Bapco Modernization Program

Cumulative Impact Assessment

Technip Italy S.p.A
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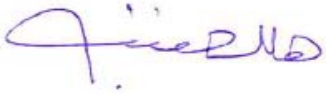
Initials/Date		24.9.18

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ALBA	Aluminium Bahrain B.S.C
AOI	Area of Influence
APC	Aromatics Production Complex
Bapco	Bahrain Petroleum Company
BMP	Bapco Modernization Program
CERP	Crisis and Emergency Response Plan
CIA	Cumulative Impact Assessment
CPC	Calcined Petroleum Coke
CPO	Central Planning Office
CO	Carbon Monoxide
EACS	Environment Arabia Consultancy Services
EBRD	European Bank of Reconstruction & Development
ESDD	Environmental and Social Due Diligence
ESIA	Environmental and Social Impact Assessment
EWA	Electricity and Water Authority
GPIC	Gulf Petrochemical Industries Company B.S.C
IFC	International Finance Corporation
LDAR	Leak Detection And Repair
LNAPL	Light Non Aqueous Phase Liquid
LPG	Liquefied Petroleum Gas
NO_2	Nitrogen Dioxide
NOGA	National Oil and Gas Authority
OSCP	Oil Spill Contingency Plan
PC	Process Contribution
PIC	Petroleum Industries Company
PS	Performance Standard
SCE	Supreme Council for Environment, Kingdom of Bahrain
SO_2	Sulphur Dioxide
TCF	Temporary Construction Facilities
TMP	Traffic Management Plan
VOC	Volatile Organic Compound
WHO	World Health Organization
WWTP	Wastewater Treatment Plant

1 INTRODUCTION

Environment Arabia Consultancy Services WLL (EACS) has been appointed by Technip Italy S.p.A to undertake a Cumulative Impact Assessment (CIA) for the Bapco Modernization Program (BMP) project. The BMP comprises a package of developments to update and expand the capacity of the Bapco Refinery, to modernize it and make it more cost competitive.

A package of reports comprising the BMP Environmental and Social Impact Assessment (ESIA) was submitted to the Supreme Council for Environment (SCE) on 30th June 2016 for review, as part of the process to obtain environmental clearance for the project. A specific CIA was not included in the ESIA and the lenders Environmental and Social Due Diligence (ESDD) consultant has requested the preparation of a scoped cumulative impact assessment to the requirements of International Finance Corporation Performance Standard 1 on Environmental and Social Sustainability (IFC PS1, 2012).

1.1 Purpose of this Document

Cumulative impacts are defined in the IFC Good Practice Note on Cumulative Impact Assessment (IFC, 2013) as "those that result from the successive, incremental, and/or combined effects of an action, project, or activity (collectively referred to as “developments”) when added to other existing, planned, and/or reasonably anticipated future ones. For practical reasons, the identification and management of cumulative impacts are limited to those effects generally recognized as important on the basis of scientific concerns and/or concerns of affected communities."

This report presents the CIA which comprises an analysis of the predicted environmental and social impacts of the BMP in interaction with other relevant past, present and future developments.

1.2 Related Reports

The following reports are related to this CIA report:

1. Environmental and Social Impact Assessment, BMP, EACS, 2016
2. Social Impact Assessment (SIA), BMP, EACS, 2018
3. Critical Habitat Assessment (CHA), BMP, EACS, 2018
4. Health Impact Assessment Camp 1, EACS, 2018
5. Health Impact Assessment Camp 2, EACS, 2018
6. Ecosystem Services Assessment, BMP, EACS, 2018

2 LEGISLATION AND GUIDANCE

There is no specific requirement under Bahraini regulations to assess cumulative impacts, but CIA is required by IFC PS1. Therefore, the CIA for the Project was primarily guided by the following international regulations, standards, guidelines, and procedures:

- International Performance Standard 1 on Environmental and Social Sustainability (IFC PS1, 2012);
- Guidance Note 1 (GN1) Assessment and Management of Environmental and Social Risks and Impacts, (IFC GN1, 2012);
- Good Practice Handbook Cumulative Impact Assessment and Management: Guidance for the Private Sector in Emerging Markets (IFC, 2013). It proposes as a useful preliminary approach for developers in emerging markets the conduct of a rapid cumulative impact assessment.

