-shore components, the development, design, engineering financing, construction, commissioning, operations and maintenance of the IWPP as well as project infrastructures and facilities.

Descriptions of the Project's facilities, infrastructure, processes and technologies are provided in the sub sections below.

2.5.1 Power Generation

Power Generation Units

The Power Generation Unit will consists of four (4) gas turbine generators (GTG), four (4) Heat Recovery Steam Generator (HRSG) systems and two (2) steam turbines (ST) (arranged in a 4-

4-2 configuration) designed to generate up to 1,524.6 MW (net) of power. The turbines will operate on natural gas only, and will operate on simple or combined cycle modes.

Under combined cycle operation, the exhaust gas system from the GTGs will direct hot exhaust gases into the HRSG in order to produce steam to operate the Steam Turbines. After the exhaust gases have passed through the HRSG boiler, they will be emitted through the main stack associated with the HRSG. The bypass stacks will enable the plant to run under simple cycle operation when required. When operating in simple cycle, the entire HRSG and steam turbine system will be bypassed resulting in emissions from the bypass stacks associated with the GTGs. Four 60m high by-pass stacks, 1 per GTG, and four 60 m high main stacks, one per HRSG are included in the proposed design.

The GTGs will be supplied by Siemens and will be SGT5-5000 types. The STs will also be supplied by Siemens and will be SST5-5000 type. The project Sponsors concluded that Siemens with the largest advanced F-class 50Hz fleet, are the best fit for the Project as it provided the best GT performance and the best optimized combined cycle performance.

Fuel

The project will operate exclusively on natural gas, supplied by Tatweer and will be delivered via the existing gas receiving station that is in place at Al Dur Phase 1. It is anticipated that RLNG fuel will be utilised in the future, which would also be delivered via the same existing gas receiving facility.

There are no provisions in the projects design or requirements by EWA for backup liquid fuel. However, the Project will incorporate emergency power supplies through smaller diesel generating units to ensure the safe and shutdown of all components in the event of emergency. As such a small diesel fuel tank will be incorporated on-site and will be re-fuelled by road tanker (as applicable).

Emissions Monitoring and Abatement Technologies

In order to ensure that the operation of the plant is compliant with the applicable regulations on emissions discharges, the plant will be powered by natural gas as the primary fuel which will eliminate emissions of sulphur dioxide (SO_2) and particulates. The Siemens GTGs will be equipped with low NO_x burners and will have emissions monitoring via Continuous Emissions Monitoring System (CEMS) on both the main and bypass stacks, for monitoring concentration of Oxides of Nitrogen (NO_x) and Carbon Monoxide (CO).

Power Block Cooling

Power block cooling will be provided on a closed loop basis by mechanical induced draft counterflow cooling towers. The project will include either 40 or 48 cooling cells. The circulating water will be pumped to the top of each cell to a distribution header from where it is discharged through spray nozzles. The water is cooled by evaporative (main effect) and sensible cooling as it descends.

The use of the closed loop cooling system will minimise the need for water and reduce the residual influence of thermal effluent on the receiving marine environment. Based on an ambient sea temperature of 30°C, the incorporation of minimal blowdown from the cooling towers is expected to result in a thermal temperature increase (ΔT) of 2.1°C when mixed with other discharge streams prior to the outfall.

2.5.2 Water Desalination

Sea Water Reverse Osmosis

The Seawater Reverse Osmosis (SWRO) plant performs the main function of separating the dissolved salts from the seawater to generate permeate water that is used in potable processes following further remineralisation. Separation is achieved by forcing seawater through membranes, with high pressure being used to drive the process. In contrast to normal osmosis, the reverse osmosis process results in the separation of almost all the dissolved salts and also removes bacteria as well as other ions.

The RO plant will consist of 2 independent blocks (50% of the total project capacity each) and each be configured with multiple independent trains. Each train will consist of a series of pressure vessels, a cartridge filter, a high-pressure pump, an isobaric energy recovery device and one or two booster pumps. An energy recovery has been included in the design to reduce the required pumping energy.

The RO membranes separate the water into two streams; the permeate (which has passed through the membrane and has had most of the dissolved constituents removed) and the concentrate/brine (which contains the dissolved solids). The seawater concentrate is returned to the sea through the exiting outfall and the permeate is treated in a second pass to make it potable.

Pre-treatment system

A pre-treatment system will be incorporated to ensure that the necessary volume of seawater is available for the RO membranes and that specific requirements in relation to chemical / biological parameters (as indicated by the manufacturer) are maintained at all times.

Pre-treatment system for each of the Desalination Units will consist as a minimum the following:

- Coagulation and flocculation;
- Dissolved Air Flotation system followed by Dual Media Filters;

- Filter backwash and air scouring system;
- Sludge handling and treatment system; and
- Potabilization.

Potable water produced via the RO process has a low mineral composition. Drinking water therefore requires the addition of mineral content via the following:

- Carbon dioxide dosing system suitable for drinking water purpose;
- Lime stone filter system (or) lime water dosing system with facilities to prepare lime water;
- Potable Water chlorination system (using food grade hypochlorite or chlorine dioxide); and
- pH correction system and other necessary dosing system.

To ensure that the minimum requirements for potable water quality are met, three analysers will be installed to monitor quality. The first analyser will be at the Potable Water storage tank located immediately after the potabilization process. The other two analysers will be located after the storage tank and before the Al Dur Forwarding Station (Water Delivery Point) in order to re-confirm the condition of the potable water.

2.5.3 Common Facilities (Al Dur IWPP Phases I & II)

Seawater Intake, Screening, Chlorination and Pumping

The project will make use of existing seawater intake (in use by the Al Dur Phase I), eliminating the need for additional offshore construction activities. As such, only minor onshore works will be required to connect the existing infrastructure to the Project and to include additional infrastructure (pumps, bar screen with mechanical rakes for debris collection, debris pit, motorised mesh screen with automatic backwash, etc.). As indicated in the Water Balance Diagram (Appendix C), the total intake water for the Al Dur Phase II Project has been estimated in 32,514 m3/hr .

It is noted that the existing seawater intake includes a sub-surface pipeline with intake headers approximately 1.5km offshore perpendicular to the coastline from the Al Dur Phase 1 Project. Seawater intake pipelines will be routed from the existing Seawater Intake Infrastructure to the Project site using a corridor of undeveloped land between the shoreline and the boundary of the Al Dur Phase 1 and the Project. The connection from the existing Seawater Intake Infrastructure to the new CCGT and SWRO will supply of raw water for the cooling requirements of the CCGT and potable water production by the SWRO.

Seawater must be conditioned to ensure it is of a suitable quality for use in the CCGT and the SWRO plant. The chlorination requirements of Al Dur Phase II intake water supply have already been considered during Al Dur Phase I, and an electro-chlorination facility is already in place and in use by the Al Dur Phase I. Like the entire intake/outfall arrangement, this was designed to have sufficient capacity to meet the chlorination requirement of both Al Dur Phase I and Phase II.

Seawater Outfall

The thermal and brine effluent will be discharged to the Arabian Gulf through the existing seawater outfall at Al Dur Phase 1, eliminating the need for additional offshore construction. Seawater outfall pipelines will be routed from the Project to the existing Outfall connection at the outfall channel.

As indicated in the Water Balance Diagram (Appendix C), the total discharge to the sea is estimated in 20,929m^3/hr (brine and minimal thermal effluent) including approximately 0.01 ton/h of treated wastewater.

Further information about the thermal and brine effluents is included in the Solid and Liquid Waste Management section of this ESIA.

Gas Supply

The Natural Gas supply headers for the Project are already constructed and in operation as a common line for the Al Dur Phase 1 project. Branch connections are provided in the existing Gas Facilities to which the Al Dur IWPP Phase 2 project will connect to.

2.5.4 Additional Project Components

The following main additional components will be included as part of the Project:

- 400 kV GIS Substation.
- Two-lane dual carriageway access road from the existing road located in the western extent of the plot.
- Internal 7m wide road for accessing existing seawater intake connections from the Phase 2 Project.
- Wastewater: The following liquid waste water facilities are included in the design.
    - Oily waste water collection and treatment system.
    - Collection of chemical drains, regeneration waste of demineralisation plant, neutralisation / attenuation of all chemical wastewater streams.
    - RO pre-treatment wastewater treatment system (including separate collection system and adequate sludge dewatering and treatment equipment).
    - Domestic and sanitary wastewater treatment plant.

Following treatment in accordance with Bahrain SCE regulations and standards and IFC requirements, the fully treated effluent streams will be discharged through the existing outfall together with the thermal and brine effluent.

2.5.5 Project Associated Facilities

Project Entrance and Road Access Connection

Access to the project site will be via a newly constructed 4-lane, two-way, dual carriageway connection to the adjacent highway, at the existing junction.

Gas Connection and Regulation Station

The connection of the CCGT component of the Project to the existing gas receiving station will be assessed within the EER this will be a short section of pipeline measuring no more than 200m to a gas regulating station within the project boundary.

Electrical Interconnection Facilities

High voltage power will be output to the Bahrain grid via a 400kV Gas Insulated Switchgear (GIS) station located adjacent to the project. The switchgear station will be constructed by EWA and will be ready by 1st March 2020. The EPC Contractor will be responsible for constructing the projects power connection to the substation. The GIS Substation will be operated by EWA.

Water Forwarding Station

EWA will expand the existing water forwarding facilities in place for the Al Dur Phase 1 IWPP, which will be undertaken in advance of the early COD timeline stated previously. These are located adjacent to the project.

2.6 Project Construction Requirements

2.6.1 Temporary Construction Facilities

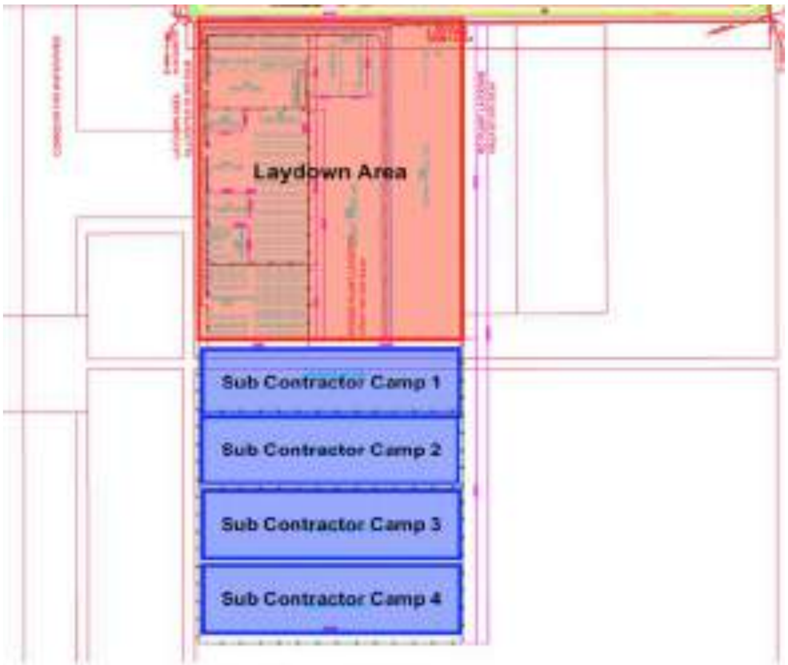
It is understood that the temporary construction laydown areas and worker accommodation for the EPC Contractor will be located directly to the south of the Project footprint as indicated in the figure below. At present there are no apparent formal or informal land uses in this area.

The laydown area is expected to include temporary construction facilities required to enable works (materials storage, staging areas), as well as construction administration facilities and sanitary buildings.

The Worker Accommodation Area, which will consist of 110 portacabins, is expected to accommodate a total of 970 employees of SEPCO III during the peak stage of construction. It is understood that SIDEM will provide accommodation to its manpower in apartments available in the city of Askar approximately 12km from the Project site.

Worker accommodation requirements for subcontractors of both SEPCOIII and SIDEM are not finalised at this stage. However, it is understood that subcontractors will provide accommodation for their workers outside the Project site. It is expected that the necessary facilities and standards of facilities for all worker accommodation/camp whether within or outside the Project site will be specified by the Project Company and will be in accordance with the IFC/EBRD Worker Accommodation Guidelines.

Figure 2-8 Temporary Laydown and Worker Accommodation Areas Located Within the Site



2.6.2 Construction Utilities

The power supply during construction will be via on-site diesel-powered temporary generators. Potable and other water requirements on site and at accommodation areas during construction will be via tankered supply delivered by road. Wastewater during the construction phase is expected to be collected in dedicated septic tanks at sanitary facilities.

2.6.3 Construction Timeline

For the construction process until operations, please refer to the timeline below. A well detailed construction timeline showing the timeline for each construction activities is provided in Appendix D

Table 2-3 Timescale and Phasing

#	Activity	Indicative Date
1	Issue of RFP	14th December 2017
2	**Bid Submission**	**27 June 2018**
3	First Envelope Opening Session	28 June 2018
4	**Second Envelope Opening (Commercial Envelope)**	**30th September 2018**
5	**Selection of Successful Bidder**	**04th October 2018**
6	**Signature of Project Agreements**	**27th October 2018**
7	**Target Financial Close**	**15th January 2018**
8	Early COD 1 - Power	01st August 2020
9	Early COD 1 - Water	01 November 2020
10	Early COD 2	01st May 2021
11	**SCOD**	**01st June 2022**

2.6.4 Workforce

The total workforce during peak period of construction is anticipated to be up to 2,200 workers.

2.7 Project Operational Requirement

Day to day operation of the project technologies and processes described above will be undertaken by NOMAC, a dedicated Operations & Maintenance Company, 100% owned ACWA Power subsidiary established in 2005. Currently, NOMAC is responsible for the operation of a portfolio of over 21.1GW of power generation facilities and 2.8 million cubic metres per day of desalinated water generation, with a large proportion of projects in the MENA region and operating on similar technologies to the proposed Project (i.e. CCGT & SWRO).

2.7.1 Operational Considerations for Early Power

The Power Facility will be developed in 2 stages:

1. The Early Power will have a Guaranteed Net Contracted Power Capacity of about 800 MW (with 4 Gas Turbines in simple cycle operation) and be completed as per the Early Commercial Operation Date (ECOD) set out in the timeframe in Table 2-3.

2. The Full Power of the Power Facility will enable combined cycle operation and be completed as per the Commercial Operation Date (SCOD) set out in set out in the timeframe below.

2.8 Decommissioning of the Project

Potential impacts relating to decommissioning will be similar to those encountered during the construction phase. Given that the decommissioning phase is not expected for at least 20 years from the Commercial Operation Date (in accordance with the term of the Power and Water Purchase Agreement (PWPA)), there are no specific requirements provided for the decommissioning of the project.

It is not considered practical at this stage to speculate on future environmental & social conditions including the sensitivity of current or future receptors at this time, or facilities that may or may not be present to handle wastes etc., or the new E&S regulation that may exist.

Therefore, all impacts relating to decommissioning stage should be planned to be approached and mitigated via a specific decommissioning plan prepared closer to the time of decommissioning as it would be able to account for changes in regulation, improvements in technology and methods of demobilization. The decommissioning plan would be developed prior to decommissioning and would be based on the projects ESMS

2.9 Project Alternatives

It is noted that the Al Dur IWPP Phase 2 project is a long-term planned strategic project for Bahrain that also forms part of the Bahrain 2030 National Plan, with specific land designated for the purpose of this power and water facility. The project technical specification was issued by EWA under strict requirements for project location and technology types. As such, there has been little scope for the project Sponsors and their contractors to consider alternative designs, or approaches to the project. Therefore the only reasonably foreseeable scenario that has been considered below is the 'No Project Scenario' as scenarios for alternative location, technology or design are not feasible under this IWPP EWA scope.

2.9.1 No Project Scenario

Given the strategic need for power and water supplies for the Kingdom of Bahrain (as outlined by EWA), the "No Project" option is not considered to be a suitable alternative, as it would not align with national policy objectives, to ensure that the future capacity is sufficient to meet water and power requirements of the Kingdom. The Project will contribute to the future demand providing 1,524 MW net power and of 50 MIGD potable water.

It is recognised that the "No Project" option may not promote a competitive energy market while meeting increasing power demand and reducing end-user prices. From a local perspective, the "No Project" option would also not contribute to the creation of local employment opportunities in the field of construction, and related to the operations of water and power facilities.

3 REGULATORY FRAMEWORK

3.1 National Regulation

3.1.1 Kingdom of Bahrain Environmental Law, Regulation and Standards

The Constitution

Environmental protection and conservation is enshrined in Bahraini Constitution in order to ensure sustainable development. Article 11 of the Constitution states "*All natural wealth and resources belong to the State, the preservation and good investment, taking in good investment, taking into account the requirements of the State Security and the national economy.*"

The National Action Charter

This Charter, also promotes the protection and conservation of the environment and natural resources. V of Chapter II states:

"In view of the increasing pressure on limited natural resources; the State seeks to exploit natural resources, eco-environment development as well as citizen's health; taking into account global trends in the prevention and treatment of major environmental problems through the development of a national strategy for the protection of the environment. Furthermore, take all appropriate legislative measures and actions to reduce pollution from various sources and provide the appropriate facilities for industrial companies to switch to cleaner production, and attain the need for environmental assessment studies prior to project implementation. On the other hand; the State ought to preserve wildlife, especially the diverse natural environments that characterize Bahrain. This includes animal and plant components through the development of appropriate plans for land use and coastal zone management as well as the establishment of a system of natural protected reserves such as Al Areen, Hawar Islands and the surrounding waters which have become global importance for their rare animals and birds."

Other applicable statutory controls include:

- Decree-Law no (2) of 1995 on Wildlife Conservation and Implementation edicts;
- Decree Law 21/1996 on the Environment;
- Decree-Law 8/1997 on adding a new Article to Decree-Law 21/1996 on the Environment;

- Decree-Law 12/2000 on amending some provisions of Decree-Law 2/1995 on Wildlife Conservation;
- Ministerial Order No. 1 of 1998 with on Environmental Evaluation of Projects
- Ministerial Order No. 1 of 1999 on Control of Ozone Layer Depleting Substances;
- Ministerial Order No. 6 of 2000 on Organisation of Industrial Safety in the Establishment, Ministry of Labour;
- Ministerial Order No. 3 of 2000 on Environment Authority's Recognition of Consulting Firms involved in the Field of Environmental Evaluation of Projects and Environmental Studies;
- Ministerial Order No. 2 of 2001 Amendment to Ministerial Order No. 10 of 1999 with on Environmental Standards (Air and Water);
- Ministerial Order No. 3 of 1996 with Respect to Banning the Importing, Manufacturing and Circulation of Asbestos Material and Product which Contain this Material.
- Ministerial Order No. 3 of 2001 Amendments of Tables in Ministerial Order No. 10 of 1999 on Environmental Standards (Air and Water) and its Amendments in Ministerial Order No. 2 of 2001;
- Ministerial Order No. 7 of 2002 on Controlling the Import and Use of Banned and Restricted Chemicals;
- Ministerial Order No. 8 of 2002 on Standards for Pollutants and Emissions from Vehicles and Inspection;
- Ministerial Order No. 3 of 2005 on Environmental Regulations and Standards in the Work Place;
- Ministerial Order No. 4 of 2005 on Used Oil Management;
- Ministerial Order No. 4 of 2006 on Management of Hazardous Chemicals;
- Ministerial Order No. 3 of 2006 on Management of Hazardous Materials;
- Ministerial Order No. 10 of 2006 with Respect to Source Emissions of Air Pollutants;
- Resolution No. 6 of 2013 amending some provisions of Resolution No. 4 of 2006 on Management of Hazardous Chemicals and Substances.
- Resolution No.7 of 2013, amending Resolution No.3 of 2006 on the Management of Hazardous Wastes;

3.1.2 National Environmental Regulator

The Kingdom of Bahrain has tasked the role of ensuring environmental regulatory compliance to the Supreme Council for Environment (SCE).

3.1.3 International and Regional Conventions/Protocols

Table 3-1 International and Regional Protocols and Conventions

CONVENTIONS, AGREEMENTS AND PROTOCOLS	SIGNED/RATIFIED
Paris Agreement within the United Nations Framework Convention on Climate Change (UNFCCC)	2016
Control of Substances that Deplete the Ozone Layer in the GCC Countries	2014
Beijing Amendment to the Montreal Protocol Concerning the Substances that deplete the Ozone Layer	2013
Convention concerning the Protection of Workers against Occupational Hazards in the Working Environment Due to Air Pollution, Noise and Vibration (Geneva, 1977)	1977
Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES)	Law 27/2012
Rotterdam Convention on the prior informed consent procedure for certain hazardous chemicals and pesticides in international trade	Law 14/2012
Cartagena Protocol on Bio-safety	Law 2/2011
Kyoto Protocol to the United Nations Framework Convention on Climate Change	Decree 45/2005
Stockholm Convention on Persistent Organic Pollutants	Law 39/2005
The Convention of Conservation of Wildlife and its Natural Habitat in the Gulf Cooperation Council	2002
Regional Protocol on the Control of Marine Trans-boundary Movements and Disposal of Hazardous Wastes and Other Wastes	Decree 41/2000
Convention on Biological Diversity	Decree-Law 18/1996
United Nations Framework on Convention on Climate Change	Decree 7/1994
Basel Convention on the Control of Trans-boundary Movements of Hazardous Wastes and Their Disposal, and its amendment	Decree-Law 11/1992 and Law 8/2005
Vienna Convention for the Protection of the Ozone Layer	Decree 10/1990
Kuwait Regional Convention for Cooperation on the Protection of the Marine Environment from Pollution (ROPME)	Decree-Law 17/1978
United Nations Convention on the Law of the Sea	1982
Protocol concerning Marine Pollution resulting from Exploration and Exploitation of the Continental Shelf and the Protocol for the Protection of the Marine Environment against Pollution from Land-Based Sources	Decree 9/1990
International Regulations for Preventing Collisions at Sea, and their Annexes, signed on October 20, 1972	Decree-Law 13/1985
United Nations Convention to Combat Desertification in Countries Experiencing Serious Drought and/or Desertification	Decree- Law 9/1997
Arab Convention No. (1) of 1981 on Work Environment	Decree 7/1983
Convention on Wetlands of International Importance especially as Waterfowl Habitat (Ramsar)	1971

In addition to the above, the Kingdom of Bahrain contributes to many regional and international organisations that are concerned with the protection of environment and conservation of natural resources, such as the United Nations Environment Program, World Health Organisation, United Nations Food and Agriculture Organization, World Meteorological Organization, UNESCO, the Regional Organization for Protection of Marine Environment, the relevant organizations working under the Arab League and the Gulf Cooperation Council (GCC).

The Kingdom of Bahrain is also a member of the International Labour Organisation (ILO). The ILO is committed to advancing opportunities for women and men to obtain decent and productive work in conditions of freedom, equity, security and human dignity. Its main aims are to promote rights at work, encourage good employment opportunities, enhance social protection and strengthen dialogue in handling work-related issues.

3.2 Lender Requirements

The Project will pursue an amount of its financing from one or more International Financial Institutions (IFIs) who are expected to either align their investment policies with international environmental and social lending standards or be signatories to voluntary commitments such as the Equator Principles. In accordance with such policies and commitments, the Project is therefore required to ensure the that the project will meet the following key requirements, during all project phases:

- Equator Principles III (2013);
- World Bank Group - International Finance Corporation's (IFC) Performance Standards (2012);
- World Bank Group – IFC General Environmental Health and Safety (EHS) Guidelines (2007);
- World Bank Group – IFC EHS Guidelines for Thermal Power Plants (2008);
- World Bank Group – IFC EHS Guidelines for Water and Sanitation (2007);
- World Bank Group - IFC EHS Guidelines for Electric Power & Distribution (2007);

3.2.1 Equator Principles III (2013)

The Equator Principles (EP) is a risk assessment framework used by financial institutions to determine, assess and manage the environmental and social risk in projects financing. Currently, over seventy-five major financial institutions from around the world have adopted the EPs. These financial institutions operate in more than 100 countries worldwide. As a result, the Equator Principles have become the project finance industry standard for addressing environmental and social issues in project financing globally.

The Equator Principles were updated in 2006 (EPII) to include projects with a capital cost of US$10 million or more across all industry sectors and these are the prevailing applicable conditions for this project. The Equator Principles Association Steering Committee reviewed the Equator Principles in 2011 and approved the latest version, EP III on April 26th 2013. These became effective from June 2013.

Based on the Equator Principles categorisations, it is expected that the Al Dur Phase II IWPP Project will be a Category A project, requiring a comprehensive ESIA. As it will be located in a Non-Designated Country (Bahrain), the Assessment process is required to evaluate and ensure compliance with the IFC Performance Standards on Environmental and Social Sustainability (Performance Standards) and the World Bank Group Environmental, Health and Safety Guidelines (EHS Guidelines).

The Equator Principles consist of the following principles:

Table 3-2 Equator Principles III (2013)

EQUATOR PRINCIPLE	DETAILS
Principle 1	**Review and Categorisation** EPFIs will categorise a project proposed for financing based on the magnitude of its potential impacts and risks in accordance with the environmental and social screening criteria of the International Finance Corporation (IFC). These categories are: ***Category A***- Projects with potential significant adverse social or environmental risks and/or impacts that are diverse, irreversible or unprecedented; ***Category B*** – Projects with potential limited adverse social or environmental risks and/or impacts that are few in number, generally site-specific, largely reversible and readily addressed through mitigation measures; and ***Category C*** – Projects with minimal or no social or environmental risks and/or impacts.
Principle 2	**Environmental and Social Assessment** For all Category A and Category B Projects, the EPFI will require the client to conduct an Assessment process to address, to the EPFI's satisfaction, the relevant environmental and social risks and impacts of the proposed Project (which may include the illustrative list of issues found in Exhibit II). The Assessment Documentation should propose measures to minimise, mitigate, and offset adverse impacts in a manner relevant and appropriate to the nature and scale of the proposed Project. The Assessment Documentation will be an adequate, accurate and objective evaluation and presentation of the environmental and social risks and impacts, whether prepared by the client, consultants or external experts. For Category A, and as appropriate, Category B Projects, the Assessment Documentation includes an Environmental and Social Impact Assessment (ESIA). One or more specialised studies may also need to be undertaken. Furthermore, in limited high-risk circumstances, it may be appropriate for the client to complement its Assessment Documentation with specific human rights due diligence. For other Projects, a limited or focused environmental or social assessment (e.g. audit), or straightforward application of environmental siting, pollution standards, design criteria, or construction standards may be carried out.

Equator Principle	Details
Principle 3	**Applicable Environmental and Social Standards** The Assessment process should, in the first instance, address compliance with relevant host country laws, regulations and permits that pertain to environmental and social issues. EPFIs operate in diverse markets: some with robust environmental and social governance, legislation systems and institutional capacity designed to protect their people and the natural environment; and some with evolving technical and institutional capacity to manage environmental and social issues. The EPFI will require that the Assessment process evaluates compliance with the applicable standards as follows: • For Projects located in Non-Designated Countries, the Assessment process evaluates compliance with the then applicable IFC Performance Standards on Environmental and Social Sustainability (Performance Standards) and the World Bank Group Environmental, Health and Safety Guidelines (EHS Guidelines) (Exhibit III). • For Projects located in Designated Countries, the Assessment process evaluates compliance with relevant host country laws, regulations and permits that pertain to environmental and social issues. Host country laws meet the requirements of environmental and/or social assessments (Principle 2), management systems and plans (Principle 4), Stakeholder Engagement (Principle 5) and, grievance mechanisms (Principle 6). The Assessment process will establish to the EPFI's satisfaction the Project's overall compliance with, or justified deviation from, the applicable standards. The applicable standards (as described above) represent the minimum standards adopted by the EPFI. The EPFI may, at their sole discretion, apply additional requirements.
Principle 4	**Environmental and Social Management System and Equator Principles Action Plan** For all Category A and Category B Projects, the EPFI will require the client to develop or maintain an Environmental and Social Management System (ESMS). Further, an Environmental and Social Management Plan (ESMP) will be prepared by the client to address issues raised in the Assessment process and incorporate actions required to comply with the applicable standards. Where the applicable standards are not met to the EPFI's satisfaction, the client and the EPFI will agree an Equator Principles Action Plan (AP). The Equator Principles AP is intended to outline gaps and commitments to meet EPFI requirements in line with the applicable standards.
Principle 5	**Stakeholder Engagement** For all Category A and Category B Projects, the EPFI will require the client to demonstrate effective Stakeholder Engagement as an on-going process in a structured and culturally appropriate manner with Affected Communities and, where relevant, Other Stakeholders. For Projects with potentially significant adverse impacts on Affected Communities, the client will conduct an Informed Consultation and Participation process. The client will tailor its consultation process to: the risks and impacts of the Project; the Project's phase of development; the language preferences of the Affected Communities; their decision-making processes; and the needs of disadvantaged and vulnerable groups. This process should be free from external manipulation, interference, coercion and intimidation. To facilitate Stakeholder Engagement, the client will, commensurate to the Project's risks and impacts, make the appropriate Assessment Documentation readily available to the Affected Communities, and where relevant Other Stakeholders, in the local language and in a culturally appropriate manner.

Equator Principle	Details
	The client will take account of, and document, the results of the Stakeholder Engagement process, including any actions agreed resulting from such process. For Projects with environmental or social risks and adverse impacts, disclosure should occur early in the Assessment process, in any event before the Project construction commences, and on an on-going basis.
Principle 6	**Grievance Mechanism** For all Category A and, as appropriate, Category B Projects, the EPFI will require the client, as part of the ESMS, to establish a grievance mechanism designed to receive and facilitate resolution of concerns and grievances about the Project's environmental and social performance. The grievance mechanism is required to be scaled to the risks and impacts of the Project and have Affected Communities as its primary user. It will seek to resolve concerns promptly, using an understandable and transparent consultative process that is culturally appropriate, readily accessible, at no cost, and without retribution to the party that originated the issue or concern. The mechanism should not impede access to judicial or administrative remedies. The client will inform the Affected Communities about the mechanism in the course of the Stakeholder Engagement process.
Principle 7	**Independent Review** ***Project Finance*** For all Category A and, as appropriate, Category B Projects, an Independent Environmental and Social Consultant, not directly associated with the client, will carry out an Independent Review of the Assessment Documentation including the ESMPs, the ESMS, and the Stakeholder Engagement process documentation in order to assist the EPFI's due diligence, and assess Equator Principles compliance. The Independent Environmental and Social Consultant will also propose or opine on a suitable Equator Principles AP capable of bringing the Project into compliance with the Equator Principles, or indicate when compliance is not possible. ***Project-Related Corporate Loans*** An Independent Review by an Independent Environmental and Social Consultant is required for Projects with potential high-risk impacts including, but not limited to, any of the following: • Adverse impacts on indigenous peoples • Critical Habitat impacts • Significant cultural heritage impacts • Large-scale resettlement In other Category A, and as appropriate Category B, Project-Related Corporate Loans, the EPFI may determine whether an Independent Review is appropriate or if internal review by the EPFI is sufficient. This may take into account the due diligence performed by a multilateral or bilateral financial institution or an OECD Export Credit Agency, if relevant.
Principle 8	**Covenants** An important strength of the Equator Principles is the incorporation of covenants linked to compliance. For all Projects, the client will covenant in the financing documentation to comply with all relevant host country environmental and social laws, regulations and permits in all material respects. Furthermore, for all Category A and Category B Projects, the client will covenant the financial documentation: a) To comply with the ESMPs and Equator Principles AP (where applicable) during the construction and operation of the Project in all material respects; and

Equator Principle	Details
	b) To provide periodic reports in a format agreed with the EPFI (with the frequency of these reports proportionate to the severity of impacts, or as required by law, but not less than annually), prepared by in-house staff or third-party experts, that i) document compliance with the ESMPs and Equator Principles AP (where applicable), and ii) provide representation of compliance with relevant local, state and host country environmental and social laws, regulations and permits; and c) To decommission the facilities, where applicable and appropriate, in accordance with an agreed decommissioning plan. Where a client is not in compliance with its environmental and social covenants, the EPFI will work with the client on remedial actions to bring the Project back into compliance to the extent feasible. If the client fails to re-establish compliance within an agreed grace period, the EPFI reserves the right to exercise remedies, as considered appropriate.
Principle 9	**Independent Monitoring and Reporting** ***Project Finance*** To assess Project compliance with the Equator Principles and ensure on-going monitoring and reporting after Financial Close and over the life of the loan, the EPFI will, for all Category A and, as appropriate, Category B Projects, require the appointment of an Independent Environmental and Social Consultant, or require that the client retain qualified and experienced external experts to verify its monitoring information which would be shared with the EPFI. ***Project-Related Corporate Loans*** For Projects where an Independent Review is required under Principle 7, the EPFI will require the appointment of an Independent Environmental and Social Consultant after Financial Close, or require that the client retain qualified and experienced external experts to verify its monitoring information which would be shared with the EPFI.
Principle 10	**EPFIs Reporting** ***Client Reporting Requirements*** The following client reporting requirements are in addition to the disclosure requirements in Principle 5. For all Category A and, as appropriate, Category B Projects: • The client will ensure that, at a minimum, a summary of the ESIA is accessible and available online. • The client will publicly report GHG emission levels (combined Scope 1 and Scope 2 Emissions) during the operational phase for Projects emitting over 100,000 tonnes of CO_2 equivalent annually. Refer to Annex A for detailed requirements on GHG emissions reporting. ***EPFI Reporting Requirements*** The EPFI will report publicly, at least annually, on transactions that have reached Financial Close and on its Equator Principles implementation processes and experience, taking into account appropriate confidentiality considerations. The EPFI will report according to the minimum reporting requirements detailed in Annex B.

3.2.2 IFC Performance Standards on Environment and Social Sustainability (2012)

The IFC Performance Standards are a key component of the IFC's Sustainability Framework and directed towards clients (i.e. party responsible for implementing and operating the project that is being financed), providing guidance on how to identify risks and impacts. The IFC Performance Standards are designed to help avoid, mitigate, and manage risks and impacts throughout the life of a project as a way of doing business in a sustainable way, including stakeholder engagement and disclosure obligations of the client in relation to project-level activities.

The 2006 version of the IFC Performance Standards was reviewed and made applicable to all new projects from 1st January 2012. The updated IFC PSs reflect IFC's stronger commitment to climate change, business and human rights, corporate governance and gender equality as well as strengthening the due diligence process for IFIs. Such updates include comparable labour terms for migrant and non-migrant workers, clarification of levels of stakeholder engagement, monitoring of supply chains and an enhanced focus on energy efficiency.

Separately, it is noted that as IFC is a shareholder in ACWA Power, all ACWA Power projects require compliance with the IFC Performance Standards including the IFC EHS Guidelines. The following presents the IFC Performance Standards (2012) and their main characteristics:

Table 3-3 IFC Performance Standards (2012)

Performance Standard	Details and Requirements
PS 1	**Assessment and Management of Environmental and Social Risks and Impacts** It underscores the importance of managing environmental and social performance throughout the life of a project. It requires the Client to conduct a process of environmental and social assessment, and establish and maintain an Environmental and Social Management System (ESMS) appropriate to the nature and scale of the project and commensurate with the level of its environmental and social risks and impacts. The ESMS must be a dynamic and continuous process initiated and supported by management, and involves engagement between the client, its workers, local communities directly affected by the project (the Affected Communities) and, where appropriate, other stakeholders. • Requires stakeholder engagement beyond Affected Communities; • Clarifies levels of stakeholder engagement under different circumstances; • Requires development of a formal environmental and social policy reflecting principles of the Performance Standards; • Introduces participatory monitoring (when appropriate) as an option during implementation; and • Requires periodic performance reviews by senior management.

PERFORMANCE STANDARD	DETAILS AND REQUIREMENTS
PS 2	**Labour and Working Conditions** Recognizes that the pursuit of economic growth through employment creation and income generation should be accompanied by protection of the fundamental1 rights of workers. The requirements set out in this PS have been in part guided by a number of international conventions and instruments, including those of the International Labour Organization (ILO) and the United Nations (UN) • Establishes requirement for comparable terms and conditions for migrant workers compared to non-migrant workers; • Introduces quality requirements for workers' accommodation; • Requires ongoing monitoring of working conditions for workers under the age of 18 years old; • Requires establishing policies and procedures to manage and monitor compliance of third parties with this PS; • Requires alternatives analysis in case of retrenchment; and • Requires ongoing monitoring and "safety' trigger in primary supply chain.
PS 3	**Resource Efficiency and Pollution Prevention** Outlines a project-level approach to resource efficiency and pollution prevention and control in line with internationally disseminated technologies and practices. During the project life-cycle, the client will consider ambient conditions and apply technically and financially feasible resource efficiency and pollution prevention principles and techniques that are best suited to avoid, or where avoidance is not possible, minimize adverse impacts on human health and the environment.3 The principles and techniques applied during the project life-cycle will be tailored to the hazards and risks associated with the nature of the project and consistent with good international industry practice (GIIP). • Introduces a resource efficiency concept for energy, water and core material inputs; • Strengthens focus on energy efficiency and greenhouse gas measurement; • Reduces greenhouse gas emissions thresholds for quantification and reporting to IFC from 100,000 tons of CO_2 to 25,000 tons of CO_2 per year; • Introduces concept of "duty of care" for hazardous waste disposal; and • Requires determination of accountability with regards to historical pollution.
PS 4	**Community Health, Safety and Security** Addresses the client's responsibility to avoid or minimize the risks and impacts to community health, safety, and security that may arise from project related-activities, with particular attention to vulnerable groups. This PS addresses potential risks and impacts to the Affected Communities from project activities. Occupational health and safety requirements for workers are included in PS 2, and environmental standards to avoid or minimize impacts on human health and the environment due to pollution are included in PS 3. • Requires evaluation of the risks and impacts to the health and safety of the Affected Communities during the project life- cycle and the establishment of preventive and control measures consistent in line with GIIP • Considers risks to communities associated with use and/or alteration of natural resources and climate change through an ecosystems approach.

Performance Standard	Details and Requirements
PS 5	**Land Acquisition and Involuntary Resettlement** Recognizes that project-related land acquisition and restrictions on land use can have adverse impacts on communities and persons that use this land. Involuntary resettlement refers both to physical displacement (relocation or loss of shelter) and to economic displacement (loss of assets or access to assets that leads to loss of income sources or other means of livelihood) as a result of project-related land acquisition and/or restrictions on land use. Where involuntary resettlement is unavoidable, it should be minimized and appropriate measures to mitigate adverse impacts on displaced persons and host communities3 should be carefully planned and implemented. • Extends scope of application to restrictions on land use; • Strengthens requirements regarding consultations; and • Introduces a requirement for a completion audit under certain circumstances.
PS 6	**Biodiversity Conservation and Sustainable Management of Living Natural Resources** Addresses how clients can sustainably manage and mitigate impacts on biodiversity and ecosystem services throughout the project's lifecycle in order to protect and conserve biodiversity; to maintain the benefits from ecosystem services; and to promote the sustainable management of living natural resources through the adoption of practices that integrates conservation needs and development priorities. • Clarifies definitions of and requirements for various types of habitats; • Introduces stronger requirements for biodiversity offsets; and • Introduces specific requirements for plantations and natural forests as well as for management of renewable natural resources.
PS 7	**Indigenous People** It requires clients to anticipate and avoid adverse impacts of projects on communities of Indigenous Peoples, or when avoidance is not possible, to minimize and/or compensate for such impacts and to promote sustainable development benefits and opportunities for Indigenous Peoples in a culturally appropriate manner. It also requires the client to establish and maintain an on-going relationship based on Informed Consultation and Participation (ICP) with the Indigenous Peoples affected by a project throughout the project's life cycle. • Expands consideration of Indigenous Peoples' specific circumstances in developing mitigation measures and compensation; • Introduces requirement for land acquisition due diligence with regards to lands subject to traditional ownership or under customary use; and • Introduces the concept of Free, Prior and Informed Consent under certain circumstances.
PS 8	**Cultural Heritage** Aims to ensure that clients protect cultural heritage from the adverse impacts of project activities and support its preservation and promote the equitable sharing of benefits from the use of cultural heritage in line with the Consistent with the Convention Concerning the Protection of the World Cultural and Natural Heritage,

3.2.3 IFC EHS Guidelines (2007)

IFC and the World Bank have developed Environmental, Health and Safety Guidelines (EHS Guidelines) for its members, which provide general and sector-specific guidance which must be put into consideration during the Environmental and Social Impact Assessment (ESIA) for this project. The following are relevant to this project:

- General EHS Guidelines, Environmental:
    - Air Emissions and Ambient Air Quality;
    - Energy Conservation;
    - Wastewater and Ambient Water Quality;
    - Water Conservation;
    - Hazardous Materials Management;
    - Waste Management;
    - Noise; and
    - Contaminated Land.
- General EHS Guidelines, Occupational Health & Safety:
    - General Facility Design and Operation;
    - Communication and Training;
    - Physical Hazards;
    - Chemical Hazards;
    - Biological Hazards;
    - Radiological Hazards;
    - Personal Protective Equipment (PPE);
    - Special Hazard Environment; and
    - Monitoring.
- Community Health & Safety:
    - Water Quality and Availability;
    - Structural Safety of Project Infrastructure;
    - Life and Fire Safety (L&FS);
    - Traffic Safety;
    - Transport of Hazardous Materials;
    - Disease prevention; and
    - Emergency Preparedness and Response.
- Construction and Decommissioning:
    - Environment;
    - Occupation Health & Safety; and
    - Community Health & Safety.

IFC also have specific industry standards that will be applicable to the project. This includes those relating to power and water generation, as well as guidelines related to power distribution (below).

3.2.4 IFC Industry Sector Guidelines:

- EHS Guidelines for Thermal Power Plants
- EHS Guidelines for Water and Sanitation; and
- EHS Guidelines for Electric Power and Distribution; Environmental Standards

The environmental standards applicable to the Project as per the national regulations and lender guidelines are outlined below. Full reference of the applicable standards is provided in each relevant chapter herein.

Table 3-4 Applicable Standards & Guidelines

Environmental Parameter	Bahraini National Standards	Lender Guidelines
Air Emissions	Ministerial Order No.3 of 2001 with Respect to Environmental Standards (Air & Water) Table No. 3 Air Emission Standard from Various Sources	IFC Emissions Guidelines for Combustion Turbines Table 6(B) pg. 21 IFC EHS Guidelines for Thermal Plants
Ambient Air Quality	Ministerial Order No.3 of 2001 with respect to Environmental Standards Table no. 1 Air Quality Standards	IFC EHS General Guidelines: Table 1.1.1 page 4: WHO Ambient Air Quality Guidelines
Noise	Noise Standards Noise Intensity and Occupational Exposure Time: Resolution No (3) of 2005 with Respect to Environmental Requirements and Standards in Workplace. (Schedule 4 table a) Exposure to Crash Noise: Resolution No. (3) of the Year 2005 with Respect to Environmental Requirements and Standards in Workplace. (Schedule 4 table b)	IFC EHS General Noise Guidelines of Noise Management: Table 1.7.1 pg. 53: WHO Noise Level Guidelines
Soil Quality	There are no established soil standards in the Kingdom of Bahrain. As such, the use of the Dutch standards is common practice for the analysis of soils and groundwater, and these are viewed as international best practice.	
Water and Industrial Effluent Discharges	Ministerial Order No.3 of 2001: Table 4 Standards for Discharge Water from Factories	IFC EHS General Guidelines for thermal Plants: Table 5 page 31 Effluent Guidelines

All the above-mentioned standards require project compliance. Where there is contradiction in limits between Bahraini standards and lender guidelines, the most stringent will apply.

In accordance with lender requirements, where specific national standards do not exist, a best practice standard should be applied. This may apply to parameters such as soil, where Bahrain and the lenders have no specific standards/guidelines.

4 APPROACH TO ESIA

This section outlines the expected methodology that will be used to describe the sensitivity of environmental & social receptors, to predict the magnitude of environmental impacts and to assess the significance of the effect of the project activities on each relevant environmental parameter or component.

4.1 EIA Team

ACWA Power (on behalf of the Sponsor consortium) has engaged 5 Capitals Environmental & Management Consulting (5 Capitals) to lead the environmental & social process with regard to this project. This includes obtaining applicable national approval and to support ACWA Power to reach Financial Close with their prospective lenders.

In order to fulfil Bahrain SCE requirements, 5 Capitals will engage with a Bahrain SCE registered Category A consultant (to be confirmed) for report preparation, submission and liaison with Bahrain SCE. 5 Capitals will lead the management of the Bahrain SCE registered consultant on behalf of ACWA Power and the sponsor consortium.

4.1.1 5 Capitals

5 Capitals is an established Environmental and Management Consultancy with Headquarters in Dubai and operations from Madrid, Bangkok & Riyadh, together with partner offices in Ho Chi Minh City and Johannesburg.

5 Capitals has developed a rich portfolio of projects and are trusted advisors to several long-term clients, particularly in the Power, Water, Mining, Development Planning and Compliance Management Sectors.

Among our expertise, we consider ourselves to be a leading E&S consultancy in the power sector, having worked with developers, lenders, Export Credit Agencies (ECAs), Engineering, Procurement and Construction (EPC) Contractors and Operation and Maintenance (O&M) Companies, on projects worldwide. We have had various inputs on a host of renewable and conventional power projects, from due diligence and project development through to implementation. An area where we add particular value is on projects that require international financing or have compliance obligations consistent with lender requirements, such as the Equator Principles, OECD Common Approaches and World Bank & IFC Performance Standards & EHS Guidelines.

The team of specialists from 5 Capitals for this assignment are presented in the table below.

Table 4-1 5 Capitals' Project EIA Team

NAME	ROLE WITHIN ESR
Ken Wade	Project Director
Max Burrow	Project Manager
Eniola Olademiji	EIA Specialist
Alejandro González-León	ESR co-author and EIA Specialist
Harry George	Marine Environmental Specialist

4.1.2 Sub-Consultants

ALS Arabia (Bahrain)

Providing field and laboratory services with respect to baseline surveys, including air quality, noise, soil and groundwater analysis.

Al Hoty Analytical Services (Bahrain)

Undertaking soil and groundwater drilling services with respect to baseline surveys for soil and groundwater sampling.

Entran (UK)

Experts in undertaking air emissions and noise modelling services.

Byrne Looby (Bahrain)

Undertaking terrestrial ecology baseline surveys and managed surveys undertaken by ALS Arabia (above).

4.2 EIA Process

The process for EIA in Bahrain comprises the primary stages as follows:

Screening

An Environmental Screening Form was submitted by ACWA Power (on behalf of the Sponsor consortium). An official letter response to the screening form was received from Bahrain SCE on 13th November 2018 (ref Appendix E).

The response to the screening form provided an outline scope of work for the EIA with key areas of focus specified. It also indicated that a full EIA is required to be undertaken by a Category A registered consultant with Bahrain SCE.

Scoping

An Environmental Scoping Report (ESR) was prepared by 5 Capitals which primarily outlines the scope of the EIA studies and scopes environmental parameters in and out of further detailed assessment at the ESIA stage. The ESR was submitted to Bahrain SCE and was supplemented by a report from *Environment Arabia Consultancy Services* in accordance with SCE normal requirements for submission from a locally registered consultant (see Appendix A).

Impact Assessment

Based on the defined process in Bahrain under EIA-2 General Guidelines an Environmental Evaluation Report (EER) (or EIA) will be prepared in accordance with the scope established by Bahrain SCE in the Screening Form response and as per the scope defined in this ESR.

This Environmental and Social Impact Assessment (this report) follows on from the Environmental Scoping Report for the Project, which was written to identify sensitive receptors and key environmental and social impacts related to the construction and operational phases of the project at an early stage in order to ensure that the baseline surveys and assessment techniques for the subsequent ESIA address these issues specifically.

4.3 Delineation of Study Boundaries and Scope of Assessment

The ESIA has assessed the potential impacts related to the proposed projects construction, commissioning and operation, as described in Chapter 2 of this ESIA.

4.3.1 Project Items for Assessment

The project items for assessment include:

- Land within the defined project footprint (project boundaries);
- Land within connection to the existing intake and outfall structures at Al Dur IWP Phase 1 (for shared use as intake and outfall);
- Construction phase temporary facilities:
  - Laydown areas;
  - Worker accommodation areas; and
  - Construction phase utilities (energy, water etc.)
- Project associated facilities:
  - Project access road
  - Connection to existing gas receiving station at Al Dur IWPP Phase 1
  - Connections to power network at existing Al Dur Phase 1 sub-station interconnection with the Bahrain electrical grid.
  - Connections to potable water network at existing Al Dur Phase 1 interconnection with the Bahrain water network.

- The projects construction phase activities, aspects and impacts;
- The projects operational phase activities, aspects and impacts Associated Facilities for Assessment (including various operational regimes linked to early power generation in simple cycle, normal operation in combined cycle);
- Impacts to the environment and defined receptors that are external to the project's footprint and within the zone of potential impacts (e.g. from air emissions, brine, thermal and treated effluent discharges, noise etc.); and
- Routes and infrastructure required to facilities construction and operations of the project.

4.3.2 Scope of Assessment

The ESIA has assessed the potential impacts related to the proposed projects construction phase, commissioning and operation. The primary study area therefore comprises the footprint of the project, land within connection to the existing intake & outfall structures, access roads to the site, internal roads, gas connections, electrical connections, potable water network and other associated infrastructures & facilities.

Where project impacts extend to areas external to the study area, (i.e. due to noise propagation, air emissions, dust impacts or wastewater discharge impacts) these have also been assessed.

4.4 ESIA Methodology

This section provides information about the data collection and consultation process followed to inform the ESIA and the methodology that has been used to describe the sensitivity of environmental receptors; predict the magnitude of environmental impacts and assess the significance of impacts upon applicable environmental parameters

4.4.1 Baseline Studies and Research

Forming an integral part of the ESIA, the baseline surveys provide a benchmark of the existing conditions by which the potential impacts of the proposed project can be assessed for the construction and operational phases.

This ESIA has been informed by a review of relevant desktop information as well as a series of physical site surveys which have been summarised in the relevant environmental and social impact assessment chapters of this report. The environmental baseline surveys carried out as part of the ESIA included:

Site Surveys	Period
Site Familiarisation	October 2018
Ambient Air Quality Monitoring	November/December 2018

Site Surveys	Period
Short term Air Quality Monitoring	November 2018
Noise Monitoring	November 2018
Soil Sampling	November 2018
Groundwater Survey	December 2018
Terrestrial Ecology Survey	November 2018

These surveys are described in the ESIA chapters herein, with analysis results provided, and included to the applicable Appendices. The surveys were conducted with the intent to provide representative data in regard to the area that may potentially be impacted by the Project.

4.4.2 Project Stakeholder Analysis and Consultations

Consultation with stakeholders is an essential part of the environmental & social assessment process. The main objective of the consultation is to establish a dialogue with those stakeholders who may be affected by aspects of the Project or may have an interest in the outcome of the EIA process.

In regard to the lender requirements, all of the IFC Performance Standards include requirements for an amount of stakeholder engagement (either in the ESIA, or as part of the future ESMS) and therefore the project will require a level of engagement. In particular, IFC Performance Standard 1 on "Social and Environmental Assessment and Management Systems" describes the stakeholder engagement requirements in more depth. It states the following:

"Stakeholder engagement is the basis for building strong, constructive, and responsive relationships that are essential for the successful management of a project's environmental and social impacts. Stakeholder engagement is an on-going process that may involve, in varying degrees, the following elements:

- Stakeholder analysis and planning;
- Disclosure and dissemination of information;
- Consultation and participation;
- Grievance mechanism; and
- On-going reporting to Affected Communities.

The nature, frequency, and level of effort of stakeholder engagement may vary considerably and will be commensurate with the project's risks and adverse impacts, and the project's phase of development."

As common and good practice, stakeholder engagement is considered a key aspect of all projects and should be undertaken at the EIA stage in order to notify, gain views and enable a better understanding of the dynamics of the local environment.

Proposed stakeholder groups consulted in regard to this ESIA include those in the table below. All consultation was approved from the Project Proponent and Project Sponsors and SCE prior to being undertaken. Bahrain Registered Environmental Consultant has issued letters to each consultee and replies are expected by 7th February 2019.

Table 4-2 Proposed Stakeholders for Consultation

Stakeholders	Justification for Consultation
The Supreme Council for Environment (SCE)	SCE governs all matters directly related to the environment and is the 'Competent Authority' for all environmental issues relating to Decree No. 21 of 1996.
Central Planning Office (CPO)	Coordinates the planning and implementation of all public infrastructure projects across the public sector as well as major industries, such as oil and gas.
Marine Resources Directorate (MRD)	The Marine Resources Directorate (MRD) plays a vital role in the regulating, developing and promoting the marine resources of Bahrain.
Ports and Maritime Affairs (PMA)	The Ports and Maritime Affairs (PMA) plays a pivotal role in regulating, developing, and promoting the ports and maritime activities in Bahrain.
Southern Tourism Company	Southern Tourism Company is a private company who operates next to the Al Dur IWPP.
Al Dur IWPP Phase 1	Located adjacent to the project, dialogue will be required in regard to shared facilities and ensuring future emergency preparedness and response plans are aligned.
Ministry of Municipality Affairs & Urban Planning	As requested by Bahrain SCE in the response to the projects Screening Form, consultation will be undertaken in regard to the disposal of non-hazardous waste at Askar landfill resulting from both construction and operational processes.
NOGA	As requested by Bahrain SCE in the response to the projects Screening Form, consultation will be undertaken with NOGA to confirm acceptance to provide natural gas for the project.
Bahrain Authority for Culture and Antiquities (BACA)	Requested by Bahrain Environmental Consultant in Scoping Report to SCE
The Agricultural, Engineering and Water Resources Directorate (AEWRD)	
The Bahrain Defence Force (BDF)/Ministry of Defence	
The Southern Governate	

Stakeholders	Justification for Consultation
The Southern Area Municipality	
The Southern Area Municipal Council	

It is noted that the Screening Form response from Bahrain SCE indicated a need to consult with the Sitra power and water station. The Sitra facility is however located approximately 25km to the north of the proposed Al Dur IWPP Phase 2 and as such is considered to be outside of the range of influence for the projects impacts. Specific consultation with this facility is therefore not proposed as part of the EIA scope of works.

Consultation in regard to the above listed stakeholders was undertaken by the local EIA consultant 'Environment Arabia' by sending letters to the above identified stakeholders in order to comments, concerns and suggestions in regard to environmental and social matters of the project.

At the time of finalising this ESIA, three (3) stakeholders have replied to the letters sent out. Summaries of their responses/ comments are presented in the table below.

Table 4-3 Responses from Some of the Consulted Stakeholders

Stakeholders	Responses/Comments
Central Planning Office (CPO)	The Central Planning Office has circulated a Survey Consultation to concerned utility stakeholder in regards to existing and proposed services in the project area. The CPO will provide feedback received from these stakeholders at the end of the consultation process which usually takes 6 weeks.
The Agricultural, Engineering and Water Resources Directorate (AEWRD)	The Agricultural Engineering and Water Resources Directorate has no comment with regards to the development of the Project. However, the project will need to obtain permits from AEWRD for the following activities. • Geotechnical/Soil Investigation • Piling • Dredging and • Reclamation
Bahrain Authority for Culture and Antiquities (BACA)	The Bahrain Authority for Culture and Antiquities has no objection in the development and implementation of the Project

Response letters from each stakeholder are provided in Appendix F of this ESIA.

4.4.3 Impact Assessment Significance Criteria

In order to obtain a credible assessment of environmental impacts, the assignment of 'effect significance' to each identified impact needs to be a robust, consistent and transparent process. The methodology to assess 'effect significance' is outlined below and follows an

International Best Practice guideline[2] based on the assumption that the significance of an impact on resources or receptors is considered to result from an interaction between three factors:

- The nature and magnitude of the impact (i.e. a change in the environment, social and/or health baseline conditions);
- The number of resources or receptors affected (i.e. humans and the environment);
- The environmental value or sensitivity of those resources or receptors to the change.

A three-step approach has been used to determine the significance of environmental effects, as follows:

- **Step 1** – Evaluation of value/sensitivity of resource or receptor;
- **Step 2** – Assessing the magnitude of the impact on the resource or receptor; a
- **Step 3** – Determining the significance of impacts

Identification and Evaluation of Sensitive Receptors

Sensitive receptors are defined as:

- Elements of the ***environment*** that are of value to the functioning of natural systems (i.e. areas or elements of ecological, landscape or heritage value, species, habitats and ecosystems, soil, air and water bodies or land-use patterns);
- ***Human*** receptors, such as stakeholders (i.e. users of dwellings, places of recreation, places of employment, community facilities or household relocation) and human systems (e.g. employment market, population disease susceptibility and disease communicability, exposure to toxicity of chemicals).

The environmental value (or sensitivity) of the environmental & social value (or sensitivity) of the resource or receptor has been defined by using the criteria in the Table below.

Table 4-4 Environmental Value of Receptor or Resource

2 See for example Scottish Natural Heritage (2009) A handbook on environmental impact assessment or Highways Agency (2008) Assessment and Management of Environmental Effects design manual for roads and bridges HA 205/08 Volume 11, Section 2, Part 5.

Value (Sensitivity)	Description of Value
Very High	• High importance and rarity on an international scale and limited or no potential for substitution. • The receptor has already reached its carrying capacity, so any further impact is likely to lead to an excessive damage to the system that it supports. • Locations or communities that are highly vulnerable to the environmental impact under consideration or critical for society (e.g. indigenous peoples, hospitals, schools).
High	• High importance and rarity on a national scale, and limited potential for substitution. • The receptor is close to reaching its carrying capacity, so a further impact may lead to a significant damage to the system that it supports. • Locations or communities that are particularly vulnerable to the environmental impact under consideration (e.g. residential areas, vulnerable/marginalized groups).
Medium	• High or medium importance and rarity on a regional scale, limited potential for substitution. • The receptor is already significantly impacted, but it is not close to reaching its carrying capacity. Further impacts will get increase the stress of the underlying system, but evidence does not suggest that it is about to reach a critical point. • Locations or groups that are relatively vulnerable to the environmental impact under consideration (e.g. commercial areas).
Low	• Low or medium importance and rarity on a local scale. • The receptor is not significantly impacted and shows a large spare carrying capacity. Impacts are not likely to generate any noticeable stress in the underlying system. • Locations or groups that show a low vulnerability to the environmental impact under consideration (e.g. industrial areas).
Very Low	• Very low importance and rarity on a local scale. • The receptor is not impacted and shows a very large spare carrying capacity. Impacts are very unlikely to generate any noticeable stress in the underlying system. • Locations or groups that show a very low vulnerability to the environmental impact under consideration (e.g. industrial areas).

The existence of receptors that are legally protected (e.g. designated areas, protected habitats or species) will be taken into consideration for the assessment of the sensitivity of the receptors.

Identification and Evaluation of Potential Impacts

The following types of impacts have been considered in line with 5 Capital's assessment methodology:

- Direct Impacts - Potential impacts that may result from the construction and occupation of the Project acting directly on an environmental or social receptor (e.g. land take for construction of the camps);
- Indirect Impacts – Potential impacts which are not a direct result of a Project activity, often produced later in time or further removed in distance, but are normally a result of a complex pathway (e.g. dust deposition on vegetation which causes reduction in photosynthetic rates);
- Beneficial Impacts – Impacts that have a positive, desirable or favourable effect on the sensitive resources or receptors (e.g. landscape providing artificial habitat for a variety of species, creating jobs during the construction and/or occupation phases of a project);
- Adverse Impacts – Impacts that are detrimental and have a negative influence on sensitive resources or receptors;
- Event Related Impacts - Potential unplanned or accidental impacts stemming from an unintentional event such as fire, explosion, oil spill, etc. taking into consideration likelihood of occurrence;
- Cumulative Impacts - The additive potential impacts that may result from the incremental potential impacts of the planned Project plus the potential impacts of reasonably anticipated future projects or future phases of a same development.

The magnitude of the impact refers to the extent of change that is anticipated to occur for the receptor(s) under consideration and is considered as a function of:

- Extent/scale;
- Duration;
- Frequency and;
- Likelihood of occurrence.

In other words, the criterion that has been used for assessing the magnitude of impacts includes: the geographical scale of the impact, the permanence of impact and the reversibility of the impacted condition. A brief description of the magnitude of the impacts is provided in the Table below.

Table 4-5 Criteria for Magnitude of Impacts

MAGNITUDE OF IMPACT	DESCRIPTION OF MAGNITUDE
Major	*Adverse:* Loss of resource and/or quality and integrity; severe damage to key characteristics, features or elements. A major impact is usually large scale, permanent and irreversible. *Beneficial:* Large scale or major improvement of resource quality; extensive restoration or enhancement; major improvement of attribute quality.

MAGNITUDE OF IMPACT	DESCRIPTION OF MAGNITUDE
Moderate	*Adverse:* Significant impact on the resource, but not adversely affecting the integrity; Partial loss of/damage to key characteristics, features or elements. Moderate impacts usually extend above the site boundary, and are usually permanent, irreversible or cumulative. *Beneficial:* Benefit to, or addition of, key characteristics, features or elements; improvement of attribute quality.
Minor	*Adverse:* Some measurable change in attributes quality or vulnerability; minor loss of, or alteration to, one (maybe more) key characteristics, features or elements. Minor impacts usually are only noticeable within the site and are temporary and reversible. *Beneficial:* Minor benefit to, or addition of, one (maybe more) key characteristics, features or elements; some beneficial impact on attribute or a reduced risk of negative impact occurring.
Negligible	*Adverse:* Very minor loss or detrimental alteration to one or more characteristics, features or elements. *Beneficial:* Very minor benefit to or positive addition of one or more characteristics, features or elements.
No change	No loss or alteration of characteristics, features or elements; no observable impact in either direction.

Determination of Significance of Impacts

Significance of impacts is determined by taking into consideration the sensitivity of an identified receptor or resource and the magnitude of the project impact. That is, the greater the environmental sensitivity of an identified receptor or resource, and the greater the magnitude of impact, the more significant the impact (project impact).

In addition to this, where a project has a major detrimental impact on a highly valued environmental resource/receptor, the consequences of that impact on the said resource would be significant adverse effect. In other words, it is the result of the impact acting on the receptor that produces an environmental effect.

Effects can be either beneficial or adverse. The table below shows the criterion used for determining the significance of environmental impacts. Definitions of each significance categories are provided in table 4-5.

Table 4-6 Criteria for Determining Significance of Impacts

		MAGNITUDE OF IMPACT (DEGREE OF CHANGE)				
		No change	**Negligible**	**Minor**	**Moderate**	**Major**
Sensitivity of Receptor	**Very High**	Neutral	Minor	Moderate to Major	Major	Major

	High	Neutral	Minor	Minor to moderate	Moderate to Major	Major
	Medium	Neutral	Negligible to minor	Minor	Moderate	Moderate to Major
	Low	Neutral	Negligible to minor	Negligible to minor	Minor	Minor to moderate
	Very Low	Neutral	Negligible	Negligible to minor	Minor	Minor

In some cases, above the significance is shown as being one of two alternatives. In these cases, a single description is decided upon with reasoned judgement for that level of significance chosen.

Table 4-7 Definition of Impact Significance

SIGNIFICANCE CATEGORY	CRITERIA
Very Large	Only adverse effects are assigned this level of importance as they represent key factors in the decision-making process. Effects are associated with sites and features of national or regional importance. Effects exceed statutory limits. Mitigation measures are unlikely to remove such effects.
Large	Important considerations at a local scale but, if adverse, are potential concerns to the project and may become key factors in the decision-making process. Mitigation measures and detailed design work are unlikely to remove all of the effects upon the affected communities or interests.
Moderate	These effects, if adverse, while important at a local scale, are not likely to be key decision-making issues. Nevertheless, the cumulative effect of such issues may lead to an increase in the overall effects on a particular area or on a particular resource. They represent issues where effects will be experienced but mitigation measures and detailed design work may ameliorate or enhance some of the consequences upon affected communities or interests. Some residual effects will still arise.
Slight	Local issue unlikely to be of importance in the decision-making process. Effects do not exceed statutory limits. Nevertheless, they are of relevance in enhancing the subsequent design of the project and consideration of mitigation or compensation measures.
Neutral	No effect or effect that is beneath the level of perception, within normal bounds of variation or within the margin of forecasting error. No mitigation is required.