Other Performance Standards on Environmental and Social Sustainability refer to 'cumulative impacts', **Table 2.1** provides a summary of the IFC requirements and references.

Table 2.1 Summary of IFC PS Requirements in Respect of CIA

PS Paragraph	Topic	Description
IFC PS 1 Assessment and Management of Environmental and Social Risks and Impacts		
Paragraph 8	Identification of Risks and Impacts	Defines the area of influence to encompass "cumulative impacts that result from the incremental impact, on areas or resources used or directly impacted by the project, from other existing, planned or reasonably defined developments at the time the risks and impacts identification process is conducted"
Paragraph 11	Identification of Risks and Impacts	Where the project involves specifically identified physical elements, aspects and facilities that are likely to generate environmental and social impacts, the identification of risks and impacts will take into account the findings and conclusions of related and applicable plans, studies, or assessments prepared by relevant government authorities or other parties that are directly related to the project and its area of influence. These include master economic development plans, country or regional plans, feasibility studies, alternatives analyses, and cumulative, regional, sectoral, or strategic environmental assessments where relevant. The risks and impacts identification will take account of the outcome of the engagement process with Affected Communities as appropriate.
footnote 16	Identification of Risks and Impacts	Limits the cumulative impacts to be addressed to "those impacts generally recognized as important on the basis of scientific concerns and/or concerns from Affected Communities" and provides examples such as "incremental contribution of gaseous emissions to an airshed; reduction of water flows in a watershed due to

PS Paragraph	Topic	Description
		multiple withdrawals; increases in sediment loads to a watershed; interference with migratory routes or wildlife movement; or more traffic congestion and accidents due to increases in vehicular traffic on community roadways."
IFC PS 3 Resource Efficiency and Pollution Prevention		
Paragraph 11	Pollution Prevention	States that, to address potential adverse project impacts on existing ambient conditions, the client will consider relevant factors, including the potential for cumulative impacts with uncertain and/or irreversible consequences.

With the regard to assessment of specific environmental impacts, project standards will be used. These are based on national standards or applicable IFC Environmental Health and Safety Guidelines or other applicable international standards where national standards are absent. Applicable project standards are identified in relevant sections of the ESIA.

3 PROJECT DESCRIPTION

The following sections provide a brief summary of the extent and content of the BMP. A more complete description is contained in the BMP ESIA.

3.1 BMP Objectives

The BMP comprises a comprehensive package of upgrades to redevelop the Bapco Refinery so that it remains competitive in the 21st Century. The new Refinery configuration post-BMP, will allow for higher throughput, improved product quality and ensure Bapco's continued competitiveness under a wide range of process and market scenarios.

The strategic objectives for BMP are:

- Refinery Configuration and Gross Margin – A revised configuration shall allow for higher throughput, improve the product slate and increase gross margin with the objective to remain competitive under a wide range of prices and market scenarios.

- Energy Efficiency – The BMP shall improve energy efficiency and lower the Energy Intensity Index (EII) of the Refinery by installing energy efficient new crude and process units. This shall also have a positive impact on reduction of carbon release per barrel processed.

- Environmental Compliance – All new units shall function in compliance with applicable local environmental regulations and applicable World Bank Environmental Health and Safety Guidelines.

The scope of the BMP comprises:

- Optimization of crude capacity.
- Upgrade process residues and reduce or eliminate fuel oil production.
- Increase middle distillates production.
- Improve energy efficiency.
- Meet all Bahrain national environmental regulations and World Bank EHS Guidelines
- Comply with future gasoline and diesel specification (Euro 5).
- Comply with future bunker fuel oil specification as per the International Maritime Organization (IMO).

Part of the BMP is the upgrade of Sitra Wharf and Sitra Tank Farm facilities to allow for the importation of MTBE-containing gasoline and importation of neat MTBE for blending into gasoline by Bapco. This will allow for MTBE blended fuels to be released for use in vehicles in the local Bahrain market. This should have a significant positive impact on air quality in Bahrain at a national level.

3.2 Project Location

The BMP will comprise development at several locations (see **Figure 3.1**):

1) BMP process units and additional Refinery storage tanks;

2) Refinery to Sitra transfer lines;
3) Sitra Tank Farm;
4) Sitra Wharf;
5) Additional gas transfer lines.

There will also be the requirement for the development of Temporary Construction Facilities (TCFs) including labour camps on the National Oil and Gas Authority (NOGA) plot and in the foreshore area to the south east of the Refinery.

3.3 Process and Capacity Changes

The BMP will increase the capacity of the Refinery from 267,000 bpd to 360,000 bpd. A range of products will be produced: naphtha, gasoline, kerosene, diesel, fuel oil, lubricating oil, asphalt, LPG and sulphur.

The BMP is designed to concentrate production on middle distillates. The BMP will not increase fuel oil production capacity and will include additional process steps to convert fuel oil fractions to middle distillate products. The quantity of gasoline produced will not change.

3.4 Process Unit Operation Changes

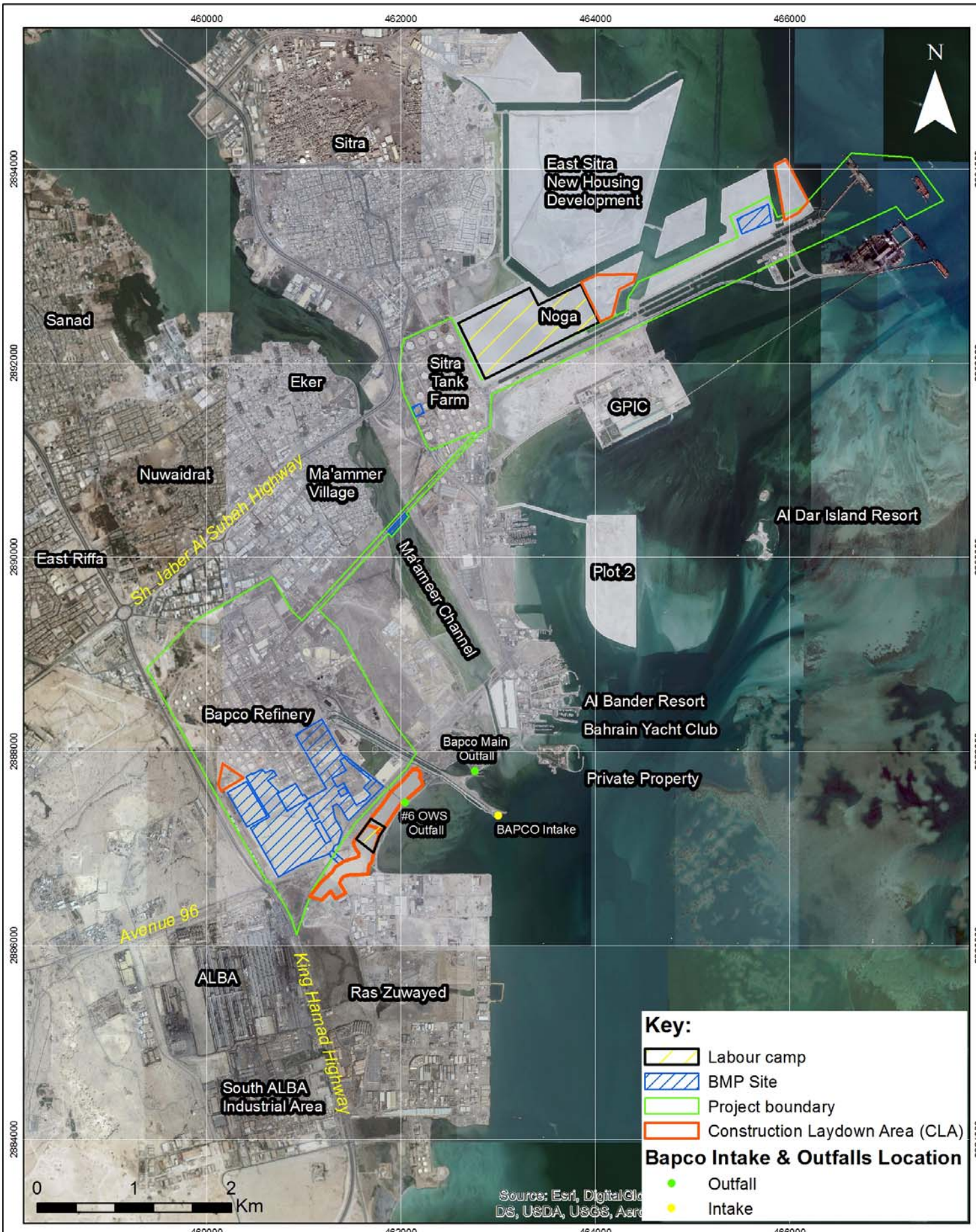
The BMP will involve the construction of several new process units and auxiliary plant and also revamp some of the existing process facilities. The BMP will replace the oldest and least efficient existing process units at the Refinery and operate alongside the remaining viable units. The modernization will include the staged implementation of at least six main process units, including: a new crude distillation unit; a new vacuum distillation unit; a residue hydrocracker; vacuum gas oil hydrocracker; diesel hydro-desulphurization unit and sulphur recovery unit. Additional process units will also be required to produce hydrogen and manage process gases.