The approach to assigning significance of impact relies on reasoned argument, professional judgement and taking on board the advice and views of appropriate organisations. For some disciplines it is determined by comparison, wherever possible with company, locally, nationally or internationally accepted standards. If no standards are available then it is necessary to develop project specific limits, based on guidance or best practice as necessary.

Such standards or limits are referred to as the **Significance Threshold**. If the size and type of impact is greater that the significance threshold, then this is termed a **Significant Impact**. Potential significant impacts need to be avoided and are therefore prioritised identifying mitigation measures to reduce the effect to an acceptable level. Significant effects will be those, which are 'Major' or 'Moderate to Major'.

Note: All predicted impacts with a beneficial impact have been colour coded green.

4.4.4 Mitigation & Management Measures

The project includes a variety of measures to ensure that environmental standards and guidelines can be achieved by the project. The projects impact assessment process as outlined above will therefore take into consideration those measures included to the projects design. In addition to specific measures included to the projects design, the ESIA will outline further mitigation and/or management measures for the construction & commissioning phases and the operational phase, upon which the project can further minimise or avoid negative impacts, and ameliorate positive impacts.

Upon approval of the project, the stated mitigation and management measures in the approved ESIA will be required for implementation as a condition of the environmental permit, or as the lenders as part of the loan agreement.

4.4.5 Residual Impacts

Following assessment of the mitigation and management measures, the projects residual impact significance will be considered to determine whether the proposed mitigation and management can be considered acceptable. The significance of such impacts is based upon the same criteria used to determine the impact significance before applying additional mitigation & management measures.

5 AIR QUALITY

This chapter describes and assesses the potential impacts that may occur as a result of the projects construction and operational activities on air quality and identifies measures to be undertaken and implemented in order to mitigate and manage such impacts.

5.1 Standards and Regulatory Requirements

5.1.1 National Requirements

Ambient Air Quality

The table below details the ambient Air Quality standards that should not be exceeded as a result of project activities (construction and operation). The standard have been referenced from the Bahraini Ministerial Order No.3 of 2001.

Table 5-1 National Ambient Air Quality Standards

POLLUTANT	UNIT	EXPOSURE PERIOD	BAHRAIN STANDARD
Sulphur Dioxide (SO_2)	µg/m^3 (ppb)	Hour	350 (134)
		24 Hours	125 (48)
		Annually	50 (19)
Nitrogen Dioxide (NO_2)	µg/m^3 (ppb)	Hour	200 (106)
		24 Hours	150 (80)
		Annually	40 (21)
Inhalable Suspended Particles (PM^{10})	µg/m^3 (ppb)	24 Hours	340
		Annual	80
Ozone	ppb	Hour	100
Carbon Monoxide	ppm	Hour	26
Non-methane hydrocarbons	ppb	3-hour	24

Air Emissions

The table below outlines the air emission standards established by the Bahraini Ministerial Order.

Table 5-2 Air Emission Standards – Combustion Processes (Fuel combustion units, Commercial, Furnaces, industrial (Ministerial Order No.3 2001)

POLLUTANT	UNIT	STANDARD
Particulate Matter (PM)	mg/m^3	50 (oil fired) (for units with input energy > 50MW)
		100 (oil fired) (for units with input energy < 50MW)
Hydrogen Sulphide (H_2S in fuel)	ppm	600 (gas fired)
Sulphur Dioxide (SO_2)	mg/m^3	500 (oil fired)
Nitrogen Oxides (NO_x)	mg/m^3	100 (gas fired)
	mg/m^3	150 (oil fired)
Carbon Monoxide (CO)	mg/m^3	100 mg/m^3

According to Ministerial Order No. 3 of 2001 the following requirements for air quality limits are to be met:

- 15% O_2 in dry flue gas at temperature 273K, and a pressure of 101.3kPa;
- HRSGs: natural gas fired only;
- If the fuel content of H_2S is more than 600 PPM, then there is a requirement to use an equivalent SO_2 removal system to bring it to this value.

EWA Project Specific Requirement

In accordance with the Minimal Functional Specification issued by EWA (Section 5.8.2), it is stated, 'that whilst the national emission limit for nitrogen oxides (or NOx) is 100 mg/m^3, *recent gas turbine development projects in Bahrain have guaranteed not to exceed 25 ppm and, therefore, this limit is considered achievable by the utilisation of Best Available Techniques (BAT).*'

The emission limits for this specific project as established in the Project's bidding 'Formsheets' are specified in the table below.

Table 5-3 EWA RfP: Formsheet – D: Performance Guarantee Data (Exhaust Gas Emissions)

Description	Unit	Data	
		Simple Cycle	Combined Cycle
Nitrogen Oxides (NO_x)	ppm	25	25
Sulphur Dioxide (SO_2)	mg/m³	Non-degraded airshed: Use of 1% or less S fuel Degraded airshed: Use of 0.5% or less S Fuel	Non-degraded airshed: Use of 1% or less S fuel Degraded airshed: Use of 0.5% or less S Fuel
Hydrogen Sulphide (H_2S in fuel)	ppm	≤ 600	≤ 600
Carbon Monoxide (CO)	mg/m³	100	100
Particulate Matter (PM)	mg/m³	Non-degraded airshed: 50 Degraded airshed: 30	Non-degraded airshed: 50 Degraded airshed: 30

Note:

- Above limits to be met when operating between 50% - 100% on natural gas fuel.
- Reference O_2 Content (273K, and pressure of 101.3 kPA is at 15%

Bahrain national standards are also applicable for emissions from auxiliary boilers, as presented in the table below.

Table 5-4 RfP National Limits for Emissions from Auxiliary Boilers (Ref: Schedule F: Minimum Functional Specifications, Table 5-2, Pg. 72)

Pollutant	Fuel Type	Unit	Limit
Particulate Matter (PM)	Natural gas fired	mg/m³	5
	Fuel oil fired		50
Sulphur Dioxide (SO_2)	Natural gas fired	mg/m³	10
	Fuel oil fired		66
Nitrogen Oxides (NO_x)	Natural gas fired	mg/m³	100
	Fuel oil fired		150
Carbon Monoxide (CO)	Natural gas fired	mg/m³	50
	Fuel oil fired		100
Hydrogen Sulphide (H_2S in fuel)	Natural gas fired	ppm	600

5.1.2 Lender Requirements

Ambient Air Quality

International financial institutions providing project finance will require adherence to the World Health Organisation Ambient Air Quality requirements, as detailed in the IFC General EHS Guidelines.

Table 5-5 WHO Ambient Air Quality Guidelines (ref: IFC General EHS Guidelines) (µg/m³ unless otherwise specified)

PARAMETER	WHO STANDARDS	
	24 HOUR	ANNUAL
PM_{10}	150 (Interim target 1)	70 (Interim target 1)
	100 (Interim target 2)	50 (Interim target 2)
	75 (Interim target 3)	30 (Interim target 3)
	50 (guideline)	20 (guideline)
$PM_{2.5}$	75 (Interim target 1)	35 (Interim target 1)
	50 (Interim target 2)	25 (Interim target 2)
	37.5 (Interim target 3)	15 (Interim target 3)
	25 (guideline)	10 (guideline)
Nitrogen Dioxide (NO_2)	200 (1 hour)	40
Sulphur Dioxide (SO_2)	125 (Interim target 1)	500 (10-minute guideline)
	50 (Interim target 2)	
	20 (guideline)	
Ozone (O_3)	100 (8 hour daily maximum guideline)	-

Air Emissions

The respective IFC guidelines for emissions are detailed below, with regard to combustion turbines. These have been referenced from the IFC EHS Guidelines for Thermal Power Plants.

Table 5-6 IFC Emissions Guidelines (in mg/Nm3 or as indicated) for Combustion Turbine

Combustion Technology/Fuel	Particulate Matter (PM)		Sulfur Dioxide (SO_2)		Nitrogen Oxides (NO_x)	Dry Gas Excess O_2 Content %
Combustion Turbine	NDA	DA	NDA	DA	NDA/DA	
Natural Gas (all turbine types of Unit >50MWth	N/A	N/A	N/A	N/A	51 (25 ppm)	15%
Fuels other than Natural Gas (Unit>>59MWth	**50**	**30**	Use of 1% or less S fuel	Use of 0.5% or less S fuel	152 (74 ppm)a	15%

Note:

- NDA= Non-degraded airshed; DA= Degraded airshed (poor air quality);
- Airshed should be considered as being degraded if nationally legislated air quality standards are exceeded or, in their absence, if WHO Air Quality Guidelines are exceeded significantly;
- S = sulfur content (expressed as a percent by mass); Nm3 is at one atmospheric pressure, 0 degree Celsius; MWth category is to apply to single units; Guideline limits apply to facilities operating more than 500 hours per year. Emission levels should be evaluated on a one hour average basis and be achieved 95% of annual operating hours;
- If supplemental firing is used in a combined cycle gas turbine mode, the relevant guideline limits for combustion turbines should be achieved including emissions from those supplemental firing units (e.g., duct burners);
- Technological differences (for example the use of Aeroderivatives) may require different emissions values which should be evaluated on a cases-by-case basis through the EA process but which should not exceed 200 mg/Nm3;
- Comparison of the Guideline limits with standards of selected countries / region (as of August 2008):
  - Natural Gas-fired Combustion Turbine – NOx
  - Guideline limits: 51 (25 ppm)
  - EU: 50 (24 ppm), 75 (37 ppm) (if combined cycle efficiency > 55%), 50*η / 35 (where η = simple cycle efficiency)
  - US: 25 ppm (> 50 MMBtu/h (≈ 14.6 MWth) and ≤ 850 MMBtu/h (≈ 249MWth)), 15 ppm (> 850 MMBtu/h (≈ 249 MWth))

(Note: further reduced NOx ppm in the range of 2 to 9ppm is typically required through air permit).

5.2 Observations and Baseline Conditions

5.2.1 General Observations

According to the Meteorological Directorate of the Ministry of Transport and Telecommunications, the climate of Bahrain is an arid type with two main climatic periods from June to September and from December to March. These two climatic periods are separated by two transitional periods experienced in April/May and October/November. Yearly precipitation is irregular with an average of 70.8mm usually confined to the winter months.

The winter period is the season of changeable weather when low pressure disturbances with their associated fronts transit the mid Gulf. Surface winds alternate mainly between south east ahead of these features and north west behind. The passage of the front and troughs may be accompanied by thunderstorms & squall and isolated severe storms can also occur.

The summer period in Bahrain is one of the mainly cloudless skies and persistently high temperature. A shallow dome relatively cool moist air over the Gulf is overlaid by hot air causing a marked temperature inversion in the first 1000 to 1500 feet of the order of 5 to 10°C. The seasonal rise in temperature peaks in August with a mean daily maximum of 38°C. However, the extreme maximum temperatures of 46.7°C are observed in May. During June and July a period of persistently strong north westerly winds known locally as the "summer shamal" occurs and arrests temporarily the seasonal rise in temperature.

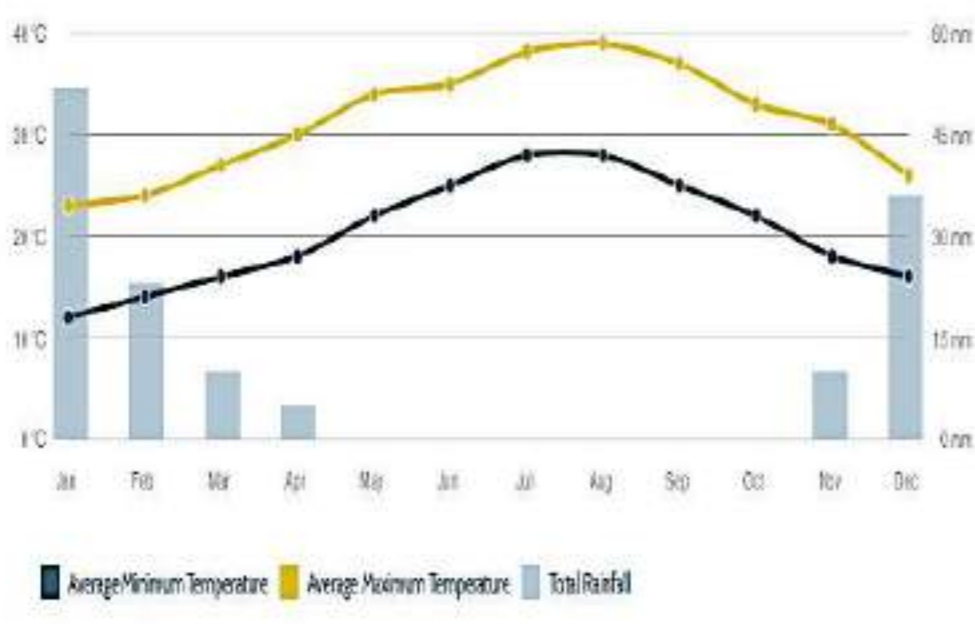
The shamal wind, which is part of the Indian Monsoon circulation is related directly to a low level jet stream concentrated near 1000ft. This causes marked wind shears at times in the boundary layer of the order 5-8 knots per 100ft. The shamal transports dusts from Iraq and visibility at Bahrain on occasions are reduced to less than 1500m over this period.

The transitional periods are important in two respects. The first is the abruptness of the change during October/November when first incursions of cool air from the north west occur and replace the quiet conditions of late summer. The second and more importantly is the spring transition. This period is known as the "Sarrayat".

The figures below presents the average monthly temperature, humidity and wind speed values averaged for the period from 2008 to 2017 in Bahrain.

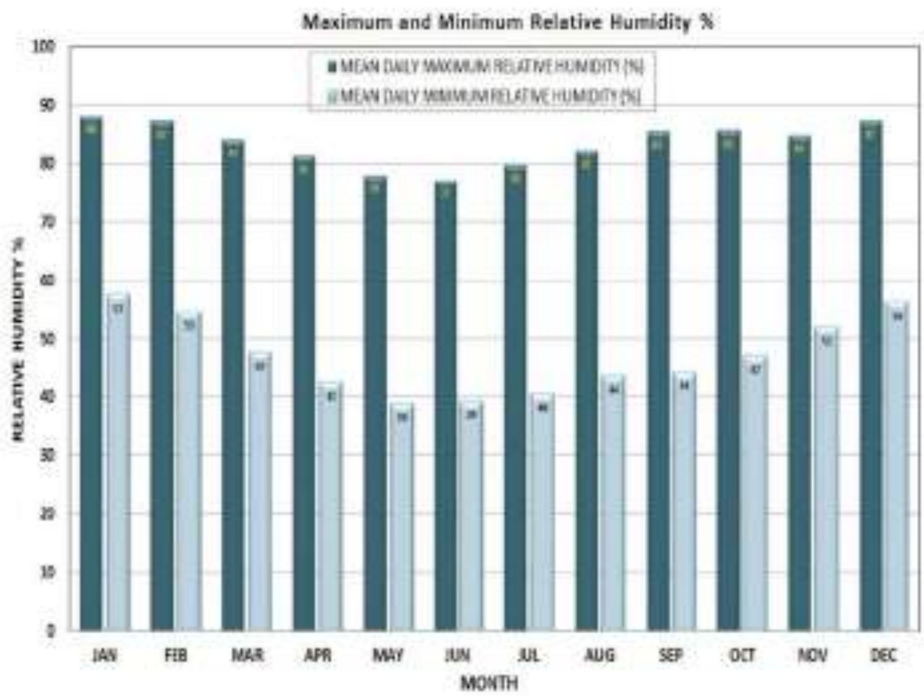
The monthly average temperature, maximum & minimum humidity in Bahrain for the year 2017 and the wind rose from 2008 to 2017 as obtained from the Meteorological Directorate are presented in the figures below.

Figure 5-1 Monthly Average Temperature in Bahrain (2017)



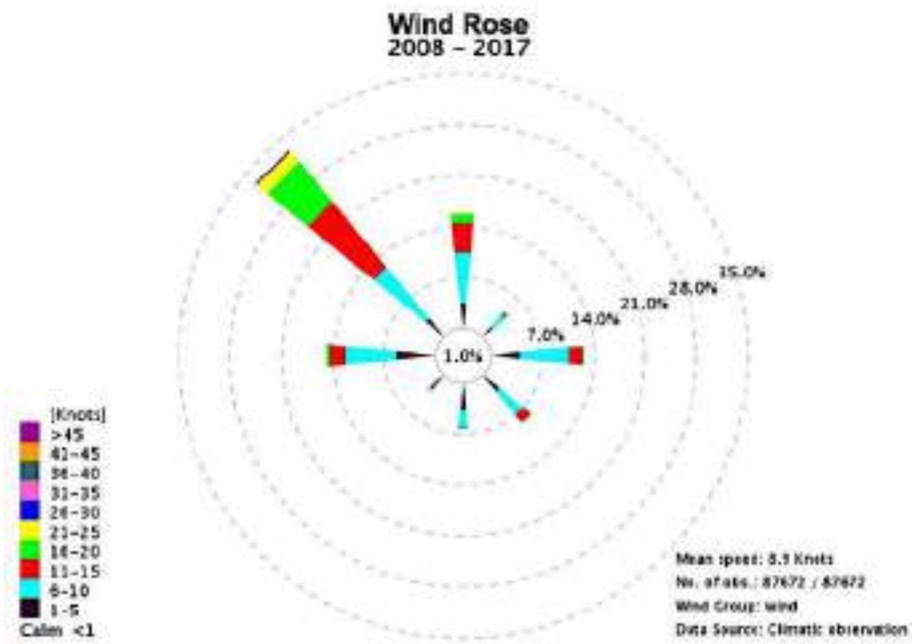
Source: http://www.bahrainweather.gov.bh/web/guest/monthly-temperature Accessed 20th November 2018

Figure 5-2 Maximum and Minimum Relative Humidity in Bahrain (2017)



Source: http://www.bahrainweather.gov.bh/web/guest/humidity Accessed 20th November 2018

Figure 5-3 Wind Direction in Bahrain 2007 to 2018



Source: http://www.bahrainweather.gov.bh/web/guest/winds Accessed 20th November 2018

5.2.2 Site Based

Air quality and in particular instances of poor air quality are influenced by geographical considerations and by proximity to pollution sources (e.g. highways and combustion facilities). Typically, the air shed closer to a pollution source is of poorer quality than at a greater distance (due to pollutant dispersion). However, air quality at a specific location is generally dependant on meteorological conditions particularly wind direction, strength, temperature and humidity; which has a large effect on the direction, buoyancy and dispersion of the pollutant plume.

On a local scale, although the surrounding area of the Project is not very populated, there are few anthropogenic sources of emissions in the vicinity of the Project that could affect the quality of air in the project area.

The nearest static point sources of emissions are the adjacent stacks at the Al Dur Phase 1 IWPP. Mobile emissions from vehicles travelling along the King Hamad motorway, located approximately 400m to the west of the proposed project boundary, and other local roads in the area will also result in impacts to the ambient airshed. The operation of the harbour (400 m north-east of the project site) and air base (to the south) are also expected to result in emissions influences within the airshed.

Emissions from all these sources result from the combustion of natural gas and hydrocarbon fuels which (depending on the fuel type used) will result in ambient increases of NO_x (as NO_2 and NO), SO_2, CO, Particulate Matter and VOCs. Pollutant emissions from these sources are expected to be relatively well mixed in the local air shed, although emissions form the Al Dur Phase 1 IWPP (particularly for NO_x and CO) may be distinguishable and more concentrated in the local area (although this is dependent on dispersion patterns linked to weather conditions). The prevailing wind from the north-north-west, is expected to direct the majority of emissions towards the Arabian Gulf and other areas in the south of Bahrain. Other noticeable winds (such as the Shamal from the South-East) may result in dispersion of emissions over more inland areas of the island.

Table 5-7 Existing Local Pollution Sources

Source	Location	Potential Pollutants
Al Dur Phase 1 IWPP	Approximately 600m north of the project site	Combustion of natural gas and hydrocarbon fuels resulting in diffuse and point sources of Nitric Oxide, Nitrogen Dioxide, Sulphur Dioxide, Carbon Monoxide, Particulate Matter, VOCs
King Hamad Highway	Approximately 400m west of the project site	Mobile source emissions of: Nitric Oxide, Nitrogen Dioxide, Sulphur Dioxide, Carbon Monoxide, Particulate Matter, VOCs
Maritime Vessels	Approximately 400m north east of the project site	
Air Base	Approximately 2.2km to the south	Combustion of hydrocarbon fuels from aircraft resulting in mobile sources of Nitric Oxide, Nitrogen Dioxide, Sulphur Dioxide, Carbon Monoxide, Particulate Matter, VOCs Diffuse emissions of VOC's from hydrocarbon fuel storage and transfer operations.
Askar Municipal Landfill	Approximately 3km to the north west	Methane, hydrogen sulphide, ammonia, VOCs from decomposing organic wastes. Mobile source emissions of: Nitric Oxide, Nitrogen Dioxide, Sulphur Dioxide, Carbon Monoxide, Particulate Matter, VOCs from HGVs and Mobile Plant.

Ambient Air Quality Monitoring

During the scoping study, it was identified that both short and medium term ambient air quality monitoring be undertaken within and outside the Project site in order to provide a baseline upon which to assess the potential for construction based impacts of dust generation & dispersion to nearby sensitive receptors; and to better understand baseline air quality conditions that may affect site personnel.

<u>Short Term Ambient Air Quality Monitoring</u>

Short term ambient air quality monitoring was undertaken from 23rd November to 2^{nd} December 2018 at three (3) monitoring locations surrounding the proposed Project site. The survey was conducted during day and night using a continuous stationary high-volume mass sampler to monitor ambient concentrations of carbon monoxide (CO), nitrogen dioxide (NO_2), sulphur dioxide (SO_2), ozone (O_3), Ammonia, Hydrogen Sulphide, Methane, Benzene and particulate matter ($PM_{2.5}$ and PM_{10}) at each location (note: calibration certificates are presented in Appendix G).

The monitoring survey was carried out as follows:

Table 5-8 Air Quality Monitoring Schedule

Location Surveyed	Date of Survey
AQ3	23rd to 25th November 2018
AQ1	26th to 29th November
AQ2	29TH to 2nd December 2018

The monitoring campaign ran for three (3) separate days at each location to ensure that conditions could be benchmarked with hourly and 24-hourly standards, as well as observing any diurnal fluctuations in ambient air quality, or influences due to local weather conditions.

The location of short term air quality monitoring stations is presented as follows:

Figure 5-4 Location of Ambient Air Quality Monitoring Station

Table 5-9 Short Term Ambient Air Quality Monitoring Locations

ID	Co-ordinates	
	Northing	Easting
AQ1	2870867.00	461004.00
AQ2	2870473.00	459487.00
AQ3	2873386.00	461272.00

Long Term Ambient Air Quality Monitoring

Long term ambient air quality monitoring was undertaken outside the Project site in order to provide an indication of longer-term pollutant concentrations in the project area. Diffusion tubes were installed to monitor the concentration of NO_2, SO_2, H_2S & Top 5 VOCs at four (4) locations (A-1, A-2, A-3 and A-4) between 2nd January 2019 and 27th January 2019. The monitoring campaign ran for a total period of three (3) weeks. The monitoring locations were selected to provide representative ambient air quality concentrations of the project site air shed due to the existing point and mobile emission sources located north, west and south of the proposed Project site (Al Dur Phase 1 IWPP, King Hamad Highway, Maritime Vessels, Air Base and Askar Municipal Landfill)).

At each monitoring location, one (1) diffusion tube was installed for each of the parameters resulting in a total of 4 diffusion tubes for NO_2, SO_2 H_2S & VOC at each location.

The table and figure below provide the long-term ambient air quality monitoring locations.

Table 5-10 Long Term Ambient Air Quality Monitoring Locations

ID	Co-ordinates		Photographs
	Northing	Easting	
A-1	2871509.59	461072.50	None
A-2	2871165.81	459587.01	None
A-3	2873856.37	460831.27	

ID	Co-ordinates		Photographs
	Northing	Easting	
A-4	2875408.43	461404.79	

Figure 5-5 Location of Long-Term Ambient Air Quality Monitoring Station

Ambient Air Quality Monitoring Results

Short Term Ambient Air Quality Monitoring Results

The hourly average results obtained for the ambient air quality monitoring survey conducted at the project site are presented in the table below showing the concentration of NH_3, CO, H_2S, CH_4, NO_2, O_3, SO_2, VOCs, Benzene, particulate matter ($PM_{2.5}$ and PM_{10}) and meteorological data. The 24-hour average results are presented in Table 5-11 showing concentration of all parameters analysed. These results have been compared with ambient air quality standards established by Bahrain and WHO.

The complete short term ambient air quality laboratory results are provided in Appendix H.

Meteorological Data

Table 5-11 Hourly Meteorological Data Obtained at AQ1

Days	AQ1				AQ2				AQ3			
	Time	RH %	Temp °C	WS m/s	Time	RH %	Temp °C	WS m/s	Time	RH %	Temp °C	WS m/s
Day1	**26/11/2018**				**29/11/2018**				**23/11/2018**			
	2 PM	69.7	24.4	5.5	**5PM**	69.8	23.9	3.9	**1AM**	69.5	21.7	3.7
	3 PM	68.1	24.4	5.7	**6PM**	79.3	22.1	2.3	**2AM**	70.2	21.9	3.6
	4PM	70.9	23.7	6.2	**7PM**	86.0	21.0	1.5	**3AM**	73.2	21.9	3.4
	5PM	78.7	22.2	5.3	**8PM**	88.8	20.4	1.3	**4AM**	74.8	21.6	3.4
	6PM	86.8	21.2	4.1	**9PM**	91.6	19.8	0.9	**5AM**	74.8	21.7	3.1
	7PM	91.3	20.7	5.1	**10PM**	90.8	19.2	1.2	**6AM**	75.5	21.8	3.4
	8PM	93.0	20.3	5.5	**11PM**	92.0	18.9	1.2	**7AM**	75.5	22.1	2.8
	9PM	93.9	19.8	4.7	**12AM**	97.4	18.6	1.2	**8AM**	69.4	24.2	2.3
	10PM	95.3	19.4	4.4					**9AM**	60.3	26.8	1.8
	11PM	96.4	19.0	4.2					**10AM**	59.6	27.0	2.0
	12AM	97.2	18.7	4.0					**11AM**	62.4	26.2	2.4
									12PM	61.6	26.6	1.9
									1PM	57.8	28.5	1.4
									2PM	60.5	27.5	2.1
									3PM	63.6	26.7	3.1
									4PM	70.3	25.5	3.4
									5PM	76.2	24.6	2.5
									6PM	78.2	24.1	1.9
									7PM	73.6	24.3	3.4
									PM	73.6	24.2	3.0
									9PM	74.4	24.0	2.5
									10PM	77.6	23.8	1.8
									11PM	79.4	23.6	2.0
									12AM	81.5	23.5	2.5
Day 2	**27/11/2018**				**30/11/2018**				**24/11/2018**			
	1AM	96.4	18.6	4.3	**1AM**	99.5	18.5	1.5	**1AM**	82.1	23.6	3.0
	2AM	95.3	18.3	4.7	**2AM**	99.1	17.9	1.8	**2AM**	81.7	23.7	3.7
	3AM	95.6	17.9	4.5	**3AM**	99.9	17.6	1.8	**3AM**	79.6	23.8	4.6
	4AM	95.0	17.8	5.3	**4AM**	99.9	17.3	1.6	**4AM**	79.7	23.8	4.2
	5AM	95.3	17.5	4.7	**5AM**	99.9	17.1	1.6	**5AM**	81.0	23.8	4.4

Days	AQ1				AQ2				AQ3			
	Time	RH %	Temp °C	WS m/s	Time	RH %	Temp °C	WS m/s	Time	RH %	Temp °C	WS m/s
	6AM	97.0	17.2	4.0	6AM	99.9	17.0	1.7	6AM	81.8	24.0	3.3
	7AM	96.4	17.6	4.5	7AM	99.9	17.8	1.5	7AM	81.0	24.1	4.4
	8AM	92.7	19.2	6.1	8AM	99.9	20.5	1.8	8AM	78.3	25.2	6.8
	9AM	88.1	20.6	7.0	9AM	96.2	23.6	3.1	9AM	75.1	26.4	6.9
	10AM	80.7	21.8	7.0	10AM	76.9	28.4	1.5	10AM	74.0	27.2	5.9
	11AM	76.1	23.0	7.7	11AM	53.8	32.4	2.0	11AM	67.0	29.4	4.7
	12PM	72.6	23.8	7.6	12PM	54.2	31.4	2.0	12PM	60.4	31.4	3.0
	1PM	64.4	25.0	6.7	1PM	55.1	31.8	2.0	1PM	58.5	31.8	2.0
	2PM	60.1	25.2	6.9	2PM	54.6	31.5	2.2	2PM	57.6	31.9	2.4
	3PM	58.7	25.1	6.5	3PM	57.0	31.3	2.7	3PM	61.7	30.9	2.9
	4PM	56.5	24.6	6.4	4PM	67.3	28.5	3.3	4PM	64.6	29.9	2.9
	5PM	62.2	22.5	5.8	5PM	78.2	25.6	2.6	5PM	71.1	27.0	3.0
	6PM	70.4	20.9	4.9	6PM	92.1	23.3	2.1	6PM	74.4	25.7	3.8
	7PM	82.6	20.2	4.3	7PM	96.9	22.6	2.0	7PM	77.2	25.2	3.3
	PM	83.9	19.5	3.3	PM	99.7	22.2	2.6	PM	83.2	24.8	2.6
	9PM	84.5	18.6	2.9	9PM	99.9	22.0	2.1	9PM	84.7	24.7	4.1
	10PM	89.7	18.6	3.7	10PM	99.9	21.6	0.5	10PM	85.3	24.7	4.4
	11PM	92.4	18.9	4.5	11PM	99.9	21.2	0.6	11PM	85.5	24.7	4.6
	12AM	92.6	18.9	4.5	12AM	99.9	20.8	1.4	12AM	86.3	24.6	5.6
Day 3	27/11/2018				01/12/2018				25/11/2018			
	1AM	93.3	18.6	4.6	1AM	99.9	20.6	1.5	1AM	86.9	24.6	6.4
	2AM	93.4	18.5	4.6	2AM	99.9	20.1	0.7	2AM	88.0	24.5	6.8
	3AM	92.8	18.4	4.5	3AM	99.9	19.8	1.0	3AM	89.8	24.4	6.9
	4AM	92.6	18.2	4.7	4AM	99.9	19.4	0.6	4AM	90.1	24.6	7.4
	5AM	93.4	17.9	4.9	5AM	99.9	19.1	0.5	5AM	91.7	24.4	7.4
	6AM	93.8	18.0	5.5	6AM	99.9	18.5	1.0	6AM	94.1	24.1	4.5
	7AM	94.9	17.8	5.1	7AM	99.9	18.9	1.0	7AM	95.2	24.4	4.5
	8AM	91.2	19.2	6.9	8AM	99.3	23.7	0.5	8AM	90.9	24.5	10.4
	9AM	84.3	21.1	7.4	9AM	90.3	28.3	1.4	9AM	97.7	20.7	5.5
	10AM	76.7	22.9	6.7	10AM	75.6	30.7	1.6	10AM	97.1	24.0	2.8
	11AM	72.5	23.8	6.2	11AM	74.6	29.7	1.7	11AM	88.4	25.9	4.8
	12PM	68.4	25.0	6.5	12PM	65.8	31.7	1.6	12PM	79.6	24.7	7.4
	1PM	66.8	25.1	6.4	1PM	62.4	32.6	1.7	1PM	86.1	22.5	6.0
	2PM	64.1	25.5	6.6	2PM	56.7	32.6	1.4	2PM	85.8	24.1	4.2
	3PM	62.3	24.9	7.2	3PM	57.8	30.2	2.0	3PM	78.1	25.2	2.1
	4PM	64.9	23.9	7.2	4PM	64.4	28.2	1.8	4PM	79.5	25.4	1.7
	5PM	68.9	22.8	6.3	5PM	86.0	25.5	0.4	5PM	87.4	24.2	1.4

Days	AQ1				AQ2				AQ3			
	Time	RH %	Temp °C	WS m/s	Time	RH %	Temp °C	WS m/s	Time	RH %	Temp °C	WS m/s
	6PM	74.6	21.4	5.0	6PM	89.1	23.9	0.0	6PM	91.4	23.3	0.3
	7PM	78.6	20.8	3.9	7PM	93.4	22.6	0.3	7PM	93.6	22.9	1.7
	8PM	80.9	20.0	3.0	8PM	99.9	21.9	0.3	8PM	94.7	22.5	1.4
	9PM	88.2	19.0	2.7	9PM	99.9	21.5	0.7	9PM	93.8	21.8	0.8
	10PM	93.8	18.5	2.7	10PM	99.9	21.1	0.4	10PM	95.5	21.7	0.4
	11PM	95.6	17.9	2.8	11PM	99.9	20.5	0.1	11PM	99.0	21.4	7.3
	12AM	96.1	18.0	2.9	12AM	99.9	20.1	1.2	12AM	99.9	21.1	0.2
Day 4	28/11/2018				02/12/2018							
	1AM	95.9	18.0	3.2	1AM	99.9	19.2	1.4				
	2AM	95.1	17.8	3.6	2AM	99.9	19.4	1.2				
	3AM	94.8	17.5	3.4	3AM	99.9	19.2	1.3				
	4AM	94.1	17.5	3.4	4AM	99.9	18.5	1.4				
	5AM	94.9	17.1	3.3	5AM	99.9	18.5	1.3				
	6AM	97.2	16.5	2.7	6AM	99.9	18.8	1.1				
	7AM	98.4	16.6	3.1	7AM	99.9	18.7	1.7				
	8AM	95.4	18.6	4.3	8AM	99.9	19.7	0.8				
	9AM	89.2	20.7	6.2	9AM	99.9	23.0	0.6				
	10AM	83.1	22.2	6.3	10AM	97.2	26.6	2.7				
	11AM	78.6	23.7	5.7	11AM	72.9	28.6	3.5				
	12PM	68.9	26.1	4.6	12PM	57.8	29.5	3.9				
	1PM	63.2	27.3	4.7	1PM	49.3	29.4	4.4				
	2PM	67.3	27.1	4.3	2PM	54.1	27.9	3.9				
					3PM	62.5	26.1	4.1				
					4PM	63.8	25.4	3.6				
					5PM	65.7	25.2	3.5				

Table 5-12 Average 24 Hours Meteorological Data Obtained at All Monitoring Stations

Location	Days	RH %	Temp (°C)	WS (m/s)
AQ1	Day 1	85.6	21.2	5.0
	Day 2	82.5	20.5	5.3
	Day 3	82.6	20.7	5.2
	Day 4	86.9	20.5	4.2
AVERAGE		**84.4**	**20.7**	**4.9**
AQ2	Day 1	87.0	20.5	1.7
	Day 2	86.6	23.4	1.9
	Day 3	88.1	24.2	1.0
	Day 4	83.7	23.2	2.4

Location	Days	RH %	Temp (°C)	WS (m/s)
AVERAGE		**86.3**	**22.8**	**1.7**
AQ3	**Day 1**	70.6	24.3	2.7
	Day 2	75.5	26.3	4.0
	Day 3	90.6	23.6	4.3
AVERAGE		**78.9**	**24.7**	**3.6**

Note: RH **– Relative Humidity** and WS**.- Wind Speed**

Temperature was observed to range from 16.5°C to 27.3°C at AQ1, from 17.0°C to 32.6°C at AQ2 and 20.7°C to 31.9°C at AQ3. During the monitoring period, the maximum temperature at each monitoring location were recorded between 01:00pm to 15:00pm on each day which is the period of peak sunlight.

Maximum temperature was recorded as 32.6°C at monitoring station 2 (AQ2) on Day 3 at 2:00pm. On each day and at each monitoring location (AQ1, AQ2 & AQ3), as temperature increased, relative humidity was noted to decrease and as temperature decreased, relative humidity was noted to increase (see graphs below).

Wind speed ranged between 2.7m/s to 7.7m/s at AQ1, from 0m/s to 4.4m/s at AQ2 and from 0.2m/s to 10.4m/s at AQ3 throughout the monitoring periods.

Figure 5-6 Hourly Results of Temperature, Relative Humidity and Wind Speed at AQ1

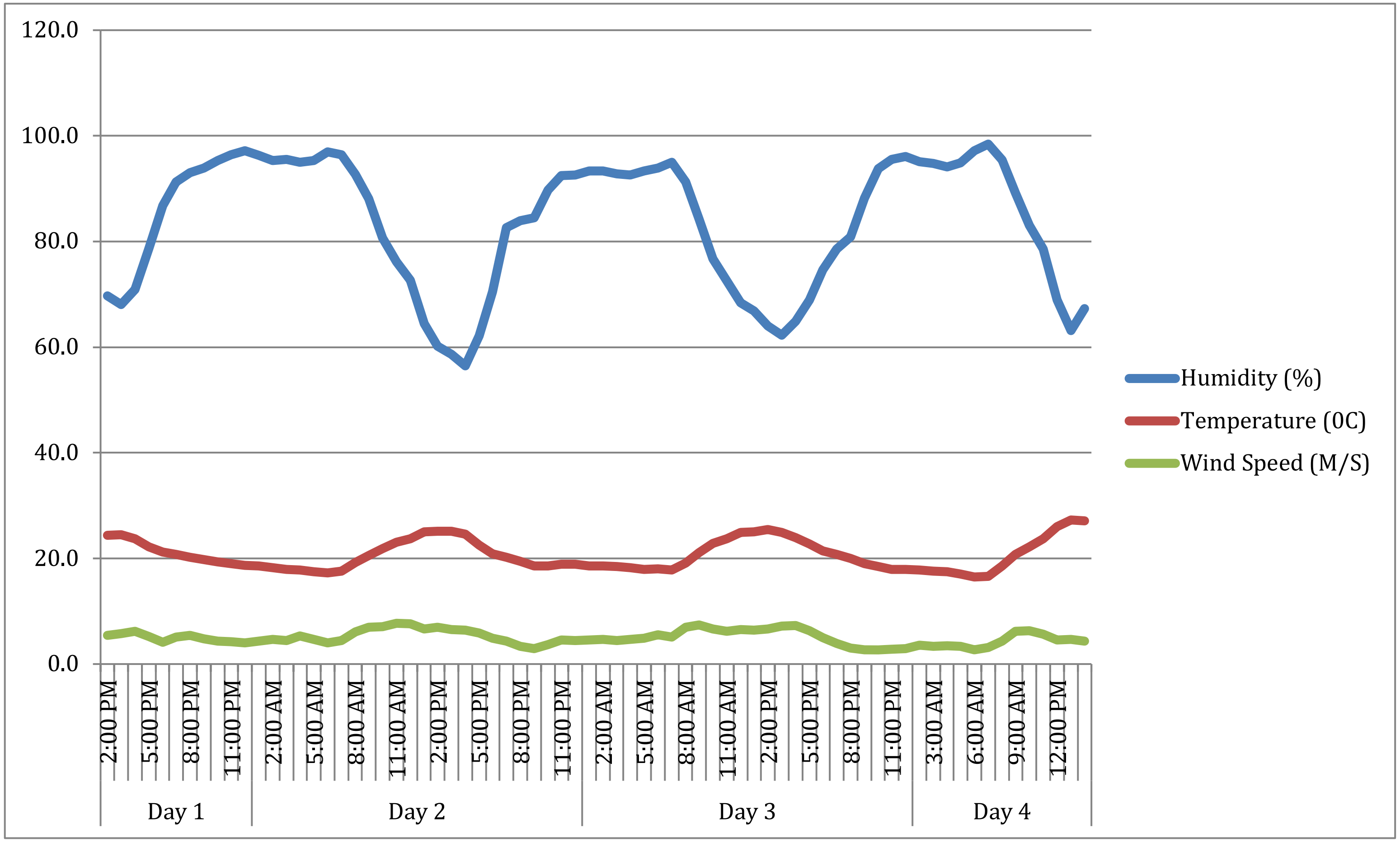


Figure 5-7 Hourly Results of Temperature, Relative Humidity and Wind Speed at AQ2

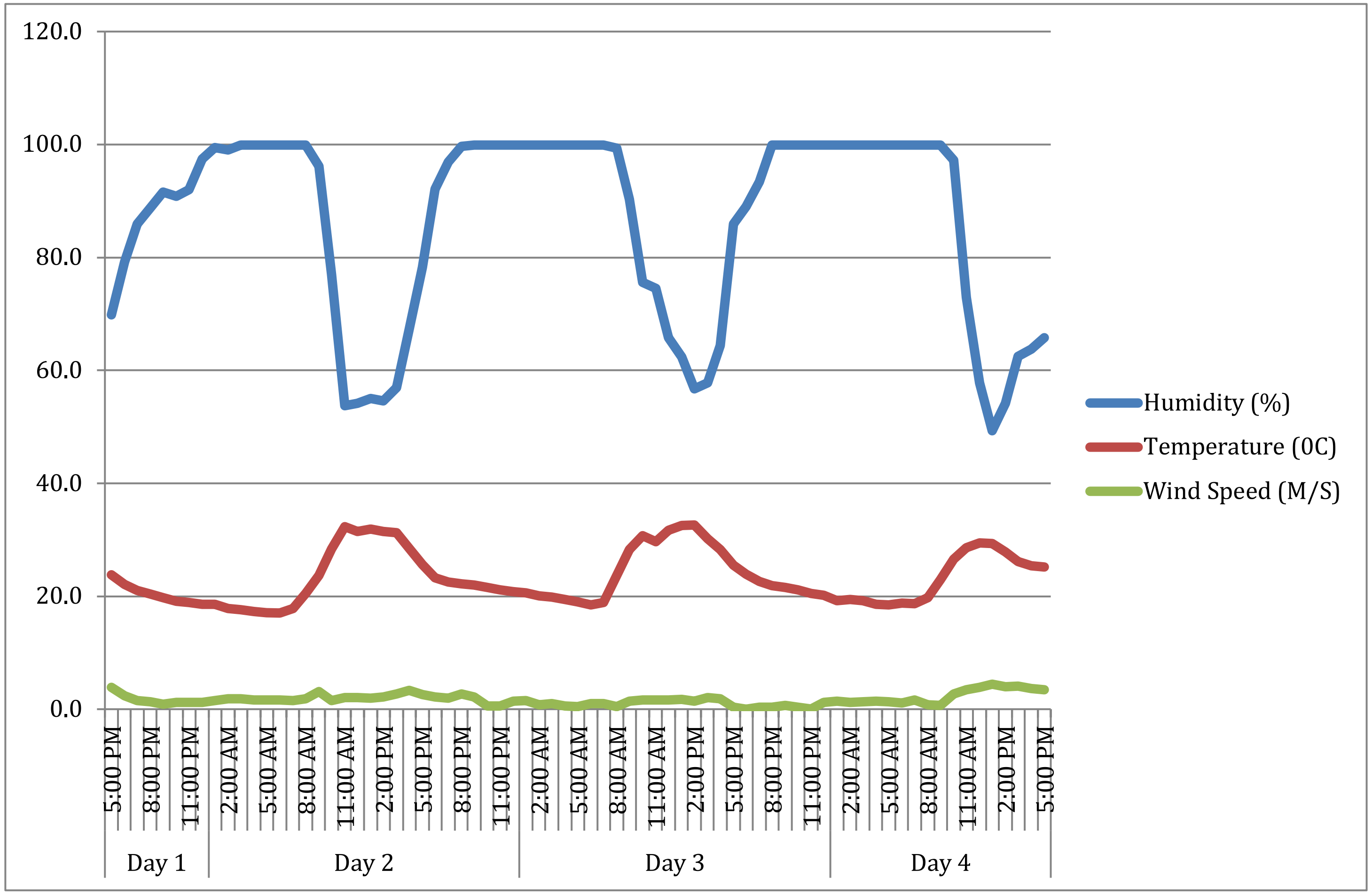
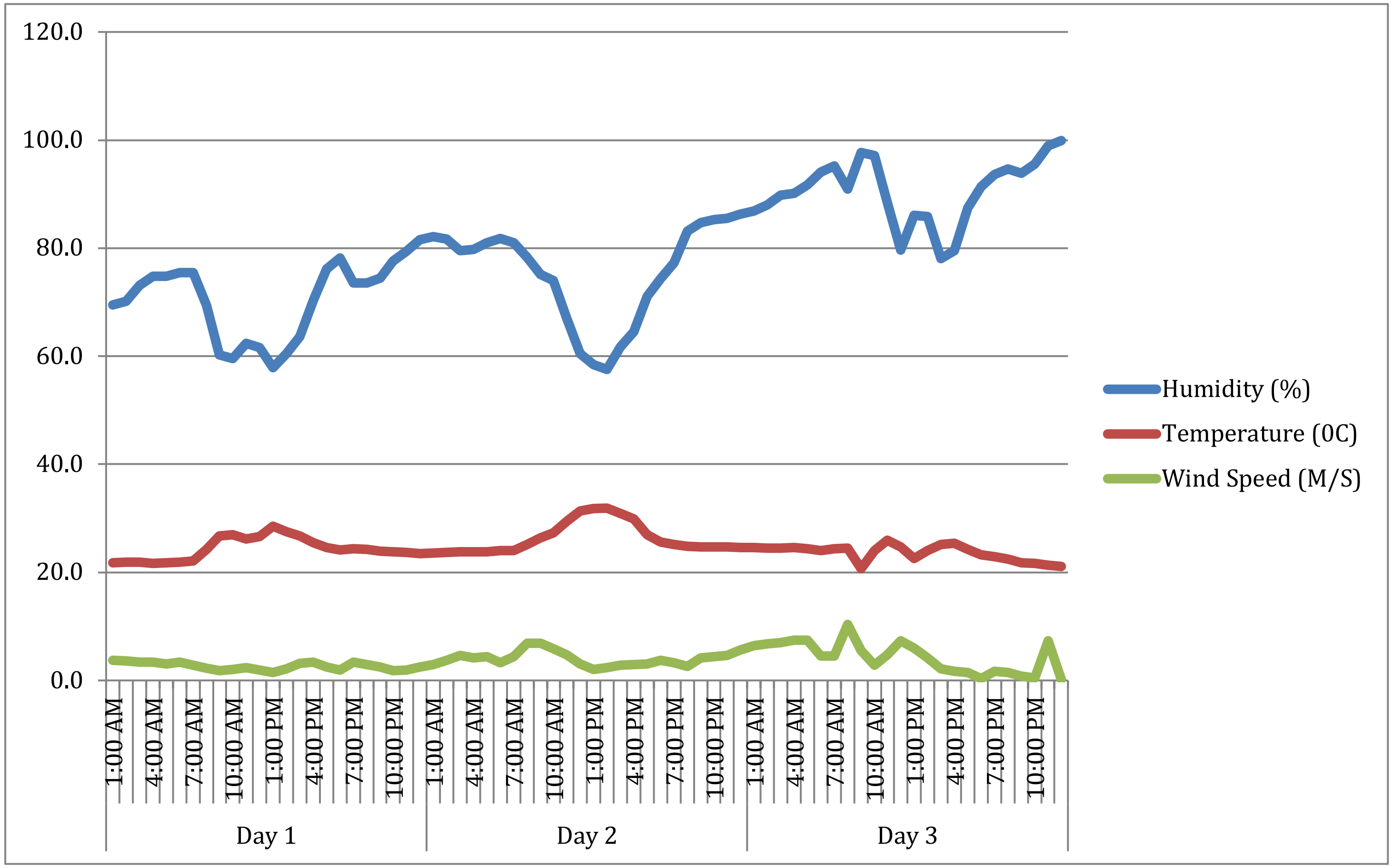


Figure 5-8 Hourly Results of Temperature, Relative Humidity and Wind Speed at AQ3



Pollutant Concentration Recorded at Each monitoring Location During the Monitoring Campaign

Table 5-13 Hourly Ambient Air Quality Result Obtained at AQ1

TIME	HOURLY AVERAGE RESULTS										
	NH_3	CO	H_2S	CH_4	NO_2	O_3	SO_2	VOCs	C_6H_6	PM_{10}	$PM_{2.5}$
26th November 2018 Day 1											
2 PM	0.0	0.9	0.0	0.0	224.3	17.4	0.0	21.9	10.9	619.1	508.1
3 PM	0.0	0.8	0.0	0.0	208.6	30.2	0.0	15.8	7.9	188.3	160.4
4PM	0.0	0.7	0.0	0.0	192.7	44.8	0.0	9.0	4.5	425.8	237.3
5PM	0.0	0.8	0.0	0.0	193.2	37.9	0.0	11.3	5.6	167.3	104.8
6PM	0.0	0.9	0.0	0.0	216.5	15.6	0.0	20.0	10.0	248.8	117.9
7PM	0.0	0.7	0.0	0.0	219.7	7.6	0.0	22.6	11.3	151.8	125.6
8PM	0.0	0.8	0.0	0.0	227.1	11.2	0.0	23.5	11.8	216.8	192.1
9PM	0.0	1.0	0.0	0.0	227.8	10.5	0.0	23.2	11.6	177.1	161.9
10PM	0.0	1.1	0.0	0.0	229.7	13.8	0.0	23.5	11.8	182.9	146.8
11PM	0.0	1.1	0.0	0.0	230.2	11.1	0.0	24.3	12.2	273.7	242.5
12AM	0.0	1.1	0.0	0.0	230.8	8.2	0.0	24.3	12.2	189.1	179.2
27th November 2018 Day 2											
1AM	0.0	4.0	0.0	0.0	231.2	11.3	0.0	24.2	12.1	140.4	124.6
2AM	0.0	1.3	0.0	0.0	229.1	9.0	0.0	23.8	11.9	691.5	583.5
3AM	0.0	1.2	0.0	0.0	232.7	12.8	0.0	24.2	12.1	331.2	293.0
4AM	0.0	1.1	0.0	0.0	233.0	12.4	0.0	24.3	12.2	581.8	527.5
5AM	0.0	1.0	0.0	0.0	230.7	15.6	0.0	23.5	11.8	897.2	697.8
6AM	0.0	0.9	0.0	0.0	230.9	10.6	0.0	23.9	12.0	430.0	256.3
7AM	0.0	0.9	0.0	0.0	230.2	8.7	0.0	24.7	12.3	364.2	293.2
8AM	0.0	1.0	0.0	0.0	233.0	8.7	0.0	24.7	12.3	299.6	269.5
9AM	0.0	1.0	0.0	0.0	230.2	10.2	0.0	24.3	12.2	191.3	175.2
10AM	6.9	0.9	0.0	0.0	222.4	19.2	0.0	20.1	10.1	418.7	366.7
11AM	6.8	0.9	0.0	0.0	203.7	54.5	0.0	9.9	4.9	126.1	93.5
12PM	7.3	0.9	0.0	0.0	191.6	60.4	0.0	6.0	3.0	493.8	231.9
1PM	7.0	0.9	0.0	0.0	185.9	66.3	0.0	4.8	2.4	467.7	383.4
2PM	5.9	1.0	0.0	0.0	183.0	67.6	0.0	2.0	1.0	129.3	84.2
3PM	3.5	0.7	0.0	0.0	181.5	69.4	0.0	2.6	1.3	247.7	181.9
4PM	0.1	1.0	0.0	0.0	200.4	32.1	0.0	12.9	6.4	159.8	89.5
5PM	0.0	1.2	0.0	0.0	213.4	30.0	0.0	16.5	8.3	174.5	149.8
6 PM	0.0	1.2	0.0	0.0	225.8	30.8	0.0	18.9	9.5	136.7	101.1
7PM	0.0	1.3	0.0	0.0	232.7	35.0	0.0	19.9	9.9	113.1	98.6
PM	0.0	1.3	0.0	0.0	233.2	38.7	0.0	19.1	9.5	120.7	114.1

TIME	HOURLY AVERAGE RESULTS										
	NH_3	CO	H_2S	CH_4	NO_2	O_3	SO_2	VOCs	C_6H_6	PM_{10}	$PM_{2.5}$
9PM	0.0	1.2	0.0	0.0	232.4	40.0	0.0	18.9	9.5	79.0	76.8
10PM	0.0	1.1	0.0	0.0	234.2	38.1	0.0	19.1	9.5	107.8	104.1
11PM	0.0	1.0	0.0	0.0	236.9	33.2	0.0	20.3	10.2	122.2	98.9
12AM	0.6	1.0	0.0	0.0	236.9	33.2	0.0	20.8	10.4	208.2	164.9
28th November 2018 Day 3											
1AM	0.5	0.9	0.0	0.0	236.9	32.4	0.0	21.0	10.5	178.1	158.0
2AM	0.0	1.0	0.0	0.0	237.3	33.2	0.0	20.0	10.0	296.3	273.5
3AM	0.0	0.9	0.0	0.2	236.8	36.7	0.0	20.2	10.1	100.3	96.2
4AM	0.0	0.9	0.0	0.0	234.6	35.4	0.0	20.2	10.1	240.4	178.7
5AM	0.0	0.9	0.0	0.0	235.8	33.0	0.0	20.5	10.3	296.7	236.3
6AM	0.0	0.9	0.0	0.0	237.4	32.1	0.0	21.2	10.6	368.1	323.9
7AM	0.0	1.0	0.0	0.0	237.8	35.3	0.0	20.5	10.3	379.1	290.6
8AM	0.0	1.0	0.0	0.0	240.2	32.2	0.0	21.9	10.9	266.0	238.7
9AM	0.8	1.0	0.0	0.0	238.2	34.1	0.0	20.5	10.2	156.8	108.6
10AM	1.9	1.0	0.0	0.0	232.7	38.2	0.0	18.4	9.2	201.7	152.9
11AM	5.8	0.9	0.0	0.0	222.9	46.8	0.0	15.8	7.9	163.0	82.8
12PM	1.7	0.9	0.0	0.7	221.4	37.6	0.0	18.2	9.1	318.9	221.5
1PM	1.2	1.0	0.0	0.0	221.2	27.6	0.0	19.5	9.8	356.7	276.3
2PM	1.0	0.9	0.0	0.0	219.5	29.7	0.0	18.3	9.1	234.5	133.2
3PM	0.9	1.3	0.0	0.3	216.3	33.1	0.0	17.8	8.9	271.7	234.2
4PM	0.0	1.1	0.0	0.9	220.3	29.6	0.0	19.8	9.9	303.4	163.8
5PM	0.1	1.2	0.0	3.4	225.1	30.6	0.0	24.0	12.0	156.7	113.4
6 PM	0.0	1.2	0.0	5.2	230.2	33.5	0.0	28.0	14.0	137.4	82.5
7PM	0.7	1.1	0.0	5.0	236.3	34.4	0.0	28.1	14.1	293.6	256.5
PM	1.0	1.2	0.0	5.2	237.8	41.7	0.0	27.5	13.8	156.5	149.8
9PM	0.7	1.2	0.0	5.8	234.6	41.4	0.0	27.1	13.6	105.6	102.2
10PM	0.0	1.1	0.0	5.8	236.3	45.7	0.0	27.0	13.5	169.6	157.3
11PM	0.0	1.0	0.0	5.7	237.4	44.2	0.0	27.3	13.6	200.4	194.9
12AM	0.0	1.0	0.0	4.6	242.3	41.5	0.0	26.4	13.2	288.0	233.1
29th November 2018 Day 4											
1AM	0.9	0.9	0.0	3.6	241.8	40.2	0.0	25.9	13.0	593.4	558.5
2AM	1.0	0.8	0.0	0.4	244.6	38.4	0.0	22.6	11.3	511.5	415.6
3AM	1.0	0.8	0.0	3.6	241.3	37.7	0.0	26.1	13.0	612.8	582.8
4AM	1.0	0.8	0.0	4.2	240.8	39.9	0.0	26.6	13.3	459.3	443.3
5AM	1.0	0.8	0.0	3.7	240.2	37.4	0.0	24.8	12.4	297.0	289.0
6AM	0.8	0.8	0.0	2.9	243.4	42.5	0.0	23.4	11.7	384.1	373.4
7AM	0.2	1.0	0.0	2.2	241.3	36.8	0.0	23.3	11.6	552.8	537.0

TIME	HOURLY AVERAGE RESULTS										
	NH_3	CO	H_2S	CH_4	NO_2	O_3	SO_2	VOCs	C_6H_6	PM_{10}	$PM_{2.5}$
8AM	1.2	1.0	0.0	3.9	245.4	36.6	0.0	27.5	13.8	332.4	316.4
9AM	2.0	0.9	0.0	2.5	244.9	32.1	0.0	26.2	13.1	327.5	274.9
10AM	3.2	0.9	0.0	1.6	241.8	37.4	0.0	23.1	11.6	260.7	229.6
11AM	7.3	0.9	0.0	0.5	234.5	41.9	0.0	19.5	9.8	183.1	120.4
12PM	2.0	1.0	0.0	0.0	228.5	41.5	0.0	17.6	8.8	212.2	159.3
1PM	2.7	0.9	0.0	0.1	219.0	42.7	0.0	15.6	7.8	246.8	159.3
2PM	3.7	1.0	1.3	3.3	218.4	43.5	0.0	19.9	9.9	226.3	113.1
Bahraini Standard	**-**	**26**	**-**	**-**	**106**	**100**	**134**	**-**	**-**	**-**	**-**
WHO Standard	**-**	**-**	**-**	**-**	**76**	**-**	**-**	**-**	**-**	**-**	**-**

Note: The Bahraini and WHO Standards of NH_3, H_2S, CH_4, NO_2, O_3, SO_2, VOCs, C_6H_6, have been converted from µg/m³ to ppb as the result for these parameter was provided in ppb. The results obtained for CO & particulate matter (PM2.5 and PM10) and standards are provided in ppm and ug/m3 respectively

Where the results obtained for certain parameters have not been color coded, this is because there are no hourly standards established by either Bahrain or WHO for such parameter.

Table 5-14 Hourly Ambient Air Quality Result Obtained at AQ2

TIME	HOURLY AVERAGE RESULTS										
	NH_3	CO	H_2S	CH_4	NO_2	O_3	SO_2	VOCs	C_6H_6	PM_{10}	$PM_{2.5}$
29th November 2018 Day 1											
5PM	3.9	1.8	11.4	0.0	208.4	84.1	0.0	3.6	1.8	387.2	414.4
6PM	0.0	1.6	0.0	0.0	203.1	99.7	0.0	0.5	0.2	456.7	433.3
7PM	4.8	1.5	0.0	0.0	216.1	81.2	0.0	5.6	2.8	156.6	143.3
8PM	2.0	1.7	0.0	0.0	222.6	79.5	0.0	7.0	3.5	240.8	227.6
9PM	2.6	1.6	0.0	0.0	226.1	83.0	0.0	7.5	3.7	244.7	235.8
10PM	1.5	1.5	0.0	0.0	229.7	75.5	0.0	8.7	4.4	250.6	239.3
11PM	1.0	1.4	0.0	0.0	234.6	76.8	0.0	10.4	5.2	233.4	215.0
12AM	0.7	1.7	0.0	0.0	233.2	78.2	0.0	9.8	4.9	286.8	274.5
30th November 2018 Day 2											
1AM	0.1	1.1	0.0	0.0	230.7	72.5	0.0	9.4	4.7	353.3	342.4
2AM	1.3	1.1	0.0	0.0	236.9	71.2	0.0	11.1	5.6	308.2	295.3
3AM	0.5	1.0	0.0	0.0	238.8	68.0	0.0	13.3	6.7	722.4	680.6
4AM	0.0	1.0	0.0	0.0	237.8	68.6	0.0	12.5	6.3	327.7	302.6
5AM	0.0	1.0	0.0	0.0	236.9	67.8	0.0	12.0	6.0	455.6	430.4
6AM	0.0	1.1	0.0	0.0	236.8	69.1	0.0	11.9	6.0	323.3	310.8
7AM	0.0	1.1	0.0	0.0	237.3	68.1	0.0	12.2	6.1	421.6	409.4
8AM	0.0	1.1	0.0	0.0	241.3	64.4	0.0	13.5	6.8	299.0	282.0
9AM	0.7	1.2	0.0	0.0	238.8	60.9	0.0	13.7	6.8	163.5	151.0

TIME	HOURLY AVERAGE RESULTS										
	NH_3	CO	H_2S	CH_4	NO_2	O_3	SO_2	VOCs	C_6H_6	PM_{10}	$PM_{2.5}$
10AM	2.4	1.3	15.0	0.0	230.2	74.4	0.0	9.8	4.9	68.3	61.4
11AM	14.1	1.4	198.6	0.0	217.5	63.8	14.9	23.8	11.9	60.5	53.2
12PM	33.4	1.2	368.5	0.1	201.8	44.4	224.7	11.1	5.6	88.8	81.7
1PM	52.2	1.2	504.9	1.5	189.3	67.7	423.0	5.9	3.0	87.3	77.2
2PM	76.5	1.2	641.4	1.9	176.6	93.8	624.7	1.3	0.6	61.5	56.6
3PM	92.3	1.2	745.9	1.5	168.3	105.1	740.9	0.0	0.0	79.8	70.9
4PM	29.1	1.2	697.9	0.7	165.5	115.6	594.6	0.0	0.0	60.1	53.7
5PM	6.3	1.2	503.1	0.0	187.1	110.4	242.0	0.0	0.0	94.0	89.2
6 PM	1.4	0.9	287.8	0.0	202.8	103.2	4.8	0.3	0.1	146.7	133.8
7PM	9.0	0.9	71.1	0.0	214.8	98.9	0.0	1.6	0.8	104.4	100.8
PM	2.5	0.9	38.0	0.0	219.0	88.6	0.0	4.1	2.1	247.4	233.2
9PM	2.0	1.1	21.0	0.0	222.5	90.5	0.0	5.2	2.6	264.3	248.9
10PM	1.9	1.1	1.9	0.0	223.6	88.4	0.0	5.1	2.5	254.7	240.0
11PM	1.0	1.0	0.0	0.0	224.1	87.3	0.0	5.7	2.8	302.4	293.8
12AM	2.6	0.9	0.0	0.0	230.8	83.3	0.0	7.8	3.9	304.7	296.3
1st December 2018 Day 3											
1AM	4.1	0.8	0.0	0.0	230.2	83.9	0.0	7.6	3.8	354.3	337.1
2AM	6.3	1.0	0.0	0.0	230.2	82.3	0.0	7.5	3.7	414.5	402.9
3AM	8.5	0.9	0.0	0.0	231.3	83.0	0.0	7.8	3.9	350.6	332.9
4AM	10.9	0.7	0.0	0.0	230.7	86.0	0.0	6.7	3.3	428.3	408.8
5AM	9.3	0.7	0.0	0.0	228.7	85.6	0.0	7.3	3.6	478.8	458.0
6AM	3.8	0.7	0.0	0.0	233.2	82.2	0.0	8.1	4.0	536.4	514.9
7AM	4.9	1.0	0.0	0.0	235.2	80.8	0.0	9.0	4.5	417.9	398.3
8AM	11.9	0.6	0.0	0.0	238.3	74.6	0.0	11.1	5.6	271.1	259.9
9AM	38.3	0.7	46.3	0.0	234.7	79.0	0.0	9.4	4.7	121.3	117.3
10AM	76.0	0.7	195.3	0.0	221.9	96.0	0.0	4.0	2.0	151.3	138.4
11AM	105.0	0.9	325.4	0.0	208.6	116.4	0.0	0.0	0.0	98.3	86.8
12PM	138.2	0.8	437.8	0.0	200.5	115.1	10.4	0.0	0.0	87.1	84.7
1PM	213.0	0.9	618.2	0.2	188.1	287.8	195.5	70.4	35.2	160.0	116.8
2PM	213.1	1.3	742.1	1.8	168.3	80.1	417.7	32.6	16.3	121.9	95.9
3PM	57.5	1.0	625.7	1.5	155.0	66.8	274.9	26.4	13.2	104.2	92.7
4PM	31.3	1.0	578.9	0.3	170.8	73.6	114.2	29.0	14.5	105.6	87.7
5PM	14.3	1.0	449.4	0.0	191.5	78.6	0.0	32.5	16.2	97.6	94.8
6 PM	5.1	1.0	270.7	0.0	207.8	86.5	0.0	38.3	19.1	67.0	65.0
7PM	15.9	0.9	96.4	0.0	216.0	41.5	0.0	30.5	15.2	96.9	82.1
PM	5.5	1.0	39.7	0.0	223.0	99.8	0.0	44.0	22.0	87.3	84.8
9PM	4.0	1.1	13.5	0.0	225.8	218.7	0.0	67.9	34.0	91.7	89.0
10PM	3.3	1.2	0.4	0.0	228.1	338.4	0.0	92.4	46.2	78.3	76.0
11PM	5.0	0.9	0.0	0.0	231.7	525.6	0.0	130.6	65.3	78.3	76.0

Time	Hourly Average Results										
	NH_3	CO	H_2S	CH_4	NO_2	O_3	SO_2	VOCs	C_6H_6	PM_{10}	$PM_{2.5}$
12AM	7.4	0.5	0.0	0.3	233.9	725.2	0.0	171.9	86.0	130.6	117.9
29th November 2018 Day 4											
1AM	2.1	0.6	0.0	0.0	237.3	567.5	0.0	140.5	70.2	229.3	211.8
2AM	1.2	0.5	0.0	0.0	238.5	402.8	0.0	108.4	54.2	250.0	237.8
3AM	2.3	0.6	0.0	0.0	238.3	341.7	0.0	95.1	47.5	117.2	114.0
4AM	1.3	0.5	0.0	0.0	239.6	302.4	0.0	86.5	43.3	125.1	112.2
5AM	1.8	0.5	0.0	0.0	238.3	280.0	0.0	82.0	41.0	654.0	496.7
6AM	4.6	0.5	0.0	0.0	240.2	276.8	0.0	82.7	41.4	244.9	225.9
7AM	4.6	0.5	0.0	0.0	243.5	266.6	0.0	80.1	40.1	492.2	381.5
8AM	9.3	0.5	0.0	0.0	242.4	264.3	0.0	80.8	40.4	108.4	104.4
9AM	18.3	0.5	0.0	0.0	242.9	265.4	0.0	80.1	40.1	347.7	318.3
10AM	30.4	0.7	10.3	0.0	239.3	255.2	0.0	78.7	39.3	113.8	103.3
11AM	29.7	0.8	57.3	0.0	223.6	221.8	0.0	67.6	33.8	128.5	82.9
12PM	20.1	0.8	70.4	0.0	207.0	204.7	0.0	60.5	30.2	203.1	166.8
1PM	11.5	0.8	82.8	0.0	190.4	187.6	0.0	54.6	27.3	120.5	101.0
2PM	10.2	1.0	102.4	0.0	191.1	194.9	0.0	56.2	28.1	71.8	63.1
3PM	7.7	0.9	98.3	0.2	204.1	201.3	0.0	61.0	30.5	219.4	169.4
4PM	6.8	1.0	73.4	0.4	214.5	203.3	0.0	63.5	31.8	197.4	137.1
5PM	6.5	1.0	62.0	0.1	215.6	203.0	0.0	63.0	31.5	179.5	146.2
Bahraini Standard	**-**	**26**	**-**	**-**	**106**	**100**	**134**	**-**	**-**	**-**	**-**
WHO Standard	**-**	**-**	**-**	**-**	**76**	**-**	**-**	**-**	**-**	**-**	**-**

Note: The Bahraini and WHO Standards of NH_3, H_2S, CH_4, NO_2, O_3, SO_2, VOCs, C_6H_6, have been converted from µg/m³ to ppb as the result for these parameter was provided in ppb. The results obtained for CO & particulate matter (PM2.5 and PM10) and standards are provided in ppm and ug/m3 respectively

Where the results obtained for certain parameters have not been color coded, this is because there are no hourly standards established by either Bahrain or WHO for such parameter.