The new process units will be constructed primarily on land to the south west of the existing Refinery. The land previously comprised a series of Pitch Ponds and contained approximately a 2m deep layer of viscous pitch. This was reclaimed between 2005-2015 by a contractor (AGAS). Following this the site comprised an area of open silty sand containing residual pitch contamination. To prepare the site for the BMP, the site has been infilled with a minimum thickness of 1m of clean sand in 2017/18. The site will require further infilling with clean sand to an average depth of 3m to achieve to desired formation levels for the BMP. Some BMP units will also be constructed on land to the south and east of the existing Refinery process units.

3.5 Changes to Ancillary Units and Utilities

3.5.1 Seawater Use and Effluent Discharges

The Refinery uses seawater for cooling and also for desalination. Desalinated seawater is used as process water and boiler feedwater. Seawater is taken from Farasiyah Bay from an intake located on a spit of land. Once used, water is returned from various parts of the Refinery for discharge to sea either through the main outfall flume or through a discharge point downstream of #6 Oily Water Separator (OWS). The water intake and effluent discharge points are shown on **Figure 3.1**.



Title: Project Location			Client: Bapco, TechnipFMC
Project: BMP Cumulative Impact Assessment			
Date: September 2018	Figure No.: 3.1		Consultant: Environment Arabia
Datum: WGS 84 - UTM 39 N	Scale: 1:50,000 (A4)		

CN:\BMP Cumulative Impact\mxd\sitelocation.mxd

Estimates of seawater intake rates before and after the BMP are shown in **Table 3.1**. Although the capacity of the Refinery will be increased post-BMP, the amount of seawater used will be reduced. This is because the BMP will include an indirect, closed-loop cooling water system with cooling towers rather than a single pass cooling system. Also, as the uses of abstracted seawater for the BMP will be similar to the existing uses for the Refinery, the composition and temperature of the effluents are expected to be relatively unchanged.

Table 3.1 Seawater Abstraction Rates

Scenario	Normal		Maximum	
	m^3/d	US gpm	m3/d	US gpm
Pre-BMP	752,232	138,000	1,004,074	184,200
Post-BMP	716,132	131,377	915,179	167,893

3.5.2 Production and Storage of Gases

The BMP will be a net producer of propane and butane. These gases will be liquefied to form Liquefied Petroleum Gas (LPG) and stored on site at the Refinery before being transferred to Sitra Wharf. The LPG will be stored in three new storage tanks located on NOGA plot prior to export.

3.5.3 Gas Supply

The BMP will utilize additional gas for use as process energy. The BMP will use 250 MM SCFD of Khuff Gas which will be supplied from the Alba and Riffa Gas distribution network.

3.5.4 Electricity Supply

The BMP will require the provision of a new sub-station that will be located on land to the immediate south of the Refinery. The sub-station will be developed by the Electricity and Water Authority (EWA).

3.6 Changes to Refinery Storage Tanks

Additional storage tanks will be required at the Refinery site for storage of crude oil and intermediate products. In addition, there will be a need for new pumps and a major rationalization of existing Refinery storage tanks including decommissioning and demolition of some storage tanks.

3.7 Changes to Transfer Lines

The existing Refinery-to-Sitra transfer lines will be revised. The use of some of the existing lines will be changed and some additional lines will be added. In addition, the pipe bridge across Ma'ameer Channel will need to be upgraded. A new pipe bridge will be constructed to the immediate south of the existing unit and the old unit will be

decommissioned and demolished. During construction of the new pipe bridge, temporary land platforms will need to be reclaimed within Ma'ameer Channel to facilitate construction. This will be a temporary reclamation measure and all fill material used will be removed from the Channel on completion of the new pipe bridge. Ma'ameer Channel is not navigable and neither the construction phase nor the operational phase will impact marine navigation rights.

3.8 Changes to Sitra Tank Farm

Some modifications to the existing Sitra Tank Farm facilities will be required as part of the BMP in particular a new naphtha/kerosene storage tank will be required as well as new shipping pumps that are able to achieve higher loading rates. There will also need to be a change of service on some existing tanks. Also, as part of the BMP, facilities for the import, storage and blending of MTBE will be provided including a storage tank at Sitra Tank Farm and transfer line(s) from Sitra Wharf. It is proposed to repurpose existing tanks and transfer lines for MTBE import and storage rather than construct new ones.

3.9 Changes to Sitra Wharf

3.9.1 Loading Facilities

Following implementation of the BMP, the increased rate of production at the Refinery will lead to an increase in the shipping rate for export of products. The export facilities at Sitra Wharf will be updated to cope with this additional demand and to replace old equipment with modern, efficient versions.

It is intended to keep the same wharf structures but to:

- add 19 new loading arms;
- add new slop facilities; and
- add new sealines and change the service on some existing sealines.

3.9.2 Temporary Construction Facilities

To facilitate the construction of the BMP there will be a requirement for laydown areas to store construction materials and elements of new process plant prior to assembly, for construction site offices and labour camps to house construction workers.

The labour camps will include: sleeping accommodation, canteens, recreational spaces and facilities, sanitary facilities and laundry facilities. The labour camps will be designed to be safe, comfortable and practical and to provide on-site recreation for workers. The labour camps will be sized to accommodate a peak of 18,000 construction workers.

The labour camps and construction site offices will be serviced with mains electricity and mains supplied potable water. Sewage from labour camps will be treated in package STPs and the treated effluent will be discharge to sea under the conditions of a discharge permit or tankered off site. In the case of the construction site offices, sewage will be discharged into septic tanks which will be periodically emptied and the waste water will be tankered away and treated at a municipal STP.

On completion of the BMP construction and commissioning, the laydown areas and labour camps will be decommissioned and removed or demolished.