Table 5-15 Hourly Ambient Air Quality Result Obtained at AQ3

Time	Hourly Average Results										
	NH_3	CO	H_2S	CH_4	NO_2	O_3	SO_2	VOCs	C_6H_6	PM_{10}	$PM_{2.5}$
23rd November 2018 Day 1											
1AM	1.6	1.0	177.6	0.1	178.6	16.0	140.0	17.4	8.7	73.4	71.5
2AM	1.2	1.0	163.0	0.1	181.5	4.8	115.1	15.4	7.7	83.5	81.3
3AM	1.5	0.9	209.0	0.1	176.0	12.8	224.2	16.7	8.3	67.0	65.0
4AM	1.0	1.0	145.6	0.3	186.6	4.8	112.1	15.7	7.9	96.5	77.0
5AM	1.5	0.9	219.3	0.3	177.3	16.4	227.8	11.3	5.7	117.6	65.7
6AM	1.5	0.9	175.5	0.3	183.8	18.1	157.6	11.8	5.9	66.7	65.0

Time	Hourly Average Results										
	NH_3	CO	H_2S	CH_4	NO_2	O_3	SO_2	VOCs	C_6H_6	PM_{10}	$PM_{2.5}$
7AM	1.3	0.9	181.4	0.1	185.0	32.4	150.3	9.4	4.7	66.9	65.0
8AM	4.2	1.1	226.4	0.1	179.9	15.1	272.5	11.5	5.7	67.0	65.0
9AM	7.4	1.1	248.4	0.0	176.4	40.4	311.5	5.5	2.8	166.5	51.0
10AM	7.9	1.0	232.3	0.0	172.1	50.5	300.6	3.1	1.6	67.0	65.0
11AM	4.9	1.0	208.7	0.0	169.8	46.5	265.1	3.3	1.7	100.9	88.7
12PM	3.5	1.0	177.8	0.0	174.9	40.4	183.4	5.0	2.5	79.2	76.8
1PM	6.0	1.0	183.9	0.0	176.9	38.6	189.0	6.2	3.1	67.0	65.0
2PM	5.0	1.2	217.8	0.0	162.2	48.4	313.8	1.7	0.8	102.3	75.6
3PM	1.2	1.1	137.8	0.0	164.4	47.1	214.4	2.0	1.0	562.2	499.5
4PM	0.7	1.2	86.1	0.0	172.7	32.1	59.8	5.9	3.0	274.4	250.2
5PM	0.4	1.2	84.8	0.0	186.1	31.1	0.0	10.3	5.2	100.3	97.6
6 PM	0.0	1.0	33.4	0.1	193.2	40.4	0.0	8.8	4.4	107.2	104.2
7PM	1.5	1.0	125.8	0.7	181.0	38.7	31.4	8.0	4.0	108.2	99.2
PM	1.0	1.0	106.9	0.0	182.5	55.6	0.0	3.9	2.0	75.4	73.1
9PM	2.1	1.0	14.9	0.3	190.9	56.4	0.0	6.1	3.0	133.6	122.4
10PM	5.6	1.0	151.7	2.5	179.5	44.3	54.2	11.4	5.7	67.0	65.0
11PM	3.0	1.0	103.4	0.5	187.1	57.7	2.4	5.6	2.8	91.3	88.6
12AM	3.4	0.9	91.8	1.0	187.6	46.9	30.2	9.2	4.6	130.3	104.2
24th November 2018 Day 3											
1AM	3.0	1.0	107.5	0.0	182.8	52.9	31.9	3.8	1.9	80.3	78.0
2AM	1.5	1.0	39.3	0.8	193.7	53.7	0.0	8.6	4.3	144.0	109.4
3AM	3.5	1.0	97.0	0.2	178.8	49.4	31.4	6.1	3.0	139.5	89.5
4AM	1.7	1.0	33.6	0.6	189.8	56.2	0.0	6.6	3.3	183.2	106.2
5AM	2.8	1.0	57.9	5.0	184.9	39.1	10.2	18.1	9.0	201.3	137.3
6AM	2.8	1.0	78.0	6.0	184.0	57.5	0.2	15.6	7.8	94.0	84.8
7AM	5.7	1.0	21.8	5.9	180.4	74.4	0.0	12.2	6.1	244.6	227.3
8AM	17.5	0.9	0.0	0.6	152.8	76.9	24.6	0.6	0.3	151.3	141.2
9AM	8.3	0.9	0.0	0.0	166.1	72.1	0.0	0.1	0.1	207.6	180.6
10AM	12.1	1.0	0.0	0.0	160.0	81.5	0.0	0.0	0.0	155.5	141.5
11AM	18.7	1.0	0.0	0.0	156.6	80.8	0.0	0.0	0.0	115.9	97.3
12PM	32.2	1.0	36.1	0.0	153.3	73.2	0.0	0.0	0.0	261.3	223.7
1PM	35.1	0.9	250.6	0.0	152.6	66.5	121.9	0.0	0.0	52.8	39.3
2PM	41.2	0.9	355.5	0.0	146.3	69.5	391.8	0.0	0.0	212.7	146.2
3PM	32.7	1.0	376.9	0.0	145.0	74.4	480.2	0.0	0.0	316.3	268.0
4PM	22.8	1.0	363.4	0.0	151.9	75.0	444.2	0.0	0.0	86.9	60.3
5PM	7.0	1.0	175.1	0.0	162.2	73.4	185.3	0.0	0.0	621.3	510.4
6 PM	0.7	0.9	97.2	0.0	178.8	58.0	17.3	2.1	1.1	332.1	255.5
7PM	0.0	1.0	39.8	0.0	189.8	51.8	0.0	6.4	3.2	418.4	151.0

Time	Hourly Average Results										
	NH_3	CO	H_2S	CH_4	NO_2	O_3	SO_2	VOCs	C_6H_6	PM_{10}	$PM_{2.5}$
PM	0.0	1.0	22.9	0.0	193.2	43.9	0.0	8.5	4.3	214.8	142.5
9PM	0.5	0.9	66.2	2.4	187.7	25.4	2.1	16.1	8.0	351.6	230.1
10PM	0.6	0.9	78.7	0.4	184.5	39.1	1.1	8.2	4.1	180.2	68.4
11PM	0.0	1.0	12.0	0.4	195.9	38.9	0.0	10.4	5.2	325.4	138.2
12AM	0.3	0.9	19.0	1.7	196.5	31.7	0.0	14.9	7.5	225.5	180.5
25th November 2018 Day 4											
1AM	1.0	1.0	140.4	0.0	182.6	40.3	5.1	6.9	3.5	413.4	183.4
2AM	0.2	0.8	76.2	0.0	195.9	38.9	0.0	8.5	4.3	377.8	265.8
3AM	0.4	0.9	66.1	0.2	197.0	31.4	4.7	12.0	6.0	369.5	254.4
4AM	1.0	1.0	155.3	0.0	185.4	37.1	41.5	7.5	3.7	360.3	260.2
5AM	0.0	1.0	81.7	0.0	194.8	39.6	0.0	8.9	4.4	223.1	166.4
6AM	0.5	0.8	95.5	0.9	197.0	30.5	16.3	13.4	6.7	351.9	262.5
7AM	1.0	0.7	157.5	0.0	186.5	36.4	37.5	7.6	3.8	308.2	241.6
8AM	0.7	0.9	78.8	0.0	196.7	40.9	0.0	9.5	4.8	386.8	264.0
9AM	0.0	1.0	4.8	3.7	194.3	32.1	0.0	18.4	9.2	327.2	248.2
10AM	0.4	0.9	10.9	4.3	197.0	34.9	0.0	18.6	9.3	252.1	157.6
11AM	0.7	0.8	21.2	4.1	192.6	37.3	0.0	16.7	8.3	237.5	129.2
12PM	0.0	0.9	0.0	3.3	189.8	40.6	0.0	13.7	6.9	289.5	180.6
1PM	0.0	0.9	0.0	3.9	196.5	36.0	0.0	17.2	8.6	225.7	167.4
2PM	0.8	1.0	52.7	6.0	187.1	24.9	0.0	23.1	11.6	227.0	197.6
3PM	1.0	0.8	123.2	6.0	182.5	44.2	0.0	18.6	9.3	107.8	38.9
4PM	0.6	0.8	97.7	6.0	190.7	48.4	0.0	18.6	9.3	419.3	301.1
5PM	7.1	0.9	36.1	1.2	189.5	50.0	0.0	8.4	4.2	426.9	358.5
6 PM	2.5	1.0	34.7	0.2	190.9	45.2	0.0	8.9	4.4	67.0	65.0
7PM	5.9	1.1	175.1	0.1	181.5	41.0	11.0	6.6	3.3	61.3	57.9
8PM	2.6	1.2	85.5	0.5	195.4	47.9	0.0	9.2	4.6	125.6	103.3
9PM	4.2	1.3	181.4	0.0	186.1	39.0	26.9	7.1	3.6	206.5	176.3
10PM	2.7	1.1	127.9	0.0	193.2	41.4	10.4	9.0	4.5	572.2	489.8
11PM	2.7	1.1	148.9	0.0	192.5	39.6	27.6	8.6	4.3	500.8	408.3
12AM	4.3	1.1	112.9	0.0	191.6	33.5	11.1	10.8	5.4	1104.4	773.8
Bahraini Standard	**-**	**26**	**-**	**-**	**106**	**100**	**134**	**-**	**-**	**-**	**-**
WHO Standard	**-**	**-**	**-**	**-**	**76**	**-**	**-**	**-**	**-**	**-**	**-**

Note: The Bahraini and WHO Standards of NH_3, H_2S, CH_4, NO_2, O_3, SO_2, VOCs, C_6H_6, have been converted from µg/m³ to ppb as the result for these parameter was provided in ppb. The results obtained for CO & particulate matter (PM2.5 and PM10) and standards are provided in ppm and ug/m3 respectively

Where the results obtained for certain parameters have not been color coded, this is because there are no hourly standards established by either Bahrain or WHO for such parameter.

Table 5-16 Average 24 Hours Ambient Air Quality Result Obtained at All Monitoring Stations

LOCATION	DAYS	24 HOURS AVERAGE RESULTS										
		NH_3	CO	H_2S	CH_4	NO_2	O_3	SO_2	VOCs	C_6H_6	PM_{10}	$PM_{2.5}$
AQ1	Day 1	0.0	0.9	0.0	0.0	218.2	18.9	0.0	20.0	10.0	258.2	197.9
	Day 2	1.6	1.2	0.0	0.0	220.6	31.2	0.0	17.9	8.9	293.0	231.7
	Day 3	0.7	1.0	0.0	1.8	232.0	35.8	0.0	22.1	11.0	235.0	185.8
	Day 4	2.0	0.9	0.1	2.3	237.6	39.2	0.0	23.0	11.5	371.4	326.6
AVERAGE		**1.1**	**1**	**0.0**	**1.0**	**227.1**	**31.3**	**0**	**20.8**	**10.3**	**289.4**	**235.5**
AQ2	Day 1	2.1	1.6	1.4	0.0	221.7	82.2	0.0	6.6	3.3	282.1	272.9
	Day 2	13.7	1.1	170.6	0.2	217.0	80.3	119.6	8.0	4.0	233.3	220.6
	Day 3	41.4	0.9	185.0	0.2	215.1	153.6	42.2	35.2	17.6	205.4	192.5
	Day 4	9.9	0.7	32.8	0.0	226.3	272.9	0.0	78.9	39.5	223.7	186.6
AVERAGE		**16.8**	**1.1**	**97.5**	**0.1**	**220.0**	**147.3**	**40.4**	**32.1**	**16.1**	**236.1**	**218.2**
AQ3	Day 1	2.8	1.0	154.3	0.3	179.4	34.8	139.8	8.6	4.3	119.6	103.4
	Day 2	10.4	1.0	97.0	1.0	173.7	59.0	72.6	5.8	2.9	221.5	158.6
	Day 3	1.7	1.0	86.0	1.7	191.1	38.8	8.0	12.0	6.0	330.9	239.7
AVERAGE		**4.0**	**1.0**	**112.4**	**10**	**181.4**	**44.2**	**73.4**	**8.8**	**4.4**	**224**	**167.2**
Bahraini Standards		**-**	**-**	**-**	**-**	**80**	**-**	**48**	**-**	**-**	**340**	**-**
WHO Standards		**-**	**-**	**-**	**-**	**-**		**7.6**		**-**	**50**	**25**

Note: The Bahraini and WHO Standards of NH_3, H_2S, CH_4, NO_2, O_3, SO_2, VOCs, C_6H_6, have been converted from µg/m³ to ppb as the result for these parameter was provided in ppb. The results obtained for CO & particulate matter (PM2.5 and PM10) and standards are provided in ppm and ug/m³ respectively

Where the results obtained for certain parameters have not been color coded, this is because there are no hourly standards established by either Bahrain or WHO for such parameter.

Ammonia (NH_3)

Generally, the concentration of ammonia was low throughout the monitoring period with concentrations identified to be >10ppm about 14% of the total monitoring period. The concentration of ammonia at AQ1 ranged from 0ppb to 7.3ppb. At monitoring station 2 (AQ2) concentration of ammonia above 10ppb was recorded at AQ2 on Day 2, Day 3 and Day 4 generally between the hours of 8:00am to 5:00pm. The highest concentration of this pollutant at this monitoring location was recorded as 213ppb which was recorded at 1:00pm and 2:00pm on Day 3.

At monitoring location 3 (AQ3) concentration of ammonia above 10ppb was only recorded on Day 2 at 8:00m and from 10:00am to 4:00pm. The highest concentration of this pollutant was recorded at 2:00pm as 41.2ppb.

The results obtained for this pollutant could not be compared with any standards as there are no hourly or 24 hourly standards established by either Bahrain or WHO for ammonia.

Carbon Monoxide (CO)

The hourly monitoring result obtained for carbon monoxide was generally low at the three monitoring locations with values ranging from 0.5ppm to 4.0ppm. The highest concentration of this pollutant (4.0ppm) was recorded at Air Quality Monitoring Station 1 (AQ1) on Day 2 at 01:00am.

When compared with the applicable hourly ambient CO standard established by Bahrain, the concentrations of this air pollutant within surrounding of the Project site was well below the required limits of 26ppm.

There are no 24 hourly standard established by Bahrain hence, the 24-hourly result obtained could not be compared. In addition, hourly average results as well as 24 hourly average results could not be compared with WHO guidelines, as WHO has not established standard values for carbon monoxide for these monitoring periods.

Hydrogen Sulphide (H_2S)

At air quality monitoring station 1 (AQ1), H_2S was recorded as 0ppb throughout the monitoring period except at 2:00pm on Day 4 when concentration of 1.3ppb was recorded. At AQ2, this pollutant was recorded above 0ppb approximately 47% of the total monitoring period with concentrations above 0ppb recorded between 9:00am and 10:00am of each day.

At AQ3, this pollutant was recorded above 0ppb approximately 92% of the total monitoring period with the highest concentration being recorded on Day 2 at 3:00pm. At air quality monitoring station 2 and 3 (AQ2 & AQ3), it was noted that once the concentration of this pollutant reaches its peak particularly in the afternoon hours of each day, it begins to decrease in concentration.

Given that both AQ2 and AQ3 monitoring stations were situated near an air base and an industrial facility respectively, the high concentration of this pollutant may be attributable to these facilities.

The results obtained for this pollutant could not be compared with any standards as there are no hourly or 24 hourly standards established by either Bahrain or WHO for hydrogen sulphide.

Methane (CH_4)

Concentration of methane was general low and mostly 5ppb with approximately 77% recorded as 0ppb throughout the monitoring period. Concentrations above 5ppm occurred approximately 8% of the monitoring period at AQ1 and AQ3 and were not recorded at all at AQ2.

The results obtained for methane could not be compared with any standards as there are no hourly or 24 hourly standards established by either Bahrain or WHO for this greenhouse gas.

Nitrogen Dioxide (NO_2)

The hourly monitoring results obtained for the three monitoring locations are high throughout the monitoring period. The concentration of this pollutant at AQ1, AQ3 and AQ3 ranged from 181.5ppb to 245.4ppb, from 155ppb to 243.5ppb and from 145ppb to 197ppb, respectively. The highest NO_2 concentration for the 1-Hour monitoring result was 245.4ppb which occurred on Day 4 at 8:00am at Air Quality Monitoring Station 1 (AQ1).

When compared with the applicable ambient air quality standards, the hourly results show that nitrogen dioxide concentrations were well above the required Bahrain and WHO/IFC ambient NO_2 concentration of 106ppb and 26ppb respectively at all monitoring locations.

The highest 24-hour average concentration for nitrogen dioxide was recorded as 237.6ppb which occurred at monitoring station AQ1 on Day 4. Comparison with Bahraini standard showed that the 24hourly concentration of NO_2 was still above the limit.

The elevated concentration of NO2 could be attributable to local and regional road traffic, and emissions from industrial sources in Bahrain and overseas oil and gas facilities.

Ozone (O_3)

During each day of the monitoring period, the concentration of ozone was noted to be low during the early morning hours but increased during daytime particularly during sunlight hours from 11:00hrs and reaching its peak at 17:00hrs before decreasing. This elevated concentration in ozone level during the daytime period can be said to be due to the sun being at its strongest at the time of increase resulting in an increase in the chemical reactions between the oxides of nitrogen (NOx) and Volatile Organic Compounds (VOC).

However, a difference in trend of this pollutant was noted at AQ2 on Day 3 where the highest concentration of this pollutant (752ppb) was recorded at 12:00am. Comparison of the results obtained with Bahraini ozone hourly standard concentration of 100ppb showed that the concentration of ozone at AQ1 and AQ3 were well below the established limit at these monitoring locations. However, the concentration of ozone was recorded above the established hourly standard at AQ2 this monitoring location was above the 1 hourly standard at AQ2 particularly on Day 2 between 3:00pm & 5:00pm, on Day 3 between 11:00am & 1:00pm and between 9:00pm &12:00am and on Day 4 from 1:00am to 5:00pm. The high concentration of this pollutant at this monitoring location can be attributable to this monitoring location situated close to the air base approximately 2.2km from the Project site.

The highest 24 hours average result was 272.9ppb, which was recorded on Day 4 at AQ2. However, this result could not be compared with any standard as there is no 24-hourly standard value established by Bahrain and WHO for ozone.

Sulphur Dioxide (SO_2)

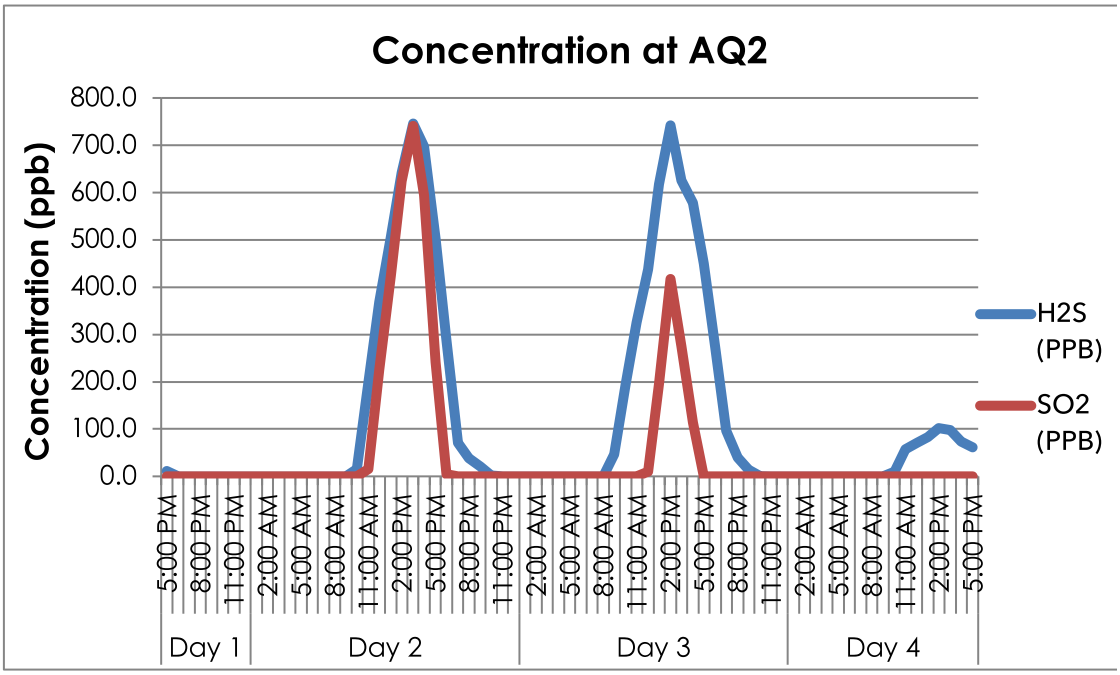
At air quality monitoring station 1 (AQ1), Sulphur dioxide was recorded as 0ppb throughout the monitoring period. At air quality monitoring station 2 (AQ2), this pollutant was recorded above 0ppb approximately 18% of the monitoring period particularly between the hours of 11:00am - 6:00pm on Day 2 and 12:00pm -400pm on Day 3. At air quality monitoring station 3 (AQ3)), this pollutant was recorded above 0ppb approximately 34% of the monitoring period.

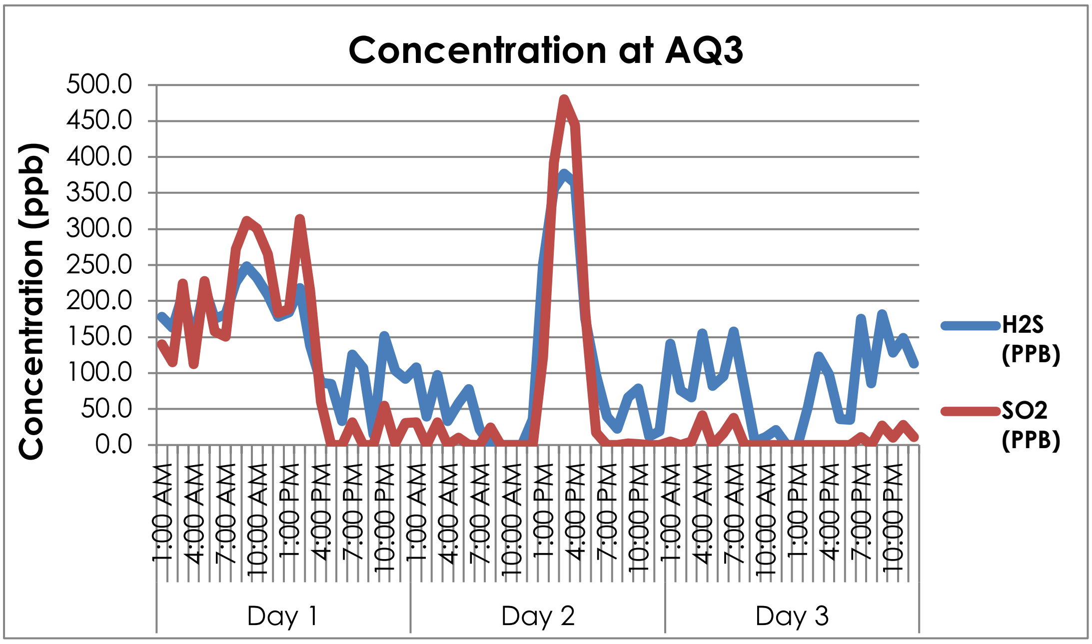
When the results obtained at AQ2 and AQ3 were compared with the hourly Bahraini concentration of 134ppb, the concentration of this pollutant at both locations were above the required limit from 12:00pm to 5:00pm on Day 2 and from 1:00pm to 3:00pm on Day 3 at AQ2. At AQ3, the concentration of this pollutant was above the limit from5:00am to 3:00pm on Day 1 and 1:00pm to 6:00pm on Day 2.

There is a relationship between Hydrogen Sulphide and Sulphur Dioxide as both pollutants were recorded to have high concentration at both monitoring locations. The graph below shows that as SO_2 increase H_2S also increases.

Given that both hydrogen sulphide and sulphur dioxide were observed to be high at the same monitoring locations (AQ2 & AQ3), the high concentration of these pollutants in the air shed could be from the Askar landfill a few kilometres to the northwest of the Project site.

Figure 5-9 Hourly Concentration of SO_2 and H_2S at AQ2 and AQ3





Volatile Organic Compounds (VOCs)

The concentration of VOCs ranged from 2.0ppb to 28.1ppb at air quality monitoring station 1, from 0ppb to 171ppb at AQ2 and from 0ppb to 23.1ppb at AQ3.

Concentrations above 30ppb were only recorded at AQ2 and the highest concentration of this pollutant was 171ppb. As this monitoring location is situated near an air base and an access road, the high concentration of VOC at this monitoring location may be from emissions from these areas.

The concentration of this pollutant could not be compared with any standard to establish whether or not this pollutant is within established limit as there are no Bahrain or WHO standards for VOC.

Benzene (C_6H_6)

The concentration of benzene ranged from 0ppb to 86ppb. The highest concentration of this pollutant was recorded at air quality monitoring station 2 (AQ2) on Day 3 at 12:00am.

The concentration of this pollutant could not be compared with any standard to establish whether or not this pollutant is within established limit as there are no Bahrain or WHO standards for Benzene.

Particulate Matter (PM_{10} and $PM_{2.5}$)

The hourly monitoring concentration of PM_{10} at all monitoring locations throughout the entire monitoring period ranged from 52.8µg/m^3 to1104µg/m^3 while the concentration of $PM_{2.5}$ ranged from 38.9µg/m^3 to 773µg/m^3. Comparison of the hourly results obtained for both PM_{10} and $PM_{2.5}$ could not be made as there are no hourly standards established for both PM_{10} and $PM_{2.5}$.

The average 24-hours monitoring results obtained for $PM_{2.5}$ could not be compared with Bahraini standards. However, the results obtained for PM_{10} were found to be well below the maximum allowable limits of 340µg/m^3 established by Bahrain.

However, when the 24-hourly results for PM_{10} and $PM_{2.5}$ were compared with WHO 24 hourly standard of 50µg/m3 for PM_{10} and 25µg/m3 for $PM_{2.5}$, the concentration of this particulate matter exceeded the limit on all days.

It must be noted that the WHO guidelines were established taking into consideration developed or undeveloped areas but in non-desert environments, and as such may not be suitable for comparison of ambient air condition in the projects environment.

Long Term Ambient Air Quality Monitoring Results

The three (3) weeks results are presented in the table below showing concentration of NO_2, SO_2, H_2S & the top 5 VOCs. These results have been compared with Bahraini and WHO annual ambient air quality standards. The complete medium-term ambient air quality laboratory results are provided in Appendix H.

Table 5-17 Medium Term Ambient Air Quality Monitoring Results

LOCATION	RESULTS (UG/M3)							
A-1				Top 5 VOC				
	NO_2	SO_2	H_2S	2,6-Diphenyl-p-benzoquinone	Benzoic Acid	m/p-Xylene	Toluene	Benzene
	55.2	95.8	0.12	224	4.7	3.3	2.6	1.4
A-2				Top 5 VOC				
	NO_2	SO_2	H_2S	2,6-Diphenyl-p-benzoquinone	Benzoic Acid	m/p-Xylene	Benzaldehyde	Toluene
	31.3	524	<0.04	494	17	3.2	3.1	2.6
A-3				Top 5 VOC				
	NO_2	SO_2	H_2S	2,6-Diphenyl-p-benzoquinone	Toluene	Benzoic acid	m/p-Xylene	Benz aldehyde
	27.6	9.4	<0.04	107	2.3	2.9	2.5	2.0
A-4				Top 5 VOC				
	NO_2	SO_2	H_2S	2,6-Diphenyl-p-benzoquinone	Benzoic Acid	Nonane	m/p-Xylene	Ethyl Benzene
	28.9	6.6	<0.04	189	18	9.4	7.1	6.2
Bahraini Annual Standards	**40**	**50**	-	-	-	-	-	-
WHO Annual Standards	**40**	**500**	-	-	-	-	-	-

The results of the monitoring indicate that the ambient concentrations of NO_2 during the 3-week monitoring period were below the established Bahraini annual NO_2 standard of 40µg/m³ as well as the WHO ambient air quality guidelines of 40 µg/m³ at monitoring station A-2, A-3 and A-4. The concentration of this pollutant at monitoring station A-1 was recorded as 55µg/m3 which is above both Bahraini and WHO annual NO_2 standard.

Monitored concentrations of SO_2 were found to be inconsistent and above the established Bahraini annual SO_2 standard of 50 µg/m³ at monitoring location A-1 and A-2 and above WHO annual standard of 500µg/m3.

The concentration of hydrogen sulphide (H_2S) was consistently below detection limit of 0.04µg/m³ at monitoring station A-2, A-3 and A-4. Concentration of this pollutant was detectable at monitoring location A-1 and recorded as 0.12µg/m^3. As there are no annual standard values established by Bahrain and WHO for hydrogen sulphide, comparison of the pollutant concentration recorded at A-1 could not be made. However, according to World Health Organisation, the concentration of H_2S recorded at all monitoring location is below the odour detection threshold of 4.5ppb (7µg/m^3) for a 30 minute averaging period. As such, it can be said that H_2S concentration is well within acceptable human odour threshold.

The top 5 VOCs monitored at all monitoring locations varied. However, the VOC that were recorded to be re-occurring at all four locations included 2,6-diphenyl-p-benzoquinone, m/p-xylene, and benzoic acid.

The concentration of 2,6-diphenyl-p-benzoquinone ranged from 107µg/m^3 to 494µg/m^3 with the highest concentration recorded at monitoring location A-2 and the lowest recorded at monitoring location A-3. This concentration of this VOC was recorded to be higher than other VOC's recorded with other VOC having concentration less than 100µg/m^3 and ranged from 1.4µg/m^3 to 18µg/m^3.

The minimum concentration of m/p-xylene was recorded as 2.5µg/m^3 at monitoring location A-3 and the maximum concentration as 7.1µg/m^3 at monitoring location A-4. Benzoic acid minimum concentration of 2.9µg/m3 was recorded at monitoring location A-3 while the maximum concentration was recorded as 18µg/3 at A-4.

It is noted that the minimum concentration of all three re-occurring VOC's where recorded at A-3 while the maximum concentration of two of these reoccurring VOC's (m/p-xylene, and benzoic acid) was recorded at A-4.

Comparison of the concentration of the top 5 VOC's recorded at all monitoring location could not be made as there are no ambient air quality standards established by either Bahrain or WHO for these VOCs.

5.3 Receptors

In relation to ambient air quality impacts from the Al Dur IWPP Phase 2 Project, the expected range of impacts are likely to be within a zone of 5km. A 5km radius has been chosen because the Project type as it is expected to result in air emissions during combustion activities.

Findings from site visits and review of satellite imagery has identified different receptor types within 5km of the proposed project site and these are outline in the table below.

Table 5-18 Potential Air Quality Receptors

Receptor	Receptor Type	Sensitivity	Justification
Al Dur Residences	Residential	**High**	As residential areas with permanent residents, these residential receptors would be particularly vulnerable to changes in ambient air quality.
Camp Areas			
Jaww			
Future residents of Al Dur IWPP Phase 2 sub contractor camps	Residential	**High**	As the contractor camp will be occupied during the construction phase of the project, residents of this camp are particularly vulnerable to changes in ambient air quality
Tree of Life	Recreational	**Medium**	Users of this recreational area approximately 3.3km north west of the Project boundary will be relatively vulnerable to changes in ambient air quality as a result of operations of the Project
Al Dur Development (Under Construction)	Commercial / Residential	**Medium**	The construction workers at this development undergoing construction will be relatively vulnerable to increase in ambient air quality.
Users of the Tourism Boat Jetty	Commercial	**Medium**	Users of the jetty area will be relatively vulnerable to changes in ambient air quality as a result of either construction of operation of the Project.
Air Base	Commercial	**Medium**	Users and workers at this air base will be relatively vulnerable to changes in ambient air quality as a result of either construction of operation of the Project.
Royal Academy of Police	Institutional	**Medium**	Individuals working at the Royal Academy of Police approximately 1.6km north east of the Project boundary will be relatively vulnerable to changes in ambient air quality as a result of either construction of operation of the Project.
Al Dur IWP	Industrial	**Low**	These industrial facilities are local pollution sources hence are of low vulnerability to changes in ambient air quality.
Al Dur IWPP Phase 1			

Figure 5-10 Air Quality Sensitive Receptor Locations

5.4 Potential impacts

5.4.1 Construction Phase

During construction, local ambient air quality may potentially be affected by increased dust, particularly during the site preparation stage (site clearance, levelling of sand dunes areas and earthworks) and by the exhaust fumes of construction vehicles, equipment and temporary power generators. The typical air emissions resulting from these activities include: nitrogen oxides, sulphur dioxides, carbon monoxide, carbon dioxide, VOCs, particulates and BTEX.

The principle sources of dust, particulate and gaseous emissions during construction will be:

- Excavations and earthworks, such as ground breaking, cutting, filling and leveling;
- Vehicle movements on unpaved, or compacted surfaces;
- Particulate matter dispersion from uncovered truckloads;

- Vehicle and Construction equipment emissions (e.g. NO_x, SO_x and CO, CO_2, VOCs, particulates and BTEX) and particulates from vehicles, generators and other mechanical equipment;
- Stored VOCs and other volatile hazardous materials and;
- Odour from temporary wastewater facilities, or containment

Dust Generation

The principle sources of dust and particulate emissions during construction will be:

- Excavations and earthworks, such as ground breaking, cutting, filling and levelling;
- Vehicle movements on unpaved, or compacted surfaces; and
- Particulate dispersion from uncovered truckloads.

Dust Emissions from Site Preparation

Dust resulting from excavations and earthworks typically comprises large diameter particles, which settle rapidly and close to the generation source.

According to the screening guidance of the UK's Institute of Air Quality Management (IAQM) for construction dust, detailed assessment relating to dust generation is required where there is a 'human receptor' within 350m of the boundary of the site. In the instance of this Project and with respect to the screening criteria above, residents at the Project subcontractor contractor camp approximately 300m south and workers of the Al Dur Phase 1 IWPP directly adjacent to the north of the project site are within 350m of the project site boundary. As such, there is the potential for impacts relating to dust emissions as a result of site preparatory activities upon these receptors.

However, the magnitude of such dust impacts from site preparatory works will depend on the wind speed and wind direction at the Project site which have been observed to predominantly come from the north-westerly direction; as indicated by the wind rose presented above. Dust emissions are therefore more likely to disperse in a south-easterly direction towards open land, prior to the Al Dur residences which are located approximately 800m to the south-east. Dust impacts to the Al Dur residences are likely to be minimal as the majority of dust is expected to fall out of suspension prior to these residences.

Dust Emissions & Particulate Emissions from Movement of Vehicles

In addition to vehicle movements on unpaved surfaces, dust generation from truck movements and particulate dispersion from uncovered truckloads would only occur where mitigation measures are not effectively implemented at the site, or by contractors bringing materials to the site.

Uncontained and/or un-sheeted trucks may be subject to losses of material where the containment is not effective (e.g. spills), or where wind or other air turbulence may disturb the contents and result in dispersion of materials. Such impacts have the potential to degrade local air quality in the immediate area of such movements.

In accordance with the UK's IAQM Guidance on the Assessment of Dust from Demolition and Construction, detailed assessment of vehicle movements should only be required where 'human' receptors are located within 50m of the route used by construction vehicles on public roads, up to 500m from the project site entrance.

In the instance of this Project, the receptors within 50m of the route to be used by construction vehicles (King Hamad Highway) is the Project subcontractor camps and the Al Dur IWPP Phase 1. As such there is the potential for impacts relating to dust generation or particulate emissions as a result of increase vehicle movement on this route.

Gaseous Emissions

The principle sources of gaseous emissions to air during construction will be the combustion of fossil fuels from the operation of vehicles, construction equipment and plant. Such vehicles and equipment are likely to include, but not be limited excavators, graders, pavers, cranes, vibratory rollers, generators, etc. The quantity of gaseous emissions from this equipment will depend on the numbers deployed on site and the hours of operation; but they are expected to be relatively few in number with respect to the geographic extent of the project site.

Any emissions from construction vehicles, plant and equipment are expected to mix in ambient air close to the point of origin and are unlikely to be discernible thereby resulting in emissions that are not distinguishable from the background concentrations or emissions that will not result in an exceedance in ambient air quality standards/concentration.

However, where old or poorly maintained equipment is operated, there is potential for noticeable and/or cumulative impacts to occur. Such impacts are not expected to be discernible at receptor locations over 500m from the project boundary and over 50m from the site access road.

When considering the existing air quality baseline of the Project area which is above Bahraini ambient air quality limit, particularly for NO_2 and SO_2 at some locations, the release of pollutants from these vehicles or equipment may likely result in additional increase in concentration of these pollutants in the local air shed of the Project area and may likely result in distinguishable change in local ambient air quality at these receptor locations.

Volatile Organic Compounds (VOC's)

Small quantity of fuels, paints, solvents and other volatile substances are likely to be required during the construction phase, which will be stored in secure areas within the construction laydown areas. If not adequately contained, such substances have the potential to result in the dispersion of volatile emissions to the immediate air shed. Given that the likely storage of such volatile substances will be in small volumes, such impacts may be negligible at the Project subcontractor camps directly adjacent to the laydown areas and will be limited to the immediate surrounding area of the Project boundary (Al Dur IWPP Phase 1 Project).

Odours

The construction phase of the project will likely include a number of toilet facilities on site for site staff and construction workers. There is the potential for release of odour to the immediate surrounding areas associated with inappropriate containment and coverage associated with wastewater holding/septic tanks. However, such impacts are likely to be temporary & negligible at the Project subcontractor camp and at the Al Dur IWPP Phase 1 Project directly adjacent to the Project boundary.

Table 5-19 Air Quality- Impact Significance, Mitigation & Management Measures and Residual Impacts – Construction

Potential Impacts	Magnitude of Impact	Receptor	Sensitivity	Potential Impact Significance	Mitigation and Management Measures	Residual Impact
Dust emissions within 500m of the project boundary – Generated as a result of site preparatory works and movement of vehicles on unpaved surfaces	**Minor Negative**	Future residents of Al Dur IWPP Phase 2 sub contractor camp	High	**Minor to Moderate**	• Any land grading, excavations and moving of uncovered waste/materials should be undertaken during periods of low winds (e.g. <15 km/h is recommended as a threshold when a review of works is conducted).	**Minor**
	Minor Negative	Al Dur IWPP Phase 1	Low	**Negligible to Minor**	• Vehicle speeds on all site roads will be restricted to 20km/h. • All dust generating activities should cease during periods of high wind conditions (15km/h) • Where sand and other dusty materials are transported to the site, trucks will not be overloaded and will be appropriately covered / sheeted to avoid loses en-route. • Cement and other fine powders should be sealed or covered after use, stored and transported in enclosed or bunded containers. • Dusty material stockpiles (i.e. any fine sands and powders) dust generating activities (stone cutting) are to be located away from the site boundaries and be contained or covered with suitable netting to avoid dust dispersion during storage or use. • Vehicle routes will be clearly demarcated and appropriate signage displayed around the site. • Wetting down of any unpaved site roads in order to reduce dust generation. • The provision of a wheel-washing facilities or high-pressure hose to ensure all vehicles leaving the site are in a satisfactory state of cleanliness.	**Negligible**

Potential Impacts	Magnitude of Impact	Receptor	Sensitivity	Potential Impact Significance	Mitigation and Management Measures	Residual Impact
					• No burning of wastes will be allowed onsite	
Gaseous Emissions – From exhaust of vehicles	**Minor Negative**	Future residents of Al Dur IWPP Phase 2 sub-contractor camp	High	**Minor to Moderate**	• Construction roads in the site will be designated and made clear to the drivers with signage for directions and speed limits placed all along the roads. • Unnecessary usage of vehicles, plant and equipment will be minimised – No unnecessary idling.	**Negligible**
	Minor Negative	Al Dur IWPP Phase 1	Low	**Negligible to Minor**	• Deliveries of equipment/plant to the site will be efficiently managed to reduce the number of trips. • Exhaust fumes and particulates emitted from trucks and vehicles will be minimised by ensuring the use of good condition vehicles (e.g. compliant to vehicle emission requirements). • Lorries and trucks engines will be turned off while waiting on site to minimize gaseous emissions. Air-conditioned or heated shelters should be provided for drivers in designated waiting, loading and unloading areas to prevent drivers waiting in vehicles. • Emissions from machinery and equipment should be free from significant black smoke.	**Negligible**
Emission of VOCs and other hazardous volatiles	**Negligible Minor**	Future residents of Al Dur IWPP Phase 2 sub-contractor camp	High	**Minor**	• Hazardous materials stored and used on site with potential gas emissions (e.g. Volatile Organic Compounds) will be located in well-ventilated, but secure low-risk areas, away from major transport routes	**Negligible**
	Negligible Minor	Al Dur IWPP Phase 1	Low	**Negligible to Minor**	• Volatile fuels and chemicals will be stored in sealed containers. On site storage of large quantities of	**Negligible**

Potential Impacts	Magnitude of Impact	Receptor	Sensitivity	Potential Impact Significance	Mitigation and Management Measures	Residual Impact
					volatile fuels will be avoided, equally prolonged exposure to direct sun and heat will be avoided. • Fires and material burning will not be allowed on the Project site. • Chemical storage areas will be purpose built and well maintained. A data log of all chemicals with MSDSs will be provided at the storage facility within easy access.	
Odour from onsite sanitary facilities	**Negligible Minor**	Future residents of Al Dur IWPP Phase 2 sub contractor camp	High	**Minor**	• Adequate and sufficient sanitary facilities for site workers must be provided. • Effective cleaning and maintenance of toilets to be undertaken to avoid odour dispersion. • All septic tanks must be sealed and fully functioning. • Septic tanks must be operated and maintained according to manufacturer recommendations.	**Negligible**
	Negligible Minor	Al Dur IWPP Phase 1	Low	**Negligible to Minor**		**Negligible**

5.4.2 Operational Phase

Air Emissions

Activities associated with the operational phase of the project will result in the emissions of gaseous pollutants from the operation of the CCGT power generation blocks. These emissions will occur under both simple and combined cycle operating modes using natural gas fuel only. Impacts from the CCGT are likely to be associated with emissions from the main stack associated with the HRSG and the bypass stack under the following operational scenarios:

- Early Power - Natural gas fired operation – simple cycle
- Typical - Natural gas fired operation – simple and combined cycle (depending on loading requirements and maintenance schedules)

For primary project operations, the key pollutants arising from natural gas combustion and emitted via the stacks will be nitrogen dioxide (NO_x as NO_2) and carbon monoxide (CO). In the event of a natural gas supply failure, or required maintenance activity, the plant will be shut down with a diesel generator. Although emergency shutdowns are not expected, where such shutdowns are required the emergency generators will result in minor emissions of NOx, SO_2, CO and Particulates. Such emissions have therefore not been further assessed.

Air Emissions Modelling

A detailed air quality dispersion modelling assessment has been undertaken to determine impacts associated with the proposed Project. Dispersion modelling has been carried out using the United States (US) Environmental Protection Agency (EPA) Breeze AERMOD 7 (version 7.12 and US EPA version 16216) dispersion model, three years of meteorological data from Bahrain International Airport (2015 to 2017), short term ambient air quality data measured at three locations in the vicinity of the site and medium term ambient NO_2 data measured at four locations outside the Project site.

The key pollutants considered in this assessment are: oxides of nitrogen (NO_x as NO_2) and carbon monoxide (CO) as these are the key pollutants emitted from combustion of natural gas that may potentially lead to exceedances of any relevant standards. Predicted concentrations are compared with guidelines outlined by the Bahraini Ministerial (Order No. 3 (2001)) and the WHO Ambient Air Quality Guidelines.

The model input stack emissions data for the main stack and the data for the by-pass stacks are shown in the tables below. The primary emission sources at the site are as follows: in Combined Cycle Mode – four main stacks associated with the HRSG; or in Simple Cycle Mode

– four bypass stacks. The key pollutants arising from natural gas combustion and emitted via the main stack / bypass stack will be nitrogen dioxide (NO_x as NO_2) and CO.

For the purposes of the assessment it has been assumed that the facility will operate at full load continuously all year.

Table 5-20 Stack Emission Parameters (Main Stack)

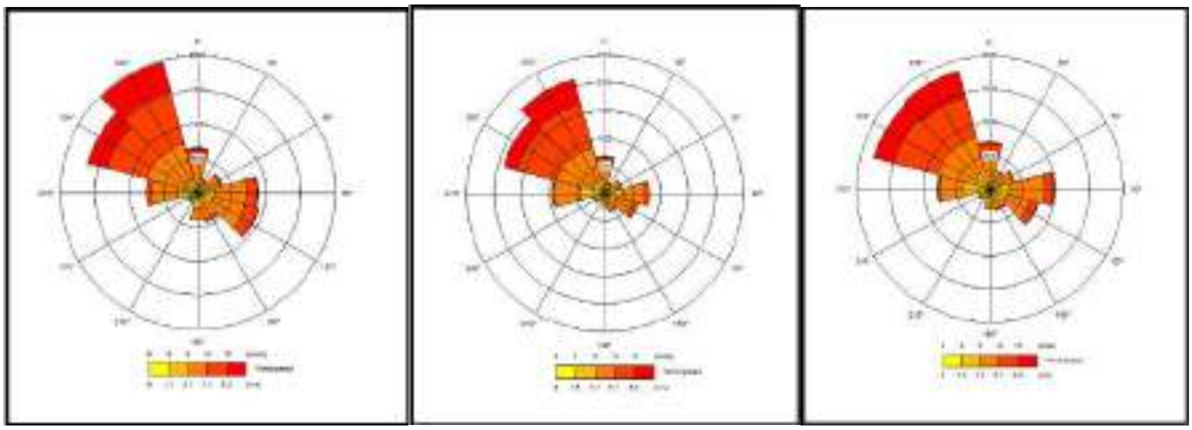
Parameter / Fuel	Natural Gas
Stack Height (m)	60
Stack Diameter (m)	7.0
Temperature (K)	399
Actual Flow Rate (Am^3/s)	769
Exit Velocity (m/s)	20
Concentration (mg/m^3)[a]	
NO_x	51
CO	100
Emission Rate (g/s)	
NO_x	31.85
CO	62.45
[a] Corrected to 273K, 15%O_2, dry	

Table 5-21 Stack Emission Parameters (Bypass Stack)

Parameter / Fuel	Natural Gas
Stack Height (m)	60
Stack Diameter (m)	7.4
Temperature (K)	912
Actual Flow Rate (Am^3/s)	1719
Exit Velocity (m/s)	40
Concentration (mg/m^3)[a]	
NO_x	51
CO	100
Emission Rate (g/s)	
NO_x	31.14
CO	61.06
[a] Corrected to 273K, 15%O2, dry	

The modelling has been carried out using three years (2015-2017) of hourly sequential meteorological data in order to take account of inter-annual variability and reduce the effect of any atypical conditions. Data from meteorological station at Bahrain International Airport (approximately 33km to the north of the site) has been used for the assessment. Wind roses for each of these years are presented in the figure below; these show that the predominant wind direction is from the northwest.

Figure 5-11 Wind Rose for Bahrain International Airport – 2015, 2016, 2017



The presence of buildings close to emission sources can significantly affect the dispersion of pollutants by leading to a phenomenon called building downwash. This occurs when a building distorts the wind flow, creating zones of increased turbulence. Increased turbulence causes the plume to come to ground earlier than otherwise would be the case and results in higher ground level concentrations closer to the stack.

Downwash effects are only significant where building heights are greater than 30 to 40% of the emission release height. The downwash structures also need to be sufficiently close for their influence to be significant. A summary of the proposed buildings and structures that have been included in the model are presented in the table below.

Table 5-22 Downwash Structures

Description	Height (m)
Gas Turbine Building (01)	25
Steam Turbine Building (02)	25
Heat Recovery Steam Generator Buildings (03)	40
Control Building (32)	25
Administration Building (38)	25

Ground-level pollutant concentrations have been predicted at both discrete receptor locations and over a coarse grid of size 20km by 20km Cartesian grid of 500m resolution and a fine grid 5km by 5km of 100m resolution both centred on the Site.

There are no local planning policies that provide criteria for acceptable impacts from proposed facilities in Bahrain. The UK Environment Agency has developed criteria for assessing the significance of an impact compared with relevant air quality standards and background air quality. A process contribution (PC) is considered significant if:

- The long-term PC > 1% of the long-term air quality standard;
- The short-term PC > 10% of the short-term air quality standard.

At 1% of the long-term air quality standard, the impact of a development is unlikely to be significant compared with background air quality. Both the short and long-term criteria are also designed to ensure that there is a substantial safety margin to protect public health and the environment.

If the screening criteria are not met, the process contribution should be considered in combination with relevant ambient background pollutant concentrations. The air quality standards are likely to be met if:

- The long-term PC + background concentration <70% of the air quality standard

The short-term PC < 20% (air quality standard – short-term background concentration), where the short-term background is assumed to be twice the long-term background concentration.

In order to predict the long-term predicted environmental concentration (PEC) the background concentrations have been combined with the long-term PC. To predict the short-term PECs, the predicted short-term PC is added to the short-term background concentrations, usual practice is to assume to be twice that of the long-term background concentration as recommended by the UK EA.

Alternative stack heights were modelled to test the suitability of the 60m high stacks. This demonstrated that increasing the stack height from 55m to 60m results in a significant lowering of the emissions on site sensitive receptors (see Appendix I)

Scenario One (Combined Cycle)

Nitrogen Dioxide (NO_2)

The maximum predicted ground-level NO_2 concentration at the identified sensitive receptor locations are presented in the table below. The results are presented for the process contribution (PC) for emissions from the proposed plant and as a percentage of the relevant standard and as the predicted environmental concentration (PEC).

Table 5-23 Maximum Predicted Long Term (Annual) NO_2 Concentrations – Combined Cycle ($\mu g/m^3$)

RECEPTOR	PC	PC AS % OF STANDARD	PEC
R1: Al Dur Residences	5.9	14.9	61.1
R2: Camp Areas	0.3	0.8	27.9
R3: Jaww	0.2	0.5	29.1
R4: Al Dur Residential Development	0.3	0.8	28.0
Standard	**40**		

The results indicate that the annual mean NO_2 PC arising from the proposed plant when operating in combined cycle mode will be less than 1% of the relevant standard (40µg/m³) at all but one of the long-term sensitive receptors. The impact at these receptors is therefore considered to be insignificant.

At the remaining sensitive receptor (R1: Al Dur Residences) which is located 750m to the southwest of the site, the predicted PC is 14.9% of the relevant standard, which in accordance with the significance criteria cannot be considered to be insignificant. At this location the background concentration is assumed to be approximately 55.2µg/m³ which was the concentration measured at diffusion tube location A-1 in January 2019. Whilst this concentration can only be considered to be indicative as it is based on only one measurement, it is above the relevant long-term standard. The PEC at this location is therefore also above the standard and in accordance with the relevant significance criteria cannot be considered to be insignificant

Figure 5-12 Predicted Maximum Annual Mean NO_2 PC Concentrations (µg/m³)

The maximum predicted ground-level short-term NO_2 concentrations at the identified sensitive receptor locations are presented in the table below. The results are presented for the process contribution (PC) for emissions from the proposed plant and as a percentage of the relevant standard and as the Predicted Environmental Concentration (PEC).

Table 5-24 Maximum Predicted Short-Term (24 Hour and 1 Hour) NO_2 Concentrations – Combined Cycle ($\mu g/m^3$)

Receptor	PC	PC as % of Standard	PEC
1-Hour			
R1: Al Dur Residences	21.3	10.7	131.7
R2: Camp Areas	10.3	5.1	65.5
R3: Jaww (south)	5.9	2.9	63.7
R4: Al Dur Residential Development	6.6	3.3	61.9
R5: Al Dur IWPP Phase I	14.9	7.4	125.2
R6: Tourism Boat Jetty	15.8	7.9	126.1
R7: Royal Academy of Police	6.0	3.0	61.3
R8: Tree of Life	7.6	3.8	62.8
R9: King Hamad Highway	24.6	12.3	135.0
R10: Control Building (Within Site)	16.5	8.2	126.8
R11: Social Building (Within Site)	10.8	5.4	121.2
R12: Admin Building (Within Site)	11.3	5.6	121.6
R13: Gate House (Within Site)	13.7	6.9	124.1
24-Hour			
R1: Al Dur Residences	15.5	10.3	125.9
R2: Camp Areas	2.1	1.4	57.4
R3: Jaww	1.2	0.8	59.0
R4: Al Dur Residential Development	2.0	1.3	57.3
R5: Al Dur IWPP Phase I	2.3	1.6	112.7
R6: Tourism Boat Jetty	2.8	1.9	113.2
R7: Royal Academy of Police	1.3	0.9	56.6
R8: Tree of Life	1.3	0.9	56.5
R9: King Hamad Highway	7.4	4.9	117.8
R10: Control Building (Within Site)	1.2	0.8	111.6
R11: Social Building (Within Site)	0.8	0.6	111.2
R12: Admin Building (Within Site)	0.9	0.6	111.3
R13: Gate House (Within Site)	1.4	0.9	111.7
1-Hour Standard	**200**		
24-Hour Standard	**150**		

The results indicate that the short-term (1-hour and 24-hour) NO_2 PCs arising from the proposed plant when operating in combined cycle mode will be less than 10% of the relevant standards which is are concentrations of 200 and 150 µg/m³ at the majority of the sensitive receptor with the exception of Al Dur Residences (1-hour and 24-hour) and King Hamad Highway (1-hour). The impact at these receptors is therefore considered to be insignificant.

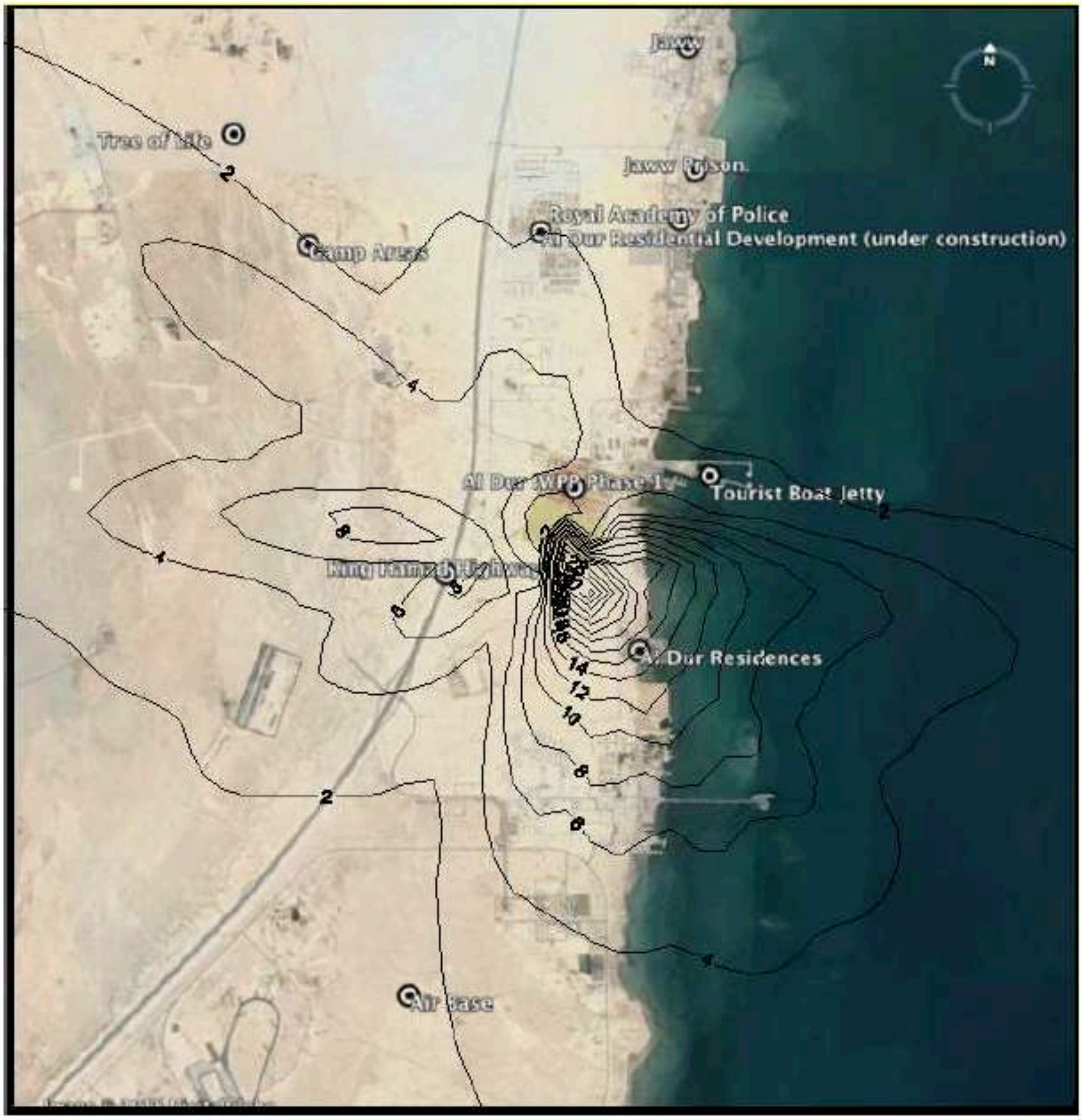
At receptor R1: Al Dur Residences location located approximately 750m southwest of the Project site, the predicted PC is 10.7% of the 1-Hour standard and 10.3% of the 24-Hour standard, which in accordance with the significance criteria cannot be considered to be insignificant. However, it should be noted that the predicted concentrations presented in the table above represent the worst-case concentration resulting from emissions at the maximum allowable level in the worst-case meteorological conditions experienced over the past three years. In reality, the concentrations are therefore likely to be lower and therefore likely to be below the relevant standards. The 1-Hour and 24-Hour PECs of 131.7µg/m^3 and 125µg/m^3 are predicted to be below the relevant standards 200µg/m^3 and 150µg/m^3 respectively.

At receptor R9: King Hamad Highway, which is located approximately 600m to the west of the Project site, the predicted PC is 12.3% of the 1-Hour standard. However, it is unlikely that anyone would be present in this location for the duration of the standard (1-hour), therefore there is unlikely to be any relevant exposure. As such, the standard is not applicable in this location.

The predicted short-term NO_2 PC concentrations are also presented as contour plots in the figures below.

Figure 5-13 Predicted Maximum 1-Hour Mean NO_2 PC Concentrations ($\mu g\ m^{-3}$)

Figure 5-14 Predicted Maximum 24-Hour Mean NO_2 PC Concentrations (μg m^{-3})



Carbon Monoxide (CO)

The maximum predicted ground-level CO concentrations at the identified sensitive receptor locations are presented in the table below.

Table 5-25 Maximum Predicted Short-Term (8 Hour and 1 Hour) CO Concentrations – Combined Cycle (µg/m³)

RECEPTOR	PC	PC AS % OF STANDARD
1-Hour		
D1: Al Dur Residences	119.3	0.4
D2: Camp Areas	57.6	0.2
D3: Jaww	33.0	0.1
D4: Al Dur Residential Development	37.2	0.1
D5: Al Dur IWPP Phase I	83.2	0.3
D6: Tourism Boat Jetty	88.3	0.3
D7: Royal Academy of Police	33.6	0.1
D8: Tree of Life	42.4	0.1
D9: King Hamad Highway	137.9	0.5
D10: Control Building (Within Site)	92.3	0.3
D11: Social Building (Within Site)	60.6	0.2
D12: Admin Building (Within Site)	63.1	0.2
D13: Gate House (Within Site)	76.8	0.3
8-Hour		
D1: Al Dur Residences	106.6	1.1
D2: Camp Areas	18.6	0.2
D3: Jaww	14.1	0.1
D4: Al Dur Residential Development	19.8	0.2
D5: Al Dur IWPP Phase I	33.9	0.3
D6: Tourism Boat Jetty	21.5	0.2
D7: Royal Academy of Police	14.7	0.1
D8: Tree of Life	13.2	0.1
D9: King Hamad Highway	70.0	0.7
D10: Control Building (Within Site)	14.6	0.1
D11: Social Building (Within Site)	11.4	0.1
D12: Admin Building (Within Site)	14.2	0.1
D13: Gate House (Within Site)	19.6	0.2
1-Hour Standard	**30000**	
8-Hour Standard	**10000**	

The results indicate that the short-term (1-hour and 8-hour) CO PCs arising from the proposed plant when operating in combined cycle mode will be less than 10% of the relevant standards which are concentrations of 30,000 and 10,000 µg/m³ respectively at all of the sensitive receptors. The impact is therefore considered to be insignificant. The predicted PECs are well below the relevant standards. The predicted CO PC concentrations are also presented as contour plots in the figures below.

Figure 5-15 Predicted Maximum 1-Hour Mean CO PC Concentrations ($\mu g\ m^{-3}$

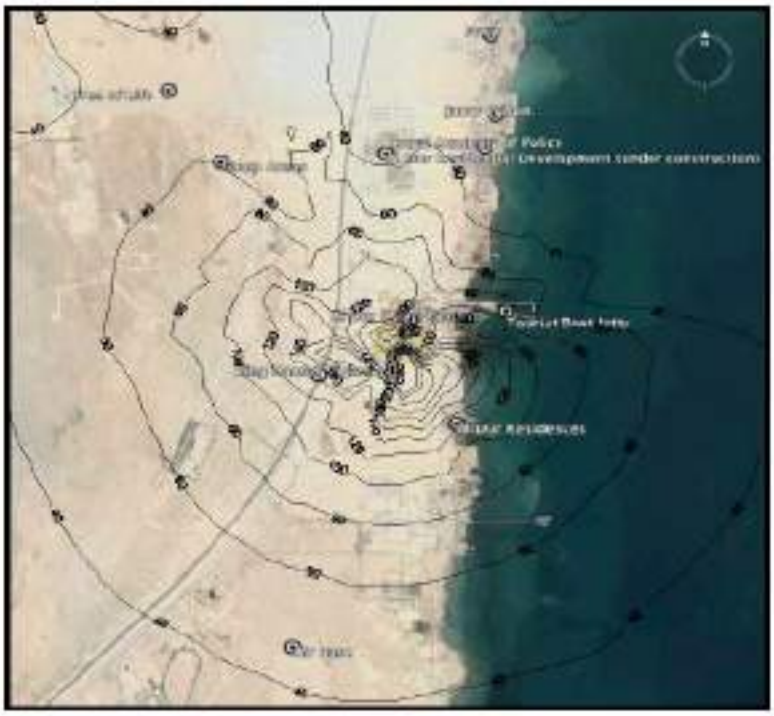


Figure 5-16 Predicted Maximum 8-Hour Mean CO PC Concentrations ($\mu g\ m^{-3}$)

Scenario Two (Simple Cycle)

Nitrogen Dioxide (NO_2)

The maximum predicted ground-level NO_2 concentrations at the identified sensitive receptor locations during periods of time when the Heat Recovery Steam Generators (HRSG) are not operational and the proposed plant is operating in Simple Cycle mode are presented in the table below. It is envisaged that the simple cycle mode would be used for short periods of time only, therefore only the short-term results are presented.

Table 5-26 Maximum Predicted Short-Term (24 Hour and 1 Hour) NO_2 Concentrations – Simple Cycle (µg/m³)

Receptor	PC	PC as % of Standard	PEC
	1-Hour		
R1: Al Dur Residences	10.8	5.4	121.2
R2: Camp Areas	2.5	1.3	57.8
R3: Jaww	2.2	1.1	60.0
R4: Al Dur Residential Development	2.9	1.4	58.1
R5: Al Dur IWPP Phase I	2.6	1.3	112.9
R6: Tourism Boat Jetty	4.1	2.0	114.5
R7: Royal Academy of Police	2.4	1.2	57.7
R8: Tree of Life	1.7	0.8	57.0
R9: King Hamad Highway	7.4	3.7	117.7
R10: Control Building (Within Site)	11.1	5.6	121.5
R11: Social Building (Within Site)	7.1	3.6	117.5
R12: Admin Building (Within Site)	10.1	5.0	120.4
R13: Gate House (Within Site)	13.1	6.6	123.5
	24-Hour		
R1: Al Dur Residences	7.3	4.8	117.6
R2: Camp Areas	0.5	0.4	55.8
R3: Jaww	0.3	0.2	58.1
R4: Al Dur Residential Development	0.5	0.3	55.7
R5: Al Dur IWPP Phase I	0.3	0.2	110.7
R6: Tourism Boat Jetty	0.5	0.4	110.9
R7: Royal Academy of Police	0.2	0.1	55.5
R8: Tree of Life	0.4	0.3	55.6
R9: King Hamad Highway	1.4	1.0	111.8
R10: Control Building (Within Site)	0.5	0.3	110.8
R11: Social Building (Within Site)	0.3	0.2	110.7

R12: Admin Building (Within Site)	0.4	0.3	110.8
R13: Gate House (Within Site)	0.6	0.4	110.9
1-Hour Standard	**200**		
24-Hour Standard	**150**		

The results indicate that the short-term (1-hour and 24-hour) NO_2 PCs arising from the proposed plant when operating in simple cycle mode will be less than 10% of the relevant standards which are concentrations of 200 and 150 µg/m³ at all of the sensitive receptors. The impact is therefore considered to be insignificant.

Carbon Monoxide (CO)

The maximum predicted ground-level CO concentrations at the identified sensitive receptor locations during periods of time when the Heat Recovery Steam Generator Plant is not operational and the proposed plant is operating in Simple Cycle mode are presented in the table below. It is envisaged that the simple cycle mode would be used for short periods of time only.

Table 5-27 Maximum Predicted Short-Term (8 Hour and 1 Hour) CO Concentrations – Simple Cycle (µg/m³)

RECEPTOR	PC	PC AS % OF STANDARD
1-Hour		
R1: Al Dur Residences	60.6	0.2
R2: Camp Areas	14.1	0.0
R3: Jaww	12.1	0.0
R4: Al Dur Residential Development	16.1	0.1
R5: Al Dur IWPP Phase I	14.5	0.0
R6: Tourism Boat Jetty	22.9	0.1
R7: Royal Academy of Police	13.6	0.0
R8: Tree of Life	9.5	0.0
R9: King Hamad Highway	41.3	0.1
R10: Control Building (Within Site)	62.4	0.2
R11: Social Building (Within Site)	39.8	0.1
R12: Admin Building (Within Site)	56.3	0.2
R13: Gate House (Within Site)	73.4	0.2
8-Hour		
R1: Al Dur Residences	44.8	0.4
R2: Camp Areas	6.0	0.1
R3: Jaww	3.0	0.0
R4: Al Dur Residential Development	6.3	0.1

Receptor	PC	PC as % of Standard
R5: Al Dur IWPP Phase I	5.0	0.0
R6: Tourism Boat Jetty	5.5	0.1
R7: Royal Academy of Police	3.1	0.0
R8: Tree of Life	4.3	0.0
R9: King Hamad Highway	13.6	0.1
R10: Control Building (Within Site)	7.8	0.1
R11: Social Building (Within Site)	5.0	0.1
R12: Admin Building (Within Site)	7.1	0.1
R13: Gate House (Within Site)	9.3	0.1
1-Hour Standard	**30,000**	
8-Hour Standard	**10,000**	

The results indicate that the short-term (1-hour and 8-hour) CO PCs arising from the proposed plant when operating in simple cycle mode will be less than 10% of the relevant standards which are concentrations of 30,000 and 10,000 $\mu g/m^3$ respectively at all of the sensitive receptors. The impact is therefore considered to be insignificant.

Conclusions

For Combined Cycle operations the predicted long-term and short-term NO_2 PCs arising from the plant are less than the relevant significance criteria at all but one receptor with relevant exposure. At these receptors the impact with regards to NO_2 concentrations is therefore considered to be insignificant. At the remaining receptor, the impact with regards to long-term NO_2 cannot be considered to be insignificant.

The impact with regards to short-term concentrations (1-hour and 24-hour) only marginally exceed the significance criteria. Due to the worst-case assumptions included in the modelling it is considered that in reality the criteria would be met and the PECs are below the relevant standards, as such the short-term impacts can be considered insignificant.

The predicted 1-hour and 8-hour CO PCs are well below the relevant significance criteria, the impact in terms of CO concentrations is therefore considered to be insignificant.

For Simple Cycle operations, the predicted long-term and short-term NO_2 and CO PCs arising from the plant are less than the relevant significance criteria at all receptors. The impact of the emissions from the plant when operating in Simple Cycle mode is therefore considered to be insignificant with regards to both NO_2 and CO concentrations.

The full air modelling report is present in Appendix I.

Acid Deposition Rates

Acidic deposition rates were tested at sensitive receptor location including The Tree of Life, Marine seagrass habitat close to Al Dur site and the protected Hawar Islands. All sites had low deposition rates within the range of 0.001 to 0.007 keq/ha/yr), with the exception of the closest marine site adjacent to Al Dur site which predicted 0.067 keq/ha/yr.

Table 5-28 Acid Deposition Rates- Combined Cycle

Receptor	Acid Deposition Rate (keq/ha/hr)
Tree of Life	0.007
H4 Seagrass	0.030
F2 Seagrass	0.067
A2 Seagrass	0.003
G4 Seagrass	0.031
B2 Seagrass	0.003
C5 Seagrass	0.005
Hawar Islands	0.002

Table 5-29 Acid Deposition Rates- Simple Cycle

Receptor	Acid Deposition Rate (keq/ha/hr)
Tree of Life	0.002
H4 Seagrass	0.010
F2 Seagrass	0.017
A2 Seagrass	0.000
G4 Seagrass	0.010
B2 Seagrass	0.001
C5 Seagrass	0.001
Hawar Islands	0.001

Operational Vehicle Emissions

The facility is likely to result in the small additional number of commuter vehicles and delivery/removal vehicles along access roads. Emissions from these vehicles will unlikely result in a noticeable impact above the existing industrial emissions from the local facilities and vehicular emissions in the area, as such detailed assessment has not been conducted.

Table 5-30 Air Quality – Impact Significance, Mitigation & Management Measures and Residual Impacts – Operation

Potential Impacts	Magnitude of Impact	Receptor	Sensitivity	Potential Impact Significance	Mitigation and Management Measures	Residual Impact
Stack Emissions from Natural Gas Combustion	**Minor Negative**	Workers on Al Dur 1 and Al Dur 2 sites including offices during single cycle phase	Medium	**Negligible to Minor**	• The Gas Turbines will be equipped with a Low NO_x Combustion System, which will ensure a high quality of combustion to reduce the generation of NO_x. • During commissioning, the stack emissions will be tested for NO_2, CO and PM_{10} to ensure that the control systems are operating correctly and that emission values comply with Bahraini and IFC EHS standards/guidelines. • During operation there will be continuous monitoring of stack emissions, by CEMS systems of NO_2 and CO, to ensure compliant conditions are maintained through appropriate process controls. Additionally, the monitoring of other stack parameters such as oxygen, and temperature will also ensure that the plant is operated efficiently to maintain compliance with the specified air emission standards. • Regular scheduled maintenance activities will be undertaken to ensure that equipment is operating in its most effective manner, to reduce emissions.	**Negligible**
	Minor Negative	Workers on Al Dur 1 and Al Dur 2 sites including offices during combined cycle phase	Medium	**Negligible to Minor**		**Negligible**
	Minor Negative	Residential and tourist areas to north of the site	High	**Negligible to Minor**		**Negligible**
	Moderate	Al Dur residential area to south of the site	High	**Minor to Moderate**		**Minor**
Gaseous Emissions from Vehicles	**Negligible Negative**	Al Dur IWPP Phase 1	Low	**Negligible to Minor**	• Appropriate quality of fuel used – Fuel of an internationally compliant standard to be sourced through a licensed supplier. • Limit unnecessary usage of vehicles – No unnecessary idling. • Planned inspection and maintenance of project vehicles and mobile equipment will be undertaken annually to ensure worthiness and compliance to the required national emission limits.	**Negligible**
						Neutral

5.5 Monitoring

The EPC Contractor and the O&M Company will undertake air quality monitoring during both the construction and operational phases of the project respectively and these are outlined in the table below. The final monitoring methodology with specific monitoring details (i.e. locations, frequencies, durations, parameters etc.) will be developed in the specific 'Environmental Monitoring Plan'.

Table 5-31 Air Quality Monitoring Requirements

MONITORING	PARAMETER	FREQUENCY & DURATIONS	MONITORING LOCATION
Construction			
Dust Generation & Dispersion	Dust	Visual observation for dust emissions to be undertaken on a daily basis. To be monitored quantitatively if generation is considered to be excessive or complaints are received.	Access Road to the Project site, Construction site and laydown areas Dispersion to external receptors from point of generation.
Emissions from engines	Vehicle Emissions	Visual assessment of emissions to be undertaken on a daily basis while vehicles & equipment are in use and annual inspection of vehicles. This would include an inspection during the initial acceptance criteria of such vehicles to site.	All non-road vehicles and engines
Sanitary Facilities & Hazardous stores	Odour & VOCs	Daily olfactory observations – as part of maintenance and inspection checks	All sanitary facilities available within the laydown areas, sub-contractor camps and work fields. All hazardous material, chemical and fuel stores.
Operation			
Emissions from natural gas combustion	Combustion emissions (NO_x, CO, O_2)	Continuous Emissions Monitoring System (CEMS).	CCGT main stacks and bypass stacks.
Emissions from engines	Vehicle emissions	Regular maintenance & servicing of project vehicles and planned annual inspection.	All road and non-road vehicles and engines

6 NOISE AND VIBRATION

6.1 Standards and Regulatory Requirements

6.1.1 National Requirements

The Project will be designed and operated in a manner that meets the minimum Bahraini noise and exposure time standards and guidelines as shown in the tables below, as referenced from the Projects Minimal Functional Specification, as issued by EWA.

Table 6-1 Noise Standards (Ref. Schedule F: Minimum Functional Specifications, Table 5-4, Pg. 73)

LOCATION	LIMIT DB (A)
At one (1) metre outside of the Plant fence when all equipment is running	70
At one (1) metre from open air installation	85
Within machine rooms, workshops etc.	85
Within central room	50

Table 6-2 Noise Intensity and Occupational Exposure Time: Resolution No. (3) of the Year 2005 with Respect to Environmental Requirements and Standards in Workplace. (Schedule 4 table a)

NOISE INTENSITY DB(A)	EXPOSURE TIME/HOUR
85	8
88	4
91	2
94	1/2
97	1/4
100	1/8

Exposure to Crash Noise

This is dependent on the number of knocks during the daily period of work.

Table 6-3 Exposure to Crash Noise: Resolution No. (3) of the Year 2005 with Respect to Environmental Requirements and Standards in Workplace. (Schedule 4 table b)

NOISE INTENSITY DB(A)	NUMBER OF KNOCKS/DAY
140	100
135	300
130	1000

Noise Intensity dB(A)	Number of Knocks/Day
125	3000
120	10000

6.1.2 Lender Requirements

The IFC EHS General Guidelines (2007) for noise indicate the maximum allowable noise levels to be imposed upon surrounding/nearby receptors.

It is stated within the IFC EHS Noise Guidelines that noise impacts should not exceed the levels which are presented in the table below, or result in a maximum increase in background levels of 3dB at the nearest off-site point of reception.

Table 6-4 IFC EHS General Noise Guidelines on Noise Management (Ref. IFC EHS Guidelines: Environmental, Table 1.7.1 pg. 53)

Receptor	One Hour LA_{eq} (dB(A))	
	Daytime 07:00 – 22:00	Night time 22:00 – 07:00
Residential, Institutional, Educational	55	45
Industrial, Commercial	70	70

Furthermore, the following requirements have also been specified in the IFC EHS noise guidelines:

- No employee should be exposed to a noise level greater than 85 dB (A) for duration of more than 8 hours per day without hearing protection. In addition, no unprotected ear should be exposed to a peak sound pressure level (instantaneous) of more than 140 dB(C).
- The use of hearing protection should be enforced actively when the equivalent sound level over 8 hours reaches 85 dB (A), the peak sound level reaches 140 dB(C), or the average maximum sound level reaches 110 dB (A). Hearing protective devices provided should be capable of reducing sound level at the ear to at least 85 dB (A).
- For every 3 dB(A) increase in sound levels, the allowed exposure period or duration should be reduced by 50%.
- Where feasible, use of acoustic insulating materials isolations of the noise source and other engineering controls should be investigated and implemented prior to the issuance of hearing protection devices as the final control mechanism.
- Medical hearing checks on workers exposed to high noise levels should be performed periodically.

6.2 Observations and Baseline Conditions

6.2.1 Noise

The project site is located adjacent to the south of the existing Al Dur Phase 1 IWPP and approximately 800m to the south of the Al Dur IWP. These industrial facilities consist of operational CCGT and SWRO processes. Such processes are observed to result in continual humming noises which propagate to the local areas. This type of noise is expected to be steady without noticeable variations in pitch, frequency or magnitude. Such noise influences are apparent on a 24-hour basis due to the continual operational nature of these facilities.

Approximately 450m west of the Project site is a major road link; the King Hamad Highway along the eastern coastline of Bahrain linking areas in the north to those in the south. Although the highway is well used, it is not near capacity. This results in the frequent passing of vehicles and related noise impacts to the local project area. It is noted that noise from the highway is partly attenuated at the project site due to the slight elevation above the project landmass and the camber of the road (in this specific project area) which slopes away from the project, and results in the blocking of much of the noise towards the site.

Besides noise from the industrial facilities and highway, local noise influences also include noises from vessels at the harbour and aircraft operating at or flying to and from the air base. Operations at the harbour are expected to be more regular and scheduled due to ferrying of passengers on trips to the Hawar islands. Operations from the air base and movement of aircraft are expected to be noticeable due to the high sound power of such military jets. In addition, the operation of the jets in close proximity to the air base (hence at low altitudes) and without blocking features (due to aerial noise sources) means that impacts from aircraft may be quite significant, but sporadic and infrequent in nature, with high magnitude and high pitched sound.

The nature of noise as a pressure wave dictates that with distance, noise prorogation will result in losses of energy and ultimately a decrease in the noise level observed at the point of reception. In addition, when noises are combined or considered in combination, the predominant noise will primarily be evident over lower magnitude noises.

As such, the existing noise influences at the Project site are likely to be limited to those within 1km of the project site boundary which are:

- Al Dur Phase 1 IWPP adjacent to the northern boundary of the Project site;
- Al Dur IWP approximately 800m north of the Project boundary;
- Vehicle movements (along King Hamad Highway) and

- The harbour approximately 800 north east of the Project boundary.

Noise from the operations at the Air Base approximately 2.2km south of the Project site will most likely be inaudible.

Figure 6-1 Local Noise Sources

Noise Monitoring Survey Methodology

Following the scoping study, noise monitoring survey was conducted within and outside the Project site in order to quantify existing noise levels at the Project site and at receptor location due to the presence of existing noise influence.

Noise monitoring was undertaken at five (5) locations surrounding the proposed Al Dur IWPP Phase 2 site to ascertain the baseline environment. The monitoring survey was carried out during the day and evening on the 28th November, the morning on the 29th November and at night on the 28th November as well as on the 1st December (for NML 2 and 5).

The noise survey was carried out with a Cirrus CR 171 B, Type 1 sound level meter (Calibration certificate provided in Appendix J). Parameters that were recorded / calculated included standard time weightings for Fast and Slow responses, frequency weighting and percentile exceedance levels. The A-weighted continuous equivalent sound level (LAeq) along with LAmax, LAmin, LA10, LA 50, LA90 and LA95 were logged for 1 Hour at each location.

The survey was conducted during periods of calm weather conditions in order to obtain representative noise baseline data at each location, without the influence of wind.

The monitoring survey was carried out as follows:

Table 6-5 Noise Monitoring Schedule (November, 2018)

Date	Time	Location Surveyed
28-11-18	14:53 to 21:53 Day/ Evening	NML 1 - 5
29-11-18	08:58 to 14:35 Morning	NML 1 - 5
28-11-18 to 29-11-18	22:03 to 01:30 Night	NML 1, 3 and 4
1-12-18 to 2-12-18	22:45 to 24:58 Night	NML 2 and 5

Measurements were taken continuously for one (1) hour periods in the morning, afternoon and night time at each location while taking note of any noise influences from the surrounding environment.

The monitoring locations are provided in the following figure and the coordinates of the monitoring locations are presented in the table below. Stations NML 1 and 2 were shifted from their original locations on instruction from onsite Bahrain Defense Force (BDF) personnel due to their proximity to the airbase and a private property belonging to the Bahrain Royal family.

Table 6-6 Coordinates of Noise Monitoring Locations (November, 2018)

Location	Easting	Northing
NML 01	461004.13	2870867.88
NML 02	459726.00	2871182.00
NML 03	461274.00	2873360.00
NML 04	461396.70	2875346.27
NML 05	460695.49	2872144.50

Figure 6-2 Noise Monitoring Survey Locations (November, 2018)

The noise monitor (Cirrus CR: 171 B instrument) was placed on a tripod at a height of 1.5 meters above the ground and kept at least 3.5 meters away from any reflecting structure such as walls, fences and vegetation. The instrument's microphone was protected with a Wind Sock to prevent any unwanted disturbances created by the wind.

Figure 6-3 Photo from Noise Monitoring Survey (NML 4) (November, 2018)

Due to the proximity of the Al Dur Residences to the Project site, it was suggested that noise survey be conducted near this location in order to provide worst-case noise data at this receptor location. The second set of noise monitoring survey was carried out on 27th December 2018 near the Al Dur Residences approximately 380m from the south east boundary of the Project site.

The survey was carried out using the same method and same sound level meter as the previous noise survey conducted in November 2018.

Table 6-7 Noise Monitoring Schedule (December, 2018)

DATE	TIME	LOCATION SURVEYED
27-12-18	09:41 to 10:41 Morning	NML 1b
	12:16 to 13:16 Afternoon	
	18:16 to 19:16 Evening	

Table 6-8 **Coordinates of Noise Monitoring Location (December, 2018)**

LOCATION	EASTING	NORTHING
NML 01	461004.00	2871531.00

Figure 6-4 Noise Monitoring Survey Location (December, 2018)

Noise Monitoring Survey Results

The noise levels obtained within and outside the project site (at receptor location) are presented in the table below.

The full noise survey report is included to Appendix K.

Table 6-9 Mean Noise Monitoring Results

MONITORING STATION	LEQ(A) – 1 HOUR AVERAGES		
	MORNING	EVENING	NIGHT
November 2018			
NML 1	41.1	47.3	45.2
NML 2	53.1	54.9	52.9
NML 3	42.1	46.8	45.7
NML 4	43.1	43.7	42.0

Monitoring Station	Leq(A) – 1 Hour Averages		
	Morning	Evening	Night
NML 5	54.3	55.8	55.8
December 2018			
NML-1b	41.9	41.2	39.5

Summary of noise monitoring influences and key observations from the surveys:

a) Low flying aircraft movements from the Sheikh Isa Airbase caused an increase in the day/ evening noise values during surveys at NML 1, NML 2 and NML 5.

b) Traffic accessing the BDF facilities near to NML 1 caused an increase in noise levels towards the end of the day.

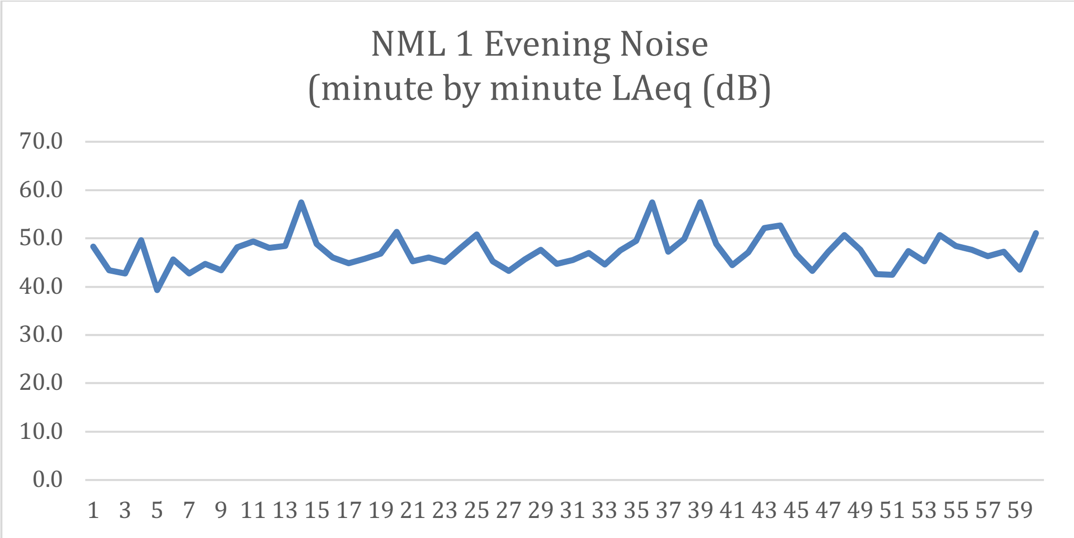
c) NML 2 is close to the King Hamad Highway and road towards the BDF area and therefore heavier day and evening traffic was factor in the higher noise levels.

d) NML 5 is close to the existing Al Dur Phase 1 power plant and therefore this had an impact on the noise levels.

e) While taking measurements at NML 3 heavy machinery was working at a nearby construction site during the day which caused the increase in noise values.

f) During the noise survey conducted in December 2018, the principal source of noise was from traffic along the King Hamad Highway during daytime and some drag racing in the area during nighttime.

In November 2018, noise levels were measured to be lowest at NML1, 3 & 5 in the morning with the highest noise levels consistently measured in the evening times at all locations. The increase in noise levels during the evening times can largely be attributed to sporadic passing of aircraft from the nearby air base. This notably led to a particular increase of noise at NML 1 compared to the morning data. The influence of such movements can be seen on the minute-by-minute data presented below for location NML 1 during the evening time, where there are quite pronounced changes in average noise levels of nearly 10dB(A) from one minute to the next.



Noise levels in the night time were noted to decrease slightly from evening noise levels, except at NML 5 which remained constant.

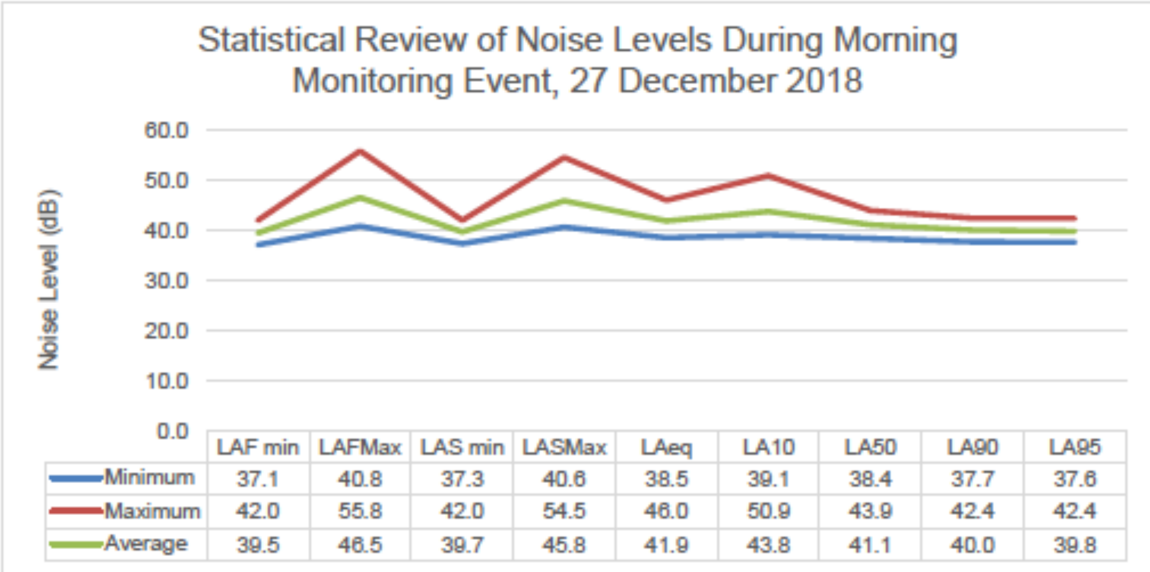
Noise sources in the night time were observed to consist primarily of noise from the existing Al Dur Phase 1 (relevant to location NML 5) as well as drag racing on the highway around NML 2. Noise levels remained more consistent at monitoring locations NML 2 & 5, with only up to a 1.5dB(A) variation in averages. The noise level at NML 5 is expected to be relatively consistent due to the primary source of noise being observed as the Al Dur IWPP Phase 1. Due to the continuous nature of the Al Dur IWPP Phase 1 operations, the noise levels are also less likely to fluctuate dramatically.

When compared to applicable WHO noise standards, it is notable that all morning and evening monitoring data is in compliance with the applicable daytime standard of 55dB(A) at residential receptors. The exception to this is the monitored data at NML 5 which averages at 55.8dB(A) during the evening and as such presents a slight exceedance to this standard. However, as there are no residential receptors at NML 5, the applicable noise standard for comparison would be the Industrial area standard (i.e. 70dB(A)), for which it is fully compliant.

With regard to night time noise monitoring at residential receptors (NML 1, 3 & 4), the noise monitoring measured slight exceedances with respect to the WHO night-time noise standards of 45dB(A) at NML 1 & 3, with NML 4 being 42dB(A). The slight exceedances at NML 1 & 3 are 45.2 and 45.7dB(A) respectively, which are considered to be very minor exceedances.

Monitoring location NML 2 & 5 have higher average noise values at night time, but were observed to have specific influences of the AL Dur IWPP Phase 1 (NML 5) and the King Hammad Highway (NML 2), which are key noise influences locally.

In December 2018, the highest noise level of 41.9dB(A) was recorded in the morning hours following which noise level is seen to decrease from the morning to night. The high noise level at this monitoring location can be attributable to the intermittent passing of vehicles along the King Hamad Highway. When compared with WHO residential ambient noise level fs 55dB(A), the results obtained in the morning (41.9dB(A)), afternoon (41.2dBB(A) and evening (39.5dB(A) were well below the established limit.



6.2.2 Vibration

In terms of baseline, no noticeable vibrations were encountered at any time during the site visits or site survey undertaken to date. There are no current facilities in the vicinity of the proposed project site that are likely to result in significant vibrations at or around the area (including the adjacent Al Dur IWPP Phase 1 – which relies on operating smoothly to eliminate vibrations).

Localised vibration may be encountered from the King Hamad highway (approximately 450m to the west of the project site), however this will typically be dependent on vehicle flows, and vehicle classification (e.g. ratio of HGV's to LGV's and private vehicles). At present, it has been identified that this highway in the Project area is not close to capacity. The dissipation of any such vibrations are furthermore expected to occur over a short distance and would be limited to the areas immediately adjacent to the highway

6.3 Receptors

In relation to noise and vibration impacts, the expected range of impacts are likely to be within a zone of 1km. This is due to noise propagation over distance.

Findings from the site visits, site survey and review of satellite imagery has identified evidence of residential, commercial and industrial properties within 1km of the proposed project site that may be susceptible to changes in noise levels.

These included the Al Dur IWPP Phase 1 directly adjacent to the Project, future residents of Al Dur IWPP Phase 2 sub-contractor camps to be located approximately 200m south of the Project boundary, the Al Dur Residences approximately 400m south east of the project site, the Al Dur IWP approximately 800m north of the Project boundary and the users of the Tourism Boat Jetty/ Harbour approximately 800m north east of the Project site.

Table 6-10 Noise & Vibration Sensitive Receptors

Receptor	Receptor Type	Sensitivity	Justification
Future residents of Al Dur IWPP Phase 2 sub-contractor camps	Residential	**High**	As the sub-contractor camps will be occupied during the construction phase of the project, residents of this camp are particularly vulnerable to increase in ambient noise levels.
Al Dur Residences		**High**	This residential area is located in an area with various noise sources. Hence, it is particularly vulnerable to increase in ambient noise levels
Users of Tourism Boat Jetty/ Harbour	Commercial	**Medium**	This commercial receptor is a local noise source as such, it is of low vulnerability to changes in ambient noise levels
Al Dur IWP	Industrial	**Low**	These industrial facilities are local noise sources hence are of low vulnerability to changes in ambient noise levels.
Al Dur IWPP Phase 1		**Low**	

Figure 6-5 Noise & Vibration Sensitive Receptor Locations

6.4 Potential impacts

6.4.1 Construction Phase

Construction Site Noise

Construction activities will likely result in temporary and short duration increases in the noise and vibration levels emanating from the project site, access road and the laydown areas; dependant on the type of works being undertaken.

Noise will be generated by construction and propagated to the surrounding areas via a range of processes. Pertinent construction activities at the project site in relation to noise are likely to include

- Site Preparation (e.g. earthworks, compaction);
- Civil Works (e.g. piling);
- Construction and Installation;
- Internal Road Paving/Compacting; and

- Vehicle movements.

The accumulation of noise from the above sources can introduce potential cumulative impacts when generated in tandem. All of these impacts may have a negative effect on the amenity of receptors within 1km of the Project site.

The anticipated construction equipment/machinery to be used at the site for various construction activities together with noise data for these equipment are presented in the table below as obtained from 'British Standards: Code of practice for noise and vibration on construction and open sites'.

Table -6-11 Noise Level of Typical Construction Equipment

Construction Activities	BS 5228-1:2009 Reference	Equipment	SPL dB (A)
Site clearance	Table C.2, 4	Tracked Excavator (22t)	52
Earthworks	Table C.2, 13	Dozer (11t)	78
	Table C.2, 20	Tracked Excavator (25t)	68
	Table C.6, 28	Wheeled Loader	76
Material Handling	C.2, 30	Dump truck (29t)	73
	C.2, 38	Roller (18t)	79
	C.2, 40	Vibratory Roller (3t)	73
	C.2, 42	Hydraulic compactor	78
	C.4, 20	Concrete mixer truck	80
	C.4, 22	Concrete mixer (26t)	76
	C.4, 41	Mobile Crane (100t)	71
Stationary	C.4, 84	Diesel generator	74
Road construction	C.5, 1	Hydraulic breaker (67kw)	88
	C.5, 32	Asphalt paver (18t)	84

The accumulation of noise from the above activities can introduce potential impacts at receptor location. Under typical circumstances where all equipment are not operating at the same time and at the same location (50%), the combined cumulative noise level would be 88.3dB(A) as perceived at 10m distance from the source. However as noise levels dissipate with distance, the potential for noise impacts at receptor location will significantly decrease with increase in distance from the noise source.

As the Project subcontractor camp will be situated approximately 200m from the southern boundary of the Project site, the noise level at this receptor location during the construction phase of the Project is anticipated to be 57.8dB(A). As a residential receptor approximately 200m from the project site, this predicted noise level is higher than the WHO noise standards of 55dB(A) established for residential receptors.

The nearest permanent residential receptor is approximately 400m from the site of works (Al Dur Residences) and a basic assessment of distance propagation and ground absorbance would reduce 88.3(A) to 50.2dB(A) at this receptor location. Given that the baseline noise level at this location was recorded at 41.9dB(A) for daytime, the additional noise level as a result of the anticipated generation of construction noise of 50.2dB(A) would result in a cumulative impact of 50.8dB(A), during the daytime. This is an increase of +0.6dB(A) compared to the baseline and is unlikely to be discernible on a continued basis.

A basic assessment of distance propagation, ground absorbance and partial barrier attenuation (from intervening structures such as Al Dur Phase 1 IWPP) of the tourism boat jetty/harbour; a commercial receptor approximately 800m north east of the Project boundary would reduce 88.3dB(A) to 37.7dB(A) at this receptor location. Construction noise impacts from the Al Dur Phase 2 IWPP to the Harbour is therefore well within the WHO noise standards of 70dB(A) established for commercial receptors.

With regards to industrial receptors, given that the Al Dur Phase 1 IWPP is located directly adjacent to the Project site, a 100m separation distance is assumed and a basic assessment of distance propagation and ground absorbance would reduce 88.3dB(A) to 65.3dB(A) at a distance of ≤ 100m from the Project works. The noise level at the AL Dur IWP project site approximately 800m north of the Project boundary is anticipated to reduce from 88.3dB(A) to 32.7dB(A) following a basic assessment of distance propagation, ground absorbance and complete barrier attenuation from intervening structures of the Al Dur Phase 1 IWPP).

As industrial receptors, the anticipated noise levels as a result of Project construction works is well within the WHO noise standards of 70dB(A) for industrial receptors.

In regard to the potential cumulative impacts of construction noise, an assessment of predicted noise at the stated receptors has been provided below with respect to recorded daytime baseline noise levels; morning values (the period at which construction noise is likely to be the loudest – due to daylight conditions). It is assumed at this stage that night works will not be undertaken during construction. The most applicable baseline noise measurement has been attributed to the receptor in the table below (as stated), and has been benchmarked against the applicable WHO standard receptor type.

It is noted that the basic assessment below incorporates noise attenuation as a factor of distance propagation only and does not consider other blocking features or noise losses due to vegetation coverage, or varies topography. As such, this is considered to be a worst case assessment of construction noise at the defined receptor locations.

Table 6-12 Summary of Construction Site Noise Assessment

Receptor	Baseline Noise Level (dBA) (Morning)	Distance from Source	Anticipated Construction Noise at Receptor Location Due to Construction Works (dBA)	Cumulative Noise Level at Receptor Location (dBA)	WHO Noise Standards (daytime) (dBA)
Future residents of Al Dur IWPP Phase 2 sub-contractor camps	54.3 (NML 5)	Approximately 200m from the southern boundary of the Project site	57.8	59.4 (+5.1)	**55**
Al Dur Residences	41.9 (NML 1)	Approximately 400m from the south eastern boundary of the Project site	50.2	50.8 (+8.9)	**55**
Users of Tourism Boat Jetty/ Harbour	42.1 (NML 3)	Approximately 800m from the north eastern boundary of the Project site	37.7	43.4 (+1.3)	**70**
Al Dur IWP	42.1 (NML 3)	Approximately 800m from the northern boundary of the Project site	32.7	42.6 (+0.5)	**70**
Al Dur IWPP Phase 1	54.3 (NML 5)	Directly adjacent to the Project site	65.3	65.6 (+1.3)	**70**

Based on the assessment above, there are not expected to be new exceedance in noise levels with respect of the WHO standards during construction at existing receptors. A noticeable change may however occur at the existing Al Dur residences located approximately 400m to the south east of the project, which may experience noise levels up to 10dB(A) in excess of the current morning baseline (despite being within the daytime noise standards).

The area of the future Al Dur IWPP Phase 2 worker accommodation, will be worst affected due to proximity to the works and due to the existing high baseline noise levels largely affected by the Al Dur IWPP Phase 1 project. Noise levels as a result of construction may reach approximately 5dB(A) above pre-construction levels at this location, but such noises may also be further attenuated by blocking structures (such as administration areas, fences and other features), and as such this is considered to be very much a worst case assessment of impacts.

Construction Vehicle Noise

The addition of temporary construction vehicles on access roads and within the site will likely result in temporary increases in traffic which will consequently result in an increase to noise levels at off-site receptors, particularly those immediately adjacent to the Project, with reduced impacts at receptors within 1km to the Project boundary, and close to the site access roads. Impacts due to vehicular noise will vary due to the phasing of works and the timing of vehicular movements, which affect both vehicle flows and the percentage of heavy vehicles.

The major transport routes to the site will be the King Hamad Highway and an unnamed paved route linking to and running adjacent to the King Hamad Highway. The King Hamad Highway is a four (4) lane, two-way, dual carriageway that runs north to south in Bahrain, located approximately 450m west of the Project site. The unnamed route that links to the Highway is approximately 150m west of the Project site. Based on observations during site visits, the King Hamad highway is fairly well used due to the frequent passing of vehicles, although it does not show signs of potential congestion at the Project area, and is not likely to yet be near its capacity. No vehicles were observed using the unnamed paved route during the site visits.

The construction of the Al Dur Phase 2 IWPP might lead to a small increase of existing vehicle flows along the highway, although given the existing level of frequent traffic flows on this road this is not expected to result in a noticeable traffic impact or secondary noise impacts to receptors. Flows of vehicles requiring access to the project site will however be brought closer to the proposed project along the unnamed route adjacent to the site. The Al Dur IWPP Phase 2 worker accommodation area will consequently be slightly closer to this site access traffic flow, as well as existing receptors such as the Al Dur Residences and the Al Dur IWPP Phase 1 project. This may result in minor increases in noise at these receptors.

Vibration

Certain construction processes, particularly those involved with site preparation and civil works, e.g. breaking, piling, vibratory rollers etc. have the potential to create vibration within the vicinity of the works. Vibration is also anticipated to occur sporadically around the construction site due to the movement of materials and equipment. However, it should be noted that vibrations dissipate rapidly as they spread due to losses of energy radiating 360 degrees from the source.

As such, vibratory impacts at Al Dur 1 IWPP will likely be negligible while impacts at the Project Contractor Camp, Al Dur Residences, Al Dur IWP and the Tourism Boat Jetty/Harbour are not expected to be discernible due to the large attenuation of vibration over distance.

Table 6-13 Noise and Vibration- Impact Significance, Mitigation & Management Measures and Residual Impacts – Construction

Potential Impacts	Magnitude of Impact	Receptor	Sensitivity	Potential Impact Significance	Mitigation and Management Measures	Residual Impacts
Construction Site Noise – Noise from general construction activities	**Moderate**	Future residents of Al Dur IWPP Phase 2 sub-contractor camps	High	**Moderate to Major**	• Consideration of noise fences, or other methods to attenuate construction noise, will be required at the worker accommodation area. This includes noise attenuation to areas to the south east towards the Al Dur residences. • The Contractor will, at all times, carry out all work in such a manner as to keep any disturbance from noise to a minimum (by phasing noisy works). • Acoustic covers on machine engines to remain closed at all times. • Where practical, electrically powered plant will be preferred to mechanically powered alternatives. • All mechanically powered plant, diesel engine vehicles and compression equipment will be fitted with noise control equipment (exhaust silencers, mufflers) as available from the manufacturer. • Where possible, the highest noise emitting activities should be undertaken in a central site area, or within an enclosed structure. For example, fabrication of materials should be carried out away from the site	**Minor to Moderate**
	Moderate	Al Dur Residences	High	**Moderate to Major**		**Minor to Moderate**
	Minor	Users of Tourism Boat Jetty/ Harbour	Medium	**Minor**		**Negligible to Minor**
	Negligible	Al Dur IWP	Low	**Negligible to Minor**		**Negligible**

Potential Impacts	**Magnitude of Impact**	**Receptor**	**Sensitivity**	**Potential Impact Significance**	**Mitigation and Management Measures**	**Residual Impacts**
	Minor	Al Dur IWPP Phase 1	Low	**Negligible to Minor**	boundaries and away from the boundaries of the future contractor camp. • Where appropriate, noise barriers /attenuation to be employed (e.g. for generators) to ensure that the maximum noise level at 1m distance outside of the plant fence when all equipment is running do not exceed 70dB(A) and maximum noise level at 1m from open air installations do not exceed 85dB(A). • Where noise levels exceeds 85dB(A) noise protection devices will be provided to personnel on-site and the area marked as a high-noise zone where ear protection is mandatory. • Items of plant on site operating intermittently will be shut down in the intervening periods between use. • The Project sub-contractor camps should be constructed with sound proof walls and acoustical window treatments such as double glazed windows, noise cancelling shutters or blinds, etc. • Night time construction works to be avoided as much as practicable to prevent noise impact at the sub contactor camp. • Dropping of metallic objects from height will be avoided as far as practicable. • Where noisy activities are located in close proximity to the sub-contractor camp, materials will be stockpiled between the source of noise and the camp so as to provide acoustic screening.	**Negligible**

Potential Impacts	Magnitude of Impact	Receptor	Sensitivity	Potential Impact Significance	Mitigation and Management Measures	Residual Impacts
Vehicular Noise- Noise from movement of construction vehicles	**Minor Negative**	Future residents of Al Dur IWPP Phase 2 sub contractor camps	High	**Minor to Moderate**	• Limit unnecessary usage of vehicles/equipment – No idling – Equipment to be shut or throttled down when in intermittent use. • Delivery vehicles will be prohibited from waiting outside the site with their engines running (consideration of driver waiting room with air conditioning). • Ensure any appropriate permits are in place for deliveries to the site and for any works performed outside normal working hours. • Notify residents in proximity to the access road of noisy activities or special deliveries of large equipment to be conducted nearby their dwellings with a minimum one week in advance. • Review vendor specifications and accept site plant & vehicles, in particular heavy vehicles, based on noise emissions (as far as practical). • The movement of heavy vehicles during the night will be avoided wherever practical. • Where construction vehicles will be operating in close proximity to the sub-contractor camps, the need for trucks to reverse will be minimized as far as practicable. This is so as to reduce the frequency at which disturbing but necessary reverse warnings sirens will be used.	**Minor**
	Minor Negative	Al Dur IWPP Phase 1	Low	**Negligible to Minor**		**Negligible**

Potential Impacts	Magnitude of Impact	Receptor	Sensitivity	Potential Impact Significance	Mitigation and Management Measures	Residual Impacts
Construction vibration impacts (including vehicle vibration)	**Negligible Negative**	Al Dur IWPP Phase 1	Low	**Negligible to Minor**	• The Contractors will, at all times, carry out all work in such a manner as to keep any disturbance from vibration to a minimum. • Operators of vibrating hand-held machinery (if any) will be provided with appropriate PPE (e.g. protective gloves) and be given suitable breaks from using such equipment to reduce the impacts of vibration. • Where practical, all vibratory generating equipment and activities will be sited away from the Project boundary.	**Negligible**

6.4.2 Operational Phase

Project Operational Noise

Noise from Combined Cycle Gas Turbine

The operation of the CCGT plants typically results in a continuous low-level humming noise due to 24-hour operation, combined with sporadic noises from certain processes, mobile equipment and moving vehicles. As such, impacts are likely to be discernible at the receptor locations. The main source of noise are anticipated to be emitted from the gas turbines, HRSG's, steam turbines, stack emissions, fans and water pumps. Noise levels may increase during transient (start-up) operation, with the potential for the facility noise to greatly exceed the noise limits if left un-attenuated. Noise levels of primary production equipment on-site will be specified to be under 85dB(A).

Noise from the SWRO

Generally the operation of SWRO plants are not considered noisy processes. Some items of equipment however do cause noise. Principle noise sources are anticipated to be associated with pumping stations, RO buildings, etc. The reverse osmosis components of the project are typically not noisy and will be housed within internal structures therefore further attenuating any noise generated.

It is unlikely that there would be any discernible impacts to receptors from the SWRO plant.

Noise Modelling Study

By taking into account the source noise levels of key equipment provided by the equipment manufacturers, the area of acoustic or non-acoustic enclosures (where available) intervening structure and the distance to the receptors, a noise model has been prepared using proprietary software 'IMMI2018', in accordance with the methodology outlined in ISO9613 (ISO 9613-2 "Acoustics – Attenuation of sound during propagation outdoors – Part 2: General method of calculation". This noise modelling was undertaken to assess the potential impact at the nearest designated noise sensitive receptors.

ISO 9613-2 computes long-term average sound levels including downwind conditions (favourable propagation of sound with significant positive wind from source to receiver).

The guidance given by ISO 9613-2 on how to determine the meteorological correction term C0 is rather unsatisfactory and therefore the following global parameters are included in the noise model:

- Temperature 20°C; relative Humidity 60%;
- Light downwind propagation towards the receptor;
- Ground attenuation factor 0.0

The noise model assumes that all conduits will be acoustically sealed, all plant will be running continuously for a worst-case assessment. Based on the model inputs, a series of environmental noise predictions using ISO9613 methodology, with input data from the equipment manufacturers of the proposed plant and baseline noise survey undertaken between 28th November and 1st December 2018, the noise model has output contour plots to illustrate predicted noise dispersion from simple cycle and combined cycle with cooling tower noise barrier. The model has also calculated predicted noise levels at the identified receptors which are presented in following tables below

Figure 6-6 Predicted Noise Levels, Simple Cycle with Cooling Tower Noise Barrier

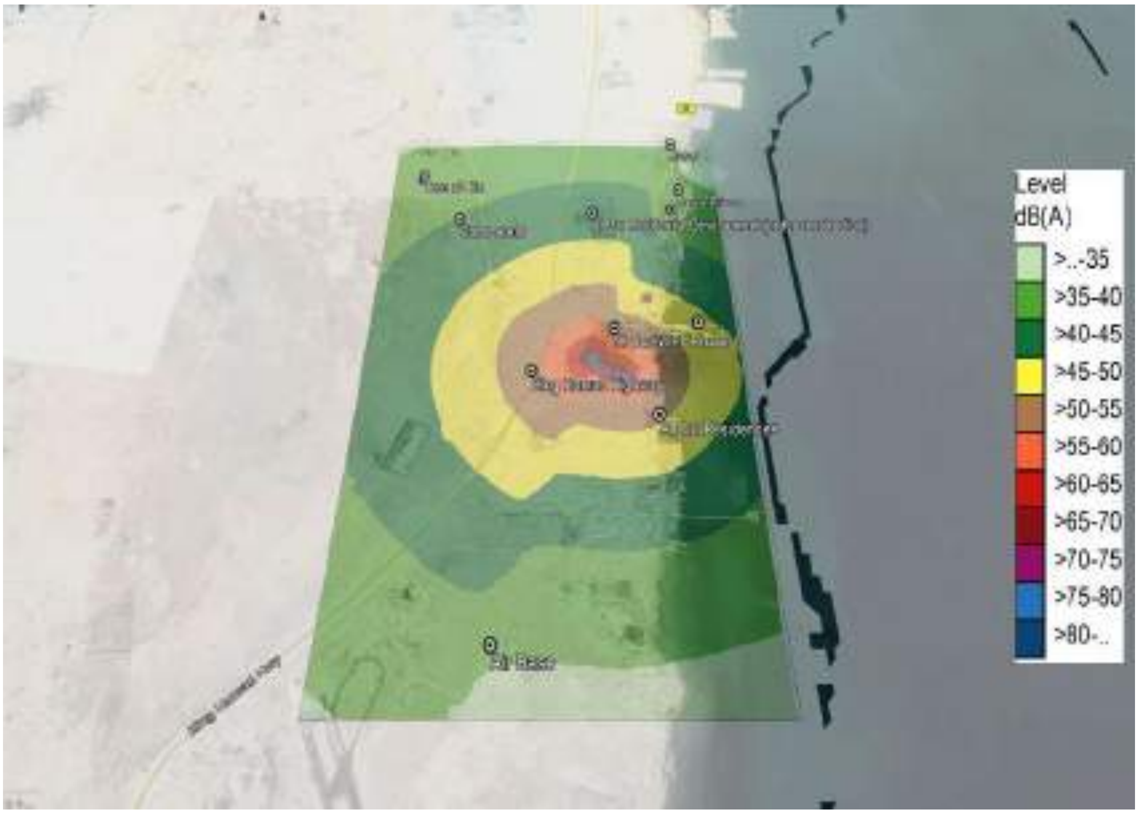


Figure 6-7 Predicted Noise Levels, Simple Cycle with Cooling Tower Noise Barrier

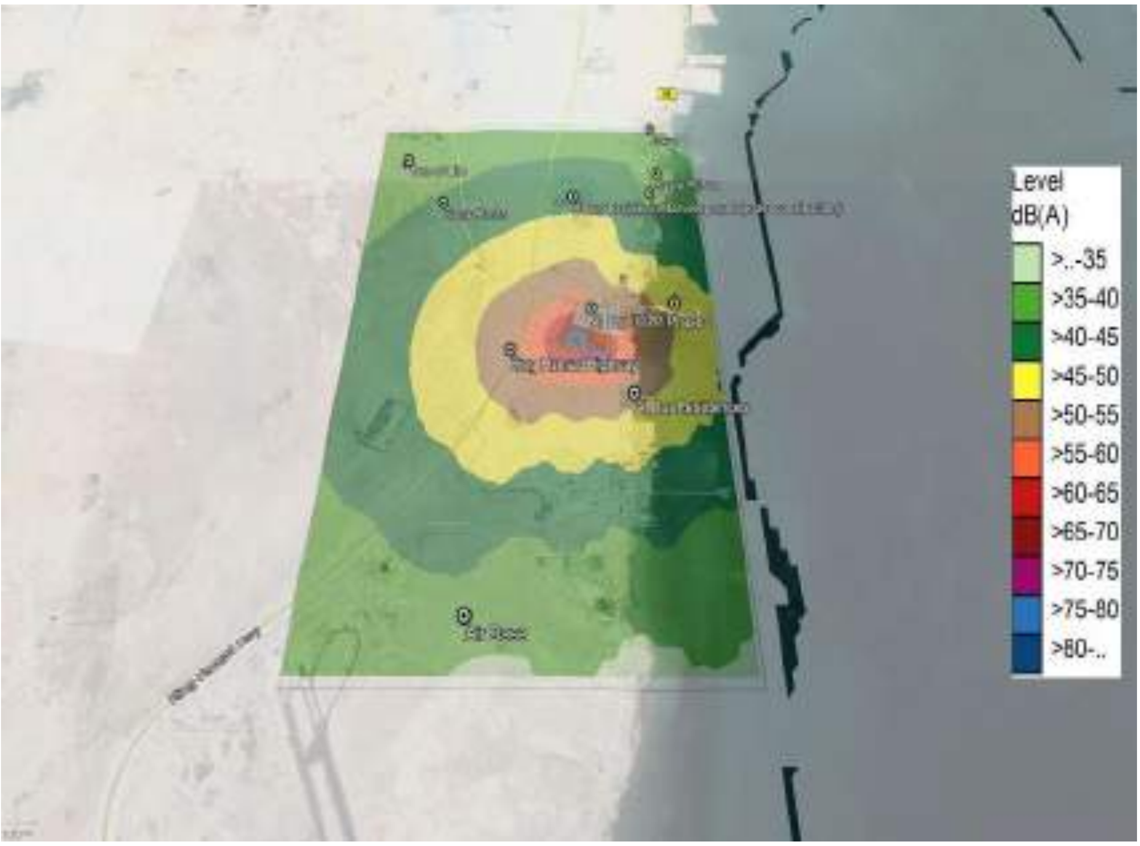


Table 6-14 Predicted Noise Levels at Nearby Receptors

Receptor	Receptor Type	Calculated Noise Levels, Simple Cycle		Calculated Noise Levels, Simple Cycle		Calculated Noise Levels, Combined Cycle		Calculated Noise Levels, Combined Cycle	
		Without cooling tower barrier		With cooling tower barrier		Without cooling tower barrier		With cooling tower barrier	
		Day	Night	Day	Night	Day	Night	Day	Night
		L_{Aeq},dB							
Al Dur Residences (Nearest survey location NML 01)	Residential	54.7	**54.7**	49.8	**49.8**	55	**55**	50.6	**50.6**
Tourist Boat Jetty (Nearest survey location NML 03)	Commercial	51.6	51.6	51.6	51.6	52.6	52.6	52.6	52.6
Jaww Prison	Institutional	39.9	39.9	39.9	39.9	40.5	40.5	40.5	40.5

Receptor	Receptor Type	Calculated Noise Levels, Simple Cycle		Calculated Noise Levels, Simple Cycle		Calculated Noise Levels, Combined Cycle		Calculated Noise Levels, Combined Cycle	
		Without cooling tower barrier		With cooling tower barrier		Without cooling tower barrier		With cooling tower barrier	
		Day	Night	Day	Night	Day	Night	Day	Night
		L_{Aeq},dB							
(Nearest survey location NML 04)									
Royal Academy of Police (Nearest survey location NML 03)	Institutional	41.7	41.7	41.7	41.7	42.3	42.3	42.3	42.3
Al Dur Residence (under construction) (Nearest survey location NML 03)	Commercial /Residential	44	44	44	44	44.5	44.5	44.5	44.5
Jaww (Nearest survey location NML 04)	Residential	37.6	37.6	37.6	37.6	38.3	38.3	38.3	38.3
Camp Area (Nearest survey location NML 03)	Residential	42.3	42.3	42.3	42.3	42.6	42.6	42.6	42.6
Tree of Life (Nearest survey location NML 04)	Recreational	38.5	38.5	38.5	38.5	38.8	38.8	38.8	38.8
Air Base (Nearest survey location NML 02)	Commercial	38.6	38.6	35.4	35.4	39.2	39.2	36.6	36.6

During operation of the project, the modelling study predicts compliance with WHO residential, institutional and educational noise standards of 55dB(A) at all modelled residential/institutional receptor locations for daytime monitoring periods with or without proposed noise barrier during both simple and combined cycle operations.

With regards to commercial receptors, the model also predicts compliance with WHO commercial noise standards of 70dB(A) at all modelled commercial & recreational receptor locations for daytime and nigh time monitoring periods with or without proposed noise barrier during both simple and combined cycle operations.

During night time, the model predicted compliance with WHO night time noise standards of 45dB(A) for residential & institutional receptors at majority of the modelled residential & institutional receptor locations with the exception of the Al Dur residences. This receptor is located south west of the Project site and may experience elevated noise levels with or without noise barrier for both operational scenarios is anticipated. However it was noted during the baseline survey that noise levels do fluctuate by up to 10 dB(A) due to aircraft taking off from the neighbouring base.

This is the only residential receptor group that may be exposed to noise levels >45dB(A) at night. As the modelled results are considered to be a worst-case, actual noise at the façade at these receptors is likely to be slightly reduced due to further attenuating effects of property perimeter walls.

When considering the cumulative project impacts, the above modelled noise levels have been combined with the baseline noise measurements as monitored during the baseline survey and presented in the baseline section of this chapter. A cumulative impacts assessment is presented in the table below for the same receptor locations identified above.

Table 6-15 Cumulative Noise Levels

Receptor	Receptor Type	Calculated Noise Levels, Simple Cycle		Calculated Noise Levels, Simple Cycle		Calculated Noise Levels, Combined Cycle		Calculated Noise Levels, Combined Cycle	
		Without cooling tower barrier		With cooling tower barrier		Without cooling tower barrier		With cooling tower barrier	
		Day	Night	Day	Night	Day	Night	Day	Night
		$L_{Aeq,T}$dB							
Al Dur Residences (Nearest survey location NML 01)	Residential	55.4	55.2	51.6	51.3	55.6	55.5	52.1	51.9
Tourist Boat Jetty (Nearest survey location NM 03	Commercial	52.8	52.9	52.8	52.9	53.6	53.7	53.6	53.7

Receptor	Receptor Type	Calculated Noise Levels, Simple Cycle		Calculated Noise Levels, Simple Cycle		Calculated Noise Levels, Combined Cycle		Calculated Noise Levels, Combined Cycle	
		Without cooling tower barrier		With cooling tower barrier		Without cooling tower barrier		With cooling tower barrier	
		Day	Night	Day	Night	Day	Night	Day	Night
		$L_{Aeq,T}$dB							
Jaww Prison (Nearest survey location NML 04)	Institutional	46.0	44.9	46.0	44.9	46.2	45.1	46.2	45.1
Royal Academy of Police (Nearest survey location NML 03)	Institutional	47.9	48.3	47.9	48.3	48.0	48.4	48.0	48.4
Al Dur Residence (under construction) (Nearest survey location NML 03)	Commercial /Residential	48.6	48.9	48.6	48.9	48.7	49.1	48.7	49.1
Jaww (Nearest survey location NML 04)	Residential	45.6	44.3	45.6	44.3	45.7	44.5	45.7	44.5
Camp Area (Nearest survey location NML 03)	Residential	48.0	48.4	48.0	48.4	48.1	48.5	48.1	48.5
Tree of Life (Nearest survey location NML 04)	Recreational	45.7	44.5	45.7	44.5	45.8	44.6	45.8	44.6
Air Base (Nearest survey location NML 02)	Commercial	56.7	54.7	56.6	54.7	56.7	54.7	56.6	54.7

Cumulative noise impacts where the noise levels are above established WHO noise standard for a particular receptor type was recorded at night (noise levels greater than 3dB(A)) at two modelled residential receptor locations; the Al Dur residences approximately 400m south east of the Project site and the camp areas approximately 1.8km north west of the Project site.

This increase in noise level occurred during both simple and combined cycle operations with or without proposed noise barrier. Although the camp areas is not considered to be a noise sensitive receptor particularly at night due to its distance from the Project site, night-time ameliorative measures will be considered (see mitigation and management measures).

Detailed noise modelling study is presented in Appendix L

Vibration

Vibration associated with the operation of the CCGT plant is anticipated to be minimal. Minimal vibrations associated with the standard operation of the plant or machinery dissipate rapidly as they spread due to losses of energy radiating 360 degrees from the source and are only anticipated to have a negligible impact at the Al Dur Phase 1 IWPP directly adjacent to the northern boundary of the Project site. Impacts to other receptors are not expected to be discernible due to the large attenuation of vibration over distance.

As the SWRO plant will not contain rotating, vibrating, or other major moving parts, impacts from vibration during the operational phase are not expected.

Table -6-16 Noise and Vibration Impact Significance – Operation

Potential Impacts	Magnitude of Impact	Receptor	Sensitivity	Potential Impact Significance	Mitigation and Management Measures	Residual Impacts
Operational Noise – Noise from CCGT, SWRO, control rooms, machine rooms, etc.	**Moderate Negative**	Al Dur Residences to the south	High	**Moderate to Major**	• Noise generated as a result of the operation of the IWPP plant components must not exceed the EWA Noise Limits specified in the RfP issued for the Project. • As per the specified noise limit in the RfP, all equipment in operation will have a noise limit 70dB(A) at 1m outside the Plant fence. • Where practicable, all noise generating equipment will be sited away from the Project site boundary to minimize impacts to surrounding environment. • Where noise generating equipment exceeds 85dB(A) at 1m away from open air installations, this equipment will be housed in appropriate shelters with suitable noise attenuating measures such as buffers, silencer or acoustical enclosures. • Areas exposed to noise levels >85dB(A) will be designated as 'High-Noise Areas' which require operation personnel to wear ear protection. • In order to reduce night time noise impact at residential receptor locations, the following should be taken into account - The number of GT/ST's operating at night should be reduced where possible. - Cooling fans should be installed with inlet and exhaust mufflers and; - All unnecessary equipment should be either switched off or throttled down at night	**Minor to Moderate**
	Minor Negative	Users of Tourism Boat Jetty/ Harbour	Medium	**Minor**		**Negligible**
	Minor Negative	Al Dur IWP	Low	**Negligible to Minor**		**Negligible**
	Minor Negative	Al Dur IWPP Phase 1	Low	**Negligible to Minor**		**Negligible**

6.5 Monitoring

The EPC Contractor and the O&M Company will undertake noise monitoring on a periodic basis during both the construction and operational phases of the project respectively. The minimum expected requirements for the noise monitoring are outlined in the table below. The final monitoring methodology with specific monitoring details (i.e. locations, frequencies, durations, parameters etc.) will be developed in the specific 'Environmental Monitoring Plan' as part of the respective construction or operational phases ESMS.

Table 6-17 Noise Monitoring Requirements

MONITORING	PARAMETER	FREQUENCY & DURATIONS	MONITORING LOCATION
Construction			
Day time noise	Leq(A)	Weekly for 10-15 minutes periods at each location	At the project contactor camps and at the Project site boundaries.
Night time noise			
Operation			
Noise from, CCGT, RO buildings and other industrial components	Leq(A)	Monthly for 5 minute periods at each location	Project site boundaries and at nearest receptor location to the Project site

7 MARINE ENVIRONMENT, HYDRODYNAMICS, WATER & SEDIMENT QUALITY

The chapter describes the potential impacts upon the marine environment (i.e. marine flora, fauna and ambient water quality) as a result of the construction and operational phases of the proposed CCGT and desalination plant as well as cumulative impacts with respect to the effects of other local projects. It also identifies the measures that will be undertaken and implemented in order to mitigate these impacts.

7.1 Standards and Regulatory Requirements

7.1.1 National Requirements

The Bahraini Ministerial Order No.3 of 2001 stipulates the regulations and 'Standards of Industrial Effluent'. These standards apply at the source and before releasing to receiving water.

In addition, the Project's Minimal Functional Specification as established by EWA, includes certain requirements not listed in Ministerial Order No.3 of 2001. These have also been included to the table below. Notes linked to the projects Minimal Functional Specification are also included below.