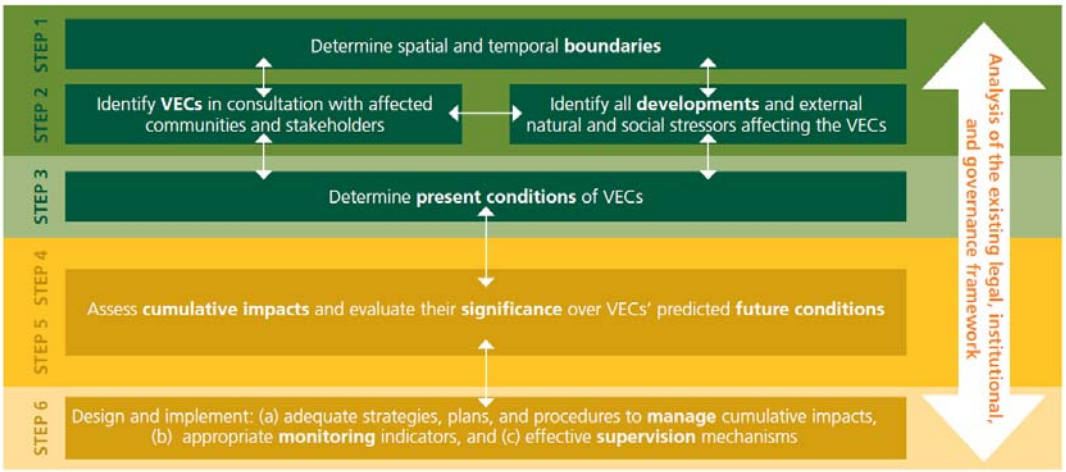
4 ASSESSMENT METHODOLOGY

4.1 Overall Approach

This CIA follows the method given in "Good Practice Handbook Cumulative Impact Assessment and Management: Guidance for the Private Sector in Emerging Markets", IFC, August 2013 for preparation of a Rapid Cumulative Impact Assessment (RCIA) which is the appropriate method to assess the cumulative impacts for a single private development project. The RCIA logical framework has been used which comprises an iterative six-step process (see **Figure 4.1**):

Step 1 Determine spatial and temporal boundaries;
Step 2 a) Identify Valued Environmental Components (VECs) and
b) All developments and external natural and social stressors affecting the VECs;
Step 3 Valued Environmental Components (VECS) baseline determination;
Step 4 Assessment of the contribution of the development under evaluation to the predicted cumulative impacts (Step 4);
Step 5 Evaluation of the significance of predicted cumulative impacts to the viability or sustainability of the affected VECs;
Step 6 Design and implementation of mitigation measures to manage the development's contribution to the cumulative impacts and risks

Figure 4.1 Six Step RCIA Process



4.2 Step 1 – Determination of Spatial and Temporal Boundaries

The spatial and temporal scope of the assessment has been defined. The spatial scope is based on the areas of impact described in the individual sections of the ESIA including AOIs 1-3 identified in the marine sections. AOI3 will be updated to account for the presence of the labour camp on the NOGA plot.

4.3 Step 2a - Identifications of VECs

4.3.1 Stakeholder Input

VECs have been identified through requirements to meet national and international environmental and social standards applicable to the project and through stakeholder consultations undertaken during the preparation of the BMP ESIA and since its completion. In particular the Supreme Council for the Environment (SCE), the national environmental regulator was consulted with regarding the scope of the ESIA and the scope was formally agreed with them through submission of an ESIA Scoping Report on 14th December 2015 and its acceptance on 25th February 2016. Throughout the ESIA process the views of stakeholders have been included within the assessment process, BMP design and mitigation measures.

4.3.2 VECs Impacted by BMP

The IFC CIA guidance documents notes that *"VECs for which the project will have no direct or indirect impact do not need to be the subject of CIA. Priority should be given to those VECs that are likely to be at the greatest risk from the development's contribution to cumulative impacts".*

In line with this requirement, the impacts of the BMP identified in the project ESIA have been screened to exclude the following impacts:

- Potential project impacts assessed as negligible are not able to interact spatially or temporally with the residual impacts from other projects and activities, therefore these were not considered in the CIA;
- Temporary and local residual impacts were excluded where they are not able to interact spatially or temporally with the residual impacts from other projects and activities.

On this basis, VECs that are identified as not impacted by the BMP have been excluded. In some cases where the impact between is potentially additive, e.g. point source emissions to air and water, the BMP impacts have been scoped in even though they have been assessed as negligible. This is to allow a discussion of the potential cumulative impacts, so that it is clear they have been addressed.

4.3.3 Identification of VECs

The VECs identified by stakeholders and those affected by the BMP will be cross referenced to create a list of VECs applicable to the BMP CIA.

4.4 Step 2b - Identification Developments and External Natural and Social Stressors affecting the VECs

4.4.1 Past and Existing Developments

Past and existing developments that have the potential to impact VECs have been identified where they have definable point source emissions. Natural and social stressor affecting VECs (e.g. capture fishing) are also described. The impact of these

developments and stressors on VECs are already accounted for within the environmental and social baseline and assessment within the BMP ESIA.

4.4.2 Planned Developments

Proposed developments in the applicable AOIs that have a reasonable chance of proceeding have been identified. Where developments are excluded from the assessment the reasons why have been noted. Information on planned developments have been obtained from the 2030 National Plan, previous stakeholder engagement meetings undertaken for preparation of the ESIA and additional consultation with the Central Planning Office (CPO) which is a division of the Ministry of Works responsible for planning and co-coordinating interactions between infrastructure projects.