Table 7-1 Standards of Industrial Effluent (ref. Table (4) Ministerial Order No. 3 of 2001)

PARAMETER	MONTHLY AVERAGE $\geq 30\ days$	MAXIMUM
Physio-chemical		
Floating materials	nil	-
Acidity (pH)	6-9	-
Total Suspended Solids (TSS)	20 mg/l	35 mg/l
Temperature (receiving water)	3± (ΔT)	-
Turbidity Level	25 NTU	75 NTU
Biochemical		
Biochemical Oxygen Demand (BOD)	25 mg/l	50mg/l
Chemical Oxygen Demand (COD)	150 mg/l	350 mg/l
Total Organic Carbon (TOC)	50 mg/l	-
Total Nitrogen (Kjeldahl)	5 mg/l	10 mg/l
Oil and Grease	8 mg/l	15 mg/l
Fluorescent Petroleum Matter	0.1 mg/l	0.1 mg/l

Parameter	Monthly Average $\geq 30\ days$	Maximum
Phenols	0.5 mg/l	1 mg/l
Non-organic Chemicals		
Ammoniacal Nitrogen as N	1mg/l	3 mg/l
Aluminium	15 mg/l	25 mg/l
Arsenic (As)	0.1 mg/l	0.5 mg/l
Cadmium (Cd)	0.01 mg/l	0.05 mg/l
Residual Chlorine	0.5 mg/l	2 mg/l
Chromium Total	0.1 mg/l	1 mg/l
Copper (Cu)	0.2 mg/l	0.5 mg/l
Total Cyanide	0.5 mg/l	0.1 mg/l
Iron (Fe)	5 mg/l	10 mg/l
Lead (Pb)	0.2 mg/l	1 mg/l
Mercury (Hg)	0.001 mg/l	0.005 mg/l
Nickel (Ni)	0.2 mg/l	0.5 mg/l
Sulphide (S2-)	0.5 mg/l	1 mg/l
Total Phosphate (Phosphorus) (P)	1 mg/l	2 mg/l
Zinc (Zn)	2 mg/l	5 mg/l
Nitrite (NO2-)	-	10 mg/l
Nitrate (NO3-)	-	1 mg/l
Biological		
Total Coliform (MPN/100 ml)	1000	10000

According to the requirements set by the EWA in the Minimal Functional Specification:

1. Receiving waters are coastal waters of the state with the depth of its territorial waters and their own economic area in which hazardous or contaminated materials are directly or indirectly discharged.

2. Average reading during 30 days.

3. Maximum value will not be exceeded at any time.

4. The standards apply to effluents at the source and before releasing to receiving water.

5. Chlorine shocking: maximum value is 2 mg/l for up to 2 hours, not to be repeated more frequently than once in 24 hours, within a 24-hour average of 0.2 mg/1;

6. The effluent should result in a temperature increase of no more than 3°C at the edge of the zone where initial mixing and dilution take place. Where the zone is not defined, use 100 metres from the point of discharge.

7.1.2 Lenders Requirements

IFC General EHS Guidelines (2007) and sector specific standards (Thermal Power Plants) set the following limits on coastal zone discharge:

Table 7-2 IFC EHS Guidelines for Thermal Power Plants- Effluent Guidelines (Ref. IFC EHS Guidelines: Thermal Power Plants, Table 5 Pg. 31)

CONSTITUENTS	UNIT	IFC
pH	pH units	6-9
Temperature	°C	Site specific requirement to be established
Oil/grease	mg/L	10
Total Suspended Solids (TSS)	mg/L	50
Fluorides (F)	mg/L	10
Residual Chlorine (Cl_2)	mg/L	0.2
Arsenic (As)	mg/L	0.5
Cadmium (Cd)	mg/L	0.1
Cyanides (Cn)	mg/L	0.1
Chromium(Cr)	mg/L	0.5
Nickel (Ni)	mg/L	0.5
Mercury (Hg)	mg/L	0.005
Iron (Fe)	mg/L	1.0
Antimony (Sb)	mg/L	0.005
Copper (Cu)	mg/L	0.5
Zinc (Zn)	mg/L	1.0
Lead (Pb)	mg/L	0.5

Note:

- The effluent should result in a temperature change of no more than 3°C at the edge of a scientifically established mixing zone which takes into account ambient water quality, receiving water use, potential receptors, and assimilative capacity. The EA for a specific project may specify a more stringent temperature change guideline.
- Elevated temperature areas due to discharge of once-through cooling should be minimized by adjusting intake and outfall design through the project specific EA depending on the sensitive aquatic ecosystems around the discharge point.
- The mixing zone may be established by local regulatory agencies or through the project's EA process. It should also be minimized as far as practicable.

With regards to ambient water and sediment quality, there are no ambient water quality standards or sediment quality guidelines in Bahrain. In accordance with lenders requirement where standards or guidelines do not exist, an international good practice standard should be used as a benchmark reference.

As such, the following guidelines have been used in accordance with lenders requirement

- Saudi Arabia 2012 Ambient Water Quality Standards for the Arabian Gulf (PME, 2012)
- Australian National Assessment Guidelines for Dredging (Commonwealth of Australia, 2009)

Note: the Australian National Assessment Guidelines for Dredging (Australian NADG) have been used as the only country that possesses a sub-tropical climate comparable to that of Bahrain

The table below sets out the KSA Gulf ambient water quality standards for comparison.

Table 7-3 KSA 2012 Gulf Ambient Water Quality Standards

PARAMETER	UNIT	KSA 2012 GULF		
		MARINE	HIGH VALUE	INDUSTRIAL
Physical Chemistry				
Temperature	°C	Δ3	Δ2	Δ4
pH	pH units	Δ0.2	Δ0.1	Δ0.3
Salinity	%	Δ0	Δ0	Δ3
TDS	mg/l	37-50000	37-50000	37-50000
TSS	mg/l	5	3	10
Turbidity	NTU	3	2	5
Dissolved Oxygen (DO)	mg/l	>5	>5	>4
Chemical Indicators and Nutrients				
BOD 5	mg/l	15	10	20
COD	mg/l	25	20	40
Oil & Grease	mg/l	3	<1	5
TKN	mg/l	3	2	5
TOC	mg/l	10	10	15
Phosphorus (total)	mg/l	0.5	0.25	1
Phosphorus (PO4 - P)	mg/l	0.1	0.05	0.2
Ammonia (free as NH3)	mg/l	0.1	0.05	1
Chloride (as Cl)	mg/l	35000	35000	35000
Calcium (CaCO3)	mg/l	1200	1200	1200

Parameter	Unit	KSA 2012 Gulf		
		Marine	High Value	Industrial
Inorganic nitrogen (as Nitrite and Nitrate)	mg/l	1.5	1.2	2
Sodium	mg/l	14000	14000	14000
Sulphate	mg/l	3000	3000	3000
Sulphide	mg/l	0.002	0.002	1
Total Petroleum Hydrocarbons	mg/l	0.3	0.2	0.5
Heavy Metals				
Aluminium	mg/l	0.2	0.2	1
Arsenic	mg/l	0.05	0.05	0.1
Barium	mg/l	0.5	0.5	1
Cadmium	mg/l	0.005	0.002	0.05
Chromium (total)	mg/l	0.05	0.05	0.1
Chromium (hexavalent	mg/l	0.005	0.005	0.02
Cobalt	mg/l	0.05	0.05	1
Copper	mg/l	0.05	0.05	0.15
Iron	mg/l	0.5	0.1	1
Lead	mg/l	0.05	0.005	0.2
Manganese	mg/l	0.01	0.01	2
Mercury	mg/l	0.0004	0.0004	0.001
Nickel	mg/l	0.05	0.05	0.2
Silver	mg/l	0.1	0.07	0.2
Zinc	mg/l	0.8	0.2	2
Organics & Inorganics				
Aldrin*	mg/l	2.2×10-6	2.2×10-6	2.2×10-6
Benzene	mg/l	0.01	0.01	0.01
Carbon Tetrachloride*	mg/l	0.001	0.001	0.001
Chlordane*	mg/l	2.3×10-6	2.3×10-6	2.3×10-6
Chlorine (residual)	mg/l	0.1	0.1	0.1
Chlorinated Hydrocarbons (total)	mg/l	0.01	0.01	0.01
Chloroform	mg/l	0.13	0.13	0.13
Cyanide (free)	mg/l	0.01	0.01	0.01
DDT (and metabolites)*	mg/l	1.7×10-5	1.7×10-5	1.7×10-5
Dieldrin*	mg/l	4×10-6	4×10-6	4×10-6
TCDD – Dioxin*	mg/l	3×10-8	3×10-8	3×10-8

Parameter	Unit	KSA 2012 Gulf		
		Marine	High Value	Industrial
Endrin	mg/l	0.000006	0.000006	0.000006
Fluoride	mg/l	1.5	1.5	1.5
Furans*	mg/l	1×10-6	1×10-6	1×10-6
Helptachlor		5×10-6	5×10-6	5×10-6
Hexachlorobenzene	mg/l	0.007	0.007	0.007
Lindane	mg/l	1.2×10-5	1.2×10-5	1.2×10-5
Mirex*	mg/l	1×10-6	1×10-6	1×10-6
MtBE	mg/l	5	5	5
Pentachlorophenol	mg/l	0.005	0.005	0.005
PAH	mg/l	0.003	0.003	0.003
PCB's (total)	mg/l	1.9×10-6	1.9×10-6	1.9×10-6
Phenols (total)		0.05	0.05	0.1
Toxaphene*	mg/l	2.1×10-5	2.1×10-5	2.1×10-5
Trichloroethane*	mg/l	0.01	0.01	0.01
Toluene	mg/l	0.002	0.001	0.002
Vinyl chloride	mg/l	0.002	0.002	0.002
Xylenes	mg/l	0.005	0.005	0.005
Microbial				
Cyanobacteria	mg/l	5000	5000	5000
E-coli	Count/100ml	<500	<250	<500
Intestinal enterococci	Count/100ml	<200	<100	<200

These chemical ranges specified are as a monthly average

The table below presents the Australian marine sediment quality guidelines

Table 7-4 Australian NAGD Sediment Quality Guideline

Parameter	Screening Level (mg/kg)
TPHs	550
Arsenic (As)	20
Cadmium (Cd)	1.5
Chromium (Cr)	80
Copper (Cu)	65
Lead (Pb)	50
Mercury (Hg)	0.15
Nickel (Ni)	21
Zinc (Zn)	200

7.2 Observations and Baseline Conditions

7.2.1 General Observations

The Kingdom of Bahrain is an archipelago of around 33 low-laying islands and islets in addition to numerous shoals and patches of reefs situated centrally off the southern coastline of the Arabian Gulf.

The Arabian Gulf is a shallow and almost land-locked sea that is 1000km long by 230 - 250 km wide, with a 60km wide entrance from the Gulf of Oman at the Strait of Hormuz. The average depth is 35 meters with a maximum of 100m on the Iranian side. There is no continental shelf and 18 % of the area of the Gulf is less than 5 m deep (27.2 % of the Gulf is less than 10 m deep, Marine Environment Protection Association, 1987).

The physico-chemical properties of the Arabian Gulf reflect an extreme environment, which limits the ecological biodiversity. Water temperatures experience extreme fluctuations between summer and winter, with maximum highs reaching 34°C and lows 17°C, although the average fluctuation is approximately 10°C between summer and winter. The Gulf's salinity is uncharacteristically high, and this is due to the high evaporation rate and minimal input of fresh water. The average salinity in the UAE is 39ppt, however summer salinities are slightly higher at 40 - 42ppt. It should be noted that in shallow intertidal areas, where flushing is limited, salinity can be substantially higher. For example, in the bays around Kuwait, naturally occurring salinity levels have been recorded as high as 48 - 52 ppt. Notwithstanding this extreme marine environment, the Arabian Gulf supports a variety of ecosystems and a healthy diversity and density of fauna and flora.

According to the Bahrain First National Report to the Convention on Biological Diversity (2006) Bahrain supports a wider range of marine habitats in spite of the prevailing harsh physical marine environment. They include inertial habitats such as rocky shores, mudflats, salt marshes, mangrove swamps and sandy beaches as well as sub tidal habitats like sea grass beds, sub tidal sands and muds and coral reefs.

Sea grass beds are amongst the most distinct key coastal habitats in Bahrain in terms of their environmental and socio-economic importance. Covering extensive areas of the northern and eastern coasts, sea grass beds are important foraging grounds for some threatened species such as the sea-cows (*Dugong dugong)* and the green turtle (*Chelonia mydas)*.

The marine environment encompassing the area under assessment has been well described following a number of surveys during recent years including the marine baseline survey conducted for the Al Dur Phase 1 IWPP Project.

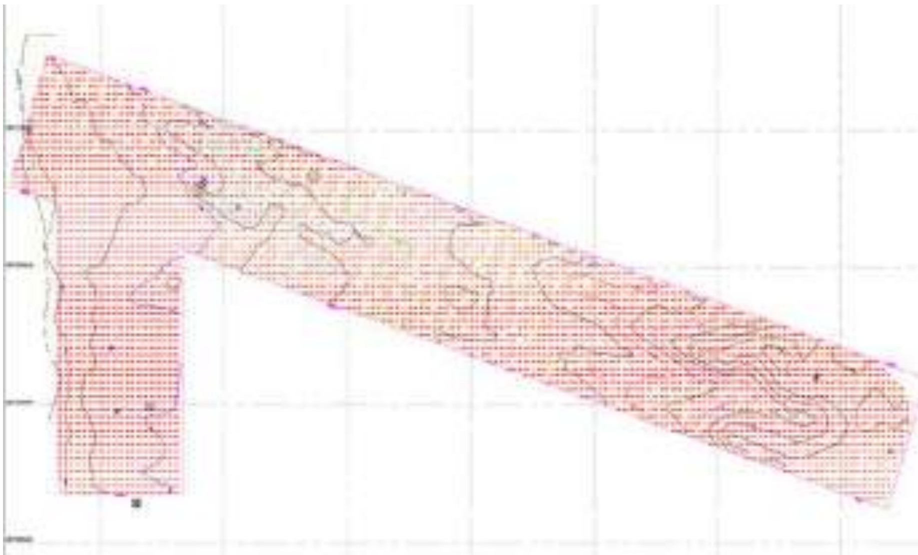
7.2.2 Physical Environment of the Project Area

Bathymetry

As reported in the "Bathymetric Survey Report" conducted in January 2009 for the Al Dur IWPP, The bathymetry of the project area is characterised by gently slopes to -8m below mean sea level (MSL) at 1.5 km offshore (the bathymetric survey covered an areas of 600m wide (N to S direction) and 1,500. long (W to E direction) as shown below).

The survey also included the nearshore area adjacent to the Al Dur IWPP Phase 2 project.

Figure 7-1 Bathymetric Survey Output from 2009 Report



Coastal Processes

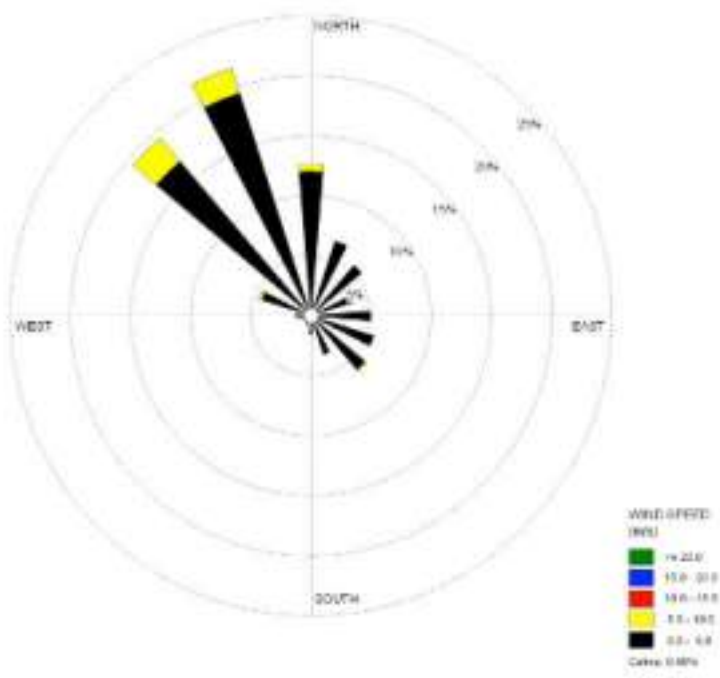
Currents

Currents are controlled by three components: tides, winds and water density. Hydrodynamic data included as part of the "Seawater Recirculation Study" for the Al Dur IWPP Phase 1, concluded that currents during mid-flood of both neap and spring tides dominantly flow from the north towards the south, following the shape of the coastline. During mid-ebb conditions of neap and spring tides, the currents are expected to flow northward. As would be expected and are normal of typical current patterns, currents are predicted to be at higher velocity during the spring tide than during the neap tide. It is also clear that the strongest currents occur along the coastline and then weaken in the open sea.

Winds

As shown in the wind rose below, the most frequent wind direction (blows from) is between 326.25° to 348.75°.

Figure 7-2 Wind Rose for the Project Area



<u>Tides</u>

Hydrodynamic data included as part of the "Seawater Recirculation Study" for the Al Dur IWPP Phase 1, concluded that:

- The most important tidal constituent in the Arabian Gulf is the semi-diurnal tidal constituent, M2. However, the most important diurnal tidal constituents, O1 and K1, are not negligible. This results in a pronounced diurnal inequality in the vertical tide.
- The Coriolis force is also an influencing factor on the formation of the amphidromic points, which are areas where the tidal range is almost zero. The interactions between the tidal elevations and current velocities around these amphidromic points produce very complex tidal elevation and current velocity regimes in the region. The interaction between the Kelvin waves in the Arabian Gulf is a common feature in the region, which leads to the unusual nature of the current velocity regime offshore.
- The tidal regime around Bahrain is also semi-diurnal, with a maximum annual tidal range of about 2.5 metres. The lowest spring tides occur during the night in the hot summer and during the day in winter.

- Although the tidal range is notable current velocities associated with the tidal motion are generally small. The order of magnitude of current velocities amounts in general to approximately 0.1 – 0.2 m s-1.

Marine Ecology, Water and Sediment Quality

It is noted that the marine environment in the project area has been subject to several influences form past construction and on-going operational activities.

Past construction works have included the marine works at the Al Dur IWPP Phase 1 Project which included dredging of a 1.5km sub-surface intake corridor and installation of intake headers, shoreline outfall structure, as well as other marine construction from the jetty, breakwater, harbour areas to the north of the project and marine works of the Al Dur IWP project approximately 800m north of the Project boundary. All of these construction activities are expected to have resulted in major changes to seabed habitats that may have previously existed in this area. Such impacts are likely to have included direct damage to habitats within the working footprint, as well as sediment and silt dispersion and settlement to areas surrounding the works; potentially resulting in the smothering of benthic habitats with sediment.

On-going operational activities from the existing Al Dur IWPP Phase 1 project may include entrainment of marine fauna via the intake headers, as well as the discharge of mixed thermal and brine effluent and treated wastewater via the shoreline outfall. Following the discharge of these effluents at the shoreline outfall, these effluents will disperse within the mixing zone, with potential impacts to marine ecology and benthic habitats.

7.2.3 Marine Survey

A number of marine surveys have been conducted within the Project's marine area of influence.

In 2008, during the development of the Al Dur Phase 1 IWPP Project directly adjacent to the northern boundary of the Project site, marine surveys were conducted at 38 monitoring locations and 3 reference locations within the intertidal and subtidal waters between 16th and 18th September 2008. Some of these monitoring survey sites were located within the coastal waters of the Al Dur Phase 2 IWPP site and the marine surveys conducted at the Project site included:

- Qualitative survey and general identification on habitat type – e.g. seagrass (26 monitoring sites);
- Quantitative assessment of marine flora & fauna species (12 monitoring sites);
- Sediment Quality Sampling & Analysis and;

- Ambient Seawater Quality Sampling & Analysis.

Out of the 41 sites surveyed in 2008, snapshot marine survey was conducted at seven (7) sites by Five Oceans in February 2018 and at one (1) location along the proposed intake pipeline in order to provide a quantitative and qualitative assessment of the marine environment.

In September 2018, AECOM on behalf of Al Dur Power & Water Company (ADPWC) conducted marine surveys at the same locations as the 2008 marine survey and the marine surveys conducted at the Project site included

- Qualitative assessment of 26 monitoring sites using Drop Down Video (DDV) only;
- Quantitative assessment of 12 monitoring sites via detailed surveys; and
- Quantitative assessment of 3 reference stations

The September 2018 marine survey study is presented in Appendix M

Marine Fauna and Flora

Methodology

During the 2008 marine survey, samples were obtained from 15 quantitative monitoring sites (including the three (3) reference locations) in triplicate with six (6) samples collected from the intertidal zone and nine (9) samples within the subtidal zone in order to assess the infauna and epifauna species composition of the study area. The samples were obtained by experienced divers on SCUBA using a 0.1m quadrat at a depth of approximately 10cm, filtered through a 1mm mesh and then fixed with ethanol-seawater solution for transportation to the laboratory.

Similar sampling methodologies with slight variations was adopted during the 2018 marine survey undertaken between 3rd and 17th September 2018 to facilitate comparison of results.

In order to enable rapid assessment of key marine ecological features, Drop Down Video (DDV) were used in 2018 for identification and mapping of seabed habitats and conspicuous epibiota over large area without the need for divers. For this, the 'Deep Blue Pro' DDV was manually deployed overboard at each monitoring location whilst the survey vessel slowly drifted for 2-4 minutes, or until adequate video footage was recorded; still images were also captured using the DDV.

Figure 7-3 Marine Survey Locations – September 2008

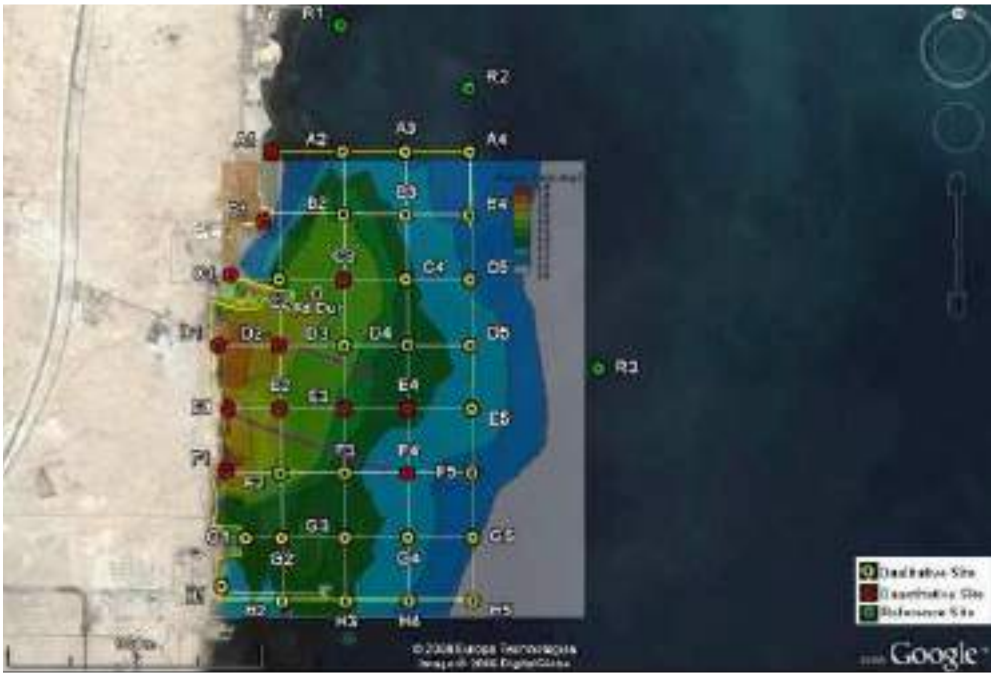
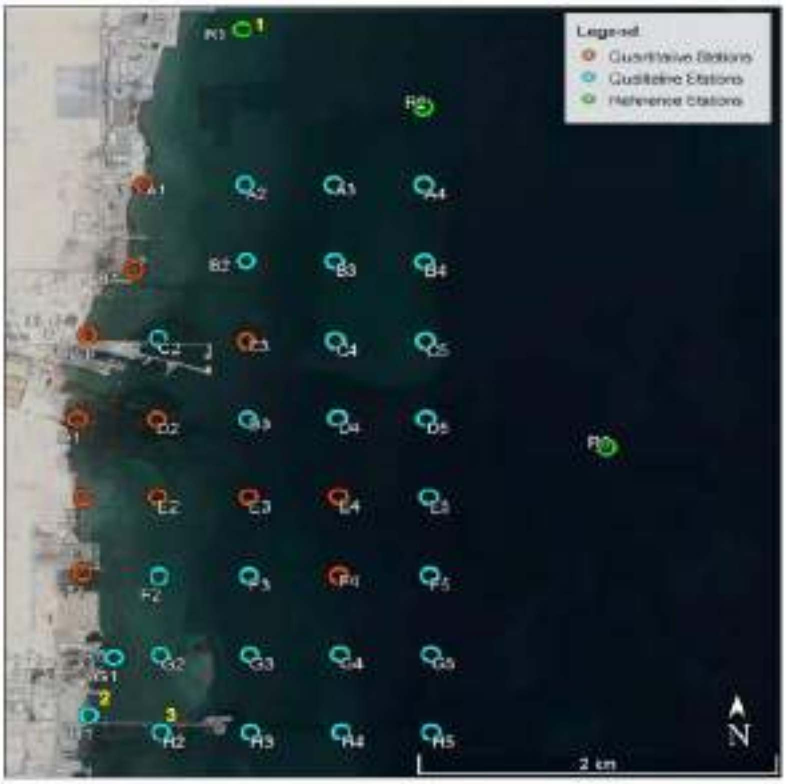


Figure 7-4 Marine Survey Locations – September 2018



Out of the sites sampled in 2008 and September 2018, four (4) sampling sites fall within the vicinity of the Al Dur Phase 2 IWPP Project site. The coordinates and sampling locations of these four (4) sites are presented in the table and figure below.

Table 7-5 Sampling Locations (2008)

Sampling Station	Coordinates (UTM WGS84)		Depth
D1	25°58'4. 78"N	50°36'48. 04"E	0.1
D2	25°58'4. 70"N	50°37'5. 41"E	2.3
E1	25°57'48. 57"N	50°36'50. 77"E	0.1
E2	5°57'48. 57"N	50°37'5. 49"E	1.6

Figure 7-5 Survey Location Within The Project's Area of Influence (2008 and 2018 – Ref. Project Site in Red)

Results

In Fauna Species

In 2008, a total of 325 individual infauna species were identified at all sampling locations. Species in the phylum group Annelida were the most dominant species encountered and accounted for over half of all individuals recorded, all of which belonged to the class Polychaeta (Bristled Worms).

Molluscs were also well represented accounting for about 30% of the total of which one third were bivalves and two thirds were gastropods with Clypeomorus bifasciatus species especially prevalent. Despite low overall abundance, the number of species and individuals showed a high variability between sampling sites.

With regards to sampling sites within the Phase 2 IWPP area of influence, findings from the survey indicate that the highest overall abundance of species were identified at D1 with 82 individuals from 8 invertebrate species identified. 72% of these species were from a single family; the predatory ragworms, Nereidideae. 28 individuals (7 species) were identified at D2, 10 individuals (3) species were identified at E1 and 8 individuals (6 species) were identified at E2.

During the February 2018 snapshot marine survey conducted by Five Oceans, the results obtained from the infaunal sampling indicated similarly homogenous and polychaete dominated communities, relatively poor in diversity as with the 2008 survey. The majority of the infaunal taxa displayed fidelity scores in the range of 0.8 to 1.2, which suggested that their distribution across the survey area was reasonably equitable.

It was noted that the abundance and diversity of infauna recorded had decreased from the 2008 survey. However, comparisons were made difficult as the volume of grabs in the 2008 survey were unknown. A possible link was suggested by Five Oceans between concentrations of heavy metals in the sediment and the low abundance and diversity of the infauna communities in February 2018.

Epi Fauna

Visual and photographic assessment of the study area during the 2008 marine survey indicated a succession of habitat types across the intertidal area, commencing with dense salt crusted algal mat along the shore and rocky outcrops exposed through shallow sands below the littoral zone, moving onto algal-turf/macro-algal dominance in the ‘surf’ zone and finally transitioning into seagrass dominated habitats in the subtidal zone. Within the deeper waters (>10m), seagrass was no longer visible, only sparse patches of sponge were observed within the silty seabed areas.

Within the subtidal areas, a seagrass percentage cover of 10–40% was recorded. Within the majority of the intertidal zone, a 70–100% seagrass cover was recorded, with three species of seagrass present (*Halodule uninervis*, *Halophila stipulacea* and *Halophila ovalis*), with *Halodule uninervis* being the most dominant. The abundance of this species decreased with increasing depth transitioning to mostly *H. stipulacea*, *H. ovalis* at approximately 5m until virtually not present at depth greater than 8m. The sediment within this region was mostly sand and broken shell with water generally clear and visibility up to 5m.

These seagrass communities were observed to support a diverse assemblage of other organisms including macroalgae, fish, echinoderms, crabs, bivalve molluscs, tunicates and cnidarians.

Whilst the majority of the intertidal zone exhibited a high seagrass percentage cover, two patches of the intertidal area (north and south of the Al Dur Power Plant) were recorded to have a slightly lower percentage cover of seagrass between 40 –70%. Onwards from the intertidal zone percentage cover decreases to 10–40%, as with the subtidal zone.

Observations made during the February 2018 snapshot marine surveys revealed two dominant habitat types across the eight (8) stations surveyed, including sand and macroalgae beds. No seagrass was observed at any of these sites, showing a significant difference with the results from the 2008 survey where 70-100% coverage had been recorded in places. It was suggested that the loss in seagrass habitat may be linked to the declining sediment quality and possible presence of a hypersaline discharge plume, although the reduction in seagrass extends some considerable distance offshore and may be due to cumulative impacts from other coastal discharges or dredging works.

The Drop-Down Video (DDV) and dive surveys revealed low densities and abundance of benthic fauna or flora. The area around the intake pipeline corridor displayed signs of former colonisation by bivalves, but no live individuals were recorded. No flora were recorded at sites D2 whilst at sites E2 the dominant biotope was benthic macroalgae.

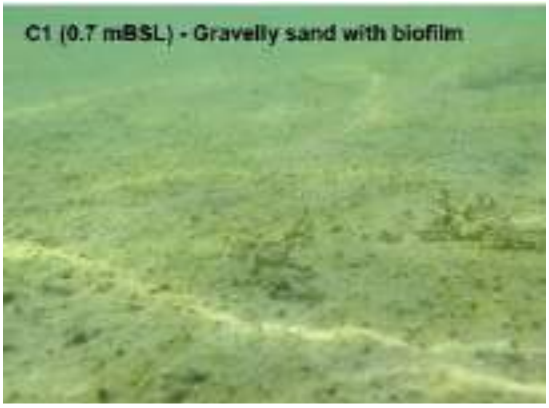
During the September 2018 marine survey, sea grass habitat of 70% cover or more was only observed at two (2) stations in the south and south west of the survey area which is in contrast with the 2008 survey results where high seagrass cover (70-100%) was observed across more than 50% of the survey area.

Medium seagrass (sand and seagrass/microalgae) cover was only recorded at one (1) monitoring station in the north west of the site as against recordings at the north east and south west during the 2008 survey. Low seagrass of 10-40% cover was recorded at two (2) monitoring stations in the north (sand with seagrass/microalgae) and south (mosaic habitat) respectively.

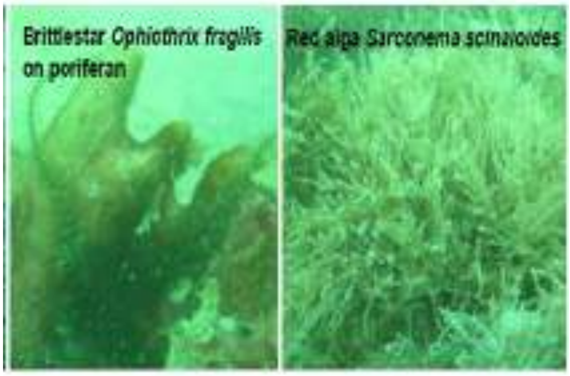
Overall, seagrass (>10% cover) was recorded at 7 out of 38 stations surveyed in 2018, with more than half of these (4) exhibiting low coverage. Nonetheless, there are similarities in the fauna associated with the seagrass habitat, encountered during both the 2008 and 2018 summer surveys, including various species of sponges, ascidians, the swimming crab Portunus *pelagicus*, seastar *Aquilonastra burtoni* and Tailspot Goby *Amblygobius albimaculatus*.

The presence of macroalgae was much more widespread during the September 2018 survey ranging from 10–70% cover across 'sand and macroalgae', 'sand and seagrass/macroalgae', 'sand and rock/macroalgae' and 'mosaic' habitats; which totals 12 stations. The most conspicuous species were the red alga *Sarconema scinaioides* and filamentous green alga *Chaetomorpha brachygona,* the former ranging across the majority of stations at which macroalgae was present, whilst the latter was present in greatest densities at stations D1 and D2, close to the Al Dur Phase 1 IWP outfall.

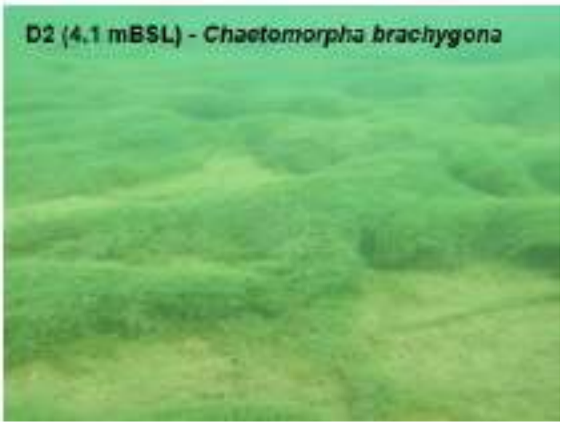
Plate 7-1 Habitat Type with Examples of Epibiota found in Such Habitat During the September 2018 Marine Survey



Sand Habitat

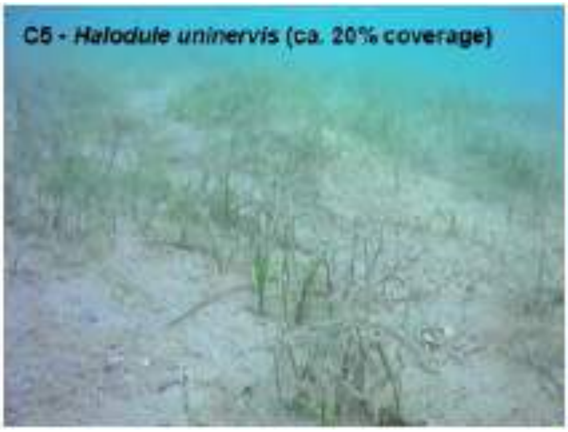


Epibiota in Sand Habitat



Sand and Microalgae Habitat

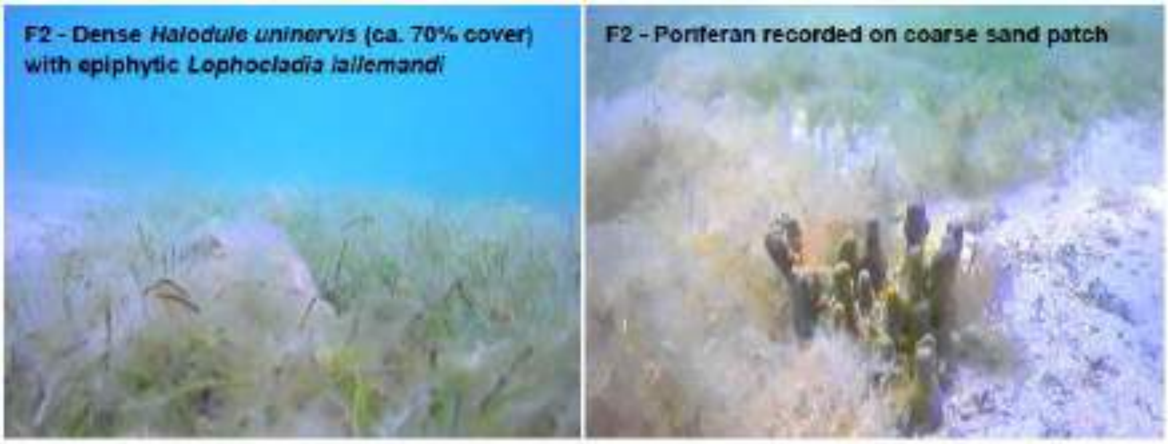
Epibiota in Sand and Microalgae Habitat



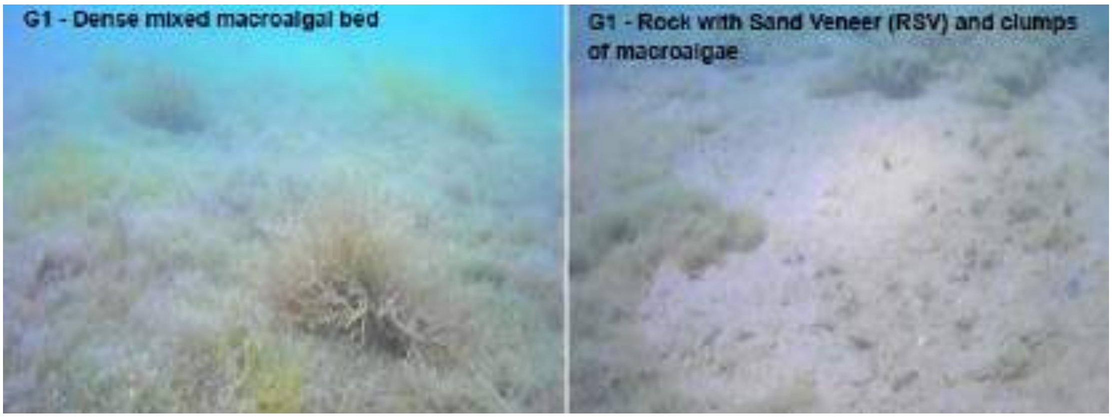
Sand and Seagrass Habitat and Associated Fauna

Sand and Seagrass/Macroalgae Habitat and Associated Fauna

Sand and Rock/Macroalgae Habitat



Seagrass Habitat with Associated Fauna



Mosaic Habitat with Associated Fauna

Mega Fauna

Incidental observations of large marine animals were made during the September 2018 marine survey. A small pod of three Indo-Pacific Bottlenose Dolphins Tursiops aduncus were observed at Station E3, a sand habitat. No other marine mammals or reptiles were sighted in the survey area. This species is cited as 'Data Deficient' on the IUCN and as such is not a species of conservation concern

Besides mammals and reptiles, avifauna species were identified within the study area. Large flocks of Socotra Cormorant Phalacrocorax nigrogularis, numbering in excess of 1,000 individuals were observed flying to and from the project area during the course of the survey on 3rd September 2018. Resident breeding colonies of this species are known to reside at the Hawar Islands, approximately 25km southeast of the Project site.

It is likely that these cormorants were migrating to the area to feed as the flock was seen to be returning to Hawar. This species is listed as 'Vulnerable' under the IUCN Red List and has a decreasing global population trend.

Plate 7-2 Megafauna Identified within the 2018 Study Area

Indo-Pacific Bottlenose Dolphins - no IUCN recognition

Large flock of Socotran Cormorants - IUCN Vulnerable Species

Ambient Seawater Quality Sampling & Analysis

During the 2008 marine dive survey conducted for the Al Dur Phase 1 IWPP Project, seawater samples were obtained at each of the 12 quantitative site and analysed for in-situ (temperature, salinity, turbidity, pH and DO), chemical and microbiological parameters. The samples for in situ parameters were obtained from the surface and seabed of each monitoring location using a calibrated YSI 6600EDS V2 multi parameter instrument while samples for the analysis of chemical and microbiological parameters were obtained near the seabed using the grab method.

During the 2018 survey, water samples were collected at the midwater column of 15 quantitative monitoring stations on 3rd and 4th September 2018 using a 1.5L Niksin sampler with the exception of the samples collected for TPH analysis, which were collected from the surface waters. The samples were analyses for physic-chemical and biological parameters including

BOD, COD, Total Chlorine, Total Coliforms, TPH (C6-C40 fractions), a suite of heavy metals and TSS.

Results

The results obtained during the 2008 marine survey are presented in the table below and provide a reliable baseline of the ambient marine water quality within the Project coastal environment prior to the development of the Al Dur Phase 1 IWPP.

Table 7-6 In Situ Quality at the Project Site (September 2008)

Parameters	Monitoring Locations & Results (Depth)								KSA Gulf Industrial Standard
	D1 (0.1m)		D2 (2.3m)		E1 (0.1m)		E2 (1.6m)		
	Surface	Bed	Surface	Bed	Surface	Bed	Surface	Bed	
pH	-	8.3	8.1	8.1	-	8.3	8.2	8.2	**Δ0.3**
Temperature (°C)	-	31.3	32.3	32.2	-	31.1	32.2	32.2	**Δ4**
Salinity	-	46.2	45.6	45.6	-	46.3	45.7	45.6	**Δ3**
Turbidity (NTU)	-	<0.2	<0.2	<0.2	-	<0.2	<0.2	<0.2	**5**
DO (mg/l)	-	9.8	6.4	7.2	-	11.0	8.5	8.6	**>4**

Table 7-7 Sea Water Quality at the Project Site (2008)

Parameters	Detection Limits	Monitoring Locations & Results (Depth)				KSA Gulf Marine Standard
		D1 (0.1m)	D2 (2.3m)	E1 (0.1m)	E2 (1.6m)	
Physico-chemical Parameters (mg/l)						
TSS	**5**	<5	<5	<5	<5	**5**
BOD_5	**2**	6	<2	<2	<2	**15**
COD	**5**	12	<5	<5	<5	**25**
Flouride	**0.1**	1.13	2.3	1.26	1.88	**-**
Residual Chlorine (Cl^-)	**0.1**	<0.1	<0.1	<0.1	<0.1	**0.1**
Sulphide (S^2)	**0.1**	<0.1	<0.1	<0.1	<0.1	**0.002**
Heavy Metals (mg/l)						
Cadmium (Cd)	**0.0006**	<0.0006	<0.0006	<0.0006	<0.0006	**0.005**
Copper (Cu)	**0.003**	0.014	0.009	0.011	0.009	**0.05**
Chromium (Cr)	**0.005**	<0.005	0.009	<0.005	<0.005	**0.05**
Nickel (Ni)	**0.002**	<0.002	<0.002	<0.002	<0.002	**0.05**
Lead (Pb)	**0.10**	0.05	0.02	0.05	0.02	**0.05**
Zinc (Zn)	**0.009**	0.099	<0.009	0.057	0.01	**0.8**
Arsenic (As)	**0.003**	<0.003	0.003	<0.003	0.003	**0.05**

Parameters	Detection Limits	Monitoring Locations & Results (Depth)				KSA Gulf Marine Standard
		D1 (0.1m)	D2 (2.3m)	E1 (0.1m)	E2 (1.6m)	
Iron (Fe)	**0.030**	0.284	0.137	0.086	<0.030	**0.5**
Phosphorus (PO_4)	**0.009**	0.150	0.173	0.125	0.152	**0.1**
Silver (Ag)	**0.006**	<0.006	<0.006	<0.006	<0.006	**0.1**
Selenium (Se)	**0.002**	<0.002	0.011	<0.002	<0.002	**-**
Mercury (Hg)	**0.001**	0.001	0.002	0.001	0.002	**0.0004**
Microbiological Parameters (cfu/100ml)						
Total Coliform	-	ND	13	ND	18	-

In 2008, the concentration of all parameters monitored were compliant with the established KSA standards for Gulf Marine environment.

The tables below present the results obtained for the September 2018 marine survey.

Table 7-8 In Situ Quality at the Project Site (September 2018)

Parameters	Monitoring Locations & Results (Depth)								KSA Gulf Industrial Standard
	D1 (0.7m)		D2 (4.1m)		E1 (0.5m)		E2 (2.3m)		
	Surface	Bed	Surface	Bed	Surface	Bed	Surface	Bed	
pH	8.3	8.3	8.2	8.1	8.3	8.3	8.2	8.2	**Δ0.3**
Temperature (°C)	36.1	37.3	35.2	37.1	36.5	36.5	34.9	34.6	**Δ4**
Salinity	49.7	58.2	49.2	59.5	49.2	49.2	49.3	49.6	**Δ3**
Turbidity (NTU)	3.3	3.2	6.9	6.9	3.1	3.1	6.5	3.2	**5**
DO (mg/l)	5.1	4.9	5.3	4.9	5.6	5.6	5.2	5.2	**>4**

Table 7-9 Sea Water Quality at the Project Site (September 2018)

Parameters	Monitoring Locations & Results (Depth)				KSA Gulf Marine Standard
	D1 (0.7m)	D2 (4.1m)	E1 (0.5m)	E2 (2.3m)	
Physico-chemical Parameters (mg/l)					
TSS	<5	<5	<5	<5	**5**
BOD_5	<2	<2	<2	<2	**15**
COD	79	75	74	60	**25**
Total Chlorine (Cl^-)	<0.2	<0.2	<0.2	<0.2	**0.1 (residual)**
Heavy Metals (mg/l)					
Arsenic (As))	<0.001	<0.001	<0.001	<0.001	**0.05**
Cadmium (Cd)	<0.0001	<0.0001	<0.0001	<0.0001	**0.005**
Chromium (Cr)	<0.001	<0.001	<0.001	<0.001	**0.05**
Copper (Cu)	<0.001	<0.001	<0.001	<0.001	**0.05**

Parameters	Monitoring Locations & Results (Depth)				KSA Gulf Marine Standard
	D1 (0.7m)	D2 (4.1m)	E1 (0.5m)	E2 (2.3m)	
Lead (Pb)	<0.001	<0.001	<0.001	<0.001	**0.05**
Nickel (Ni)	<0.001	<0.001	<0.001	<0.001	**0.05**
Zinc (Zn)	<0.005	<0.005	<0.005	<0.005	**0.8**
Total Petroleum Hydrocarbons (ug/l)					
C6-C9	<20	<20	<20	<20	-
C10-C14	<50	<50	<50	<50	-
C15-C28	<100	<100	<100	<100	-
C29-C36	<50	<50	<50	<50	-
C37-C40	<50	<50	<50	<50	-
C10 – C40 (sum)	<100	<100	<100	<100	-
Microbiological Parameters (cfu/100ml)					
Total Coliform	ND	13	ND	18	-

At the four survey locations that are situated within the Project's area of influence, BOD was <2 mg/l which is well below the KSA standard value of 15 mg/l. When compared with the results obtained in 2008 both results are similar with the 2008 survey results ranging from <2 mg/l for three monitoring stations with the exception of D1 where 6mg/l was recorded. COD exceeds the KSA standard value of 25mg/l for ambient marine waters.

The concentration of total chlorine and all heavy metals were not detectable and were recorded well below the KSA established limits.

Sediment Sampling Quality & Analysis

During the 2008 marine dive survey, experienced divers on SCUBA using a 0.1m quadrat to standardise the sampling area obtained sediment samples at a depth of approximately 10cm.

During the September 2018 survey, Sediment samples were collected using a manually deployed 0.05 m^2 Van-Veen Grab (Figure 4-5). The samples were collected, decanted into the laboratory-provided containers and stored according to standard laboratory protocol prior to being transported to the laboratory for the analysis of BOD, COD, TPH, a suite of heavy metals and total coliforms

<u>Results</u>

The results presented in the table below will provide a reliable baseline of the ambient sediment quality within the Project coastal environment.

Table 7-10 Sediment Quality at the Project Site (2008)

Parameters	Detection Limits	Monitoring Locations			
		D1	D2	E1	E2
Physico-chemical Parameters (mg/l)					
Flouride	**0.1**	8	2.28	3.7	2.52
Sulphide (S^2)	**0.01**	<0.01	<0.01	<0.01	<0.01
Heavy Metals (mg/l)					
Cadmium (Cd)	**0.03**	0.38	0.22	0.46	0.24
Copper (Cu)	**0.40**	6.23	4.32	8.15	3.75
Nickel (Ni)	**0.20**	6.08	3.33	6.61	4.56
Lead (Pb)	**0.30**	2.88	1.62	3.42	3.15
Zinc (Zn)	**1.10**	21.3	9.65	29.58	9.78
Chromium (Cr)	**0.40**	10.1	1.51	11.6	1.54
Aluminium (Al)	**19**	2318	1385	2393	1864
Iron (Fe)	**12.1**	1884	1227	1931	1865
Arsenic (As)	**0.5**	2.68	0.56	1.44	2.28
Selenium (Se)	**0.5**	2.75	4.68	2.66	3.71
Silver (Ag)	**0.17**	<0.17	<0.17	<0.17	<0.17
Phosphorus (PO_4)	**37**	336	336	567	690
Mercury (Hg)	**0.1**	<0.10	0.10	<0.10	0.10
Microbiological Parameters (cfu/100ml)					
Total Coliform	**-**	ND	ND	8	7

Table 7-11 Sediment Quality at the Project Site (2018)

Parameters	Monitoring Locations & Results (Depth)				Australian Sediment Standard
	D1 (0.7m)	D2 (4.1m)	E1 (0.5m)	E2 (2.3m)	
Physico-chemical Parameters (mg/l)					
BOD_5	46	21	7	24	-
COD	2810	6130	4130	5090	-
Total Chlorine (Cl^-)	7.4	11.8	<5.0	<5.0	-
Heavy Metals (mg/l)					
Arsenic (As))	7.4	11.8	<0.001	<0.001	**20**
Cadmium (Cd)	<1.0	<1.0	<1.0	<1.0	**1.5**
Chromium (Cr)	5.9	19.1	8.8	5.6	**80**
Copper (Cu)	<5.0	23.4	<5.0	<5.0	**65**
Lead (Pb)	<5.0	13.1	<5.0	<5.0	**50**
Mercury (Hg)	<0.10	<0.10	<0.10	<0.10	**0.15**
Nickel (Ni)	3.8	14.9	6.2	4.1	**21**
Zinc (Zn)	20.6	70.7	19.0	13.2	**200**

Parameters	Monitoring Locations & Results (Depth)				Australian Sediment Standard
	D1 (0.7m)	D2 (4.1m)	E1 (0.5m)	E2 (2.3m)	
Total Petroleum Hydrocarbons (ug/l)					
C6-C9	<10	<10	<10	<10	-
C10-C14	<50	<50	<50	<50	-
C15-C28	<100	<100	<100	<100	-
C29-C36	<100	<100	<100	<100	-
C37-C40	<50	<50	<50	<50	-
C10 – C40 (sum)	<100	<100	<100	<100	-
Microbiological Parameters (cfu/100ml)					
Total Coliform	<10	<10	<10	<10	-

Cadmium and mercury were recorded below detection limits while the concentration of other heavy metals were well below the Australian established sediment standards

7.3 Receptors

The table below outlines identified receptors in relation to Marine Ecology and Seawater and Sediment Quality.

Table 7-12 Marine Environment, Hydrodynamics, Water & Sediment Quality – Receptors

Receptor	Receptor Type	Sensitivity[3]	Justification
Marine Ecosystem	**Ecological**	**High**	The ecosystem relies upon the health and maintenance of biodiverse habitats such as seagrass and intricate food webs including plankton and benthic fauna upon which fish, reptiles and mammals depend.
Seagrass	**Ecological**	**High**	Biodiverse habitat for macroinvertebrates and benthic infauna and spawning/nursery for many species of fish. Main food source for green turtles and dugong.
Benthic infauna	**Ecological**	**High**	Benthic infauna provide an indicator of the health of the seabed where pollutants such as heavy metals may accumulate attached to the substrate.

[3] The sensitivity of the coastal waters at Al Dur remains high despite the reduction in the seagrass habitat and benthic biodiversity recorded in 2018 when compare with the 2008 survey.

Plankton	**Ecological**	**High**	Plankton (phytoplankton and zooplankton) provide an indicator of the health of the coastal water quality and are important food source for fish and some large cetaceans such as the whale shark.
IUCN Red Data Species	**Ecological**	**High**	Sensitive species as Dugong and Turtles are protected by law and are listed under IUCN Red data book due to declining numbers arising from loss of habitat and pollution impacts.
Ambient Water Quality	**Environmental**	**Medium**	The impacts of the marine discharge should be largely confined within the predicted mixing zone avoiding wider impacts
Ambient Sediment Quality	**Environmental**	**Medium**	The impacts of the marine discharge should be largely confined within the predicted mixing zone avoiding wider impacts

7.4 Potential impacts

7.4.1 Construction Phase

Offshore works for the construction of intake and outfall pipeline will not be required as the Project will use the already constructed intake/outfall structures that were constructed as part of Al Dur IWPP Phase 1 Project. The intake facility has the capacity for both Phase 1 and Phase 2, while the outfall for Phase 2 is a separate facility to allow monitoring and control of the discharge according to the Plant operation. As such, the main activity that could negatively impact the marine environment, hydrodynamics sediment and water quality during construction is related to the discharge of groundwater due to dewatering required for on-shore construction activities.

Groundwater Dewatering

On-shore excavations for foundation works are anticipated to encounter groundwater at a relatively shallow depth due to the proximity of the Project site to the sea. A soil and groundwater survey is currently being undertaken at the Project site as detailed in Section 9 Geology, Soils and Groundwater. Typically, during dewatering processes, the construction team will make use of pumps to continuously remove water which is then discharged into the sea after appropriate treatment to ensure that the discharge is compliant with Bahraini and WB/IFC standards. With respect to this project, during dewatering processes, provisions will be made for sediment settlement prior to discharge into the Arabian Gulf in order to comply with applicable discharge standards. It is likely that an NOC will be required from the SCE prior to being permitted to discharge to the sea. Following these control measures, impacts to water quality as a result of groundwater discharge into the marine environment would be minimal.

Table 7-13 Marine Environment, Hydrodynamics, Water and Sediment Quality- Impact Significance, Mitigation & Management Measures and Residual Impacts- Construction

Potential Impacts	Magnitude of Impact	Receptor	Sensitivity	Potential Impact Significance	Mitigation and Management Measures	Residual Impacts
Groundwater Dewatering Discharge	**Minor Negative**	Ambient Water Quality	High	**Minor to Medium**	• Provisions for the settlement of de-watered effluent will be provided (i.e. settlement tanks) to ensure that discharged de-watered effluent can meet the respective discharge standards. • Regular and event-based monitoring of dewatering discharge will be conducted to ensure that compliance can be demonstrated, with TSS standards, as well as minimizing hydrocarbons. • Site drainage controls will include provisions to limit pollution to the marine environment from storm-water runoff, specifically from oily water and sediments. • Discharge of untreated and unmonitored effluent will be prohibited at all times.	**Negligible to Minor**

7.4.2 Operational Phase

The main impacts on the marine environment from the operation of the project are linked to the following operational elements:

- Intake of the seawater resulting with fauna entrainment; and,
- Mixed thermal and brine discharge.

Seawater Intake Resulting in Entrainment of Fauna

Depending on the design of the existing intake, seawater drawn by the intake system for the production of freshwater may contains a variety of aquatic organisms.

Some organisms are small enough to pass through the mesh screens into the intake. This process, called entrainment, may affect plankton and larval stages of benthic organisms such as shellfish (i.e., meroplankton), and fish eggs and larvae (ichthyoplankton). Because of the abundance and short regeneration times of plankton, impacts of entrainment on these organisms have rarely been documented outside the immediate vicinity of the plant and are considered to be of little consequence. Therefore, entrainment impacts to phytoplankton and zooplankton are considered to have a relatively negligible significance.

Aquatic organisms that are drawn into the existing intake and are too large to pass through the debris screens may be impinged against the screens. Mortality of fish that are impinged is high because they are eventually suffocated by being held against the screen mesh or are abraded, which can result in fatal infection. Depending on the design and location, impingement can affect large numbers of fish and invertebrates (crabs, shrimp, jellyfish, etc.), and is considered a moderate negative impact.

Impingement occurs when the intake through-screen velocity is too high for species, such as crab or fish, to swim away and are retained against the screens. The US EPA has determined that if the intake velocity is lower or equal to 0.15 m/s, the intake facility is deemed to have met impingement mortality performance standards. Therefore, designing intake screening facilities to always operate at or below this velocity would address impingement impacts.

It is anticipated that the intake velocity of the existing intake structure is compliant with the impingement mortality performance standard set by US EPA and IFC Guidelines. As such, it is not likely that impingement of large numbers of fish and invertebrates such as crabs, shrimp, jellyfish, etc. as a result of seawater intake would occur. Thus, this impingement impact is considered to be a negligible negative impact.

Discharge of Treated Wastewater Effluents

The Project will include dedicated wastewater treatment facilities for the following streams:

- Sanitary Wastewater;
- Chemical Wastewater; and
- Oily Wastewater.

Following treatment, the residual effluents form these processes will be mixed with the brine and thermal effluents and discharged to the Arabian Gulf via the shared outfall with the Al Dur IWPP Phase 1 discharges. Although treated to acceptable standards to meet the necessary discharge quality standards, the treated wastewater effluents may contain residual trace concentrations of pollutants (e.g. chlorine), which may potentially have a minor effect on ambient water quality prior to full mixing with the waters in the Arabian Gulf.

Note: all discharge effluents will meet the necessary Bahraini Industrial Effluent standards and /or World Bank/IFC whichever is the most stringent.

Thermal Discharge from the Operation of the CCGT

The effect of a thermal discharge into the marine environment can have a local impact on the marine ecosystem. Warm water has a lower saturation capacity for oxygen, and if dissolved oxygen levels falls below 5mg/L it can impact marine organisms. Warmer nutrient rich waters can also promote algal bloom which potentially results in a fluctuation in oxygen levels in the water.

Warm water can trigger a response that causes motile organisms to migrate to alternative cooler locations away from the thermal effluent plume. The resulting migration, a potentially permanent and widespread, loss of biodiversity from a particular area.

During operation of the CCGT component of the project, there will be a slight increase in the temperature of discharged effluent (expected to be up to ΔT +2.1°C – based on ambient water temperature of 30°C) due to elevated temperatures of blowdown water from the cooling towers. During the discharge process the thermal discharge will be pumped to the discharge point at the shoreline and mixed with other discharges from the Project.

Although the temperature change of the mixed discharged effluent is relatively low there remains the potential for impacts to occur to marine ecology throughout the mixing zone as the thermal plume disperses within the surrounding seawater, with potential adverse impacts on the marine habitats, including flora and fauna. Such impacts may be noticeable when considering the cumulative impacts of the existing Al Dur IWP and the Al Dur IWPP Phase 1 project in combination with the Al Dur IWPP Phase 2 Project.

Discharge of Brine from the Operation of the SWRO

During operation, brine and backwash generated from the reverse osmosis process will be discharged to the marine environment from the same shoreline outfall as the existing Al Dur IWPP Phase 1. This concentrated brine (diluted by the larger thermal effluent) can impact water chemistry within proximity to the discharge point and potentially throughout the mixing zone as the plume disperses within the surrounding seawater with potential local adverse impacts on sensitive marine habitats, flora & fauna, due to increases in salinity.

Hyper-saline water (brine) affects the osmoregulation capability of marine organisms, which consequently may cause acute toxicity due to an excess, or deficiency of specific ions. Hyper-saline water is denser that background seawater, which may result in stratification in the water column, with the denser water settling at lower depth.

Due to need for chlorine dosing and shock dosing at the point of intake (for protection of bio-accumulation within the plant systems), the projects effluent will include residual chlorine concentrations which will be discharged to the marine environment with potential impacts upon water quality and almost all types of marine ecology. However whilst the Bahrain standard for chlorine in the discharge is 2mg/l, the Project will comply with a much more stringent standards (0.2mg/l) in compliance with World Bank/IFC standards.

Due to the discharge of project brine effluent via the shared outfall with the Al Dur IWPP Phase 1, there is also the potential for cumulative impacts when considering the existing Al Dur IWP and the existing Al Dur IWPP Phase 1 Project in combination with the proposed Al Dur IWPP Phase 2 Project.

The long-term indirect effects of both thermal and brine discharges to the marine environment may, if not adequately dispersed, result in local degradation of ecosystem diversity and reduced diversity of fish, flora, crustaceans and other benthic organisms in the surrounding area.

In order to assess the effect of thermal and brine discharges on the water quality of the coastal zone and the marine ecology, predictive modelling of thermal and brine dispersion plumes were performed as discussed below.

Thermal and Brine Discharge Modelling Assessment and Results

In order to assess the effects of thermal, brine and residual chlorine discharge on the water quality of the coastal zone and marine ecology, HR Wallingford on behalf of ACWA Power performed hydrodynamic modelling for the operational phase of the proposed Project.

Hydrodynamic modelling was used to assess the effects of thermal and brine discharge on the water quality and the marine ecology within the coastal zone.

The existing facility at the Al Dur site consists of a seawater intake with a capacity of 47,400m^3/h to convey the seawater to the IWPP Phase 1 for water desalination and power generation, the outfall facility consists of an open channel shoreline discharge at a rate of 36,400m^3/hr. The proposed Phase 2 facility will consider an intake rate of 27,360m^3/hr during winter months & flow rate of 31,567m^3/hr during summer months and an outfall discharge of 16,920m^3/hr during winter months and 20,125 m^3/hr during summer months.

The hydrodynamic modelling study were conducted using the TELEMAC modelling system.

TELEMAC is a finite element modelling system that solves the depth averaged shallow water equations and is used to model various hydraulic phenomena such as tidal and coastal flows, storm surges, etc. The model uses a completely flexible triangular mesh of variable size to represent the area being modelled. As meshes are unstructured, they can be easily refined to represent coastlines and other important structures efficiently and accurately. Small elements are used in the vicinity of the intakes & discharges and larger elements are used in more remote areas. This allows the near and far-fields to be represented in the same model.

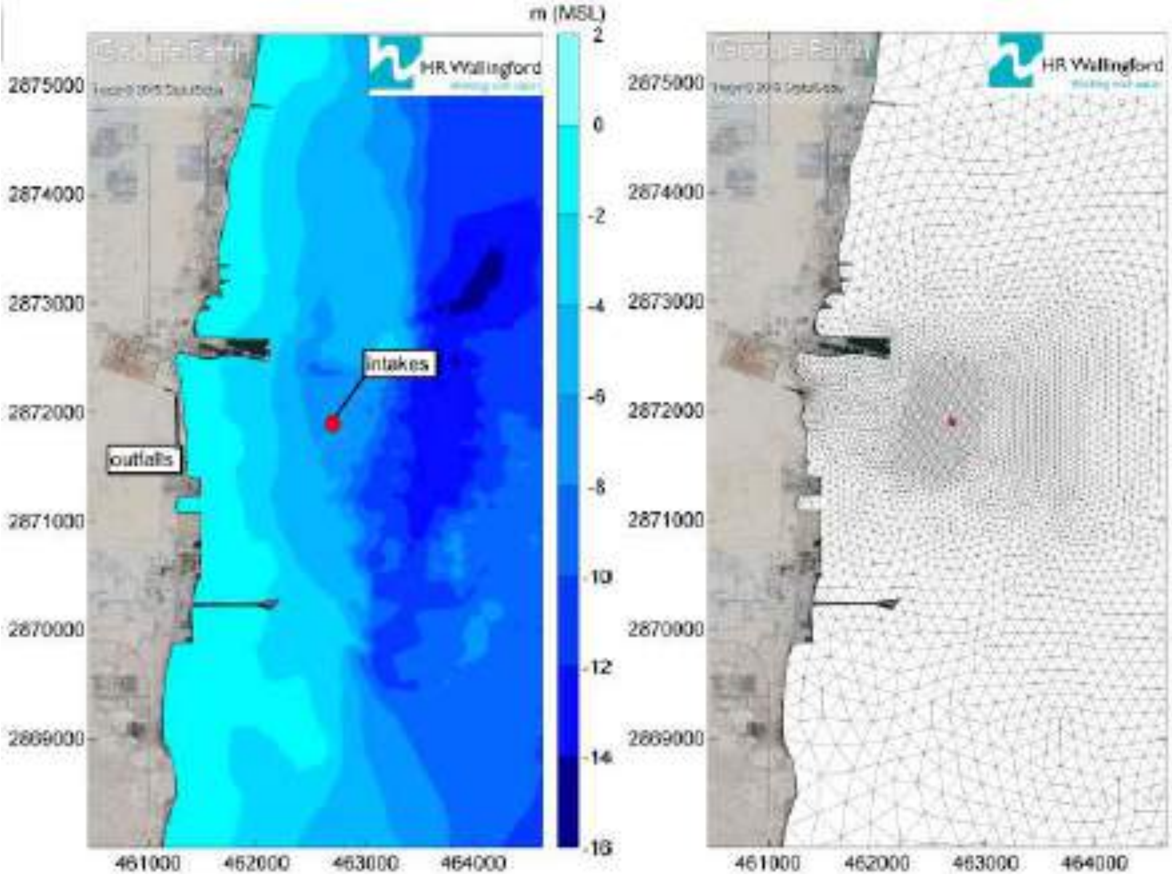
The Al Dur Phase 2 IWPP Model was built using the TELEMAC 3D model. The TELEMAC-3D solves the equations of motion and transport in multiple layers, including the important effects of gravitational spreading of buoyant effluents at the sea surface, or of dense effluents over the seabed, inhibition of vertical mixing associated with sharp density gradients, and shear of wind driven currents.

Model Set Up

The detailed bathymetry used for the model was obtained from HR Wallingford's model of Bahrain's coastal waters which covers the entire Gulf of Bahrain and is approximately 200 km long and 115 km wide. The coastline is based on data provided by SLRB and supplemented by data from international hydrographic offices supplied through the C-Map database. The model mesh element size is as low as 5 m in the vicinity of the outfalls and intakes, rising gradually to 2km at the northern sea boundary and to 3km at Salwa at the southern boundary. For the assessment of this Project, small mesh refinements were made near the Al Dur Phase 2 outfall, to allow resolution of the Phase 2 discharge.

The bathymetry and mesh in the vicinity of Al Dur is presented in the figure below.

Figure 7-6 Model Bathymetry and Mesh Close of Al Dur



The following proposed design parameters & operational data for the Al Dur Phase 2 IWPP were used to develop the model and run the simulations.

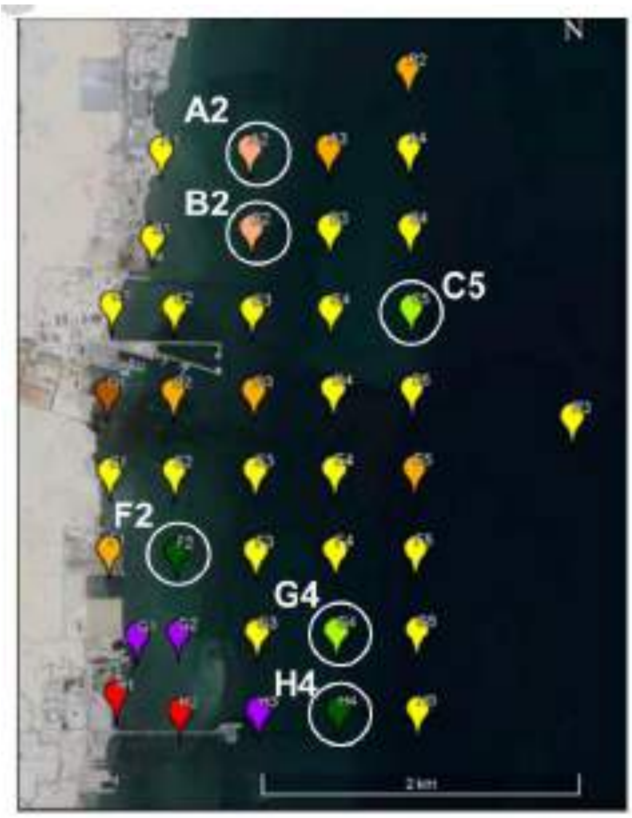
Table 7-14 Seawater Intake and Outfall Parameters for Al Dur Phase 2 IWPP

Salinity	Temperature	Residual Chlorine	Phase 1		Phase 2	
			Intake Flowrate (m^3/hr)	Outfall Flowrate (m^3/hr)	Intake Flowrate (m^3/hr)	Outfall Flowrate (m^3/hr)
43g/l	Winter: 22.9°C Summer: 30.6°C	0.2mg/l	47,400	36,400	Winter: 27360 Summer: 31567	Winter: 16920 Summer: 20125

- The marine discharge mixing zone established by Bahrain's Supreme Council for Environment (SCE) requires that the appropriate standards for temperature, salinity and chlorine are to be met at 50m from the point of discharge.

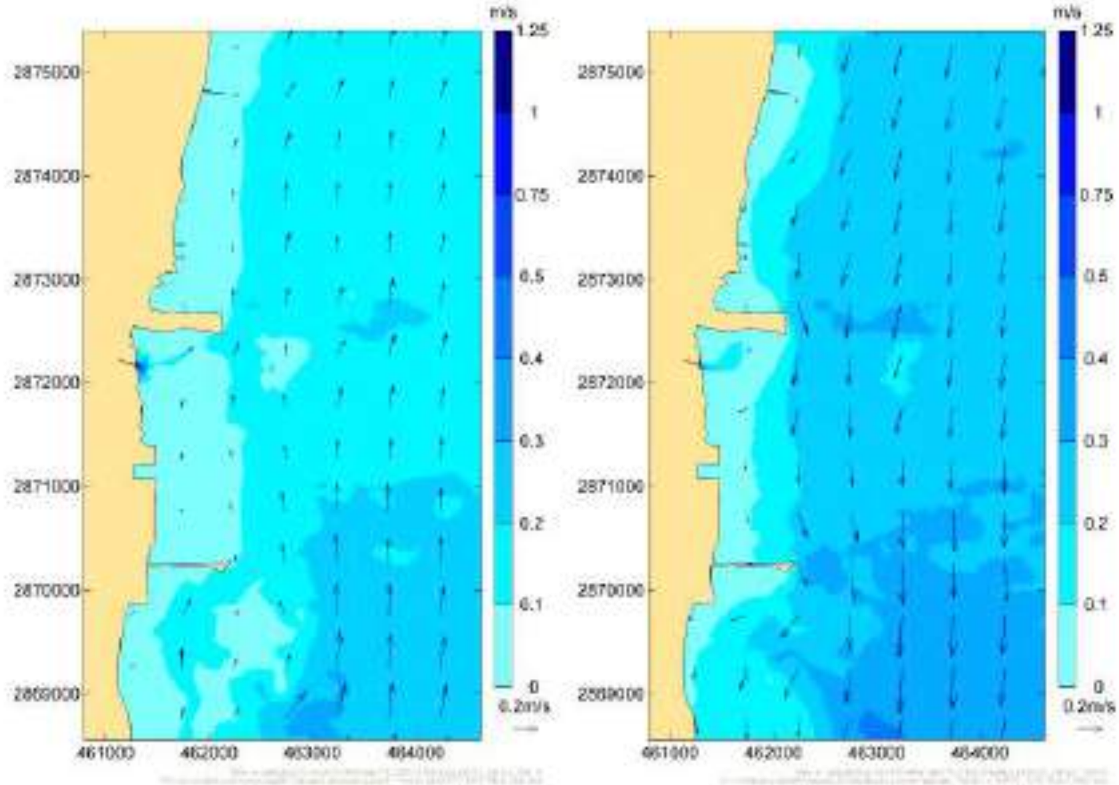
- The guidelines state that, on a case by case basis, SCE may require more or less stringent standards due to ambient environmental conditions, and technical and economic considerations.
- The model considered the following mixing zone standards:
  - ∆Salinity – Monthly average of +3ppt and maximum limit of +5ppt
  - ∆Temperature – Maximum limit of +3oC
  - Residual Chlorine – Monthly average of 0.5mg/l and maximum limit of 1.0mg/l
- Environmentally sensitive ecological receptors most of which include seagrass were also considered in the model and the predicted excess temperatures, excess salinities and residual chlorine concentrations at these locations were assessed. These environmentally sensitive receptors included:
  - H4 100% seagrass
  - F2 70% seagrass
  - A2 50% seagrass and macro algae
  - G4 40% sand and seagrass
  - B2 30% seagrass and macro algae
  - C5 20% sand and seagrass

Figure 7-7 Nearby Seagrass Sites



Tidal ranges are much smaller at Al Dur than at coastal sites in the north of the country, due to the presence of Fasht Al Adhm, which significantly influences the propagation of the tide between the north and south of the island. This means that current speeds near Al Dur are relatively weak. Furthermore, the outfall discharges into a relatively sheltered and shallow region formed between a jetty a few hundred metres north, and a jetty approximately 2 km south. Peak current speeds offshore of the site are typically around 0.2 m/s, but weaker currents are found inshore. Predicted spring tide current patterns are shown in the figure below.

Figure 7-8 Predicted Spring Tide Current Patterns Near Al Dur: Peak Ebb (Left) and Peak Flood (Right)



Results

The predicted maximum and average sea surface and seabed change in temperatures and salinity at the end of the simulation period for both summer months are presented in the figures and tables below (for winter simulations see Appendix O).

Figure 7-9 Predicted Average Change in Temperature During Summer for Phase 1 to Phase 1 + Phase 2 (Surface and Seabed)

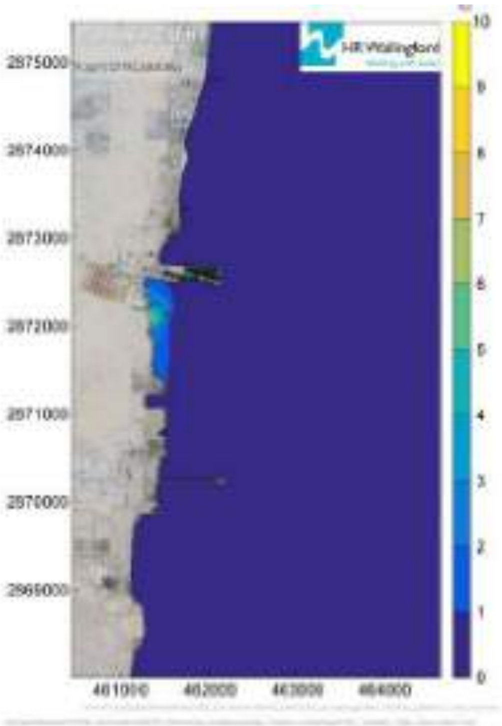
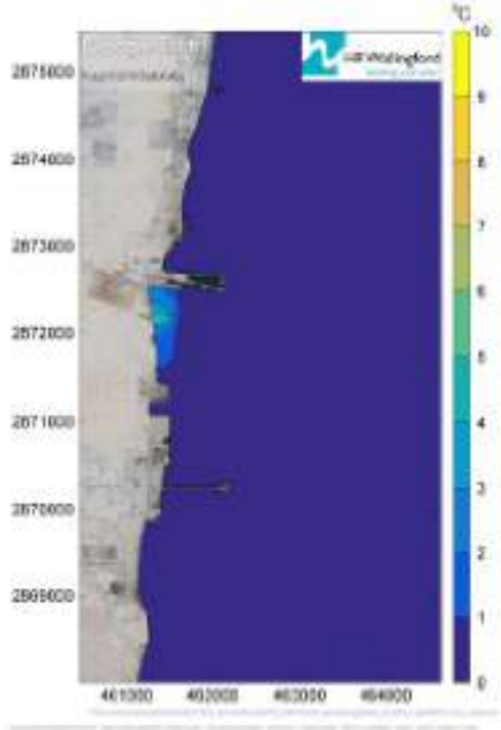
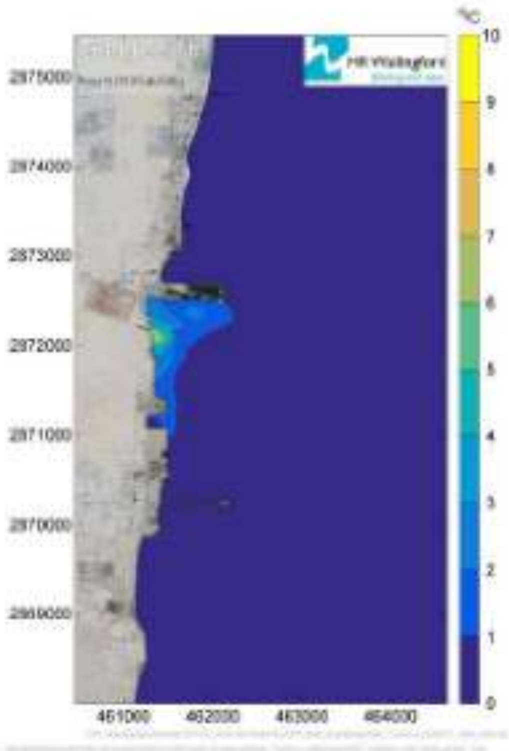
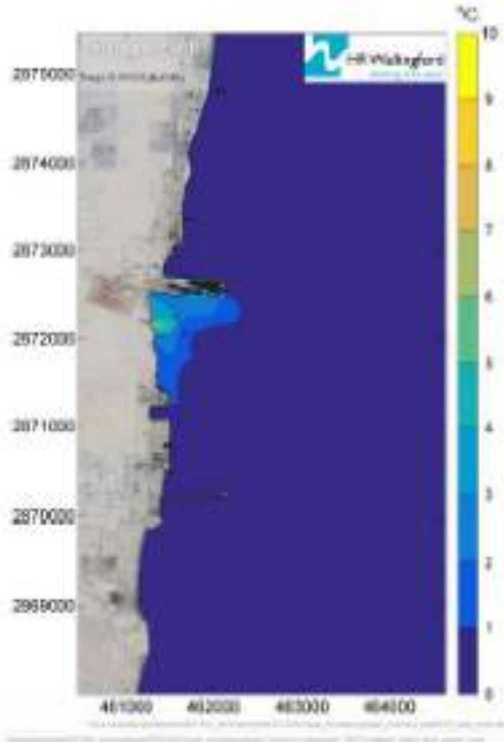
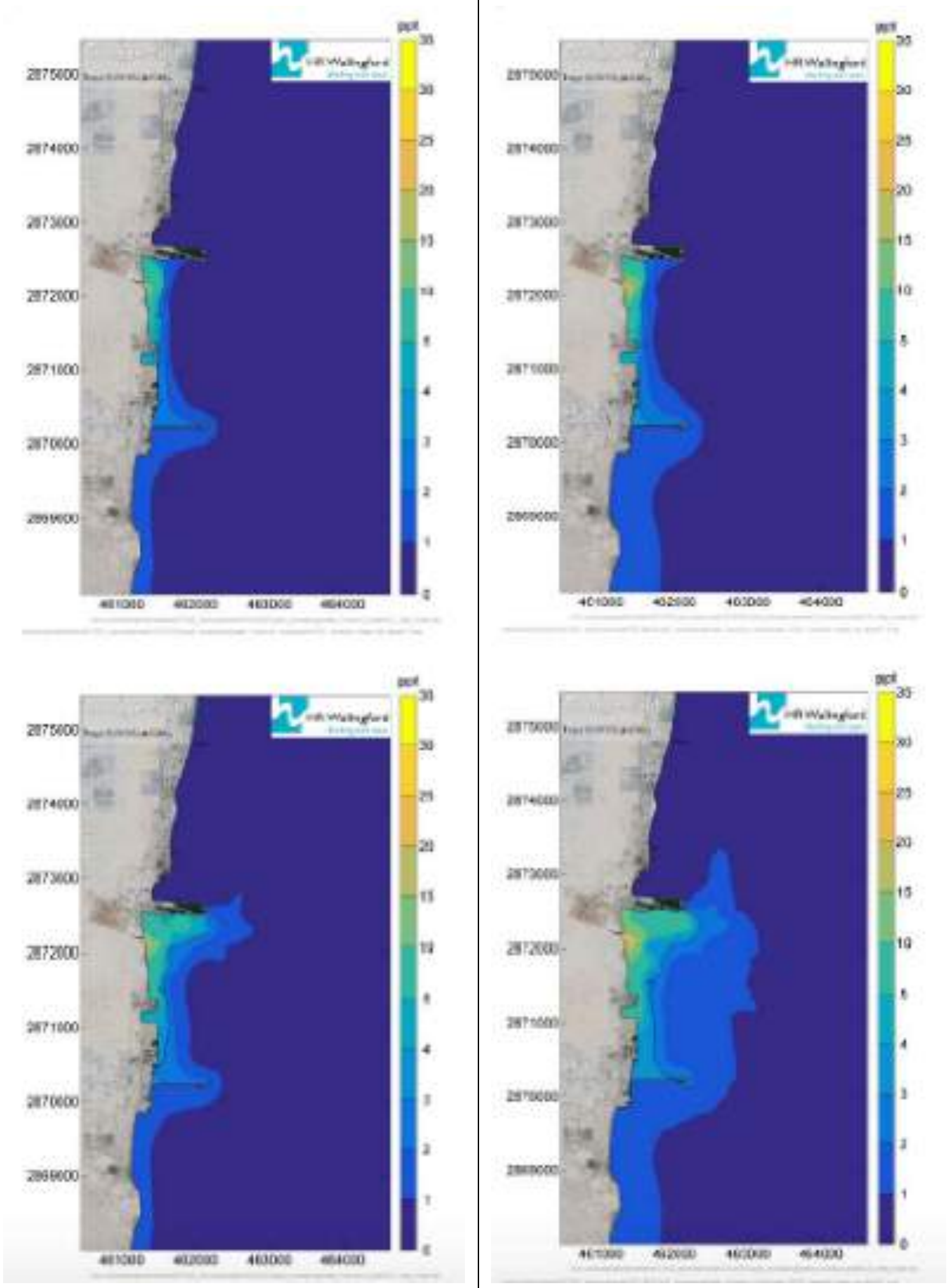
Phase 1	**Phase 1 + 2**
	
	

Figure 7-10 Predicted Average Change in Salinity During Summer for Phase 1 to Phase 1 + Phase 2 (Surface and Seabed)

Phase 1	Phase 1 +2



The maximum and averages were calculated over 16 days containing a full spring-neap cycle. It should be noted that the plots of maximum and average temperature show the maximum and average predicted values at each model node over the course of the simulation. As the maxima and averages do not occur at the same time at each location, these plots should be thought of as overall plume "footprints".

The time series of excess temperature and excess salinity at the intake and at the seagrass sites are presented in the tables below.

Table 7-15 Predicted Mixing Zone Area for Phase 1 and Phase 1 together with Phase 2 in the Summer

Mixing Zone Areas (ha)				
Standard	∆Temp (oC)		∆Salinity(ppt)	
	Maximum (>+3)	Average (>+3)*	Maximum(>+5)	Average (>+3)
Phase 1				
Surface	42.8	4.5	98.1	31.0
Seabed	82.2	9.6	162.7	68.2
Phase 1 +2				
Surface	43.8 (+2%)	5.4 (+20%)	169.2 (+72%)	40.4 (+30%)
Seabed	87.3 (+6%)	10.6 (+10%)	293.6 (+80%)	107.7 (+58%)

* = Not a regulatory threshold, but included to give context to the maxima

Table 7-16 Predicted Mixing Zone Area for Phase 1 and Phase 1 together with Phase 2 in the Winter

Mixing Zone Areas (ha)				
Standard	∆Temp (oC)		∆Salinity(ppt)	
	Maximum (>+3)	Average (>+3)*	Maximum(>+5)	Average (>+3)
Phase 1				
Surface	50.0	5.3	97.0	30.4
Seabed	92.5	11.4	162.2	66.5
Phase 1 +2				
Surface	40.8 (-18%)	5.4 (+2%)	162.2 (+67%)	34.6(+14%)
Seabed	82.7 (-11%)	10.1 (-11%)	278.2 (+72%)	97.2 (+46%)

* = Not a regulatory threshold, but included to give context to the maxima

The summarised findings of the modelling are presented below.

Phase 1 Mixing Zone – key findings:

- The plume moves offshore from the discharge channel under its own momentum before being deflected to the north and south by the alongshore currents.

- As the plume is negatively buoyant, the seabed footprints are larger than those at the surface, and the plume tends to flow offshore down the bed gradient.
- The maximum extent of the +3°C mixing zone for Phase 1 is 1.5-2 km from the outfall.
- On average the predicted ΔT falls to within 3°C of the ambient seawater temperature a few hundred metres from the outfall.
- The largest predicted extents of the excess salinity mixing zones are around 2-2.4 km from the outfall.
- The IFC residual chlorine mixing zone extends to about 2 km from the outfall for Phase 1.
- Residual chlorine concentrations are predicted to remain below the SCE mixing zone threshold.

Phase 1+2 Mixing Zones combined:

- The two discharge streams will merge close to the outfalls to form a combined plume.
- The Phase 2 discharge excess temperatures are lower than those assumed for Phase 1, and the additional heat loads for Phase 2 are only about one tenth of those assumed for Phase 1.
- Therefore, in summer, the maximum extents of the +3°C mixing zones are similar to Phase 1.
- In winter, as the Phase 2 discharge ΔT is below the mixing zone threshold, the combined mixing zone extent is actually reduced by a few hundred metres, due to the effects of dilution.
- The predicted salinity mixing zones are larger, with the largest extents up to 3 km from the outfall.
- The IFC residual chlorine mixing zone extends to slightly more than 2 km from the outfall.
- Residual chlorine concentrations are predicted to remain below the SCE mixing zone threshold.

Sensitive sites Excess Temperatures:

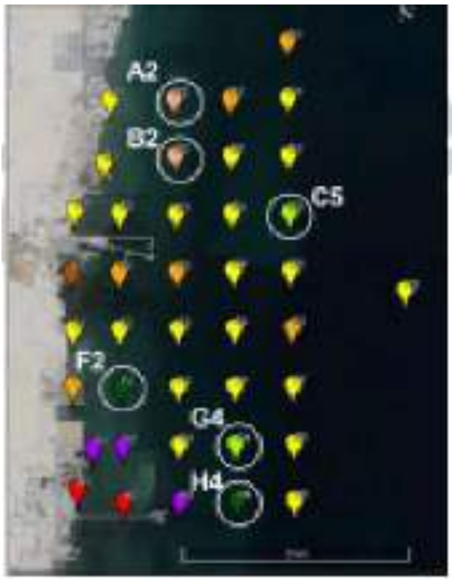
- Peak ΔT predictions at each of the seagrass sites are generally below about 0.7°C, with only small changes predicted due to the addition of Phase 2 (within 0.2°C).

- Site F2 (in the sheltered bay near the outfalls) is an exception, with peaks up to about +3°C for both Phase 1 and Phase 1+2. (Averages here are lower, around 0.5°C, for both Phase 1 and Phase 1+2).

Sensitive sites Excess Salinities:

- For Phase 1, peak ΔS predictions at each of the sites are generally below about 2.2 ppt, and averages are generally below 1 ppt.
- Again, the exception is at site F2, where the peak ΔS is above 8 ppt, and the average ΔS is above 1 ppt.
- The Phase 2 discharge increases the ΔS predictions at each of the sites.
- Peak and average values at F2 are increased by around 3.1 ppt and 0.8 ppt, respectively.
- Increases in the average salinities at the other sites are generally predicted to be below 0.5 ppt, but peak increases are higher.

The sensitive receptor location remain protected with the exception of one site (F2) which is close to the coastline (in the sheltered bay near the outfalls).



The model results for the location of seagrass (F2) close to the shoreline and the outfalls shows that it requires 12 days of modelling before reaching a state of equilibrium. At this time the temperature increase is < 0.5 C above the background. The temperature at G4 is also < 0.5 C but reaches equilibrium very quickly due to the tidal flushing (see Figure 7-11).

Figure 7-11 Change in Temperature at Ecological Receptor Sites F2 and G4 surface and seabed (Phase 1 = blue line; Phase 2 = red line)

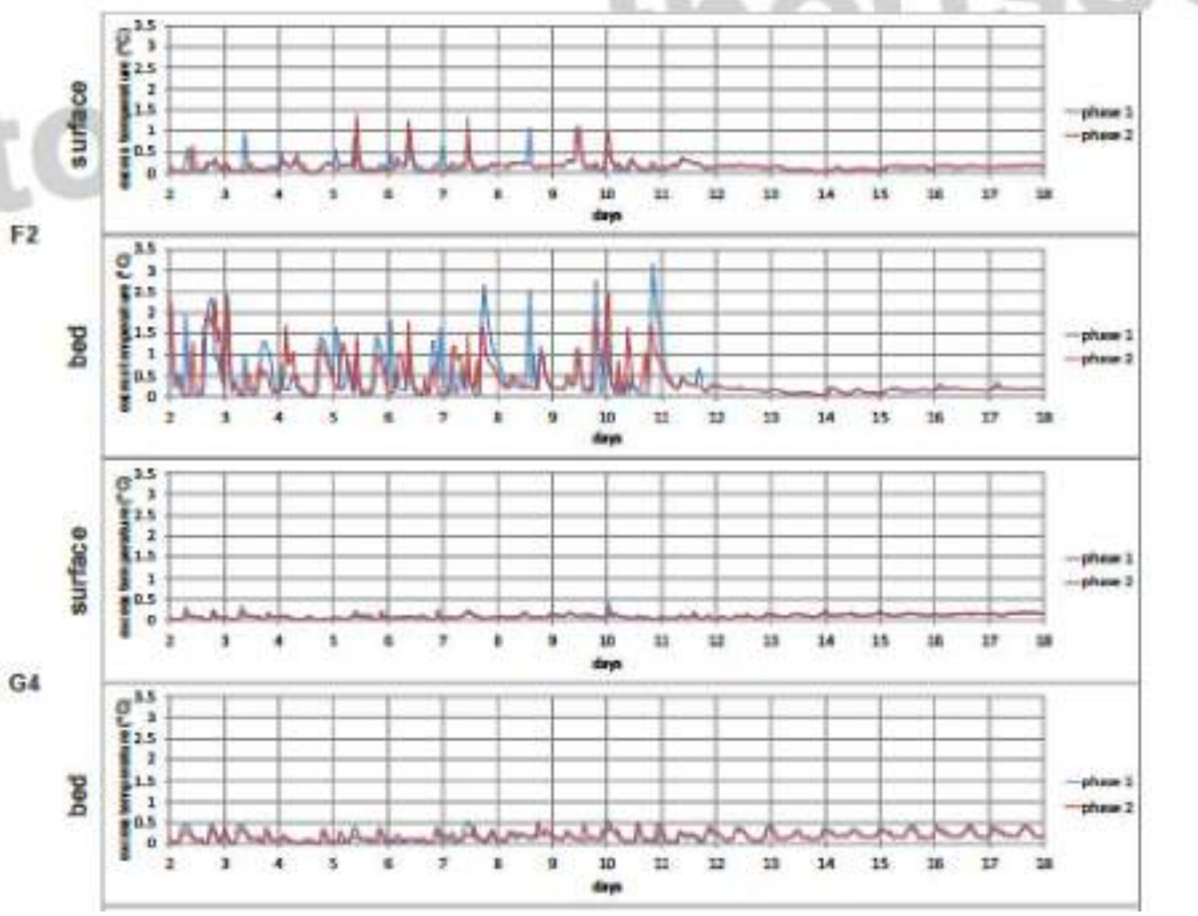


Table 7-17 Summary of Predicted Change in Temperature at Sensitive Sites

Sites	Excess Temperature (°C) and Uplift from Phase 1											
	Summer						Winter					
	Maximum			Average			Maximum			Average		
	Phase 1	Phase 1+2	Δ1 &1+2	Phase 1	Phase 1+2	Δ1 &1+2	Phase 1	Phase 1+2	Δ1 &1+2	Phase 1	Phase 1+2	Δ1 &1+2
A2	0.5	0.5	0	0.1	0.1	0	0.5	0.5	0	0.1	0.2	0
B2	0.6	0.6	0	0.1	0.1	0	0.6	0.6	0	0.1	0.1	0
C5	0.4	0.4	0	0.1	0.1	0	0.4	0.4	0	0.1	0.1	0
F2	3.0	2.8	-0.2	0.4	0.5	+0.1	3.1	2.4	-0.7	0.4	0.4	0
G4	0.5	0.7	+0.2	0.2	0.2	0	0.5	0.5	0	0.2	0.2	0
H4	0.6	0.7	+0.1	0.1	0.2	+0.1	0.7	0.7	0	0.2	0.2	0

The table above shows that temperature changes at the sensitive marine sites are generally quite small between Phase 1 and Phase 1+Phase 2. There is even a reduction in temperature at F2.

Table 7-18 Summary of Predicted Change in Salinity at Sensitive Sites

Sites	Excess Salinity (ppt) and Uplift from Phase 1											
	Summer						Winter					
	Maximum			Average			Maximum			Average		
	Phase 1	Phase 1+2	Δ1 &1+2	Phase 1	Phase 1+2	Δ1 &1+2	Phase 1	Phase 1+2	Δ1 &1+2	Phase 1	Phase 1+2	Δ1 &1+2
A2	1.3	1.6	+0.3	0.2	0.3	+0.1	1.3	1.6	+0.3	0.2	0.3	+0.1
B2	1.7	2.4	+0.7	0.4	0.6	+0.2	1.7	2.3	+0.6	0.4	0.6	+0.2
C5	1.2	1.6	+0.4	0.3	0.5	+0.2	1.2	1.6	+0.4	0.3	0.5	+0.2
F2	8.3	11.4	+3.1	1.3	2.1	+0.8	8.3	10.8	+2.5	1.2	1.9	+0.7
G4	2.1	2.8	+0.7	0.6	1.0	+0.4	2.1	2.3	+0.2	0.6	0.9	+0.3
H4	2.2	3.5	+1.3	0.5.	1.0	+0.5	2.2	3.3	+1.1	0.5	0.9	+0.4

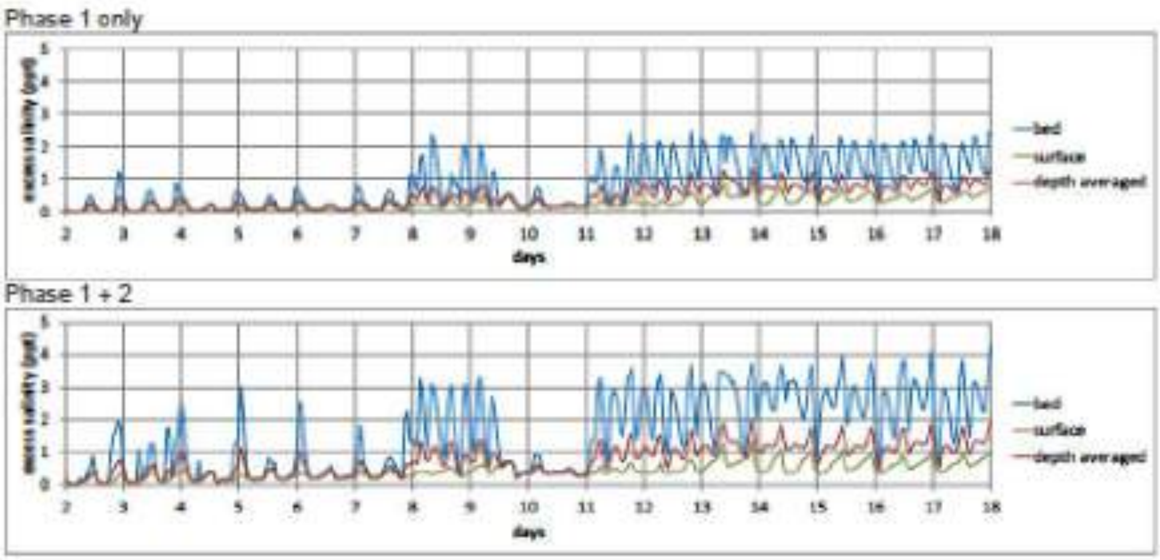
The table above shows that salinity changes at the sensitive marine sites are generally increasing between Phase 1 and Phase 1+Phase 2.

Recirculation

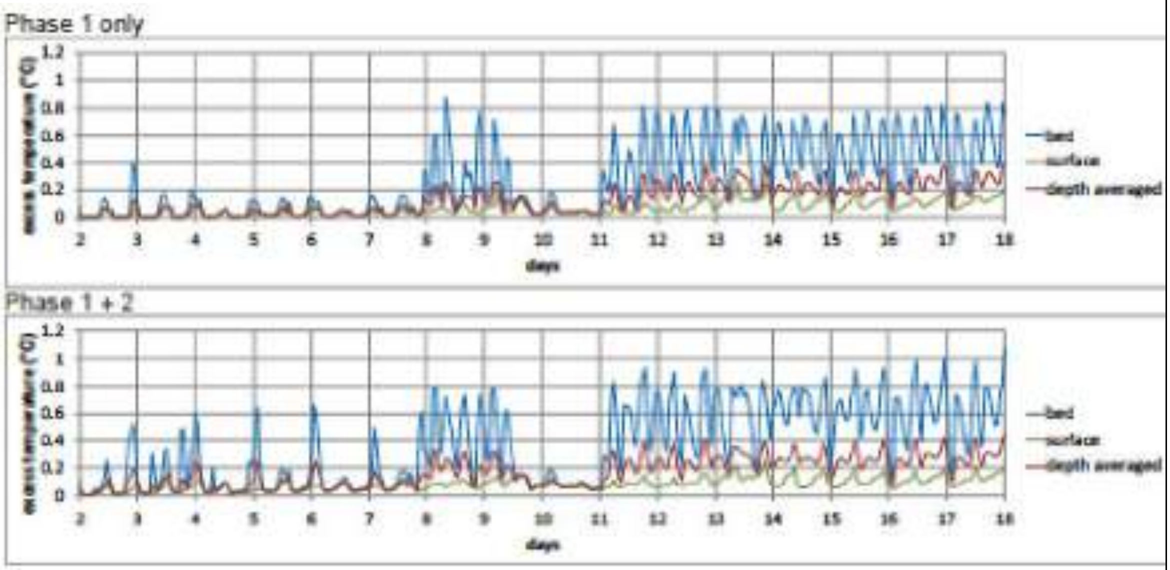
- The addition of Phase 2 is predicted to make small increases to summer recirculation temperatures.
- For the winter parameters assumed, predicted levels of thermal recirculation are similar for both Phase 1 and Phase 1+2.
- Peak excess salinities at the seabed near the intake are increased from about +2 ppt for Phase 1 to around +4 ppt with the combined Phase 1+2 discharges. However, the depth-average excess salinities typically remain below +2 ppt (see tables below).

Figure 7-12 Predicted Change in Salinity and Temperature at the Intake During Summer for Phase 1 and Phase 1 +2 (Seabed, Surface and Depth Average)

Salinity



Temperature



It can be concluded from the key findings that the modelling demonstrates that average changes in temperature and salinity from Phase 1 to Phase 2, are moderate. In addition there is little change in recirculation temperature from Phase 1 to 2, whilst excess salinities typically remaining below +2 ppt which is manageable by Operations.

Table 7-19 Marine Environment, Hydrodynamic, Water & Sediment Quality- Impact Significance, Mitigation & Management Measures and Residual Impacts - Operation

Potential Impacts	Magnitude of Impact	Receptor	Sensitivity	Potential Impact Significance	Mitigation and Management Measures	Residual Impacts
Entrainment of marine fauna during seawater intake	**Medium Negative**	Marine Ecology	High	**Medium**	• The intake velocity of the intake pipeline will be compliant with applicable IFC guidelines in order to reduce the entrainment of fish and other marine fauna. The intake riser will be equipped with bar screens or nets, or bubble curtain to prevent fish impingement.	**Minor**
Increased temperature due to discharge of thermal effluent	**Minor Negative**	Ambient Water Quality & Marine Ecology	High	**Minor to Medium**	• Provision of large number of cooling towers in Project design will reduce excess thermal discharge temperature to 3.7C in summer and 2.1C in winter. • Monitoring of temperature of discharge as part of CEMS	**Minor**
Increased salinity due to discharge of brine effluent	**Medium to High Negative**	Ambient Water Quality & Marine Ecology	High	**Medium to High**	• Regular and event-based monitoring of brine & thermal discharges will be conducted to demonstrate compliance with discharge limits. • Defined operational management procedures will be employed at the site in order to reliably maintain these standards. • Mixing thermal and brine effluent to reduce salinity prior to discharge	**Medium**
Increased chlorine levels due to defouling of pipes	**Medium Negative**	Marine Ecology	High	**Medium**	• Compliance with World Bank/IFC standard is 10 times lower than permitted Bahrain discharge standard. • Monitoring residual chlorine in discharge as part of CEMS	**Negligible to Minor**

POTENTIAL IMPACTS	MAGNITUDE OF IMPACT	RECEPTOR	SENSITIVITY	POTENTIAL IMPACT SIGNIFICANCE	MITIGATION AND MANAGEMENT MEASURES	RESIDUAL IMPACTS
Discharge of Treated Wastewater	**Medium Negative**	Ambient Water Quality & Marine Ecology	High	**Medium**	• All wastewater will either be treated at site prior to discharge or reused or transported off site. • All wastewater streams including backwash, will be treated prior to discharge before mixing with the thermal and brine effluent. • No sludge will be discharged to coastal waters. • Residual chlorine discharge will be within the World Bank/IFC discharge limit. • Potentially hazardous materials and water treatment chemicals will be stored in designated areas in accordance with international best practice guidelines so as to prevent any spills or seepage to groundwater or sea waters. • Process Monitoring and planned maintenance of desalination equipment to ensure no unintentional discharges into the brine water resulting from equipment failure.	**Minor**

7.5 Monitoring

The EPC Contractor and O&M Company will undertake marine monitoring during the construction and operational phase of the project respectively. The minimum expected requirements for the monitoring are outlined in the table below. The final monitoring methodology with specific monitoring details (i.e. locations, frequencies, durations, parameters etc.) will be developed in the specific 'Environmental Monitoring Plan' as part of the respective construction or operational phases ESMS.

Table 7-20 Marine Environment, Hydrodynamics, Sediment & Water Quality- Monitoring Requirements

Monitoring	Parameters	Frequency & Duration	Monitoring Location
Construction			
Water Quality	pH, DO, TSS, Turbidity, Nutrients	Prior to discharge, weekly for first month, then monthly	Point of discharge of dewatered effluent
Marine fauna	All identified marine species of conservation value.-turtles, dolphins dugong, birds	Daily visual observations in construction working areas near the shoreline at the commencement of working activities, and general observations during day/night.	In all working area requiring excavation, land grading or earthworks along the coastline. (Maintain log of sightings and any records of injured or dead animals or birds)
Operation			
Water Quality	pH, DO, TSS, Temperature, Salinity, Residual Chlorine	Continuous	At point of discharge
Water Quality	Nutrients, BOD, COD Heavy Metals, Oil & Grease	Quarterly	At point of discharge
Marine Fauna and Flora and associated sediment quality	Habitat survey and transects for seagrass, infauna, fish and plankton	Bi-annual (6-monthly)	Edge of Mixing Zone and Area of Influence
Marine Fauna	Cetaceans, Mammals, Reptiles, Birds	Maintain log of sightings and any records of injured or dead animals or birds	Coastal area adjacent to Project site.

8 BIODIVERSITY (TERRESTRIAL)

8.1 Standards and Regulatory Requirements

8.1.1 National Requirements

The legislative Decree No.9 of 2002 with respect to ratifying the agreement for the Preservation of the National Wildlife and Their Natural Habitat in the Gulf Co-Operation Council States establishes the framework for the preservation of wildlife and its natural habitat; especially the endangered species particularly the ones that grow on the international level of two or more neighbouring States or when such species migrate through these States including the territorial waters and aerial zone subject to its sovereignty.

This Decree specifies the following relevant objectives:

- To protect and manage sufficient areas of suitable habitation for the wildlife as protected areas whether natural or artificial according to the international criteria and national legislations
- To strive to protect the wildlife and their environment from all threats i.e. pollution and environment deterioration and adopt the necessary precautions warranting their combat and control upon occurrence to reduce their effect.
- To ban or limit the human activities which leads to either:
  - The deformation of the nature of such habitats;
  - Polluting or poisoning;
  - Deterioration or the threat of deterioration of living diversity of these habitats or environmental production.
- To ban all forms of hunting, purposely kill, destroy or collect the eggs and disturb them during the season of reproduction or raising their young

8.1.2 Lenders Requirements

The assessment of impacts upon terrestrial ecology will be made with due consideration to the IFC Performance Standard 6 on Biodiversity Conservation and Sustainable Natural Resource Management which establishes requirements for protecting and conserving biodiversity, maintaining ecosystem services, and sustainably managing living natural resources.

This ESIA has considered relevant threats to biodiversity and ecosystem services, focusing on habitat loss, degradation, fragmentation and pollution in relation to the construction and/or operational phases of this project.

8.2 Observations and Baseline Conditions

8.2.1 General Observations

The baseline condition of this section has been informed by:

- Review of satellite imagery;
- Review of information available from online resources;
- Several site visits during the scoping and ESIA phases and;
- Project Ecological Survey.

Besides a narrow fertile strip extending along the northern and north western coastline of the kingdom, the desert environment is the predominant terrestrial landscape in Bahrain. Despite the barren appearance of the desert of Bahrain, it supports recognizable diversity of vascular plants providing food and shelter for many animals such as mammals, birds, reptiles, arachnids and insects.

The northern and western coastal areas have been heavily cultivated with date palms and alfalfa plantations for thousands of years forming a biologically important habitat. Date palm farms are the most diverse terrestrial habitat in the country supporting a wide range of introduced and native species, including vascular plants and algae, insects, brackish water fish, amphibians as well as resident and migratory birds. These farms were once watered by numerous freshwater springs, which, in turn, represented the most biologically diverse inland water ecosystem. However, the freshwater springs have vanished due to over-exploitation of underground water.

According to the Bahrain First National Report to the Convention on Biological Diversity (2006), about 357 species of vascular plants have been recorded in the desert and cultivated areas of Bahrain. Desert plants are predominantly perennial or annual herbs and shrubs exceptionally adapted to the harsh desert environment. At least 20 species of reptiles and one species of amphibian (the Marsh frog) are known to occur on the islands, and lizards particularly the spiny tailed lizards are abundant.

Many migratory bird species, up to 330, including the osprey, sooty falcon, caspian tern, socotra cormorant, western reef heron, etc. breed in Bahrain, especially in spring and autumn months. The Hawar Islands, Tubli Bay and Maqaba have been recognized by Birdlife International as Important Bird Areas in the Middle East with 26 species out of the 330 bird species identified on the islands. The breeding colony of socotra cormorant *Phalacrocorax nigrogularis* on Hawar Islands is the largest in the world. Similarly, the breeding colony of the western reef heron *Egretta gularis* on Hawar Islands is the largest in the Middle East.

Eighteen species of terrestrial mammals (in addition to 3 species of dolphins) are found in Bahrain including gazelles, desert hares and hedgehogs which can still be found in the wilderness. Of particular note, the dugong herd around Hawar Islands is the second largest after Australia.

With regards to the total number of species identified in Bahrain for wild vascular plants, butterflies, migratory birds and terrestrial mammals, it is highly probable that this number is an underestimate since many taxa have not been adequately identified and inventoried.

8.2.2 Habitat Classification

The Project site consists of two (2) principal habitat types;

- Sand sheets interspersed with low-lying vegetation sporadic in nature. The vegetation is mainly at the western and southern region of the Project while other regions of the Project site consist of little or no vegetation
- Sabkha (coastal salt flats) interspersed with sandy areas and very sparse vegetation.

During the ecological survey conducted in November 2018, some low lying areas were observed with drainage lines in which water collects and forms small pools. Flora and subsequently fauna species were noted to be more abundant around these low-lying pools and drainage areas than other areas of the site.

According to good practice guidelines such as IFC Performance Standard 6, habitats directly or potentially affected by a project can be classified as 'Natural', 'Modified' or 'Critical'. With respect to the habitat types, the habitat at the project site can be classified as 'Natural' habitat, as it has not been significantly modified as a result of human activities.

However, an area of the proposed site (approximately 70m by 70m) noted during the site visits to have been previously cleared and graded with evidence of vehicular movement can be considered as 'Modified' habitat as this area has evidently been modified by human activities.

Plate 8-1 Sand Sheet Habitat With Low Lying Vegetation

Plate 8-2 Sabkha Habitat

Plate 8-3 Evidence of Modified Habitat with Vehicle Tracks within the Project Site

8.2.3 Project Site Ecological Survey

Methodology

In order to assess the potential impacts from construction and operational activities, the ecological condition within the Project site as well as species composition was investigated on 14th November 2018 between the hours of 09:00 and 14:00.

The surveys was undertaken through a combination of walkover transects and drive over for general observations. Transects of 100m length were surveyed within the inland and at the coastline by two members of the survey team. All flora and fauna species encountered within an 80m radius of the transect including animal tracks & existential traces of fauna were documented.

Figure 8-1 Ecological Survey Area

Results

The flora and fauna species identified within the Project site are presented in the following tables.

<u>Flora</u>

The vegetation across most of the site includes native species of salt bush and drought tolerant species as presented in the table below.

Plate 8-4 Flora Species within the Sand Sheet Habitat Inland

***Salsola imbricate* - no IUCN recognition**

***Limonium axillare* - no IUCN recognition**

Zygophyllum qatarense - **no IUCN recognition**

Haloxylon persicum **- no IUCN recognition**

Heliotropium bacciferum **- no IUCN recognition**

The following dominant species (or evidence thereof) where identified at the site within the coastal area:

Plate 8-5 Flora Species Identified Around the Coast Line

"Algal Matts" possibly *Chaetomorpha* sp

Sargassum

Fine plant matter **Fine plant matter**

<u>Fauna</u>

During the site visit, small lizards were observed, likely to be the Hadramaut sand lizard. Although the Spiny Tailed Lizard is a common lizard in Bahrain this was not noted on the site during the survey. Dog tracks at the site show evidence of feral dogs present. Large burrow holes were also noted, which may indicate the presence of larger reptiles or rodents.

No mammals were observed during the survey.

Avian species were observed within the site and along the coastline during the survey and species identified included crested larks (*Galerida cristata* – **IUCN Least Concern**), White Cheeked Terns (*Sterna repressa* - IUCN Least Concern) specifically along the coastal areas, Grey Western Reef Heron (*Egretta gularis* - **IUCN Least Concern**) as well as the Socotra Cormorant (*Phalacrocorax nigrogularis* – **IUCN Vulnerable**).

Plate 8-6 Fauna Species Identified Inland Within the Project Site

Bird tracks

Dog tracks

Beetle

Burrow hole

Although no live species were found along the coastline, many cuttlefish, gastropod shells and other mollusc shells were noted. Additionally, a dead cormorant was observed in the shallow waters along the coastline and another on the shore.

Plate 8-7 Fauna Species Identified at the Coastline

Gastropod Shells

Dead cormorant

8.3 Receptors

Table 8-1 Potential Biodiversity (Terrestrial) Receptors

RECEPTOR	SENSITIVITY	JUSTIFICATION
Flora	**Low**	The flora species identified within the Project site are common to the region and are of low ecological value or vulnerability.
Fauna – Avifauna species	**High**	The Cormorant species are of IUCN 'Vulnerable' Conservation Status due to its small range, which is suspected to be undergoing a continuous decline in population number.
Fauna – Other fauna species	**Low**	The survey did not identify any specific habitat and only identified few species of least concern relating to terrestrial ecology.

8.4 Potential impacts

8.4.1 Construction Phase

The presence of construction equipment, workers, temporary facilities and environmental externalities resulting from construction processes (i.e. noise, vibration, waste and wastewater) have the potential to impact upon ecology during the construction phase. Such impacts may include the partial or direct loss of habitat and flora species as well as disturbance to fauna.

Loss of Habitat Loss

Site preparation works will result in complete removal of all vegetation within the site, grading for foundations, excavations for below ground infrastructures, trenching and backfilling for cables and pipelines, etc. therefore complete loss of the existing habitat is anticipated. In terms of ecosystem services, the site for Al Dur II IWPP is within a development area set aside by EWA for Water and Power projects. In addition there are new residential developments to the south and camping areas set aside to the north west. The Al Dur site has also been used as a laydown area for the Phase 1 project. This overall uses and wider development has resulted in fragmentation of habitats due to development pressures.

Disturbance to Fauna

Fauna at the project site and local areas may be disturbed due to the loss of the habitat and temporary effects of noise and vibration during construction. This may result in a flight response from the project area and fauna species will be required to migrate away from the works to find suitable alternative habitat in the surrounding area.

Movement of vehicles and heavy machinery within the project site as well as the site clearance and excavation could potentially cause a direct mortality of fauna species such as invertebrates, reptiles, birds or small mammals. This could particularly affect reptiles such as lizards and small mammals that may not abandon their burrows during site clearance in which case, there is a potential for the use of construction equipment to injure or kill such species in the project area.

Table 8-2 Biodiversity (Terrestrial) Impact Significance, Mitigation and Management Measures and Residual Impacts – Construction

Potential Impacts	Magnitude of Impact	Receptor	Sensitivity	Potential Impact Significance	Mitigation and Management Measures	Residual Impacts
Habitat Loss	**Minor Negative**	Flora	**Low**	**Negligible to Minor**	• All vehicles and equipment to be restricted to within the project boundaries. • There will be no encroachment to land outside of the project footprint, or defined laydown areas, site access road, or designated construction access road. • Any sightings of fauna must be reported to the Environmental Manager. • Any sightings of avifauna species must be reported to the Environmental Manager; • The Project area boundaries will be fenced to avoid fauna from entering the active construction site where they may be injured. • To aid re-vegetation, topsoil from the vegetated sand sheets (containing the most nutrient rich soils) should be removed and stored safely and spread over any off-site laydown areas once construction has been completed. • Although the loss of ecosystem services is relatively minor, mitigation will include retaining any natural areas on site and restoration of laydown areas together with avoiding the use of invasive or exotic species in landscaping works.	**Negligible**
	Minor Negative	Fauna – Avifauna species	**High**	**Minor to moderate**		**Minor**
	Minor Negative	Fauna – Other fauna species	**Low**	**Negligible to Minor**		**Negligible**
Disturbance to Fauna	**Minor Negative**	Flora	**Low**	**Negligible to Minor**	• It is strictly prohibited to capture or remove any fauna from their natural habitat. • Where lizard burrows are encountered on the project site the contractor will make efforts to ensure that they vacate their burrows prior to excavation works. • It is not permitted to kill or eat any fauna on site or in the coastal waters. Any mortality must be formally reported and	**Negligible**
	Minor Negative	Fauna – Avifauna species	**High**	**Minor to Moderate**		**Minor**
	Minor Negative	Fauna – Other fauna species	**Low**	**Negligible to Minor**		**Negligible**

Potential Impacts	Magnitude of Impact	Receptor	Sensitivity	Potential Impact Significance	Mitigation and Management Measures	Residual Impacts
					recorded on the same day of occurrence (This includes mortality or injury due to collision with construction vehicles). • A 20km/h speed limit will be imposed across the construction site in order to minimise risk of direct mortality of fauna.	

8.4.2 Operational Phase

Due to the likely paving and hard standing construction over the majority of the proposed site, it is anticipated that impacts during the operational phase to any on site vegetation will be minimal. As such, the only activities that could negatively impact the ecology of the site would be through indirect measures, relating to poor management practices of any designated landscaped areas; or to the fauna species inhabiting/using these areas.

Inadequate storage and handling of hazardous materials/wastes, chemicals and fuels could directly affect habitats (e.g. landscaped areas). The use of any herbicides, pesticides and fertilisers may potentially impact on faunal species and local vegetation, thereby increasing the secondary poisoning of non-targeted species.

Pests and vermin such as rodents, cockroaches and flies may be attracted to site by the accumulation of wastes (particularly domestic food wastes) if these are not stored and disposed of appropriately. Pests have the potential to spread disease to fauna and humans, as well as driving away faunal species.

Table 8-3 Biodiversity (Terrestrial) Impact Significance, Mitigation and Management Measures and Residual Impacts - Operation

Potential Impacts	Magnitude of Impact	Receptor	Receptor Sensitivity	Potential Impact Significance	Mitigation and Management Measures	Residual Impacts
Exposure of habitats to chemical additives and hazardous materials	**Negligible Negative**	Flora	Low	**Negligible to Minor**	• Landscaping on site should incorporate indigenous halophytic and xerophytic plant species to minimise irrigation requirements and the need for fertilisers/pesticides. Intentional replanting of vegetation would enhance the biodiversity of the site as well as improve the visual aesthetics of the site. • Prevent introduction of any alien or invasive flora species that might spread beyond the boundary of the Project site. • Hazardous materials and chemicals will be stored in designated areas in accordance with the requirements of SCE and good practices guidelines so as to prevent any spillages on the site.	**Negligible**

8.5 Monitoring

The EPC Contractor will undertake terrestrial ecology monitoring during the construction phase of the project. The minimum expected requirements for the monitoring are outlined in the table below. The final monitoring methodology with specific monitoring details (i.e. locations, frequencies, durations, parameters etc.) will be developed in the specific 'Environmental Monitoring Plan' Plan' as part of the construction phase ESMS.

Table 8-4 Biodiversity (Terrestrial) - Monitoring Requirements

Monitoring	Parameters	Frequency & Duration	Monitoring Location
Construction			
Fauna	Fauna species observed on the site	Daily visual observations of live fauna and burrow locations by workers at the commencement of working activities, and general observations throughout the day – to inform evacuation of specific burrows	In all working area requiring land grading or earthworks.

9 GEOLOGY, SOILS AND GROUNDWATER

9.1 Standards and Regulatory Requirements

Decree No.21 of 1996 with respect to the Environment stipulates the environmental requirements in regard to environmental pollution, as well as related issues which are set forth in Articles 10 and 11 of the Decree as outlined below.

- "The spraying or use of pesticides or other chemical compounds for agricultural, public health or other purposes will be prohibited except after considering the conditions, regulations and guarantees determined by the Environmental Body in agreement with the Ministry of Health and the Ministry of Works and Agriculture so as to guarantee that the environment will not be directly or indirectly affected, whether at present or in future by the damaging effects of such pesticides or chemical compounds".
- "All individuals and projects will undertake upon carrying out excavation, digging, building, demolishing or transporting the resulting debris or earth, to take the necessary precautions and measures to prevent damages to the environment and in particular what relates to the storage, transport and the safe disposal of such debris or earth in the manner determined in the Orders issued by the Minister for Housing, Municipalities and Environment in this respect".

The Kingdom of Bahrain does not specify standards relating to soil and groundwater quality. Therefore in accordance with lender requirements, where standards do not exist, a best practice standard should be applied. With respect to soil the use of the Dutch standards can be considered as a good practice standard for the analysis of soils and are viewed as international best practice.

Where concentrations of contaminants are identified to exceed 'intervention' levels, this is considered to be a case of soil contamination, which is dangerous to the health of humans and the natural environment. Such a level of contamination will require remediation, appropriate treatment and disposal. 'Target' values are considered to reflect a good standard of soil and groundwater quality.

It is noted that the use of Dutch Soil and Groundwater standards are not required by law in Bahrain. They have therefore been referenced as best practice standards.

Table 9-1 Dutch Ministry of Housing Soil Intervention Values Guidelines

Contaminant	Soil Sediment (mg/kg dry weight)		Groundwater (µg/L)	
	Target	Intervention	Target (7)	Intervention
Metals				
Antimony	3	15	-	20
Arsenic	29	55	10	60
Barium	200	625	50	625
Cadmium	0.8	12	0.4	6
Chromium	100	380	1	30
Chromium III	-	180	-	-
Chromium VI	-	78	-	-
Cobalt	9	240	20	100
Copper	36	190	15	75
Mercury	0.3	10	0.05	0.3
Mercury (inorganic)	-	36	-	-
Mercury (Organic)	-	4	-	-
Lead	85	530	15	75
Molybdenum	3	200	5	300
Nickel	35	210	15	75
Zinc	140	720	65	800
Other Inorganic Compounds				
Chloride (mg Cl/l)	-	-	100	-
Cyanide (free)	1	20	5	1500
Cyanide (complex)	5	50	10	1500
Thiocyanate	1	20	-	1500
Aromatic Compounds				
Benzene	0.01	1	0.2	30
Ethylbenzene	0.03	50	4	150
Toluene	0.01	130	7	1000
Xylene (sum)(1)	0.1	25	0.2	70
Styrene (vinylbenzene)	0.3	100	6	300
Phenol	0.5	40	0.2	2000
Cresol (sum)(1)	0.5	5	0.2	200
Polycyclic Aromatic Hydrocarbons (PAH) (5)				
Naphtalene	-	-	0.01	70
Phenanthrene	-	-	0.003*	5
Anthracene	-	-	0.0007*	5
Fluoroanthrene	-	-	0.003	1

Contaminant	Soil Sediment (mg/kg dry weight)		Groundwater (μg/l)	
	Target	Intervention	Target (7)	Intervention
Chrysene	-	-	0.003*	0.02
Benzo(a)anthracene	-	-	0.0001*	0.5
Benzo(a)pyrene	-	-	0.0005*	0.05
Benzo(k)fluoranthrene	-	-	0.0004*	0.05
Indenol(1,2,3-c,d)pyrene	-	-	0.0004*	0.05
Benzo(g,h,i)perylene	-	-	0.0003	0.05
PAH (total) (sum 10) (1)	1	40	-	-
Chlorinated Hydrocarbons				
Volatile hydrocarbons				
Monochloroethene (Vinlchloride) (2)	0.01	0.1	0.01	5
Dichloromethane	0.4	3.9	0.01	1000
1, 1 Dichloroethane	0.02	15	7	900
1, 2 Dichloroethane	0.02	6.4	7	400
1, 1 Dichloroethene (2)	0.1	0.3	0.01	10
1, 2 Dichloroethene (sum) (1)	0.2	1	0.01	20
Dichloropropanes (sum) (1)	0.002	2	0.8	80
Trichloromethane (chloroform)	0.02	5.6	6	400
1, 1, 1 Trichloroethane	0.07	15	0.01	300
1, 1, 2 Trichloroethane	0.4	10	0.01	130
Trichloroethene (Tri)	0.1	2.5	24	500
Tetrachloromethane (Tetra)	0.4	0.7	0.01	10
Tetrachloroethane (Per)	0.002	8.8	0.01	40
Chlorobenzene (5)				
Monochlorobenzene	-	15	7	180
Dichlorobenzenes (sum) (1)	-	19	3	50
Trichlorobenzenes (sum) (1)	-	11	0.01	10
Tetrachlorobenzenes (sum) (1)	-	2.2	0.01	2.5
Pentachlorobenzenes	-	6.7	0.003	1
Hexachlorobenzene	-	2.0	0.00009*	0.5
Chlorophenols (5)				
Monochlorophenols (sum) (1)	-	5.4	0.3	100

Contaminant	Soil Sediment (mg/kg dry weight)		Groundwater (µg/L)	
	Target	Intervention	Target (7)	Intervention
Dichlorophenols (sum) (1)	-	22	0.2	30
Trichlorophenols (sum) (1)	-	22	0.03*	10
Tetrachlorophenols (sum) (1)	-	21	0.01*	10
Pentachlorophenol	-	12	0.04*	3
Polychlorobiphenols (PCBs)				
PCBs (sum 7) (1)	0.02	1	0.01*	0.01
Other chlorinated hydrocarbons				
Monochloroanilines (sum) (1)	-	50	-	30
Dioxin (sum I-TEQ) (1)	-	0.00018	-	N/A(6)
Chloronaphthalene (sum) (1)	-	23	-	6
Pesticides				
Organochlorine pesticides				
Chlorodane (sum) (1)	-	4	0.02 ng/l*	0.2
DDT (sum) (1)	-	1	-	-
DDE (sum) (1)	-	1.3	-	-
DDD (sum) (1)	-	34	-	-
DDT/DDD/DDE (sum) (1)	0.01	-	0.004 ng/*l	0.01
Aldrin	0.00006	-	0.009 ng/l*	-
Dieldrin	0.0005	-	0.1 ng/l*	-
Endrin	0.00004	-	0.04 ng/l*	-
Drins (sum) (1)	0.005	0.14	-	0.1
Alpha endosulphan	-	4	0.2 ng/l*	5
alpha HCH	0.003	17	33 ng/l	-
beta HCH	0.009	1.6	8 ng/l	-
gamma HCH (lindane)	0.000005	1.2	9 ng/l	-
HCH compounds (sum) (1)	0.01-	-	0.05	1
Heptachlor	0.0007	4	0.005 ng/l*	0.3
Heptachlor epoxide (sum) (1)	0.0000002	4	0.005 ng/l*	3
Organotin pesticides				
Organotin compounds (sum) (1)	0.001	2.5	0.05* – 16 ng/l	0.7
Chlorophenoxy-acetic acid herbicides				
MCPA	0.00005	4	0.05	50

Contaminant	Soil Sediment (mg/kg dry weight)		Groundwater (µg/l)	
	Target	Intervention	Target (7)	Intervention
Other pesticides				
Atrazine	0.0002	0.71	29 ng/l	150
Carbaryl	0.00003	0.45	2 ng/l*	50
Carbofuran(2)	0.00002	0.017	9 ng/l	100
Other Substances				
Asbestos(3)	-	100	-	-
Cyclohexanone	0.1	150	0.5	15,000
Dimethyl phthalate	-	82	-	-
Diethyl phthalate	-	53	-	-
Di-isobutyl phthalate	-	17	-	-
Dibutyl phthalate	-	36	-	-
Butyl benzyl phthalate	-	48	-	-
Dihexyl phthalate	-	220	-	-
Di(2-ethylhexyl)phthalate	-	60	-	-
Phthalates (sum) (1)	0.1	-	0.5	5
Mineral Oil(4)	50	5,000	50	600
Pyridine	0.1	11	0.5	30
Tetrahydrofuran	0.1	7	0.5	300
Tetrahydrothiophene	0.1	8.8	0.5	5,000
Tribromomethame (bromoform)	-	75	-	630

9.2 Observations and Baseline Conditions

9.2.1 National Soil Geology

The Kingdom of Bahrain is an archipelago of around 33 low-laying islands located between the eastern shore of Saudi Arabia and the western coast of the Qatar Peninsula. The main island in Bahrain is about 48.3km long, about 16.1km wide and reaches a maximum altitude of 134.1m (440ft) at Jabal Al Dukhan “Mountain of Smoke”. The Kingdom of Bahrain occupies a total land mass of about 770 km^2. The country is bounded by 161km long coastline.

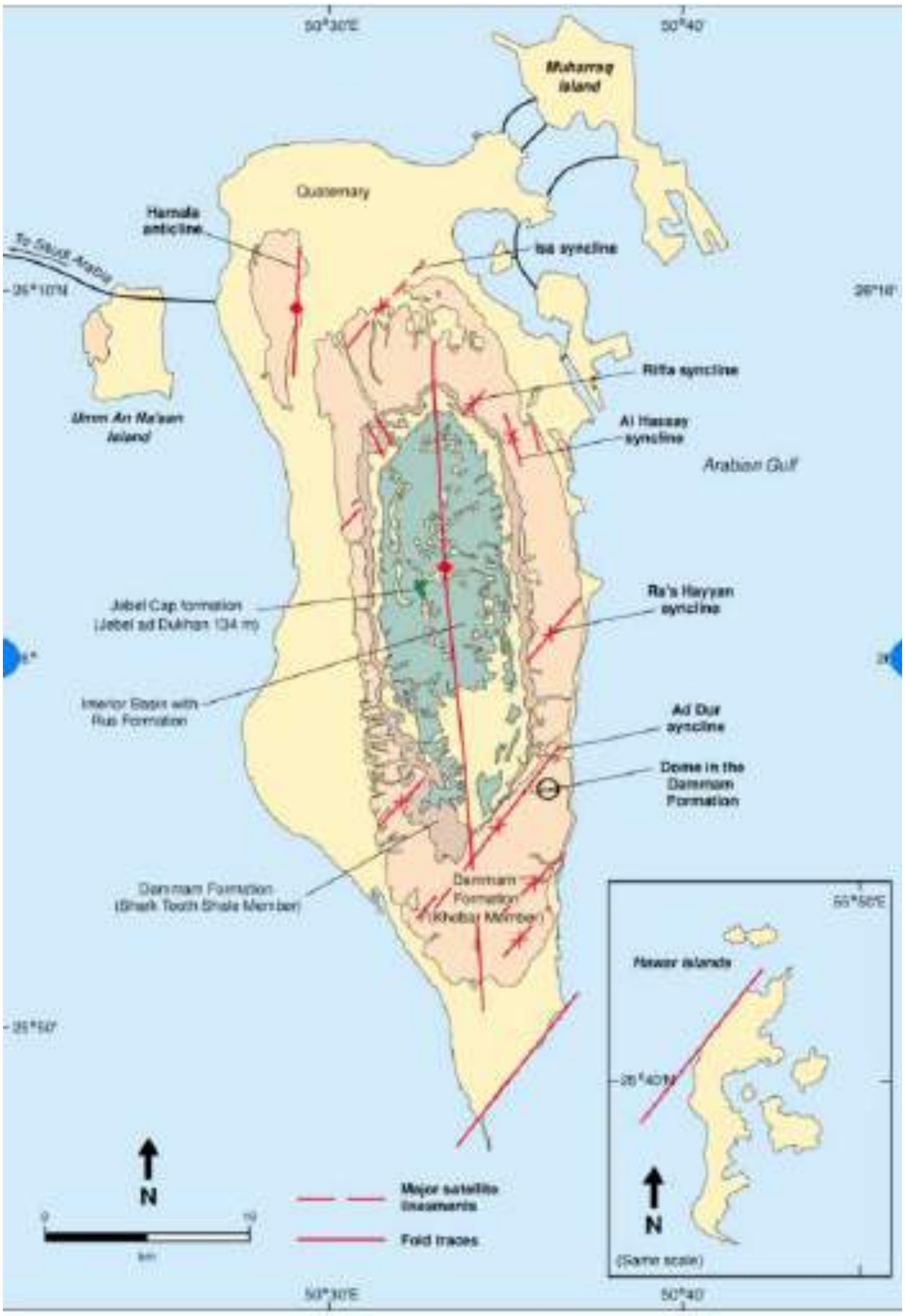
Bahrain is part of the structural province of Arabia. The geological sediments exposed at surface are dominated by tertiary calcareous sediments overlain by Pleistocene and Recent deposits. Tertiary and older rocks are folded in domes and anticlines with a north-south trend.

Regionally, Quaternary and Recent sediments exist in off dome synclinal areas exposed mainly in Damman (Saudi Arabian coastal region) and Bahrain.

The geological sequence is composed of three main formations:

- Dammam Formation - which consists of fossiliferous dolomitized limestone, dolomitic marl and dolomitic limestone, has two forms, known as Alat limestone and Khobar dolomite, from the Middle Eocene.
- Rus Formation of the Lower Eocene consists of chalky dolomitic limestone, shale, gypsum, and anhydrite.
- Umm er-Radhuma - formation of the Palaeocene is composed of dolomitic limestone and calcarenite with some argillaceous and bituminous facies, which is underlain by shales, marls and argillaceous limestone of the upper Arma formation of the Cretaceous.

Figure 9-1 Geological Map of Bahrain with Structural Trends



Source: Dill et al (2005)

9.2.2 Groundwater Table

There are a number of groundwater aquifers which underlie parts of Bahrain, namely the Umm er Radhuma, Rus Formation and the Dammam Formation. The latter can be divided into the 'A' Aquifer (Alat Limestone Aquifer) outcrops inland close to Dammam and at the centre of Bahrain and the 'B' Aquifer (Kobhar Aquifer) which outcrops at the centre of Bahrain. The Aquitard Rus and the Umm Er Radhuma Aquifer are considered as one unit as they are hydraulically connected and is referred to as the 'C' Aquifer.

<u>Dammam Formation</u>

The Alat Member of this aquifer is a low productivity aquifer whereas the Khobar aquifer is classified as a major aquifer with high permeability in the upper 5 – 10 meters. These two members' thickness ranges from 15 – 45 meters towards the east and west of Bahrain.

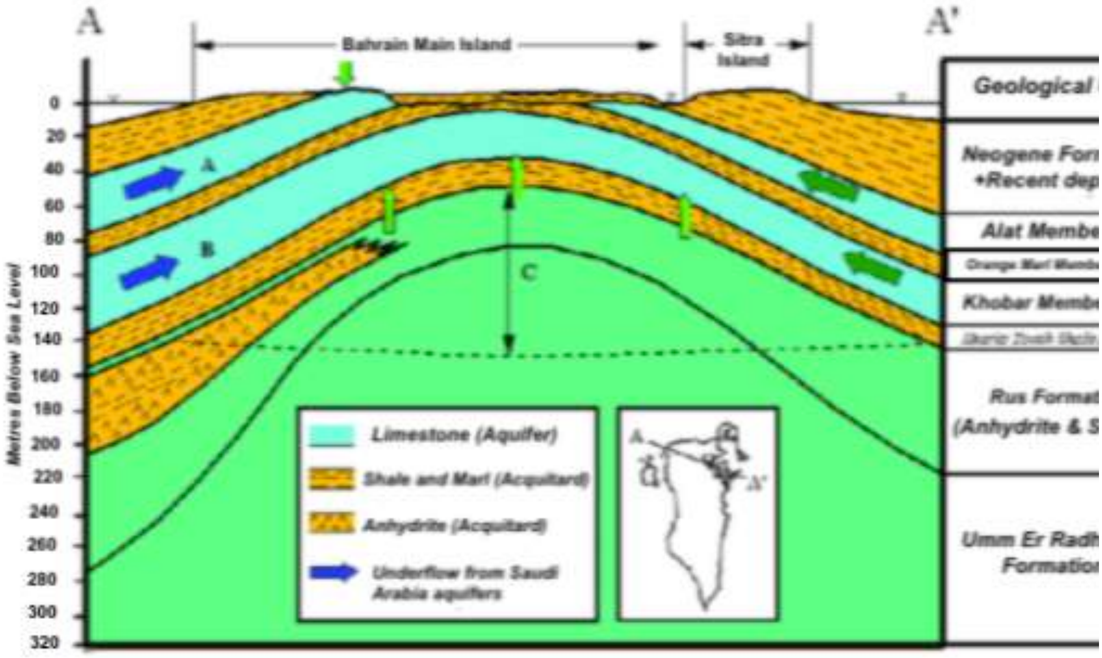
<u>Rus Formation</u>

In central Bahrain this forms a hydraulic head with Umm er Radhuma but is otherwise classified as an aquitard. The average thickness throughout Bahrain is 105 m.

<u>Umm er Radhuma</u>

Only the upper part of this aquifer is connected to the Rus aquifer whereas the lower part has low permeability and is saline. Umm er Radhuma is the thickest aquifer in Bahrain at 350 m.

Figure 9-2 Bahrain's Groundwater Aquifer System



Source: Mohammed G (2017)

9.2.3 Project Site Conditions

The proposed Project site is located on an unoccupied plot immediately to the south of existing the Al Dur IWPP Phase 1 project. The Project footprint appears to have limited past use, although it does include an area which has been previously cleared and is slightly elevated above the surrounding landscape. It is suspected that this land was used at some point during the construction of the previous Al Dur IWPP Phase 1 project, but does not appear to be large enough to have included all necessary temporary laydown facilities.

This specific area of land showed no visual or olfactory signs of pollution during the site visits. Other signs of pollution were also not observed during the site visit elsewhere on the site.

Plate 9-1: Potential Previous Land Use (partially on-site)

Topography

The Project is located in close proximity to the shoreline of the Arabian Gulf, although it was notable that there is a steady slope of land from the west to east towards the coastline at the location of the project site. Specific details in regard to topographic elevations are not available at this stage.

The wider Project site has minimal fluctuation in elevation and there are minimal observations of dune peaks and troughs, as can be viewed in the image below.

Plate 9-2: Overview of Project Site

Project Site Soils

Based on the initial site visit, and as can be seen in the photographs above, topsoil at the site is largely unconsolidated and loose, but with some rocky fragments. As stated above, specific instances of potential contamination were not observed during the initial site visit.

Groundwater

As reported in the "Onshore Soil investigation Report" for Al Dur Phase 2 IWPP issued in January 2018, the water table is the area is likely to be at approximately 0.5 m deep.

9.2.4 Soil & Groundwater Quality Analysis

Following the ESR prepared for the Project, a site survey for evidence of potential contamination on-site in both the soils and groundwater was carried out.

Soil Sampling and Analysis

Methodology

Soil investigation at the Project site was conducted to identify existing soil quality conditions and characteristics. During the survey, surface soil samples were collected from four (4) sampling locations within the proposed Project site and the laydown area.

One (1) topsoil sample of about 1kg was collected from each sampling location using a metal scoop (after scraping away the immediate surface layer). The purpose of sampling the topsoil is based on the likely influence of above ground features.

All samples were analysed at the Al Hoty Laboratory in Mina Salman for concentrations of Oils & Greases, TPH, PAH, BTEX/MTBE, Phenols, PCBs, sulphate, chloride, carbonate and a suite of heavy metals. The primary purpose of this analysis was to ascertain the presence of potential soil subsurface contamination.

Figure 9-3 Soil Sampling Locations

<u>Results</u>

The soil samples obtained were analysed for the presence of Oils & Greases, TPH, PAH, BTEX/MTBE, Phenols, PCBs, sulphate, chloride, carbonate and a suite of heavy metals. The results of the soil laboratory analysis are presented in the table below as compared with the Dutch Soil Standards (intervention/action values).

Table 9-2 Soil Analysis Results

Parameters	S-1	S-2	S-3	S-4	Dutch Standards
pH	7.5	8.0	8.0	7.4	-
Sulphate (SO_3)	0.26	3.3	0.08	4.3	-
Chloride (Cl)	1.34	1.9	0.17	0.16	-
Organic Matter	0.97	0.52	0.19	0.58	-
Carbonate (as $CaCO_3$)	68.4	48.0	72.1	49.7	-
Oil & Grease	<50	<50	<50	<50	-
Heavy Metals (mg/kg)					
Nickel (Ni)	9	10	8	17	**210**
Arsenic (As)	<0.5	<0.5	<0.5	<0.5	**55**
Selenium (Se)	<0.1	<0.1	<0.1	<0.1	-
Copper (Cu)	13	7	16	16	**190**
Zinc (Zn)	25	10	32	40	**720**
Cadmium (Cd)	0.22	0.17	0.26	0.33	**12**
Mercury (Hg)	<0.2	<0.2	<0.2	<0.2	**10**
Chromium (Cr)	11	15	11	19	**380**
Lead (Pb)	<0.5	<0.5	<0.5	<0.5	**530**
Phenols & PCB (mg/kg)					
Phenols	<0.1	<0.1	<0.1	<0.1	**40**
Polychlorinated Biphenyl (PCB)	<0.1	<0.1	<0.1	<0.1	**1**
Total Petroleum Hydrocarbons (TPH) (mg/kg)					
C6 - C9 (GRO)	<0.2	<0.2	<0.2	<0.2	-
C10 - C28 (DRO)	<10	<10	<10	<10	-
C29 - C40 (Heavy Fractions)	<50	<50	<50	<50	-
Polycyclic Aromatic Hydrocarbons (PAHs) (µg/kg)					
Naphthalene	<100	<100	<100	<100	-
Acenaphthene	<100	<100	<100	<100	-
Fluorene	<100	<100	<100	<100	-
Phenanthrene	<100	<100	<100	<100	-
Anthracene	<100	<100	<100	<100	-
Fluoranthrene	<100	<100	<100	<100	-
Pyrene	<100	<100	<100	<100	-
Benz (a) anthracene	<100	<100	<100	<100	-
Chrysene	<100	<100	<100	<100	-
Benzo (b.k) fluoranthene	<100	<100	<100	<100	-
Benzo (a) pyrene	<100	<100	<100	<100	-
Indeno (1,2,3-cd pyrene)	<100	<100	<100	<100	-
Dibenz (a,h) anthracene	<100	<100	<100	<100	-

Parameters	S-1	S-2	S-3	S-4	Dutch Standards
Benzo (g.h.h) perylene	<100	<100	<100	<100	-
BTEX (µg/kg)					
Benzene	<10	<10	<10	<10	**1,000**
Toluene	<10	<10	<10	<10	**130,000**
Ethylbenzene	<10	<10	<10	<10	**50,000**
Xylenes	<10	<10	<10	<10	**25,000**

Note: Where the results obtained have been provided in µg/kg, the Dutch Intervention Standard has been converted from mg/kg to µg/kg. The results highlighted in green are those well within the established Dutch Soil Intervention Values while those that have not been highlighted are parameters for which there are no established standard values.

The concentration of oil & grease, As, Se, Hg, Pb, Phenols, PCB's, TPH, PAHs and BTEX were recorded below detectable limits.

Upon comparing the soil analysis results obtained with Dutch Soil intervention/action values, it is apparent that the parameters for which standard values have been established were well below the established values. Such parameters included heavy metals, Phenols, PCBs and BTEX. This suggests that the soils within the project site and the proposed laydown area are not potentially contaminated.

The full sets of the soil analysis results from the laboratory are presented in Appendix P.

Groundwater Sampling and Analysis

Methodology

Three (3) groundwater samples were obtained from three different boreholes outside the Project site on 31st December 2018 by using a groundwater sampling pump after drilling with a mobile percussion drill to groundwater level. The borehole locations are presented in the figure below. Groundwater was encountered at different depth for all three boreholes with the most shallow depth encountered close to the sea.

The samples obtained were analysed for pH, COD, BOD, TDS, TOC, nutrients, a suite of heavy metals, TPH, PAH, BTEX and other physicochemical parameters. The results are presented in Appendix P.

Table 9-3 Groundwater Depth

Groundwater Boreholes	Location	Depth
GW-1	Approximately 1.1km to the coastal waters located east of the Project site.	15.65m
GW-2	Approximately 190m to the coastal waters located east of the Project site	3.9m
GW-3	Approximately 306m to the coastal waters located east of the Project site	7.65

Figure 9-4 Groundwater Sampling Locations

Results

The groundwater samples were analysed for pH, COD, BOD, TDS, TOC, TPH, PAH, nutrients, a suite of heavy metals and other physicochemical parameters.

Table 9-4 Groundwater Analysis Results

Parameters	GW-1	GW-2	GW-3	Dutch Standards
Physico-chemical Parameters				
pH at 25°C	7.5	7.2	7.2	-
Electrical Conductivity @ 25°C	27100	18000	53700	-
Total Dissolved Solids (TDS)	18152	11650	37224	-

PARAMETERS	GW-1	GW-2	GW-3	DUTCH STANDARDS
Biochemical Oxygen Demand (BOD)	4	4	3	-
Chemical Oxygen Demand (COD)	29	25	34	-
Total Organic Carbon (TOC)	0.8	1	2	-
Healy Metals (mg/kg)				
Arsenic (As)	<0.005	<0.005	<0.005	**0.06**
Cadmium (Cd)	<0.005	<0.005	<0.005	**0.006**
Chromium (Cr)	<0.005	<0.005	<0.005	**0.03**
Copper (Cu)	<0.01	<0.01	<0.01	**0.075**
Lead (Pb)	<0.05	<0.05	<0.05	**0.075**
Mercury (Hg)	<0.002	<0.002	<0.002	**0.0003**
Nickel (Ni)	<0.01	<0.01	<0.01	**0.075**
Iron (Fe)	0.03	0.01	0.01	-
Zinc (Zn)	<0.01	<0.01	<0.01	**0.8**
Selenium (Se)	<0.01	<0.01	<0.01	-
Other Inorganic Substances				
Chloride (Cl)	8863	5530	20384	-
Calcium (Ca)	745	609	802	-
Nitrate Nitrogen (NO_3-N)	1.4	1.3	2.8	-
Total Phosphate (PO_4^{3-})	<0.1	<0.1	<0.1	-
Total Hardness as $CaCO_3$	4380	2880	6800	-
Total Alkalinity as $CaCO_3$	90	118	118	-
Sulphate (SO_4^{2-})	2522	1710	2782	-
Magnesium (Mg)	612	330	1166	-
Potassium (K)	210	150	480	-
Sodium (Na)	4982	3047	11334	-
Polycyclic Aromatic Hydrocarbons (PAHs) (µg/l)				
Naphthalene	<5	<5	<5	**70**
Acenaphthene	<5	<5	<5	-
Fluorene	<5	<5	<5	-
Phenanthrene	<5	<5	<5	**5**
Anthracene	<5	<5	<5	**5**
Fluoranthene	<5	<5	<5	**1**
Pyrene	<5	<5	<5	-
Benz (a) anthracene	<5	<5	<5	**0.5**
Chrysene	<5	<5	<5	**0.02**
Benzo (b.k) fluoranthene	<5	<5	<5	-
Benzo (a) pyrene	<5	<5	<5	**0.05**
Indeno (1,2,3-cd pyrene)	<5	<5	<5	**0.05**

PARAMETERS	GW-1	GW-2	GW-3	DUTCH STANDARDS
Dibenz (a,h) anthracene	<5	<5	<5	-
Benzo (g.h.h) perylene	<5	<5	<5	**0.05**
Phenols & PCBs				
Phenols	<0.002	<0.002	<0.002	**2000**
Polychlorinated Biphenyl (PCB)	<10	<10	<10	**0.01**
Total Petroleum Hydrocarbons (TPH) (µg/l)				
C6 - C9 (GRO)	<1	<1	<1	-
C10 - C28 (DRO)	<10	<10	<10	-
C29 - C40 (Heavy Fractions)	<50	<50	<50	-
BTEX (µg/l)				
Benzene	<1	<1	<1	**30**
Toluene	<1	<1	<1	**1000**
Ethylbenzene	<1	<1	<1	**150**
Xylenes	<1	<1	<1	**70**

Note: Where the results obtained have been provided in mg/kg, the Dutch Intervention Standard has been converted from µg/kg to mg/kg. The results highlighted in green are those well within the Dutch Groundwater Intervention Values while those that have not been highlighted are parameters for which there are no established standard values.

The result of the laboratory analysis indicate that the groundwater samples analysed have less than detectable concentrations for all heavy metals with the exception of iron (Fe), Total Phosphate (PO_4^{3-}), all PAHs, Phenols, PCBs, TPH and BTEX.

Comparison of the groundwater analysis results with Dutch groundwater established standards show that all the parameters for which standard values have been established were well below the established standards.

9.3 Receptors

Table 9-5 Geology, Soils & Groundwater - Receptor Sensitivity

RECEPTOR	RECEPTOR SENSITIVITY	JUSTIFICATION
Soil Quality	**Low**	Based on the results from the soil analysis, there are no elevated concentration of heavy metals above established limits or detectable concentrations of hydrocarbons. With no apparent areas of contamination within the site, the site can be said to be characteristically greenfield in nature. The soil within the Project site is typical of the soil characteristics found in Bahrain. Hence, it is of low importance and rarity on a local scale.

Receptor	Receptor Sensitivity	Justification
Groundwater Quality	**Low**	The Project site is located within other nearby industrial facilities and groundwater at the site is expected to be brackish (due to the sea). As such, it is not a source of drinking water importance.

9.4 Potential impacts

9.4.1 Construction Phase

Site preparation, infrastructure, civil works, electrical and mechanical works and other construction related activities will result in interactions with site geology, and may affect chemical and physical properties of the local soil and potentially groundwater quality.

Excavation or Removal of Soils

The Project will require excavation activities in order to establish a base at suitable level and design elevation for construction. Soil compaction using vibratory rollers to provide soil structural stability after the removal of soils will have direct impacts to surface soils thereby changing soil characteristics within the Project site.

Cross Contamination of Soil

The possibility of encountering some form of contamination due to accidental spills or leaks in areas within the Project site that have been used previously as vehicle tracks cannot be ruled out. In the event that such contamination is present within the Project site (or arises from construction works), there is a possibility for construction activities particularly those related to site clearance, excavation etc. to spread contaminated soils to other soils. The same impact may occur where contamination impacts caused by construction works are also cross-contaminated in the same respect within the Project site.

Spill and Leaks Associated with Construction

Soil and groundwater may be susceptible to contamination from various sources during the construction phase. Primary sources of contamination are typically those placed along the handling of products where liquid waste and hazardous liquids/materials can escape directly into the soil potentially resulting in contamination to exposed soils and potentially being transferred via the high porosity sandy soils to the groundwater.

The risk of accidental spillage and leakage of various chemical products, are often attributable to storage areas of the construction site as well as during the transportation of such materials on and off the site. Improper methods of storing, transferring, and handling of these products can result in spillage to the ground and result in soil contamination.

If pollutants reach groundwater, the spread of pollution may require measures for its control. These risks will be managed through the implementation of the project CEMP and associated plans and procedures.

Inadequate Waste Management

Construction of the proposed project will involve activities that generate solid and hazardous waste, as well as potential liquid wastes resulting from sanitary waste streams, hydrotesting of tanks (for CCGT and SWRO), chemical and steam cleaning of piping and equipment prior to commissioning (CCGT). Waste generated during these activities poses a threat to the site soils. Of particular concern is the management of hazardous waste generated during the construction phase and its handling. Although the hazardous fraction of construction waste such as used oil, machinery lubricants and paints, etc. will represent a very small proportion of the total amount of construction waste it will however require special attention for management and disposal.

If the temporary storage and handling of such waste on the construction site is inadequate prior to being removed for disposal, the risk of soil and potentially indirect effects to groundwater quality increases. Potential environmental impacts arising from the generation of hazardous wastes are covered in the 'Solid & Liquid Waste Management' Section of this report.

Table 9-6 Geology, Soils and Groundwater Impact Significance, Mitigation & Management Measures and Residual Impacts-Construction

Potential Impacts	Magnitude of Impact	Receptor	Sensitivity	Potential Impact Significance	Mitigation and Management Measures	Residual Impacts
Cross - contamination of Soils	**Minor Negative**	Soil Quality	Low	**Negligible to Minor**	• Training – Contractor staff to recognise signs of potential contamination (oils, chemicals, staining). • Washing of equipment, machinery and vehicles will only be permitted in designated areas, with impermeable surfaces and dedicated drainage systems that lead to separate sumps or, treatment facilities and/or lined evaporation ponds. • Where concrete washout areas will be established onsite, these areas should be located away from storm drainage & water bodies and should be designed with adequate holding capacity. The wastewater should be contained within the designated impervious bund. • If contaminated soils are observed during construction activity, the identified contaminated soil should be excavated separately, and stored or disposed of in accordance with environmentally adequate measures for waste management, to avoid cross-contamination.	**Negligible**
Accidental Leaks & Spillage	**Minor Negative**	Soil Quality	Low	**Negligible to Minor**	• Storage of all hazardous materials and chemical on an impermeable base with liners and/or secondary containment with enough capacity to hold 110% of the maximum potential stored volume. • Use of hazardous items in working areas requires containers/drums/tanks to be stored on spill containment (drip) trays. • Develop and implement an Emergency Response Plan (ERP) that includes or is linked to a Spill Response and Contingency Plan.	**Negligible**
	Negligible Negative	Groundwater Quality	Low	**Negligible to Minor**		**Negligible**

Potential Impacts	Magnitude of Impact	Receptor	Sensitivity	Potential Impact Significance	Mitigation and Management Measures	Residual Impacts
					• Maintain an inventory of all potentially hazardous materials and chemicals used and stored on-site, including volumes. • All spills and leaks to be reported promptly to the Construction Manager and to be investigated to confirm root cause and ensure appropriate corrective and preventative actions. • Refuelling and maintenance of vehicles/ equipment will only be undertaken within a dedicated depot area at the camp, on impermeable surface with impermeable surfaces, lipped edges to prevent runoff to soils and separate drainage systems that lead to separate collection or treatment facilities • Well stocked spill kits (i.e. with absorbent materials, PPE and hazardous waste collection provisions) will be available in at specific risk areas of the Project site (e.g. chemical and fuel stores, or areas for refuelling). • Relevant personnel (such as HSE staff or environmental staff) to be trained on emergency and spill response, containment, material handling and storage procedures. • Regular emergency drills to practice timely and effective spill response. • Fuel transport vehicles and equipment to be maintained and routinely inspected to ensure the tank, pumps, pipe work and the vehicle itself are free from leaks and fit for purpose - No equipment will be placed in service until deficiencies are corrected. • Implement regular maintenance program for vehicles and equipment to minimise leaks or mechanical failures and keep documentary evidence.	

Potential Impacts	**Magnitude of Impact**	**Receptor**	**Sensitivity**	**Potential Impact Significance**	**Mitigation and Management Measures**	**Residual Impacts**
					• When in use, temporary equipment (containing fuel) to have drip trays to avoid any leaks to the soil surface.	
Inadequate Waste Management	**Minor Negative**	Soil Quality	Low	**Negligible to Minor**	• All hazardous materials or waste being temporarily used or otherwise stored outside of its designated storage areas should be kept in well-equipped, leak-tight containers with drip protection to avoid leaks to the ground. • Wherever possible, the quantity of chemicals and fuel stored on site will be kept to minimum practical level. Infrequently used chemicals should be ordered in suitable quantities only when required. • Concrete washout will only be undertaken at designated and signed areas, with adequate protection to soils, to prevent leaks or spread of concrete washings. • Excavated materials will be kept in the stockpiles for as short a time as possible. • Implementation of good housekeeping practices during construction activities including proper handling, storage and transport of hazardous materials and waste. • The implementation of the project CEMP and associated Waste Management Plan and Procedures will ensure that spills are kept to a minimum and are cleaned up quickly using spill kits located in risk areas • The EPC contractor and sub-contractors will provide training & TBT's relating to the management, transportation and handling of hazardous materials and wastes – in line with any procedures developed to guide the on-site management of such activities.	**Negligible**

9.4.2 Operational Phase

Accidental Leaks and Spillage Associated with Operation

Specific project impacts to soil, geology and groundwater are not expected during the operational phase as the site will be static and will not have direct interactions with these environmental parameters i.e. soil & groundwater.

Potential risks of concern during the operational phase are expected to be limited to the management and storage of hazardous materials/wastes/wastewater. The CCGT component of the Project will require the storage of chemicals such as oils, lubricants associated with operation of the plant while the SWRO components will require the storage of process chemicals for water dosing & treatment and cleaning chemicals for general maintenance and routine cleaning of the RO membranes.

Uncontrolled releases to soils during the operational phase have the potential to occur during material transportation, handling and storage as well as during cleaning activities and accidental spillages to the ground. However, such instances are considered unlikely as all such chemicals and lubricants will be stored inside structures and buildings with impermeable base and where appropriate with secondary containment. This will ensure that any leaks or spills will be fully contained, resulting in a negligible likelihood of impact to soil, as is the potential for impacts to groundwater which would rely on infiltration through exposed soils.

Inadequate temporary storage and handling of sanitary wastewater prior to being removed for disposal, could also pose a contamination risk, specifically where septic tanks overflow or are not adequately contained.

Table 9-7 Geology, Soils and Groundwater Impact Significance, Mitigation & Management Measures and Residual Impacts - Operation

Potential Impacts	Magnitude of Impact	Receptor	Sensitivity	Impact Significance	Mitigation and Management Measures	Residual Impacts
Accidental Leaks & Spillage	**Minor Negative**	Local Soil Quality	Low	**Negligible to Minor**	• Integrity of all storage tanks and bunds to be tested and inspected for leaks and flaws. • Storage of all fuel/chemical or other hazardous liquid/waste tanks will be on an impermeable base with liners and/or secondary containment with enough capacity to hold 110% of the maximum volume stored. • Where multiple containers are stored, the bund capacity will be suitable to contain 25% of the volume of all containers. • Operator to develop and implement an Emergency Response Plan (ERP) to include or link to a Spill Response and Contingency Plan. • Personnel in contact with such materials will be trained on emergency and spill response, containment, material handling and storage procedures. • Availability of suitable containment and spill clean-up materials/equipment at specific locations within the Project site. Particularly at chemical and lubricant oil storage areas • Conformance with ERP procedures (preventative and response) will be monitored through routine inspections. • Loss of containment to be reported promptly. This should be investigated to confirm the cause and appropriate corrective/preventative actions put in place.	**Negligible**
	Negligible Negative	Local Groundwater Quality	Low	**Negligible to Minor**		**Negligible**

POTENTIAL IMPACTS	MAGNITUDE OF IMPACT	RECEPTOR	SENSITIVITY	IMPACT SIGNIFICANCE	MITIGATION AND MANAGEMENT MEASURES	RESIDUAL IMPACTS
					• Spill kits and clean up materials will be well located and visible in key areas of the site (e.g. chemical stores and close to any fuel storage areas). Larger provisions for spill clean-up and control should be available in the event of significant spills.	
Inadequate sanitary storage and handling	**Minor Negative**	Local Soil Quality	Low	**Negligible to Minor**	• Toilet and sanitary facilities to be deployed should be provided with belowground collection tanks of appropriate size depending on the number of personnel to be deployed. • Collection tanks should be placed in lined pits to ensure spillage is contained. • Collection tanks and associated pipes should be inspected for any leaks or overflow.	**Negligible**
	Negligible Negative	Local Groundwater Quality	Low	**Negligible to Minor**		**Negligible**

9.5 Monitoring

Table 9-8 Geology, Soils and Groundwater Monitoring Requirements

MONITORING	PARAMETER	FREQUENCY & DURATIONS	MONITORING LOCATION
Construction & Operation			
Soil Quality	Hydrocarbons and other potentially hazardous or chemical pollution sources	Daily visual inspection.	The entire Project area during construction and operation

10 SOLID AND LIQUID WASTE MANAGEMENT

This chapter assesses the projects expected generation of solid and liquid waste at the construction and operational phases. It does not consider the significance of impacts with respect to a specific receptor (i.e. soil or groundwater quality); as such impacts to soil or groundwater quality with respect to solid and liquid waste have been assessed in the respective section of this ESIA (Section 9 Geology, Soil and Groundwater).

The primary purpose of this chapter is to identify specific management measures in regard to solid waste and wastewater generation that can be adopted in the construction and operational phases ESMS' in order to ensure compliance with applicable regulations and standards.

10.1 Standards and Regulatory Requirements

10.1.1 National Requirements

Decree No.21 of 1996 with respect to the Environment stipulates the environmental requirements in regard to waste management, as well as related issues which are set forth in Articles 14, 18 and 19 of the Decree as outline below:

- *"Dealing in hazardous materials and waste without a permit from the Environmental Body, will be prohibited".*
- *"Various persons and projects will be prohibited from storing or disposing of waste in any manner which does not comply with the systems, standards and methods laid down by the Environmental Body".*
- *"All industrial projects determined by the Environmental Body will be required to establish waste treatment units for waste resulting from their activities, particularly the hazardous and toxic ones".*

Other national regulations applicable to this section included:

- Ministerial Order No.1 of 2001 with respect to Managing Waste Hazardous to Health Care;
- Resolution No.3 of 2006 with respect to the management of Hazardous Wastes and;
- Solid waste management guidelines and legislation relating to Occupational Health and Safety.

It should be noted that currently, there is an absence of policy implementation to control waste generation and disposal quantities. Separation is occasionally undertaken at transfer stations, or else collected waste is deposited directly to landfill.

10.1.2 Lender Requirements

Waste

International financial institutions providing project finance will require adherence with the IFC General EHS Guidelines. With regard to waste, these guidelines require that projects:

- Establish waste management priorities at the outset of activities.
- Identify EHS risks and impacts with regards to waste generation and its consequences.
- Establish a waste management hierarchy that considers prevention, reduction, reuse, recovery, recycling, removal and finally disposal of wastes.
- Avoid or minimize the generation waste materials, as far as practicable.
- Identify where waste generation cannot be avoided but can be minimized or where opportunities exist for, recovering and reusing waste.
- Where waste cannot be recovered or reused, identify means of treating, destroying, and disposing of it in an environmentally sound manner.

Wastewater

IFC/World Bank General EHS Guidelines (2007) establish general requirements for direct or indirect discharge of process wastewater, wastewater from utility operations or storm water to the environment.

'Projects with the potential to generate process wastewater, sanitary (domestic) sewage, or storm water should incorporate the necessary precautions to avoid, minimize, and control adverse impacts to human health, safety, or the environment'.

However, wastewater effluent pollutant limits are only established for sanitary wastewater for discharge to the sanitary sewer systems. The following table provides the indicative values for treated sanitary wastewater effluent limits as established by the World Bank General EHS Guidelines (2007) (ref. Table 1.3.1 of IFC EHS Guidelines).

Table 10-1 Indicative Values for Treated Sanitary Wastewater Discharges

Pollutants	Units	Guideline Value
pH	pH Units	6 – 9
BOD	mg/l	30

Pollutants	Units	Guideline Value
COD	mg/l	125
Total Nitrogen	mg/l	10
Total Phosphorus	mg/l	2
Oil and Grease	mg/l	10
Total Suspended Solids	mg/l	50
Total Coliform Bacteria	MPN/100ml	400

10.2 Observations and Baseline Conditions

Solid and liquid waste can exhibit certain characteristics according to its chemical, physical and biological features. Different types of waste require different management and disposal techniques according to the potential risk that the material poses to human health or the environment. In order to categorise the different risks to these receptors, it is often useful to demarcate the streams into different categories that effectively equate to the level of the management and disposal which are required for each.

Industrial or domestic wastewater streams have the potential to contribute to a number of environmental problems if not properly handled, stored and/or managed, such us direct contamination to water bodies potentially leading to severe environmental and public health issues downstream.

10.2.1 Waste Management in Bahrain

The Waste Management Department at the Supreme Council for the Environment studies waste disposal of both non-hazardous and hazardous wastes in the Kingdom.

Increase in population growth and industrialisation in the kingdom has resulted in the generation of large quantities of domestic, commercial and industrial waste. Waste in Bahrain is grouped into four:

- Municipal solid and liquid wastes;
- Industrial Solid and effluent wastes;
- Medical/Healthcare waste and;
- Chemical and Hazardous waste.

Municipal solid waste generated in the kingdom is characterised by high percentage of domestic wastes which mainly comprises of food wastes. Recyclables in the form of paper, plastics and glass makes the Bahraini Municipal Solid Waste a good recyclable feedstock, though informal sectors are responsible for recycling activities and the collection of recyclables. Generally, municipal waste collection, transportation and disposal in Bahrain is managed by two (2) private contractors; Gulf City Cleaning Company and Sphinx Services (Ansari, 2012). These two private contractors serve the five governorates of the Kingdom with Gulf City Company being responsible for the Muharraq & Manama (capital) area and Sphinx services responsible for waste collection & disposal in the Southern Middle and Northern areas. These contractors collect the solid wastes and dispose it at the only existing landfill in Bahrain; Askar Landfill. This landfill is located in proximity to urban habitats and is situated in an area of more than 700 acres and caters for municipal wastes, agricultural wastes and non-hazardous industrial wastes.

Due to the increase in waste generation, the potential for the only existing landfill to reach its capacity in the next few years and the growing concerns of the Askar landfill to have impact on air, soil & groundwater quality in the surrounding areas, the Government of Bahrain is trying to improve waste management in the Kingdom by launching recycling initiatives, waste-to-energy projects and public awareness campaigns.

10.3 Potential impacts

The construction phase can often be the most environmentally damaging phase of a project, particularly in regard to the volumes of waste that are generated, if not properly managed.

Solid Waste

During construction, waste will be generated during earthworks, construction of the fences, paths, road accesses and buildings.

Typical construction wastes include concrete, asphalt, scrap steel, glass, plastic, wood, packaging materials and domestic waste from construction workers (i.e. relating to food consumption). Concrete may be found in two forms on the construction site; structural elements containing reinforced concrete, while foundations (such as surface level concrete slabs) have mass non-reinforced concrete.

Solid waste generated from construction activities at the Project site will include the following:

- Non-hazardous waste such as;
  - Waste related to construction processes, including earthworks (such as rubble, soils and potentially rock);
  - Paper/cardboard, plastics, packaging, plastic bottles, glass, scrap metal, excess fill materials, sand, gravel, excess construction materials, concrete, subsoil and rock (not contaminated)
  - Domestic waste generated by the construction workforce (e.g. food/organic waste, paper trash, cardboard, aluminium, plastic)

- Hazardous waste such as;
  - Batteries, spend filtration cartridges, chemical drums, oil filters, aerosol cans, contaminated metals, empty containers, expired and unused chemicals, adhesives, machinery lubricants, clean-up materials such as rags, containers and tins with remains of hazardous substances, used spill kits and clean-up materials
  - Replacement parts from vehicles, plat and equipment such as tyres.

Inappropriate handling, storage, transport and/or disposal of these solid wastes during construction might pose the potential to pollute the surrounding environment (i.e. soil and groundwater resources), cause odour and visual nuisance, encourage pests or result in occupational health and safety issues.

<u>Non-Hazardous Solid Waste</u>

Non-hazardous construction waste is typically inert and does not pose a threat to human health or the environment. However, proper management is required in order to reduce associated secondary impacts such as unnecessary resource use, dust emissions, and increased pressure upon local landfills.

<u>Hazardous Solid Waste</u>

Due to the nature of the project and the construction works being undertaken, there will be a few hazardous materials used. Such materials may result in fuel containers waste, oily residues, paints, paint cans and wastes from chemical cleaning products.

Although the hazardous fraction of construction waste represents a relatively small portion of the total amount of construction waste likely to be generated, its management requires careful consideration, as the impacts associated with hazardous waste can potentially result in contamination to soils and potentially groundwater, as assessed in the geology, soils and groundwater sections of this ESIA.

Inappropriate management, storage, handling, transfer or transportation may lead to accidental spills or leaks to the soil or groundwater resulting in environmental impacts and potential health risk to workers. Contamination events may also arise as a result of transportation by unlicensed waste contractors or disposal to unlicensed landfills.

Waste management strategy and planning is therefore critical in order to minimise potential significant effects on sensitive receptors such as soil and groundwater. Sub-contractors (if any) will be responsible for their own waste management, however their practices must be in line with the prescribed requirements of the CESMP and/or site waste management plan to be enforced and updated as necessary by the contractor.

Solid waste streams likely to be associated with the construction phase of the project are listed in the table below.

Table 10-2 Anticipated Solid Waste Types Associated with the Construction Phase

TYPE	WASTE STREAM
Inert	Subsoil and Rock
	Glass
Non-Hazardous	Concrete and cement
	Asphalt
	Scrap metal
	Wood
	Plastic
	Packaging
	Municipal waste from construction workers
Hazardous	Contaminated soil/asphalt
	Resins and paints
	Waste oils
	Waste solvents and thinners
	Waste fuel and chemicals.
	Batteries
	Used spill kits and clean up materials.

The majority of the non-hazardous wastes generated onsite will be recycled and reused in order to reduce the quantity of waste to be disposed at the landfill to as low as practicable.

Liquid Waste/Wastewater

Wastewater generated from construction activities at the project site will include the following:

- Sanitary and domestic wastewater generation;
- Wastewater from any vehicles or equipment washing/cleaning
- Liquid hazardous waste such as fuels, chemicals, paints, lubricants, solvents, waste oil, hydraulic fluid, resins, waste solvents and thinners, etc.; and
- Storm water runoff events on site.
- Concrete washout and
- Commissioning Wastewater (hydro test, steam and acid cleaning)

For sanitary and domestic wastewater, it is anticipated that there will be a significant number of workers at the peak period of construction. The quantities of sanitary & domestic wastewater can be estimated as an average of $0.1m^3$/person/day (100 litres). Assuming the estimated number of construction workers during peak periods will be up to 2,200 personnel, sanitary wastewater is estimated to total 220m^3 at peak periods of construction. Wastewater generated on-site will be stored within septic tanks for removal by a licensed wastewater contractor.

It should be noted that the figure of 100 litres/worker/day relates to overall water consumption including at accommodation areas (expected to be located in temporary areas adjacent to the project site). Such wastewater will be stored within septic tanks on-site, prior to removal by a licensed contractor. Improper handling, storage and transportation of sanitary and domestic wastewater could potentially cause contamination to soil or groundwater resources; as assessed in the Geology, Soils and Groundwater section of this ESIA.

The commissioning phase of construction will likely require the hydro testing, steam cleaning and perhaps chemical cleaning of plant components such as tanks and pipework. These commissioning activities will generate large volumes of wastewater that may contain heavy metals, as well as oils and greases. This wastewater will be directed to an on-site temporary holding/evaporation pond.

Storm water is not expected to occur on a regular basis due to the climatic condition of Bahrain. However, when rainfall occurs, storm water may runoff into areas containing hazardous materials and either leach these into the soil or carry these off the site, potentially contaminating soil and reaching the groundwater.

10.3.1 Operational Phase

The operational phase of the Project will result in the production of few waste streams from the maintenance activities, with the vast majority of these streams being non-hazardous. Nevertheless, if these waste streams are not managed and disposed of effectively they could result in significant impacts upon the surrounding environment (i.e. soil and groundwater resources).

Solid Waste

Solid waste is not expected to be generated in significant quantities during the operational phase of the CCGT & SWRO, besides maintenance for RO membranes, waste sludge (from wastewater treatment processes) and general day-to-day maintenance activities.

Non-Hazardous Solid Waste

The operation of the proposed Project will generate small amounts of non-hazardous domestic waste from the operation of the administration facilities and from activities of the employees, which are not directly associated with the production processes.

This waste can be classified as both recyclable and non-recyclable. Recyclable waste includes paper, tin cans, plastics, cartons, rubber, and glass, while non-recyclables will consist mainly of food residues and other organic waste. The quantity of domestic waste will be small given the few anticipated personnel required to operate the plant.

<u>Hazardous Solid Waste</u>

This fraction of the waste streams can potentially cause significant adverse impacts on human health and the environment if managed inadequately.

Examples of likely hazardous waste streams that may arise during the operation of the Project include the following:

- Used chemical containers and drums;
- Used RO filters;
- Waste oil, oily sludge, waste chemicals;
- Miscellaneous wastes such as batteries:
- General clean-up materials and solvents from general maintenance of on-site plant and machinery.

Table 10-3 Anticipated Solid Waste Streams Associated with the Operational Phase

TYPE	WASTE STREAM
Inert	Office waste
Non-Hazardous	Spent RO Membranes, Landscaping waste (mostly maintenance of green areas)
Hazardous	Hazardous-waste components, e.g. maintenance activities and cleaning.

Wastewater

When in operation, the project will use seawater to generate potable water via the SWRO processes and an amount of treated seawater for make-up water in the closed loop cooling process.

The proposed Project will generate the following tentative liquid waste streams as a result of operational activities:

Brine (RO)

Concentrate (or brine) from the RO membranes will contain elevated concentrations of the dissolved salts and minerals naturally occurring in seawater. The concentrate will also contain trace amounts of the chemicals added to the SWRO process and treated (where applicable) residual material from backwash water, floated material, waste from RO membrane cleaning and occasionally lime saturator waste. As indicated in the Water Balance Diagram (Appendix C), the EPC Contractor has estimated that the expected maximum brine flow will be approximately 13,829 ton/h.

Heated effluent (CCGT cooling)

Thermal effluent from the CCGT closed loop cooling system blowdown will comprise elevated temperature seawater with trace amounts of the chemicals added to the intake process and during pre-treatment to inhibit corrosion. The effluent will be discharged and mixed with the brine effluent from the SWRO plant before discharging via the existing outfall. As indicated in the Water Balance Diagram (Appendix C) the temperature of the thermal effluent has been estimated by the EPC Contractor to be 32.1°C above (intake temperature 30°C) and 3,750 ton/h.

Sewage from canteens and lavatories

Domestic waste will be conveyed to the sanitary wastewater treatment facility will be included as part of Project. Treated wastewater will be mixed with other project effluents and discharged at the projects shared outfall with the Al Dur Phase 1 IWPP.

Stormwater / runoff (non-polluted)

Non Polluted storm water will be collected via on-site drainage services and directly discharged without treatment to the outfall.

Stormwater / runoff (oily)

Oily stormwater will be collected via on-site drainage services and directed to the oil/water separator prior to discharge with other project effluents at the outfall.

Industrial Treated Wastewater

Wastewater effluents from the CCGT include boiler blowdown and SWRO plant include backwash water from pre-treatment filters, waste from RO membrane cleaning and occasionally lime saturator waste. Following treatment on-site, treated wastewater effluent will be sent to the outfall blended with the RO brine reject. As indicated in the Water Diagram (Appendix C), the EPC Contractor has estimated that the expected maximum volume of treated wastewater discharged to the sea via the outfall will be 0.01 ton/h.

Brine and small volumes of thermal wastewater will be discharged directly to the Arabian Gulf where it will mix and dilute with seawater to background concentrations within the projects mixing zone, which will also coincide with the Al Dur Phase 1 IWPPs mixing zone, due to the use of the existing shared outfall. Given that the brine wastewater is more dense than ambient seawater, it is expected to sink through the water column as mixing takes place, contrasting with the buoyant nature of thermal components of the discharge. Impacts relating to brine and thermal effluent will be assessed in the marine environment section of the EIA.

Other wastewater will be generated from sanitary systems, and mechanical processes on site. Wastewater streams will be treated at on-site at the respective treatment facilities (either chemical / oily or sanitary treatment plants) prior to mixing with other wastewater effluents and discharged at the project shared outfall with the Al Dur Phase 1 IWPP.

Impacts related to inadequate solid and liquid waste management can impact on soil, groundwater or marine water quality, landscape and visual effects (e.g. unattended materials that are blown away by wind) or in marine and terrestrial ecosystems (e.g. accumulation of plastics in the marine environment, algae blooms, etc.,).

10.4 Mitigation and Management Measures

10.4.1 Waste Characterization

Waste can exhibit certain characteristics according to the process stream from which it is generated and any pre-treatment processes that are undertaken. Different types of waste require different management and disposal techniques according to the potential risk that the material poses to human health or the environment. For the purpose of this Project, waste has been classified into four (4) main categories below.

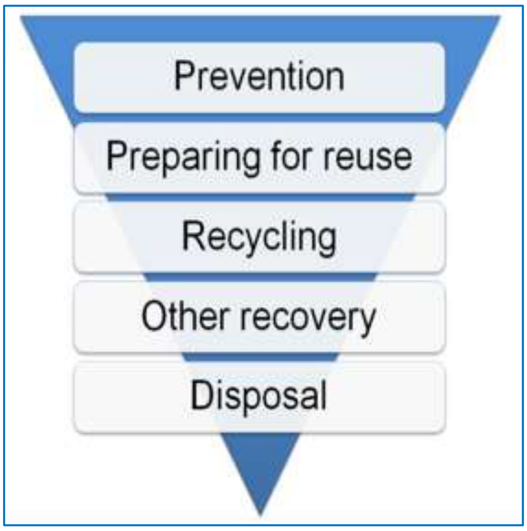
Table 10-4 Waste Characterization

WASTE CLASSIFICATION	DESCRIPTION
Domestic Waste	Household, commercial, agricultural, governmental, industrial and institutional wastes, which have chemical and physical characteristics similar to those of household such as garbage, paper, cardboard, plastic, cans, etc. Disposal of such waste can generally be routed to municipal recycling or disposal facilities
Industrial Waste	Non-hazardous wastes that have physical and chemical characteristics that are different from domestic wastes such as construction waste, glass, scrap metal, wood, used containers, tyres etc. This waste generally poses little risk to the environment and can be disposed to normal municipal facilities after waste minimisation options are exhausted and prior obtaining approval
Hazardous Waste	Waste is classified as being hazardous because of its concentration; physical, chemical or infectious characteristics, which may pose a present or potential threat to human health or the environment and/or may cause an increase in serious irreversible or incapacitating reversible illness or contribute to an increase in mortality. In accordance with the Basel Convention, hazardous waste is any waste (i.e. solid, liquid or gaseous) having the following properties: • Explosive; • Radioactive (which includes NORM (LSA) scale); • Ignitable or flammable substances; • Poisons with acute and chronic (delayed) toxicity; or • Substances that by interaction with water might become spontaneously flammable or give off flammable gases. • Hazardous waste must be segregated, stored, transported and ultimately treated and disposed by approved waste services provider.

10.4.2 Waste Management Hierarchy

The waste management hierarchy illustrates best practice for waste management considerations by ensuring consideration of the most sustainable available application for waste management in preference of disposal and eventual contribution to adverse environmental and economic impacts associated with landfill. The hierarchy as illustrated below should form a key element of any waste management strategy and if implemented effectively will achieve maximum reductions on waste quantities combined with the limited use of resources and fill space. The waste management hierarchy also has the potential to reduce costs that may be incurred by the main contractor or the proponent for handling, transportation and the disposal of waste.

Figure 10-1Waste Hierarchy



Initially, options to prevent or reduce waste should be considered. Where waste generation cannot be avoided or further reduced at source, opportunities for reuse of materials should be explored, either for use for the same or a different purpose. Disposal to landfill is the least favoured option in the waste hierarchy and is the last resort after all other options have been considered.

10.4.3 Construction Phase Mitigation and Management Measures

Table 10-5 Solid & Liquid Waste Mitigation and Management Measures - Construction

IMPACT/SOURCE	MITIGATION AND MANAGEMENT MEASURES
Inappropriate handling, storage, transport and disposal of solid non-hazardous waste	• The project will develop and implement a Project specific Construction Waste Management Plan (CWMP) in line with committed mitigation measures in this ESIA report and the provisions of the CESMP. • Domestic solid wastes to be segregated and identified from the other waste streams into separate waste containers/skips clearly to facilitate recycling and reuse. • Waste containers/skips should be clearly labeled and placed in designated waste storage locations. Labels will be waterproof, securely attached, and written in English and other languages as required for the workforce. • For litter (food waste, domestic waste), an adequate number of covered bins should be strategically placed throughout the site at

IMPACT/SOURCE	MITIGATION AND MANAGEMENT MEASURES
	locations where construction workers and staff consume food. These will be regularly collected and taken to the main waste storage area. • Food waste must be stored within a sealed metal or plastic skip or bin, in order to prevent pests gaining access. • On-going housekeeping training should be provided to all staff on the importance of the need to avoid littering. • Heavy waste may be contained within an open skip, provided that segregation occurs effectively enough to remove all lightweight material that could be blown away. • Waste generated during construction will be recycled and reused until reduced to as low as practicable prior to collection for disposal by an appropriately licensed waste contractor. • Only licensed waste transporters and waste management facilities will be engaged. • The Contractor will maintain copies of the waste management licensed on site. • Develop and maintain a waste inventory to document and track domestic solid wastes generated, segregated, reused and consignments • Completed waste manifests are required to show the chain of custody of the waste generated on site, its transportation and treatment/disposal. All records will be maintained on site. • Mandatory training program for employees to increase their awareness of waste management protocols including proper handling and storage of waste, recycling waste, reusing plastics, rebar, wood & other reusable non-hazardous materials.
Inappropriate/uncontrolled handling, storage, transport and/or disposal of solid hazardous waste	• Develop and maintain a hazardous waste inventory to document and track hazardous wastes generated, segregated, reused and consignments. • Segregate and identify hazardous waste from the other waste streams into separate waste containers/skips clearly signed and labeled. • Store hazardous waste in allocated impervious hard standing areas in sealed containers stored with impermeable bases, sufficient containment and separation capacity, sun/rain shelter, separate drainage system, good ventilation and equipped with spill kits & spill response procedures. This area must be placed away from any sources of ignition. • Hazardous waste storage area should be constructed away from drainage system and a rain shelter to avoid any potential instance of runoff, or leakage of runoff. • Waste containers should be clearly marked with appropriate warning labels to accurately describe their contents and detailed safety precautions. Labels will be waterproof, securely attached, and written in English and other languages as required for the workforce. Wherever possible, chemicals will be kept in their original container. • Keep hazardous waste storage areas away from any ignition sources or fire hazards.

Impact/Source	Mitigation and Management Measures
Inappropriate/un controlled handling, storage, transport and/or disposal of sanitary wastewater	• Contractor to develop and implement a Project Specific Construction Waste Management Plan (CWMP) in accordance with committed mitigations measures in this ESIA report and provisions of the CESMP. • Develop and maintain a hazardous waste inventory to document and track sanitary waste generated and segregated. • Sanitary wastewater tanks should be placed in allocated impervious hard standing areas with bonding capacity to hold 110% volume of the maximum volume stored. • Sanitary wastewater tanks to be properly maintained and inspected to ensure tanks do not overflow. • Site inspections will be carried out regularly by the EPC contractor to ensure that all wastewater generated is properly managed, and no leakages or spill occur. In the event of a spill or overflow, immediate action will be taken in accordance with spill containment procedures and clean up procedures (to be developed in line with the CESMS). • Engage a licensed waste contractor for the periodic removal of tank. • In common with the IFC EHS Guidelines, effort will be made in training construction personnel to minimise water consumption for ablutions and to ensure an understanding of water resource and wastewater issues.
Inappropriate handling and disposal of contaminated soil from clearing and excavation works causing cross-contamination of soils	• In-situ testing of soil to ensure it is not contaminated and can be re-used or disposed into land. • Training –Contractor staff to be able to identify signs of potential contamination (smell of HC, staining). • If contamination is found, develop and implement a Contaminated Soil Management Plan for appropriate handling, treatment and disposal of soil

10.4.4 Operational Phase Mitigation and Management Measures

Table 10-6 Solid & Liquid Waste Mitigation and Management Measures- Operation

Source	Mitigation and Management Measures
Inappropriate handling, storage, transport and disposal of non-hazardous solid waste	• Contractor to develop and implement a Project specific Construction Waste Management Plan (CWMP) in line with committed mitigation measures in this ESIA report and the provisions of the CESMP. • Training will be provided to employees to ensure awareness of waste management including proper waste; training and orientation on waste minimisation, segregation and good housekeeping practices. • Domestic solid wastes to be segregated and identified from the other waste streams into separate waste containers/skips clearly to facilitate recycling. • Waste containers/skips should be clearly labeled and placed in designated waste storage locations. Labels will be waterproof, securely attached, and written in English and other languages as required for the workforce. • For litter (food waste, domestic waste), an adequate number of covered bins should be strategically placed throughout the site at locations where

Source	Mitigation and Management Measures
	construction workers and staff consume food. These will be regularly collected and taken to the main waste storage area. • Food waste must be stored within a sealed metal or plastic skip or bin, in order to prevent pests gaining access. • Heavy waste may be contained within an open skip, provided that segregation occurs effectively enough to remove all lightweight material that could be blown away. • Paper cardboard, metal cans, plastic, glass to be collected for recycling by a licensed waste contractor. • Only licensed waste transporters and waste management facilities will be engaged. • The Contractor will maintain copies of the waste management licensed on site. • Develop and maintain a waste inventory to document and track domestic solid wastes generated, segregated, reused and consignments • Completed waste manifests are required to show the chain of custody of the waste generated on site, its transportation and treatment/disposal. All records will be maintained on site.
Inappropriate/un controlled handling, storage, transport and/or disposal of sanitary wastewater	• Sanitary facilities should be provided with adequately designed underground storage tanks. • Sanitary wastewater tanks to be properly maintained and inspected to ensure tanks do not overflow. • Sanitary wastewater tanks in allocated impervious hard standing areas with bunding capacity of 110% volume of the maximum volume stored. • Sanitary wastewater treated at the onsite sewage treatment plant must meet established discharge limits prior to discharge. • Where there are no onsite sewage treatment plant, a licensed waste contractor will be engaged for the periodic removal of tank.
Discharge of brine and thermal effluent	• All wastewater will either be treated at site prior to discharge or reused or transported off site. • Discharge of untreated backwash to the marine environment will be prohibited.
Inappropriate/un controlled handling, storage, transport and/or disposal of solid hazardous waste	• Develop and maintain a hazardous waste inventory to document and track hazardous wastes generated, segregated, reused and consignments. • Segregate and identify hazardous waste from the other waste streams into separate waste containers/skips clearly signed and labelled. • Store hazardous waste in allocated impervious hard standing areas in sealed containers stored with impermeable bases, sufficient containment and separation capacity, sun/rain shelter, separate drainage system, good ventilation and equipped with spill kits & spill response procedures. This area must be placed away from any sources of ignition. • Waste containers should be clearly marked with appropriate warning labels to accurately describe their contents and detailed safety precautions. Labels will be waterproof, securely attached, and written in English and other languages as required. Wherever possible, chemicals will be kept in their original container.

11 CHEMICALS

This chapter assesses the anticipated chemical for use by the Project during the construction and operational phases of the Project. It does not consider the significance of impacts with respect to a specific receptor (i.e. soil or groundwater quality); as such impacts to soil or groundwater quality with respect to chemicals and hazardous materials management have been assessed in the respective section of this ESIA (Section 9 Geology, Soils and Groundwater and Section 10 Solid and Liquid Waste Management).

Therefore the primary purpose of this chapter is to identify specific management measures that can be adopted in the construction and operational phases ESMS' in regard to chemicals and hazardous materials in order to ensure compliance with applicable regulations and standards.

11.1 Standards and Regulatory Requirements

11.1.1 National Requirements

The management of chemicals in Bahrain comes under Ministerial Order No. 4 of 2006 with Respect to the Management of Hazardous Chemicals.

This Resolution aims at establishing an appropriate monitoring and management system for the management of hazardous chemical materials listed in *Ministerial Order No.7 of 2002 with Respect to the Control over the Import and Use of Banned and Strictly Restricted Chemicals* and any other chemicals specified by the SCE under this Regulation.

Additional regulations are provided in *Ministerial Order No. 3 of 2006 with Respect to the Management of Hazardous Wastes*, regarding the subsequent disposal of chemicals and materials.

11.1.2 Lenders Requirements

With regards to chemical management, the IFC Performance Standards requires adherence to IFC Performance Standard 3 on 'Resource Efficiency and Pollution Prevention' requires the client and/or the Project to:

- Avoid the release of pollutants or when avoidance is not feasible, minimise and/or control the intensity and mass flow of their release. This applies to the release of pollutants to air, water and land due to routine, non-routine and accidental circumstances with the potential for impacts.

- Avoid or, when avoidance is not possible, minimise and control the release of hazardous materials. In this context, the production, transportation, handling, storage and use of hazardous materials for project activities should be assessed
- Avoid the use of chemicals and hazardous materials subject to international bans or phase-outs due to their high toxicity to living organisms, environmental persistence, potential to bioaccumulation or potential for depletion of the ozone layer.

11.2 Observations and Baseline Conditions

The SCE, represented by the Environmental Assessment and Control Department monitors the import, export, use, storage and handling of chemicals used in industry and services of all kinds with the exception of human use or household cleaning products as well as other materials that are not used I the industrial processes such as pesticides, fertilizers, automotive lubricants, etc.

Hazardous materials include chemicals which are

- Carcinogens, toxic agents, irritants, corrosives, sensitizers; agents which act on the hematopoietic system;
- Agents which damage the lungs, skin, eyes, or mucous membranes; chemicals which are combustible, explosive, flammable, oxidizers, pyrophorics, unstable-reactive or water-reactive; and
- Chemicals which in the course of normal handling, use, or storage may produce or release dusts, gases, fumes, vapours, mists or smoke which may have any of the previously mentioned characteristics.

11.3 Potential impacts

11.3.1 Construction Phase

Hazardous materials will be transported to the site in small quantities during the construction phase and will be handled and stored on-site and in contractor temporary laydown areas. Examples of expected hazardous materials required during construction included:

- Diesel/fuel;
- Solvents;
- Lubricants;
- Resins and paints;
- Batteries;
- Adhesives and;
- Other VOCs

Poor handling, transportation and storage can potentially cause significant adverse impacts on human health and the environment, including soil contamination. Potential impacts to soil, groundwater quality and marine water quality have been assessed in other chapters.

11.3.2 Operational Phase

During the operational phase of the Project, few chemicals and hazardous materials will be used onsite including but not limited to oils and lubricants for the CCGT component if the Project and process chemicals required for water dosing and treatment for the SWRO component of the Project. The table below provides the indicative list of chemicals that the main components of the project will use during operations.

Table 11-1 Anticipated Chemicals for use during Operations

ID	Name	Type*	Constituents	Consumption (T/Y)	Usage**
SWRO Component					
1	Ferric Chloride	l	$FeCl_3$	1460	P
2	Sodium Metabisulfite	s	Na_2S2O_5	128	P
3	Antiscalant	l	Phosphonate	105	A
4	Caustic Soda	l	NaOH	365	P
5	Sodium Hypochlorite	l	NaOCl	365	P
6	Lime	s	$Ca(OH)_2$	6150	P
7	Carbon Dioxide	l	CO_2	6570	P
8	Potassium Silicate	l	K_2SiO_5	62	P
9	Polymer	s	Polymer	10	P
10	Caustic Soda	l	NaOH	17	CI
11-	Citric Acid	s	$C_6H_8O_7$	160	CI
12	Sulphuric Acid	l	H_2SO_4	48	CI
CCGT Component					
13-	Phosphate	s	Phosphate	5 (TBC)	P
14-	Ammonia	l	Ammonia	5 (TBC)	P
15-	O2 scavenger	l	O2 scavenger	5 (TBC)	P
16-	Sodium Hypochlorite	l	NaOCl	17 (TBC)	P
17-	Anti-scalant	l	Anti-scalant	10 (TBC)	P
18-	Sodium bisulfite	l	Sodium bisulfite	10 (TBC)	P
19-	Corrosion inhibitor	l	Corrosion inhibitor	20 (TBC)	CP
20-	Hydrochloric acid/		HCl	5 (TBC)	P
21-	Caustic soda		Caustic soda	5 (TBC)	P

* **s** = solid ; **l** = liquid, **g** = gas

** **C**leaning, **A**nti-scaling, in the **P**rocess, **C**orrosion **P**rotection, and Others Chemicals used

Mis-management of the above listed chemicals and hazardous materials either during transportation, handling, storage or during maintenance activities could lead to accidental spillage to the soil.

In order to minimise the potential of such occurrence, the above listed chemicals will be stored in designated chemical storage areas with impermeable base or in appropriate containers with secondary containment. This will ensure that in the event of an accidental spill or leakage, such chemicals will not overflow to the surrounding environment.

Potential impacts to soil, groundwater quality and marine water quality as a result of operation of the Project has been assessed in respective chapters of this ESIA.

11.4 Mitigation and Management Measures

Table 11-2 Chemicals Mitigation and Management Measures

Impact/Source	Mitigation and Management Measures
Construction and Operation	
Inappropriate/uncontrolled handling, storage, transport and use of chemicals and hazardous materials	• All chemical storage areas must be marked with signs and clearly delineated. • Chemical storage areas must be well ventilated and constructed to protect chemicals from sun, rain and other agents that could result in potential risk to the environment or affect their integrity of the chemicals. • Chemical storage areas should be secured and only accessible by trained personnel. • Storage of all chemicals/materials according to manufacturer's instructions and MSDSs; MSDSs for all chemicals to be readily available on-site in close proximity to storage areas. • An inventory of all potentially hazardous materials and chemicals used and stored on-site should be maintained. • Single oil drums to be stored on spill containment trays, but multiple drums must be inside a constructed impervious bund with a capacity of 110 % of the maximum volume stored. • Hazardous materials storage containers should be clearly marked and labelled in accordance with the instructions on the MSDS. • Appropriate warning labels should accurately describe contents of the storage container and the labels will be waterproof, securely attached, and written in English and other languages as required for the workforce. Wherever possible, chemicals will be kept in their original containers. • Chemical storage areas will not have open floor drains. If floor drains are installed, it will be equipped with protection to prevent leakage. E.g. tight fitting lids. • Acids and alkali-based chemicals should not be stored together. • Where combustible materials will be stored onsite, they must be stored in fireproof cupboards or stored in separate storage areas away from other hazardous materials.

12 NAVIGATION

This chapter assesses the projects impacts to existing navigational routes in proximity to the Project site during the construction and operational phases of the Project. It does not consider the significance of impacts with respect to a specific receptor (i.e. air, noise, marine ecology); as such impacts to such receptors with respect to navigation have been assessed in the respective section of this ESIA (Section 5 Air Quality, Section 8 Noise and Vibration and Section 9 Marine Environment, Hydrodynamics, Water & Sediment Quality).

12.1 Standards and Regulatory Requirements

No specific standards in relation to navigation activities have been identified from the desk study, although as part of the stakeholder consultation there will be dialogue with the Bahrain Coastguard and maritime organisations regarding any specific requirements that must be adhered to during the construction work close to the shoreline and any offshore surveying that may be required.

12.2 Observations and Baseline Conditions

Navigation system is designed to guide and control vessel movement systematically to avoid accident. Faulty navigation system can result in maritime accidents such as collision, grounding and stranding with a potential to cause marine pollution in the event of an oil spill.

The Project site is located in close proximity; approximately 800m from the north east corner of the Project site) to a small size harbour with relatively small fleet primarily related to tourism and fishing activities. The harbour includes several breakwater structures and jetties that have related impacts on maritime navigation, as shown in the satellite imagery below.

Figure 12-1 Overview of Existing Marine Navigation Obstacles (Ref. Project Site in Red)

12.3 Potential impacts

As the offshore components of the Project have already being constructed and are already operational as part of the Al Dur IWPP Phase 1 Project, no additional offshore works such as dredging is anticipated for the Project. The Al Dur IWPP Phase 2 Project will connect to the existing intake and outfall facilities without any major offshore construction works. However, there may be a requirement for survey boats to inspect the underwater facilities to check on the condition and any requirements to connect to the Phase 2 Pant.

As such, existing navigational routes or ongoing harbour activities are not anticipated to be impacted by construction activities as a result of the Project. During operations, it is likely that inspection of the intake/outfall facilities will be required from time to time as part of the planned maintenance programme or for periodic environmental monitoring surveys.

13 Tourism and Recreation

13.1 Standards and Regulatory Requirements

There are no specific standards in relation to tourism and recreation

13.2 Observations and Baseline Conditions

It is understood that construction activities or a new industrial development can negatively affect any specific reason that draws and creates touristic activity in a determined area, particularly in those that are recognised by their inherent natural beauty or other features that character the area.

Based on the observations made during the initial site visit and a basic secondary research, the tourism and recreation industry is not representative in the immediate project footprint. The only element related to the tourism and recreation industry is the harbour located to the northeast of the proposed Project site, and this will not be impacted by the Project during its lifecycle.

13.3 Potential impacts

13.3.1 Construction Phase

During the scoping study, potential impacts to tourism and recreational activities/ industry resulting from construction activities were not identified as being significant. However, ongoing consultation with the local boat owners carrying tourists, expat residents and Bahrainis to the Hawar Islands should be maintained during the construction phase to address any direct/indirect issues that may arise.

13.3.2 Operational Phase

Impacts to tourism and recreational activities / industry resulting from operational activities were not identified or deemed significant. However, ongoing consultation with the local boat owners carrying tourists, expat residents and Bahrainis to the Hawar Islands should be maintained during operations to address any direct/indirect issues that may arise.

14 TRAFFIC AND ACCESS

This section focuses on the transportation related impacts associated with the construction and operational phase of the proposed Project.

This chapter assesses transportation related impacts associated with the construction and operational phase of the proposed Project.

14.1 Standards and Regulatory Requirements

There are no specific standards in relation to traffic and access. However The Ministry of Transportation and Telecommunications (MITT) is responsible for all transport related activities and their requirements should be fully complied with in terms of routing of HGVs and site vehicles, licensing, road diversions, heavy/wide loads etc.

14.2 Observations and Baseline Conditions

14.2.1 Traffic and Transportation in Bahrain

Journeys within the Kingdom of Bahrain are typically made by road, which is affordable due to the low price of gasoline in the Kingdom. The Bahraini road network comprises routes ranging from four to six lane paved well lit, well maintained highways to narrow single lane tracks within & around villages and older parts of Manama & Muharraq.

More than 35 international airlines operate flight to and from the Kingdom of Bahrain. Bahrain International Airport is located at Muharraq Island is a regional hub for the Bahrain national carrier; Gulf Air, a 10 minute drive from the centre of the capital, Manama and approximately 33km from the Project site. This airport has a handling capacity of more than 100,000 passengers a week.

Beside the Bahrain International Airport, there are no other civil airports within the Kingdom. However, there are three (3) military airports within the Kingdom which included; the Shaikh Isa Air Base is located approximately 2.2km south of th project site, the Sakhir Air Base located approximately 10km west and the Riffa Air Base located approximately 15km north west of the Project site.

The Khalifa Bin Salman port is located in the north-east of Bahrain, in the Hidd Industrial Area. The port has a 1,800m quay which includes a 900m^2 container terminal served by four 61m post-Panamax cranes, as well as general cargo and passenger facilities. The port is located approximately 28km north -east of the project site.

A 25km causeway; the King Fahad Causeway which opened in 1986 links Bahrain with the Arabian Peninsula through Saudi Arabia. Ferries and steamers operate between Bahrain and other Gulf ports.

14.2.2 Site Based Observations

Road Network

The proposed site can be accessed by road for transport of materials, equipment and machinery and by workers. Approximately 450m west of the Project site is a modern road network. This comprises of a four-lane dual carriage way (the King Hamad highway) which links the southern region of Bahrain to the eastern region by connecting to the Hawar highway in a more or less south to east alignment.

An existing unpaved road runs parallel to the east of the Kind Hamad Highway and is approximately 400m west of the Project site. Transport to and from the Project site will be via an unnamed arterial paved route that links the unpaved road to the King Hamad Highway, as shown in the satellite image below.

Ports

A small harbour and jetty areas (primarily for tourism boats and fishing activities is located approximately 800m to the north east of the Project site.

Figure 14-1 Satellite Image of local Project Road Network (Source Google Earth)

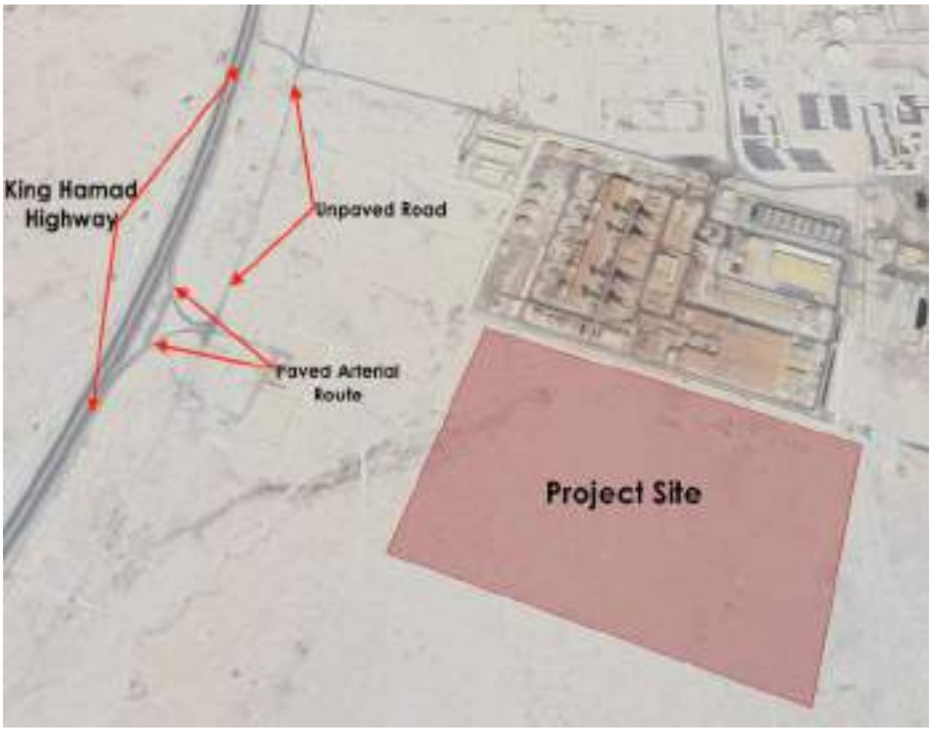


Figure 14-2 Existing Unpaved Access Road to the West of the Project Site

14.3 Receptors

Table 14-1 Traffic and Access – Receptor Sensitivity

Receptor	Sensitivity	Justification
Users of the King Hamad Highway	**Low**	Although this highway is well used, it still has sufficient spare carrying capacity. As such, the users of this highway are of low vulnerability to an increase in traffic on the highway.

14.4 Potential impacts

14.4.1 Construction Phase

The scope of construction includes the construction of a four lane (two-way dual carriageway) access road from the site to the existing King Hamad highway connection located to the west of the proposed project site.

Ports will likely be used to bring equipment/ plant into the Kingdom of Bahrain. The EPC Contractor has advised that, construction material & equipment will be shipped to Khalifa bin Salman Port. Following customs clearance, they will be transported to the Project site via trailers through Prince Khalifa bin Salman causeway, Sheikh Jaber A Al Subah Highway and King Hamad Highway. The distance from Port to Site is approximately 46km by road.

For heavy lifts such as gas turbines, generators, steam turbines and transformers, these will be offloaded through ship to barge then delivered to a Jetty in Askar area of Bahrain. Following customs clearance they will be transported to Project site by hydraulic trailers via the King Hamad Highway.

Construction activities will likely result in an increase of the numbers of movements of Heavy Goods Vehicles (HGV) and other vehicles for the delivery of heavy plant, equipment, materials or Project's staff transportation. The volume of traffic will vary over the course of construction, in accordance to the phase of construction, demand for materials, removals and construction personnel on site.

Impacts due to additional vehicular transportation are not expected to be significant due to the existing traffic flows and capacity of the nearby highway and such impacts have ben assessed in the Noise and Vibration Chapter of this ESIA. As such, impacts may not be noticeable and will be negligible.

Table 14-2 Traffic & Access Mitigation & Management Measures and Residual Impacts - Construction

Potential Impacts	Magnitude of Impact	Receptor	Sensitivity	Potential Impact Significance	Mitigation and Management Measures	Residual Impacts
Increased vehicle flow	**Negligible Negative**	King Hamad Highway	Low	**Negligible to Minor**	• A Traffic Management Plan will be developed to confirm the designated access routes, site entrance points, waiting and parking areas etc. The plan will outline how construction traffic, will be managed to limit impacts upon local communities, on-site personnel and other road users. • Construction access roads to be clearly signposted. • Buses will be used to transport labourers to/from the site. • Route directions will be placed from the King Hamad Highway exit into the project site.	**Negligible**

14.4.2 Operational Phase

In general transportation impacts during operations are not expected to be significant, as the operation of the CCGT and SWRO will not require continuous delivery of materials, or other equipment in order to operate. Occasional deliveries and waste removals are not expected to result in noticeable increases in vehicle traffic along the King Hamad Highway due to the existing flow capacity. Staff movements will also contribute to a minimal additional vehicle flows.

Table 14-3 Traffic & Transportation, Mitigation & Management Measures and Residual Impacts - Operation

Potential Impacts	Magnitude of Impact	Receptor	Sensitivity	Potential Impact Significance	Mitigation and Management Measures	Residual Impacts
Increased vehicle flow	**Negligible Negative**	King Hamad Highway	Low	**Negligible to Minor**	• A Traffic Management Plan will be prepared which identifies preferred access routes • Wherever possible deliveries and waste removals will be scheduled outside of peak hours.	**Negligible**

15 SOCIO-ECONOMICS

15.1 Standards and Regulatory Requirements

International Financial Institutions (IFI's) will require adherence to IFC Performance Standard 1. This standard establishes requirements for the assessment of social risk and impacts associated with the project.

IFC Performance Standard 2 places an emphasis on the safety, security and well-being of the projects workforce and ensures that they have appropriate working rights and access to services and facilities. This Performance Standard will also be assessed within the ESIA.

15.2 Observations and Baseline Conditions

15.2.1 Population and Demographics

According to the CIA World Factbook, the population of Bahrain was estimated to be 1,4442,659 as of July 2018 of which approximately 692,476 individuals are non-nationals/ immigrants representing 48% of the total population. The population has experienced rapid growth over the last five decades with the official growth rate estimate putting the current rate of annual growth at 2.19% as of 2018.

73.7% of the population in Bahrain are Muslims, 9.3% Christians, 0.1% Jewish while other religions represent 16.9%.

Bahrain has the smallest population among the Gulf States but urbanization rate exceeds 90%. Largest settlement concentration is found in the far northern end of the Island, in and around Manama and Muharraq. Approximately 565,000 individuals reside in Manama the capital city.

The table below gives a summary of Bahrain population information.

Table 15-1 Bahrain Population Data Summary

CRITERIA	DATA (2018 ESTIMATES UNLESS OTHERWISE STATED)
Population	1,442,659 Including 692,476 non-nationals
Age Structure	0-14 years: 18.8% (male 138.309/ female 134,067) 15-24 years: 15.49% (male 126,564 /female 96,834) 25-54 years: 56.06% (male 527,417 /female 281,391) 55-64 years: 6.49% (male 59,404 /female 34,284) 65 years and over: 3.08% (male 22,258 /female 22,131)

CRITERIA	DATA (2018 ESTIMATES UNLESS OTHERWISE STATED)
Median Age	Total: 32.5 years Male: 34 years Female: 29.8 years
Annual Growth	2.19%
Urbanisation	89.3% of total population 4.38% annual rate of change (2015-2020 estimate)

Source:https://www.cia.gov/library/publications/the-world-factbook/geos/ba.htmlAccessed 25th November 2018

15.2.2 Economy and Employment

Although prone to fluctuation, oil production and Bahrain's fast growing financial centre are the primary components of the Island's economy and employment. Despite the government's effort to diversify the economy, oil still accounts for more than half (85%) of Bahraini budget revenues. In the last few years' lower world energy prices have generated sizable budget deficits - about 10% of GDP in 2017 alone. Other major economic activities are production of aluminum - Bahrain's second biggest export after oil and gas –finance, and construction. Bahrain continues to seek new natural gas supplies as feedstock to support its expanding petrochemical and aluminum industries.

Official figures from the CIA World Factbook 2017 place the Gross Domestic Product (GDP) of Bahrain at approximately $71.17 billion. National GDP growth rate for 2017 was estimated to be 3.8%.

As of 2017, official records estimate the total labour force in the Kingdom to be approximately 831,600 individuals with the exclusion of the unemployed. About 44% of these individuals aged between 15 to 64 years are non-nationals. Unemployment rate in the country was estimated to be 3.6%.

Official inflation figures for 2017 place the level of general annual Inflation rate at 1.4%, with a major influencing factor being the removal of subsidy from meat, diesel, kerosene and gasoline with the government phasing in higher prices for electricity and water.

Table 15-2 Summary of Bahrain Economic Data

CRITERIA	DATA (2017 ESTIMATE)
GDP (Purchasing Power Parity)	US$ 71.17 billion
GDP (Official Exchange Rate)	US$ 35.33 billion
GDP (Real Growth Rate)	3.8 %
GDP per Capita	US$ 49,000

CRITERIA	DATA (2017 ESTIMATE)
Industrial Production Growth Rate	0.6%
Labour Force	831,600
Unemployment Rate	3.6%
Budget	**Revenues**: 5.854 billion **Expenditures**: 9.407 billion
Inflation Rate (Consumer Prices)	1.4%
Exports	$15.38 billion
Imports	$16.08 billion

Source: https://www.cia.gov/library/publications/the-world-factbook/geos/ba.html Accessed 25th November 2018

15.2.3 Social Development & Infrastructure

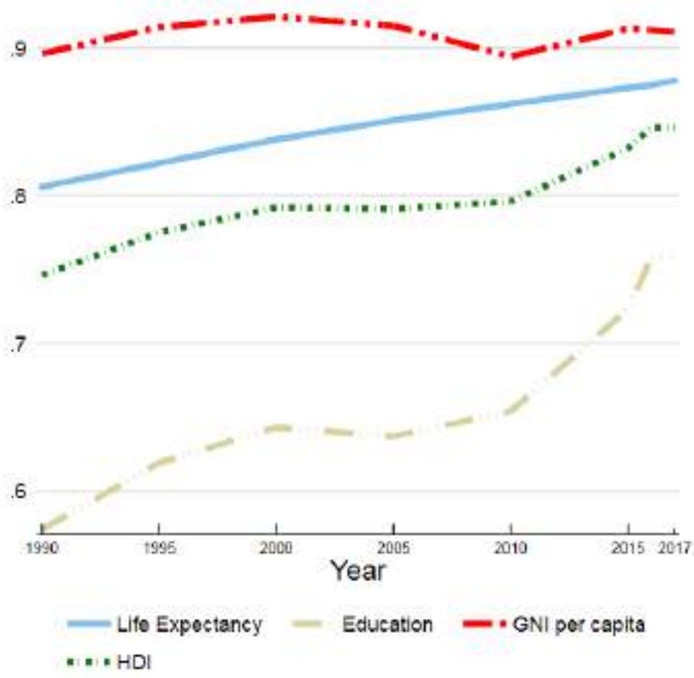
Using the United Nations Human Development Index as a guide, Bahrain is ranked 43 out of 189 countries with an index score of 0.846(2017) placing it within the Very High Human Development category. This places Bahrain within the global top 50 at an overall level and compares favourably with the regional average (0.699).

Between 1990 and 2017, Bahrain's HDI value increased from 0.746 to 0.846, an increase of 13.4%. The table below reviews Bahrain's progress in each of the HDI indicators. Between 1990 and 2017, Bahrain's life expectancy at birth increased by 4.6years, mean years of schooling increased by 3.4years and expected years of schooling increased by 2.6years. Bahrain's Gross National Income per capita increased by about 10.5% between 1990 and 2017.

Table 15-3 Bahrain HDI Trends Based on Consistent Time Series Data and New Goalposts

YEAR	LIFE EXPECTANCY BY BIRTH	EXPECTED YEARS OF SCHOOLING	MEAN YEARS OF SCHOOLING	GNI PER CAPITA (2011 PPP $)	HDI VALUE
1990	72.4	13.4	6.0	37,622	0.746
1995	73.4	13.7	7.2	42,395	0.775
2000	74.4	13.2	8.3	44,452	0.792
2005	75.3	12.8	8.4	42,678	0.791
2010	76.1	13.5	8.4	37,244	0.796
2015	76.8	14.8	9.3	42,178	0.832
2016	76.9	16.0	9.4	41,918	0.846
2017	77.0	16.0	9.4	41,580	0.846

Figure 15-1 Trends in Bahraini's HDI Component Indices 1990-2017



Source: United Nations Human Development Indices and Indicators: 2018 Statistical Update

15.2.4 Administrative Structure of Bahrain

Administratively, the Kingdom of Bahrain is divided into four Governorates which includes:

- Manama;
- Muharraq;
- Northern Area; and
- Southern Area.

The project area is located within the Southern Governorate.

15.2.5 Indigenous People and Physical Displacement

There are no ethnic minorities, indigenous groups, internally displaced people or any evidence of land use likely to be attributable to indigenous peoples within the project site area or immediate adjacent areas.

15.2.6 Commercial and Industrial

Other than the existing power and desalination plants; Al Dur IWP, Al Dur Phase 1 IWPP approximately 800m north an directly adjacent to the northern boundary of the Project site and the tourism boat jetty/habour approximately 80m north east of the Project site, there are no other facilities of commercial or industrial importance within 1km of the project site.

15.2.7 Site Based Observations

Based on site observations and review of satellite imagery, there are no residential or commercial activities on-going within the proposed project site. As such, the project will not result in economic or physical displacement.

15.3 Receptors

Figure 15-2 Potential Socio-Economic Receptors

RECEPTOR	SENSITIVITY	JUSTIFICATION
Welfare of Local Population	**High**	Any change to infrastructure, population or regional inputs is likely to have knock on effects for the welfare of the local population.
Local / Regional Economy	**Low**	The proposed project is likely to influence regional businesses. Not only local contractors and those directly involved in the construction, but also for local commercial operations such as accommodation, food retailers etc.
Employment Market	**Medium**	The development of the Project will result in the creation of employment opportunities and will offer an opportunity for greater dissemination of skills.

15.4 Potential impacts

15.4.1 Construction Phase

The primary economic impact during construction is likely to result from employment creation during this phase. As well as the direct monetary uplift to the families of those employed, money paid to workers will also stimulate the local economy via the multiplier effect, whereby money earned on the project expended locally will re-circulate within the local economy. Whilst we have no evidence quantifying the multiplier effect within Bahrain studies undertaken in Europe and the US suggests the impact of expenditure on a local economy prior to leakage to be in the order of 4:1.

Notwithstanding the above, our experience of similar sites in the Middle East suggests that a lack of available construction workforce among the immediate local population makes it probable that a significant proportion of work on the site will be undertaken by expatriate workers. This could result in the repatriation of wages and a reduction in the benefit to the local economy of wage expenditure.

In addition to the direct monetary impact of employment created during construction, there also exists the potential for the project to promote the dissemination of construction and construction support skills from expatriate workers into the local labour force.

A secondary impact is likely to arise from spending on local and foreign goods and services during the construction process. The nature of the development, and specialised nature of required materials, suggests that these will be sourced internationally, apart from construction materials (e.g. concrete, cabling, etc.).

There are no ethnic minorities, indigenous peoples or internally displaced people in the project area, or nearby. Therefore, the potential negative social impacts of the project are likely to be relatively limited due to the relative isolation of the project.

Table 15-4 Socio-Economics Impact Significance, Mitigation & Management Measures and Residual Impacts-Construction

POTENTIAL IMPACT	MAGNITUDE OF IMPACT	RECEPTOR	SENSITIVITY	IMPACT SIGNIFICANCE	MITIGATION AND MANAGEMENT MEASURES	RESIDUAL IMPACTS
Employment Opportunities	**Minor Positive**	Employment Market	Medium	**Minor Positive**	• Contractor should seek to employ local workers where possible. • The EPC and Sub-Contractors HR Policy will be prepared to ensure consistency in line with local labour laws and international ILO and UN conventions. The EPC Contractor is to ensure that this is applied as an overarching policy for all sub-contractor company HR policy as part of their contractual arrangements.	**Minor Positive**
Training and dissemination of construction skills	**Minor Positive**	Welfare of Local Population	High	**Minor to Moderate Positive**	• All project workers will receive induction training at the project, as well as vocational specific training for on-site construction works. • All workers will receive training in regard to health and safety, as well as environmental awareness. • Toolbox talks will be conducted before work on each day to ensure workers are reminded of key topics. • Cultural awareness training for all foreign workers.	**Minor to Moderate Positive**
Purchase of construction materials locally	**Minor Positive**	Local / Regional Economy	Low	**Negligible to Minor Positive**	• Contractor to purchase goods and materials from the local/regional economy where possible	**Negligible to Minor Positive**

15.4.2 Operational Phase

At a strategic level the operation of the CCGT and SWRO facilities offers potential to support the continued growth of the local and national economies, through the provision of sufficient power & water supplies and strategic economic development of Bahrain.

As with the construction phase, a significant economic impact during operation will result from any local employment created by the project. Whilst the size of the required workforce is significantly smaller, the type of work and the increased time-scales involved offer an opportunity for greater dissemination of skills. A targeted system of local recruitment and investment in the human capital of the local workforce will enhance this process and consequently increase the benefit to the local economy.

Table 15-5 Socio-Economics Impact Significance, Mitigation & Management Measures and Residual Impacts-Operation

Potential Impact	Magnitude of Impact	Receptor	Sensitivity	Impact Significance	Mitigation and Management Measures	Residual Impacts
Supply of power & potable water	**Moderate Positive**	Electricity and Water Authority (EWA)	High	**Moderate to Major Positive**	• Ensure the appropriate operation and maintenance of the CCGT & SWRO facilities to enable provision of sufficient power and a secure supply of portable water	**Moderate to Major Positive**
Employment Opportunities, facilitating development and dissemination of skills	**Minor Positive**	Employment Market	Medium	**Negligible to Minor Positive**	• The projects recruitment policy will ensure a preference for employing workers from the local population where appropriately skilled workers are available locally (or if unskilled positions are available). • The HR Policy will be prepared to ensure consistency with the ACWA Power corporate policy which will ensure compliance with local labour laws and international ILO and UN conventions. • Workers will be encouraged to develop their careers and may be provided with opportunities to attend training courses and other career development processes. • Training plans to be developed and implemented to facilitate career development and advancement within the local workforce.	**Negligible to Minor Positive**

16 Cultural Heritage and Archaeology

16.1 Standards and Regulatory Requirements

16.1.1 National Requirements

The Bahrain Authority for Culture and Antiquities (BACA) is responsible for overseeing the culture sector in the Kingdom i.e. the Culture and National Heritage Sector which is responsible for planning and promoting various programmes related to culture, arts and heritage in the Kingdom with the vision to update and develop the cultural infrastructure and activate the role of culture in social and economic development.

The sector also supports cultural movements of Bahrain through developing the role of museums, folklore, and other cultural components within Bahraini society with the aim of enhancing the local community's knowledge about its origins and civilization which date back to several millennia.

These programmes and initiatives seek to enhance the awareness of Bahraini's culture and ensure that cultural and archaeological sites are provided suitable rehabilitation, protection and preservations.

16.1.2 Lenders Requirements

In accordance with the Equator Principles' requirements for projects located in non-OECD countries (as defined by the World Bank Development Indicators Database), the assessment will refer to applicable IFC Performance Standards on Social and Environmental Sustainability, specifically with due consideration of IFC Performance Standard 8 on Cultural Heritage.

16.2 Observations and Baseline Conditions

16.2.1 Cultural Heritage and Archaeological Sites in Bahrain

Bahrain has a rich cultural history and a number of historical assets including archaeological remains (both inland and offshore), historic monuments and areas of historic urban character. There have been archaeological excavations at several sites, specifically within the north of Bahrain, providing key information on the nation's historical timeline. These studies have shown Bahrain to be a historical important place that was a vital trading point in the Gulf.

However, it was only in the 19th century that the archaeological landscape of Bahrain was brought to international attention. In 1879, the discovery of a shoe-shaped inscription in Bilad Al-Qadim established the links between ancient Bahrain and Mesopotamia. Moreover, the report of thousands of burial mounds on the Island paved the way for the archaeological exploration of Bahrain. In 1953, the arrival of the Danish archaeological expedition to Bahrain put an end to over seventy years of occasional research. The ground breaking discoveries at the sites of Barbar and Qal'at Al-Bahrain confirmed the historical significance of Bahrain and its identification with Dilmun.

Over the past decades, major archaeological work has been undertaken across Bahrain by both local and international teams. The results of those excavations produced seminal research and uncovered major episodes in the settlement history of Bahrain from the first prehistoric sites and glorious Dilmun settlements, burials and temples to the extraordinary Tylos cemeteries and Islamic sites.

16.2.2 International Cultural Heritage Sites in Bahrain

According to the UNESCO World Heritage List and the Bahrain Authority for Culture and Antiquities (BACA), there are two (2) cultural sites in Bahrain designated on the World Heritage List (year of designation in brackets):

- Qal'at Al-Bahrain, the Ancient Harbour and Capital of Dimun (2005) and
- Pearling, Testimony of an Island Economy (2012)

A number of sites have also been included in the UNESCO Tentative List and these included

- Hamad Town Tumuli Moundfield (2001)
- Barbar Temple (2001)
- Saar Heritage Park (2001)
- Hawar Islands Reserve (2001)
- Burial Ensembles of Dilmun and Tylos (2008)
- Manama, City of Trade, Multiculturalism and Religious Coexistence (2018)

16.2.3 Archaeological and Cultural Heritage Sites in Bahrain

Archaeological features and items of cultural heritage in Bahrain not of international interest include:

- The Dilmun Settlement;
- Barbar Temple;
- Saar Settlement;

- Deraz Temple;
- Khamis Mosque;
- Burial Mounds found in A'ali and Hamad town, etc.

16.2.4 Project Site Observation

Based on the observations made during the site visits and a basic secondary research, there are no features of cultural value or evidence suggesting the presence of archaeological features within the proposed Project footprint.

No archaeological sites within or nearby the Project site have been referenced in publicly held data such as the Bahrain Authority for Culture and Antiquities website.

16.3 Receptors

Table 16-1 Archaeology & Cultural Heritage – Sensitive Receptors

Receptor	Sensitivity	Justification
Unknown Buried archaeological artefacts or remains	**Low**	The proposed project site or local area is generally not known to be of importance archaeologically or culturally. As such, the only expected receptors relate to potential underground buried artefacts. Such unknown buried artefacts may be of importance on a local scale.

16.4 Potential impacts

16.4.1 Construction Phase

Excavation and earthwork activities can result in damage and destruction of undiscovered archaeological artefacts.

Given the absence of cultural heritage features and lack of evidence of previous land use before industrial development took place in the area, the presence of archaeological features within the project footprint is likely to be low.

A "Chance Find Procedure" will however be incorporated within the project CESMP such that in the unlikely event any items of archaeological significance are discovered, these can be appropriately managed by archaeological experts and identified, recovered and preserved.

16.4.2 Operational Phase

The operational phase will not result in further impacts to cultural heritage, as the site will be static and further excavations will not be required.

Table 16-2 Cultural Heritage and Archaeology Impact Significance, Mitigation & Management Measures and Residual Impacts - Construction

Impacts	Magnitude of Impacts	Receptor	Sensitivity	Impact Significance	Mitigation and Management Measures	Residual Impacts
Accidental destruction of unknown archaeological resources buried within the Project site.	**Minor Negative**	Unknown Buried archaeological artefacts or remains	Low	**Negligible to Minor**	• An archaeological 'Chance Find Procedure' will be developed prior to construction and the start of site earthworks, as part of the CESMP. This will include protocols and procedures to stop work and methods preserve potential finds, as well as reporting requirements and co-ordination with the Bahrain Authority for Culture and Antiquities. • Where artefacts or archaeological remains are encountered, the site will be clearly signed/delineated with high visibility flagging to impede access and prevent any damage or loss of the artefacts which have just been found. • Contractor crew to be informed during morning toolbox meeting about any suspected archaeological finds to avoid disturbance. • Removal of any archaeological artefacts from the site by site workers is strictly prohibited.	**Negligible**

Table 16-3 Cultural Heritage and Archaeology - Monitoring Requirements

Monitoring	Parameter	Frequency & Durations	Monitoring Location
Construction			
Archaeological Resources & Artefacts	Undiscovered archaeological remains within the Project site	Daily continued visual observations by site staff involved in excavations.	The Project area requiring excavations, earthworks or grading during construction and operation

17 Landscape & Visual Quality

17.1 Standards and Regulatory Requirements

Specific legislation in regard to landscape and visual assessment has not been published in Bahrain to date. Therefore reference to the guidelines set out by the UK Landscape Institute 'Guidelines for Landscape and Visual Impact Assessment 3rd Edition' (2013) has been used for this assessment. As such, The 'Landscape and Visual Assessment' presented herein will distinguish between:

- Effects on landscape as a resource in its own right; and
- Effects on specific views and general visual amenity experienced by people.

17.2 Observations and Baseline Conditions

17.2.1 Landscape

Landscape character could be defined as "a distinct, recognisable and consistent pattern of elements, be it natural (soil, landform) and/or human (for example settlement and development) in the landscape that makes one landscape different from another, rather than better or worse" (Natural England, 2014).

The landscape within the Project site is characterised by a mixture of residential, commercial and industrial facilities. The proposed project will be constructed on a predominantly undeveloped land with the landscape typology characterised by flat plains of sand (sand sheets) with sparse low-lying vegetation and coastline.

Following the development of the Al Dur IWP and Al Dur Phase 1 IWPP, the Project area has undergone character changes to a more industrialised feel and sight. This is visually apparent by the development of large metal and concrete superstructures (i.e. storage tanks and stack structures) which create a vertical anthropogenic intrusion into the existing landscape..

17.2.2 Visual Quality

When establishing the value of views and visual amenity, the inter-relations between individuals or groups of people and landscape will be considered such as the change of views that people have of the landscape and the effects of change on their visual amenity. The visual baseline has therefore been established by:

- Identifying views, viewpoints and extent of possible visibility;
- Identifying receptors that may be affected.

Besides views of the large superstructures of the industrial facilities in close proximity to the site; Al Dur Phase 1 IWPP and Al Dur IWP which have resulted in an amount of disturbance to the visual envelope of the landscape, views across the Project site is typical of the typology found in a desert environment.

Besides existing industrial receptors, findings from the site visits undertaken within the site and satellite imagery of the site identified residential & commercial receptors within 1km of the Project boundary. This included the Al Dur Residences approximately 400m south east of the Project site and a tourism boat jetty/harbour approximately 800m north east of the Project site.

Other visual residential/commercial receptors are several kilometres away from the Project boundary and have no direct visibility of the Project site.

17.3 Receptors

The potential landscape and visual receptors are presented in the table below.

Table 17-1 Landscape and Visual Impacts – Sensitive Receptors

Receptor	Receptor Type	Sensitivity	Justification
Landscape Character	Open area- Across the entire Project site	**Low**	Local landscape character is considered to be of medium sensitivity due to presence of industrial, residential and commercial receptors within 1km of the Project site.
Al Dur Residences	Residential	**High**	Residents of the Al Dur Residences have a direct visibility of the Project site and will be particularly vulnerable to changes in landscape character and views.
Tourism Boat Jetty/Harbour	Commercial	**Medium**	Users of the Habour have a direct visibility of the Project site and will be relatively vulnerable to changes in landscape character and views.

17.4 Potential impacts

17.4.1 Construction Phase

Change in Landscape Character

The construction of a new development, particularly those on a large scale have the potential to result in changes to the landscape character of a locality through land use and topographical changes or other factors. In situations where the visual horizon is disturbed by a development, such impacts may include the anthropogenic intrusion of the landscape by buildings/structures where no intrusion previously existed; or the change in the landscape character of an area, which could arise from new/out of place development or from changes in the land use.

One of the first stages of construction activities will result in the levelling, grading and preparation of the site prior to the commencement of construction. However, given the existing flat nature of the site, grading and levelling activities are not expected to be extensive. Also, the development of the CCGT and SWRO plant is not expected to result in significant changes to the landscape character of the area as the new structures to be installed and constructed for the Project will embed with the existing large superstructures of the industrial facilities in close proximity to the site.

Reduction in Visual Quality

The movement of heavy construction vehicles and earthworks on sandy surfaces can potentially result in dust generation and a resulting temporary haze causing disturbance to the current visual envelope of receptors.

Impacts to the visual envelope of surrounding receptors will also occur at night where the addition of lighting during construction will illuminate the proposed project area. The use of lighting across the site will result in a night time light haze likely to be visible for several kilometres from the project area. However, it is not anticipated to have a significant impact on receptors due to the existing lighting at industrial facilities within the Project area.

Any impacts from lighting are anticipated to be minimised by the implementation of a CESMP on-site.

Table 17-2 Landscape and Visual Quality Impact Significance, Mitigation & Management Measures and Residual Impacts-Construction

Potential Impact	Magnitude of Impacts	Receptor	Sensitivity	Impact Significance	Mitigation and Management Measures	Residual Impacts
Changes in Landscape Character	**Minor Negative**	Landscape character of the entire Project site	Low	**Negligible to Minor**	• Land clearance to be limited within the boundaries of the Project site. • Construction works to be limited within the boundaries of the Project site.	**Negligible**
Changes in landscape character and Disturbance to Visual Envelope of Receptors	**Minor Negative**	Al Dur Residences	High	**Minor to Moderate**	• Where appropriate, construction laydowns and working areas of the site will be screened to reduce the visual intrusion to existing off site receptors. • When not in use, cranes and other construction plant will be lowered, so they are at their minimum height and do not protrude unnecessarily within the visual envelope of local receptors. • Mitigation and management measures relating to the generation of dust (as detailed in the Section 5 Air Quality) will be implemented to minimise visual impacts during construction activities. • Minimise construction works at night-time to those strictly required. • Any flood lights required during night time construction activities will be directed onto the working areas, with a maximum position angle of 30° from vertical, and back spill shields, therefore minimising any unwanted light spill.	**Minor**
		Tourism Boat Jetty/ Harbour	Medium	**Minor**		**Minor**

17.4.2 Operational Phase

Following the impacts of construction and establishment of project features, the operational phase will not result in changes to the landscape character or visual envelope of receptors overlooking the Project site. Although lighting impacts will occur, this will be similar to the construction phase, and as such significance has not been re-assessed. The mitigation and management measures with regards to light pollution will be the same as construction phase. This will include the deployment of lighting for safety and security that seeks to avoid light spill, skyglow and glare and will utilise efficient low energy systems where approriate.

18 Community Health and Safety

This chapter assesses the impacts relating to the health & safety of the local community who live and work in the surrounding area and may be subject to project related impacts.

The majority of secondary impacts relating to the local community in terms of air quality, noise, wastewater, waste etc., have been addressed in specific chapters elsewhere in this ESIA. This chapter therefore concentrates more specifically on the potential emergency impacts that could relate to the project, and the security of the project to avoid instances of trespass, malicious intrusions and other misdemeanors.

The primary purpose of this chapter is therefore to identify specific management measures in regard to community, health and safety.

18.1 Standards and Regulatory Requirements

18.1.1 National Requirements

Law No.3 of 19775 amended by legislative Decree No.16 of 1993 on Public Health in Bahrain provided regulatory requirements aimed at protecting the public against diseases and pollution.

18.1.2 Lenders Requirements

The project lenders will require compliance with IFC Performance Standard 4: Community Health, Safety and Security. The objectives of IFC PS4 are to:

- *To anticipate and avoid adverse impacts on the health and safety of the Affected Community during the project life from both routine and non-routine circumstances.*
- *To ensure that the safeguarding of personnel and property is carried out in accordance with relevant human rights principles and in a manner that avoids or minimizes risks to the Affected Communities.*

The project will therefore need to ensure:

- Suitable design of the CCGT & SWRO and related infrastructure to ensure safe operation.
- Minimising the potential for community exposure to hazardous materials and substances that may be released by the project.

- Avoidance of community exposure to disease (e.g. from worker influx or supply of contaminants or other water related illness in the supply of potable water).
- Consideration of any third-party impacts to project emergencies and disaster scenarios (or vice versa impacts form external sources to the project), including preparing emergency response plans.
- Appropriate training of security personnel employed by the projects, including appropriate consideration of hiring protocols, training of staff, code of conduct, provision of weapons and weapons protocols.

18.2 Observations and Baseline Conditions

The project is located in an area with industrial facilities as well as residential and commercial receptors.

The nearest residential receptor is the Al Dur Residences approximately 400m south east of the Project site. A commercial receptor is located approximately 800m northeast of the Project boundary. Other residential and commercial or institutional receptors are located over 1km from the Project boundary.

Given the nature of the Project, associated construction and operational activities and distance from the Project site, the receptors over 1km from the Project site will not be directly affected by the Project and therefore are not considered 'Affected Communities'. Impacts relating to the local community in terms of air quality, noise, wastewater, waste etc., have been addressed in specific chapters elsewhere in this ESIA.

Project related activities might result in the increase of risks associated with those who may visit areas in and around active project sites.

18.3 Potential impacts

18.3.1 Construction Phase

Public/Community Health

The project is located in an area with industrial facilities as well as residential and commercial receptors.

The construction phase of the Project will require additional workforce as well as site-based security at the gates and on patrol around the site. Hence there will be an increase in the population of the local area.

The construction phase of the project will require about 2,200 workers as well as suitable accommodation areas for this workforce. As outlined in the Project Description section of this ESIA, the Sub contractor worker accommodation will be located approximately 200m south of the Project boundary.

In addition to the subcontractor camps, it is anticipated that other workers/staff involved in the Project will be housed/accommodated in the local Project area. As such, there is a potential for both workers accommodated in the subcontractor camps and those in the local Project area to come into contact with local populations. Hence, the likelihood for spread of diseases to local communities.

Public/Community Safety

All construction projects have potential risks relating to public safety that could arise, particularly in regard to the use of high powered equipment, heavy construction machinery, excavations, transportation amongst others, including fire and pollution releases.

Public risks during construction have the potential to result in isolated incidents, which could be of a devastating magnitude to a person or group of people in the wrong place at the wrong time.

With particular regards to this Project, there are not expected to be specific works that could result in widespread pollution incidents, due to the limited use of hazardous material or chemical storage on-site. However, there is a risk of isolated incidents around the shoreline. Such risks will be suitably managed in the construction phase through the implementation of a robust CESMP and an Emergency Preparedness and Response Plan.

Although unlikely, the construction phase may present an opportunity for the public to access the site, in terms of trespassing due to the proximity of the Al Dur Residences and the Tourism Boat Jetty/ Harbour. However, this will be prevented by fencing the entire project area and through the deployment of security staff at the gates and checking the site boundary.

Public/ Community Security

The construction phase of the Project will require site-based security at the gates and on patrol around the site in order to prevent the public from trespassing to the construction site. This is so as to minimize the potential for construction site incidents to occur.

Following suitable security risk assessment by the EPC Contractor, the security arrangements should be guided by UN Code of Conducts for law enforcement officials and UN Basic Principles on the use of Force and Firearms by law enforcement officials (if staff are armed).

In addition to this, security personnel will receive internal training in regard to grievances, reporting such grievances and dialogue with any members of the local community.

18.3.2 Operational Phase

Public/Community Safety

The project will carry various risks that could result in impacts to public safety where such impacts are transferred or received outside of the project site. Such impacts may relate to fire, VOC fumes, explosions, spills of back up fuels, un-warranted releases of wastewater and security concerns of trespassers.

The extent of such impacts may range outside of the projects boundaries and require the involvement of outside agencies to help manage and abate such impacts (e.g. Civil Defence, Police and Army).

Public risks during operation have the potential to result in incidents, which could have a significant impact upon neighbouring communities and populations. Risks to public safety will be appropriately addressed and prepared for in the operational phase 'Emergency Preparedness and Response Plan' and via appropriate training of staff.

Public Security

The project constitutes a facility of high importance due to the generation of electricity and potable water for consumption. The project will also include site based security at the project main entrance and on patrol around the site.

As is consistent with the construction phase, the O&M Contractor will undertake a security risk assessment to determine the appropriate level of security required at the facility. Security arrangements should be guided by UN Code of conducts for law enforcement officials and UN basic principles on the use of Force and Firearms by law enforcement officials (if staff are armed).

In addition to this, security personnel will receive internal training in regard to grievances, reporting such grievances and dialogue with any members of the local community.

18.4 Mitigation and Management Measures

Table 18-1 Health & Safety Mitigation & Management Measures - Construction

Potential Impact	Mitigation and Management Measures
Public/Community Health	• The Health and Safety teams on site will provide advice during training/inductions on exposure to disease. • During construction, staff will have access to medical professionals and suitable medical facilities, which will aim to prevent the spread of diseases internally and externally Site personnel will only be cleared for work after with a medical fitness certificate from an authorized medical center. • Any reportable disease will be diagnosed by the authorized occupation health center doctor. Diagnosis includes identifying any new symptoms, or any significant worsening of existing symptoms. • Any external and internal spreading diseases will be diagnosed and taken the precautions as per the instructions from the national/ local medical authority. • The potential for exposure to water-borne, water-based, vector-borne diseases and communicable diseases as a result from project activities will be avoided or minimised.
Public/Community Safety	• Risks to public safety will be appropriately addressed and prepared for in the operational phase 'Emergency Preparedness and Response Plan' and training. • The plan will include the appropriate procedure to respond to any such incidents, as well as site specific contact details and details of external agencies who may be required. • All high-risk areas including fuel storage areas will be secured with internal fencing and will be patrolled by security throughout the day. • Appropriate mechanisms for emergency control (e.g. firefighting equipment) will be placed at suitable positions around the site.
Public/Community Security	• The project will employ its own security staff who will provide 24/7 security control across the Project site and dedicated security staff at gatehouses. • The project will be fenced during enabling works stage. • All vehicles entering the site will require pre-approved clearance and will need to be registered. Project security will record all instances of incoming vehicles. • CCTV will be installed at key locations around the site and at gatehouses. • Appropriate lighting will be provided at gatehouses for security personnel to prevent unauthorised access. • Project personnel will only be provided access to the construction site with valid ID cards and permits to work in line with HSE requirements.
Grievance Mechanism	• The project will implement an appropriate system to allow external parties to raise a grievance in regard to the project. • The Grievance Mechanism will be clearly defined, transparent and accessible to identified stakeholders.

Table 18-2 Health & Safety Mitigation & Management Measures - Operation

Potential Impact	Mitigation and Management Measures
Public/Community Safety	• Risks to public safety will be appropriately addressed and prepared for in the operational phase 'Emergency Preparedness and Response Plan' and training. • The plan will include the appropriate procedure to respond to any such incidents, as well as site specific contact details and details of external agencies who may be required. • Appropriate mechanisms for emergency control (e.g. firefighting equipment) will be placed at suitable positions around the site.
Public/Community Security	• The project will employ its own security staff who will provide 24/7 security control across the Project site and dedicated security staff at gatehouses. • All vehicles entering the site will require pre-approved clearance and will need to be registered. Project security will record all instances of incoming vehicles. • CCTV will be installed at key locations around the site and at gatehouses. • Appropriate lighting will be provided at gatehouses for security personnel to prevent unauthorised access. • Project personnel will only be provided access to the construction site with valid ID cards and permits to work in line with HSE requirements.

18.5 Monitoring

Monitoring of Community Health and Safety will be undertaken as required via the management measures outlined above. For instance, monitoring of the security plan will form part of the wider Environmental and Social Management System internal audits to be undertaken monthly during construction and quarterly during operations.

19 Labour and Working Conditions

19.1 Standards and Regulatory Requirements

19.1.1 National Requirements

The labour law in Bahrain is governed by Labour Law No.36 of 2012 which replaced the labour law No.23 of 1976. The law aligns with several Arab and International Labour treaties and conventions which Bahrain is a signatory to.

The law revitalises the private sector Labour Market by giving more rights to employees such as improving working conditions, creating better investment, preventing human trafficking, employment of minors, compensation for work injuries and occupational diseases, prohibiting discrimination practices such as discrimination in the payment of wages based on sex, ethnic origin, language, religion or beliefs, occupational safety, health and working environment and many more.

19.1.2 Lender Requirements

The following applicable IFC Performance Standards aim to identify and ensure that social and economic impacts of a project are addressed in the relevant areas, in particular:

- Performance Standard 2: Labour and Working Conditions;
  - Equal opportunity and non-discriminatory HR Policies and procedures appropriate to the size of the workforce.
  - Provision of clear documented terms of employment and worker rights to all staff; including sub-contractor staff.
  - Provision of suitable labour accommodation (in accordance with the provisions of IFC & EBRD Guidelines on Worker Accommodation).
  - Implementation of a robust Occupational Health & Safety plan;
  - Implementation of a grievance mechanism to ensure internal grievances can be raised in an easily accessible, understood and transparent process.

In accordance with IFC Performance Standard 2 (Labour and Working Conditions) there is a requirement to align with the following conventions:

- ILO Convention 29 on Forced Labor;
- ILO Convention 105 on the Abolition of Forced Labor;
- ILO Convention 138 on Minimum Age (of Employment);
- ILO Convention 182 on the Worst Forms of Child Labor;

- ILO Convention 100 on Equal Remuneration;
- ILO Convention 111 on Discrimination (Employment and Occupation);
- UN Convention on the Rights of the Child, Article 32.1; and
- UN Convention on the Protection of the Rights of all Migrant Workers and Members of their Families.

19.2 Observations and Baseline Conditions

Any construction project will introduce health and safety risks associated with the use of plant, machinery and construction processes. Risks can be severe depending on the type of activities required, materials used and site condition.

For projects where the local population/skill sets require influx of people from other regions/countries consideration will need to be given associated with accommodation, welfare, sanitary provision, health care, hygiene, food potable water etc.

19.3 Potential Impacts

19.3.1 Construction Phase

Occupational Health and Safety

Common activities undertaken during construction such as the movement of heavy machinery, excavation, handling of chemicals, works undertaken at height etc. can all introduce significant risk to the health and safety for the associated work force. In particular, risks are more likely to be apparent for those who are not familiar with the type of works undertaken and/or the associated hazards.

The type of hazards attributable to a construction site will vary significantly dependant on the construction methods employed and the degree of control implemented by the EPC and affiliated sub-contractor. It is therefore of the utmost importance that the EPC and affiliated sub-contractors demonstrate consideration of health and safety risks as part of their chosen construction methods and that these risks are appropriately mitigated.

As occupational health and safety is a risk rather than a potentially defined impact, its significance has not been assessed further in this ESIA. Health and safety risks to the site force will be managed through effective risk assessment, development and implementation of an Occupational Health & Safety Plan.

Working Conditions

Labour exploitation on construction sites unfortunately has become a reality in some parts of the world. Inequalities in income, education and opportunities has led to opportunistic immoral practices with labourers and site staff suffering as a consequence.

To ensure the wellbeing of the staff associated with the project, the EPC and associated subcontractors will need to plan for necessary provisions relative to the requirement of the required workforce. This includes appropriate labour accommodation plans and mechanism for inspections and corrective actions.

As with occupational health & safety risk, worker conditions are a defined aspect of site planning rather then a potentially environmental impact as such, its significance is not assessed further in this ESIA. Risks associated with worker welfare during construction will be managed through effective project planning, and the enforcement of fair and just treatment throughout the construction phase.

19.3.2 Operational Phase

Occupational Health and Safety

The risks associated with the operational phase of the project are anticipated to be significantly less than during the construction phase due to reduced site activity and requirements for heavy plant and machinery.

There will however be outgoing electrical connections and the movement of large volumes of water by high powered pumps, all of which pose a significant risk to worker health and safety. Maintenance and inspection will also require the use of site vehicles and activities that pose risks to human health and safety.

The severity and likelihood of risks during the operational phase will be dependent on the frequency and requirements for planned and unplanned maintenance. The operation and maintenance team will need to ensure that a robust plan is in place to appropriately manage these risks.

Workers Conditions

No long-term accommodation requirements are anticipated for the project. However, as with construction, operational activities will need to plan for and enforce just and fair treatment of operation and maintenance staff (including any engaged sub-contractors). Allowance will also need to be made for site staff welfare facilities including sanitation, rest, recreational and medical facilities.

19.4 Mitigation and Management Measures

Table 19-1 Workers Condition & Occupational Health & Safety Mitigation & Management Measures - Construction

POTENTIAL IMPACT	MITIGATION AND MANAGEMENT MEASURES
Occupational Health and Safety	• Workers will be provided with a safe and healthy work environment, taking into account inherent risks and specific classes of hazards associated with the project. • Chemicals and Hazardous materials should only be handled by trained personnel and personal protection equipment (gloves, face mask, nose mask, etc.) will be provided. • Workers will be informed of the chemicals that are hazardous to health or flammable and must be trained on handling such chemicals. • The EPC Contractor will implement and maintain an OHS management system taking into account specific risks associated with the project, legal requirements and duty of care. • The EPC Contractor will be responsible for ensuring that all affiliated sub-contractors comply with the Occupational Health and Safety (OHS) management system. The OHS management system will be in-line with recognised international best practice and as a minimum, this plan will include: - Means of identifying and minimising, so far as reasonably practicable, the causes of potential H&S hazards to workers. - Provision of preventive and protective measures, including modification, substitution, or elimination of hazardous conditions or substances. - Provision of appropriate equipment to minimise risks, and requiring and enforcing its use. - Training of workers, and provision of appropriate incentives for them to use and comply with H&S procedures and protective equipment. - Documentation and reporting of occupational accidents, diseases and incidents. - Emergency prevention, preparedness and response arrangements
Workers Conditions-Terms of Employment, Non-discrimination and equal opportunities, Working Relationships	• The EPC contractor will provide a plan detailing how working conditions and terms of employment are compliant with national labour, social security and occupational health and safety laws. • Employment relationship will be on the principle of equal opportunity and fair treatment, and will not discriminate with respect to any aspects of the employment relationship, including recruitment and hiring, compensation (including wages and benefits), working conditions and terms of employment, access to training, promotion, termination of employment or retirement, and discipline. • The EPC contractor will not make employment decisions on the basis of personal characteristics, such as gender, race, nationality, ethnic origin, religion or belief, disability, age or sexual orientation, unrelated to inherent job requirements. • The EPC contractor will document and communicate to all workers their working conditions and terms of employment including their entitlement to wages, hours of work, overtime arrangements and overtime compensation, and any benefits (such as leave for illness, maternity/paternity, or holiday).

POTENTIAL IMPACT	MITIGATION AND MANAGEMENT MEASURES
	• The EPC Contractor will base the employment relationship on the principle of equal opportunity and fair treatment, and will not discriminate with respect to all aspects of the employment relationship, including recruitment and hiring, compensation (including wages and benefits), working conditions and terms of employment, accommodation, access to training, promotion, termination of employment or retirement, and discipline. *Special measures of protection or assistance to promote local employment opportunities or selection for a particular job based on the inherent requirements of the job which are in accordance with national law, will not be deemed discrimination.*
Workers Conditions-Forced Labour	• The EPC contractor will not employ forced labour, which consists of any work or service not voluntarily performed that is exacted from an individual under threat of force or penalty. This covers any kind of involuntary or compulsory labour, such as indentured labour, bonded labour or similar labour-contracting arrangements. • HR policies and procedures will be adapted appropriately to the size of the workforce required for the Project. Policies and procedures must be prepared to demonstrate consistency with the requirements of national legislation and IFC PS 2.
Workers Conditions-Child Labour	• The EPC contractor will comply with all relevant national laws provisions related to the employment of minors. • In any event, the client will not employ children in a manner that is economically exploitative, or is likely to be hazardous or to interfere with the child's education, or to be harmful to the child's health or physical, mental, spiritual, moral, or social development. • Young people below the age of 18 years will not be employed in hazardous work and all work of persons under the age of 18 will be subject to an appropriate risk assessment
Workers Conditions-Wages, benefits, conditions of work and retrenchment	• Wages, benefits and conditions of work offered should, overall, be comparable to those offered by equivalent employers in the relevant region of that country/region and sector concerned. • If the EPC contractor anticipates collective dismissals associated with the proposed project, the EPC contractor will develop a plan to mitigate the adverse impacts of retrenchment, in line with national law and good industry practice and based on the principles of nondiscrimination and consultation. Without prejudice to more stringent provisions in national law, such consultation will involve reasonable notice of employment changes to the workers' representatives and, where appropriate, relevant public authorities so that the retrenchment plan may be examined jointly in order to mitigate adverse effects of job losses on the workers concerned. The outcome of the consultations will be reflected in the final retrenchment plan.
Workers Conditions-Grievance Mechanism	• The EPC contractor will provide a grievance mechanism for workers to raise reasonable workplace concerns. The client will inform the workers of the grievance mechanism at the time of hiring, and make it easily accessible to them. The mechanism should involve an appropriate level of management and address concerns promptly, using an understandable and transparent process that provides feedback to those concerned, without any retribution. The

POTENTIAL IMPACT	MITIGATION AND MANAGEMENT MEASURES
	mechanism should not impede access to other judicial or administrative remedies that might be available under law or through existing arbitration procedures, or substitute for grievance mechanisms provided through collective agreements.
Workers Conditions- Supply Chain	• The Contractor will devise a supply management system to ensure the measures above are implemented by any sub-contractors.

Table 19-2 Workers Condition & Occupational Health & Safety Mitigation & Management Measures - Operation

POTENTIAL IMPACT	MITIGATION AND MANAGEMENT MEASURES
Occupational Health and Safety	• Workers will be provided with a safe and healthy work environment, taking into account inherent risks and specific classes of hazards associated with the project. • Chemicals and Hazardous materials should only be handled by trained personnel and personal protection equipment (gloves, face mask, nose mask, etc.) will be provided. • Workers will be informed of the chemicals that are hazardous to health or flammable and must be trained on handling such chemicals. • The Project's Operator will implement and maintain an OHS management system specific to the operational phase taking into account specific risks associated with the project, legal requirements and duty of care. • The Project's Operator will be responsible for ensuring that all affiliated sub-contractors comply with the OHS management system. The OHS management system will be in-line with recognised international best practice and as a minimum, this plan will include: - Means of identifying and minimising, so far as reasonably practicable, the causes of potential H&S hazards to workers. - Provision of preventive and protective measures, including modification, substitution, or elimination of hazardous conditions or substances. - Provision of appropriate equipment to minimise risks, and requiring and enforcing its use. - Training of workers, and provision of appropriate incentives for them to use and comply with H&S procedures and protective equipment. - Documentation and reporting of occupational accidents, diseases and incidents. - Emergency prevention, preparedness and response measures
Workers Conditions- Terms of Employment, Non-discrimination and equal opportunities, Working Relationships	• The O & M Company will provide a plan detailing how working conditions and terms of employment are compliant with national labour, social security and occupational health and safety laws. • Employment relationship will be on the principle of equal opportunity and fair treatment, and will not discriminate with respect to any aspects of the employment relationship, including recruitment and hiring, compensation (including wages and benefits), working conditions and terms of employment, access to

Potential Impact	Mitigation and Management Measures
	training, promotion, termination of employment or retirement, and discipline. • The O & M Company will not make employment decisions on the basis of personal characteristics, such as gender, race, nationality, ethnic origin, religion or belief, disability, age or sexual orientation, unrelated to inherent job requirements. • The O & M Company will document and communicate to all workers their working conditions and terms of employment including their entitlement to wages, hours of work, overtime arrangements and overtime compensation, and any benefits (such as leave for illness, maternity/paternity, or holiday). • The O & M Company will base the employment relationship on the principle of equal opportunity and fair treatment, and will not discriminate with respect to all aspects of the employment relationship, including recruitment and hiring, compensation (including wages and benefits), working conditions and terms of employment, accommodation, access to training, promotion, termination of employment or retirement, and discipline. *Special measures of protection or assistance to promote local employment opportunities or selection for a particular job based on the inherent requirements of the job, which are in accordance with national law, will not be deemed discrimination.*
Workers Conditions- Forced Labour	• The O & M Company will not employ forced labour, which consists of any work or service not voluntarily performed that is exacted from an individual under threat of force or penalty. This covers any kind of involuntary or compulsory labour, such as indentured labour, bonded labour or similar labour-contracting arrangements. • HR policies and procedures will be adapted appropriately to the size of the workforce required for the Project. Policies and procedures must be prepared to demonstrate consistency with the requirements of national legislation and IFC PS 2.
Workers Conditions- Child Labour	• The O & M Company will comply with all relevant national laws provisions related to the employment of minors. • In any event, the client will not employ children in a manner that is economically exploitative, or is likely to be hazardous or to interfere with the child's education, or to be harmful to the child's health or physical, mental, spiritual, moral, or social development. • Young people below the age of 18 years will not be employed in hazardous work and all work of persons under the age of 18 will be subject to an appropriate risk assessment
Workers Conditions- Wages, benefits, conditions of work and retrenchment	• Wages, benefits and conditions of work offered should, overall, be comparable to those offered by equivalent employers in the relevant region of that country/region and sector concerned. • If the O & M Company anticipates collective dismissals associated with the proposed project, the O & M Company will develop a plan to mitigate the adverse impacts of retrenchment, in line with national law and good industry practice and based on the principles of nondiscrimination and consultation. Without prejudice to more stringent provisions in national law, such consultation will involve reasonable notice of employment changes to the workers' representatives and, where appropriate, relevant public authorities

Potential Impact	Mitigation and Management Measures
	so that the retrenchment plan may be examined jointly in order to mitigate adverse effects of job losses on the workers concerned. The outcome of the consultations will be reflected in the final retrenchment plan.
Workers Conditions-Grievance Mechanism	• The O & M Company will provide a grievance mechanism for workers to raise reasonable workplace concerns. The client will inform the workers of the grievance mechanism at the time of hiring, and make it easily accessible to them. The mechanism should involve an appropriate level of management and address concerns promptly, using an understandable and transparent process that provides feedback to those concerned, without any retribution. The mechanism should not impede access to other judicial or administrative remedies that might be available under law or through existing arbitration procedures, or substitute for grievance mechanisms provided through collective agreements.
Workers Conditions-Supply Chain	• The O & M Company will devise a supply management system to ensure the measures above are implemented by any sub-contractors.

20 Cumulative Impacts

Cumulative impacts are those that '*result from the successive, incremental, and/or combined effects of an action, project, or activity when added to other existing, planned, and/or reasonably anticipated future ones*'. CIA is therefore the process of:

- Analysing the potential impacts and risks of proposed developments in the context of the potential effects of other human activities and environmental and social external drivers on the chosen Valued Environmental and Social Components (VECs) over time; and
- Proposing concrete measures to avoid, reduce, or mitigate such cumulative impacts and risk to the extent possible.

The purpose of a cumulative impact assessment is to determine how the potential impacts of a proposed development might combine cumulatively, with the potential impacts of other projects or human activities as well as natural stressors such as droughts or extreme climatic events.

The objectives and expected outcomes of a Cumulative Impact Assessment process are as follows:

- Identification of Valued Environmental and Social Components (VECs) such as air, water, soil etc. that may be affected by the Project and the selected VECs the assessment will focus on;
- Identification of existing and reasonably anticipated and/or planned developments, as well as natural environmental and external social drivers, that could affect the selected VECs;
- Assessment and/or estimation of the future condition of selected VECs, as the result of the cumulative impacts that the development is expected to have, when combined with those of other reasonably predictable developments;
- Evaluation of the future condition of the VECs relative to established or estimated thresholds of VEC condition or to comparable benchmarks;
- Avoidance and minimization of cumulative impacts of the Project on the VECs and
- Monitoring and management measures to ensure the VEC viability over the life span of the development or its impacts.

20.1 Identification of Valued Environmental and Social Components (VECs)

This ESIA has assessed cumulative impacts of several environmental and social parameters in the main sections of this ESIA. For instance, construction air quality (particulates), construction noise impacts and operational marine discharges have considered the measured baseline conditions in combination with the predicted process contributions. As a result, this has provided an assessment of cumulative impacts, as a result of the project itself.

20.2 Identification of other Activities and Environmental Drivers

At this stage, it is unknown whether or not there are future development plans within the Project area. As such, the CIA cannot establish whether there are barriers to unknown future development within the projects area of influence.

20.3 Assessment of Cumulative Impacts on VECs

Given that there are no known future development plan within the Project's area of influence, it is not possible in this ESIA to speculate on the potential cumulative impacts relating to future projects, as there is no available information regarding any future development plans in the local project area.

The assessment of cumulative impacts with reference to this Project will therefore go as far as those cumulative impacts upon specific receptors as a result of the proposed project and existing impacts from other local facilities. As described above, these cumulative impacts have already been assessed in the respective sections of this ESIA.

21 REFERENCES

1. Scottish Natural Heritage. A Handbook on Environmental Impact Assessment (2013). Natural Heritage Management. 4th Edition.

2. Guidance on the Assessment of Dust from Demolition and Construction (2014). Institute of Air Quality Management.

3. BSI British Standards (2009). Code of Practice for Noise and Vibration Control on Construction and Open Sites.

4. Calculation of Road Traffic Noise (1988). UK - Department of Transport, Welsh Office.

5. Design Manual for Roads and Bridges (2005). Volume 11 Environmental Assessment, Section 3 Environmental Assessment Techniques, Part 7 Noise and Vibration.

6. Coles S.F., Brown B.E. (2003) Coral bleaching – Capacity for Acclimatization and Adaptation. Advanced Marine Biology (46) 183 – 223.

7. Bahrain First National Report to the Convention on Biological Diversity (2006).

8. Dutch Ministry of Housing, Soil and Groundwater Intervention Values Guidelines (Updated 2013)

9. Dill, H.G., Botz, R., Berner, Z., Stüben, D., Nasir S., and Al-Saad, H. (2005). Sedimentary Facies, Mineralogy, and Geochemistry of the Sulphate-Bearing Miocene Dam Formation in Qatar. Sed. Geology, 174/1-2, 63-96 - Scientific Figure on ResearchGate.

10. Mohammed, Ghadeer. (2017). Bahrain's Second National Communication_ Under the United Nations Framework Convention on Climate Change 2012.

11. Ansari Mohammed (2012). Municipal Solid Waste Management Systems in the Kingdom of Bahrain. International Journal of Water Resources and Environmental Engineering. Vol. 4(5), pp 150-161.

12. United Nations Educational Scientific and Cultural Organisation (UNESCO) World Heritage List. http://whc.unesco.org/en/statesparties/BH

13. Bahrain Authority for Culture and Antiquities. http://culture.gov.bh/en/

14. Guidelines for Landscape and Visual Impact Assessment (2013). Landscape Institute and Institute of Environmental Management & Assessment. Third Edition.