4.5 Step 3 - VECS Baseline Determination

The baseline of the VECs identified as relevant to the BMP project in Step 2a has been described using the baseline data collected for the BMP ESIA and other related reports listed in **Section 1.2**.

4.6 Step 4 - Impact Assessment

4.6.1 Identification of Potential Cumulative Impacts

For each planned project identified, the key environmental impacts on identified VECS have been stated based on our experience and knowledge of the projects. These impacts have then been compared to the screened residual impacts of the BMP to identify any potential cumulative impacts on VECs. These potential cumulative impacts have then been assessed to determine their significance.

In most cases the assessment has been qualitative as details regarding the impacts of other planned developments are not available. In some cases the assessment is based on quantitative assessments where details of the other development are available and a quantitative assessment is warranted.

4.6.2 Impact Assessment

The impact significance has been determined by considering a combination of following factors:

- **Magnitude** of the impact;
- **Sensitivity** of the receptor;
- **Extent** of the impact; and
- **Duration** of the impact.

For the purpose of the assessment, these indicators will be assessed on a 5 point scale, with 1 being of low impact and 5 being a high impact. In each case, the values assigned can either be positive (+) indicating a beneficial impact, or negative (-) indicating an adverse impact. Values of zero / in the region of zero are considered to have a negligible impact.

Table 4.1 provides a scale for conducting the impact assessment. The impacts will be estimated qualitatively using expert judgment by reference to this scale.

Table 4.1 Impact Assessment Evaluation Criteria

Scale	Sensitivity	Magnitude	Extent	Duration
-5	High significance to stakeholders and affected communities.	Those affected will generally experience significant deterioration to quality of life/ health/ ecosystem service.	International	Permanent
-4	Medium significance to stakeholders and affected communities.	Those affected will generally experience moderate deterioration to quality of life/health/ecosystem service.	National	Long Term (over 10 years)
-3	Low to Medium significance to stakeholders and affected communities.	Those affected will generally experience a slight to moderate deterioration to quality of life/health/ecosystem service.	Regional	Medium Term (5-10 years)
-2	Low significance to stakeholders and affected communities.	Those affected will generally experience a slight deterioration to quality of life/health/ecosystem service.	Community	Short Term (1- 5 years)
-1	Impact is undesirable but acceptable.	Those affected will generally experience negligible deterioration to quality of life/health/ecosystem service.	Localized or single receptor	Temporary (less than 1 year)
0	Either no impact or the impact is neural (neither adverse nor beneficial)	Either no impact or the impact is neural (neither adverse nor beneficial).	No extent	No duration
+1		Those affected will generally experience very negligible improvement to quality of life/health/ecosystem service.	Localized or single receptor	Temporary (less than 1 year).

Scale	Sensitivity	Magnitude	Extent	Duration
+2	Positive and low significance to stakeholders and affected communities.	Those affected will generally experience a slight improvement to quality of life/health/ecosystem service.	Community	Short term (1 to 5 years)
+3	Positive, low to medium significance to affected communities.	Those affected will generally experience a slight to moderate improvement to quality of life/health/ecosystem service.	Regional	Medium Term (5-10 years)
+4	Positive medium significance to affected communities.	Those affected will generally experience moderate improvement to quality of life/health/ecosystem service.	National	Long Tem (over 10 years)
+5	Positive high significance to affected communities.	Those affected will generally experience significant improvement to quality of life/ health/ ecosystem service.	International	Permanent

To calculate the level of significance, an additive formula will be used as highlighted in **Table 4.2** to generate a numerical Impact Score.

Table 4.2 Impact Significance Calculation Matrix

[+/- value 0-5 **Magnitude**]	[+/- value 0-5 **Sensitivity**]
[+/- value 0-5 **Extent**]	[+/- value 0-5 **Duration**]
Impact Score= [Magnitude] + [Sensitivity] + [Extent] + [Duration]	

Once the Impact Score has been generated, the significance of the effect will be determined as highlighted in **Table 4.3**.

Table 4.3 Impact Significance

Impact Score Range	Impact Classification
-18 to -20	Major adverse impact
-14 to -17	Moderate adverse impact
-10 to -13	Minor adverse impact
-9 to 9	Negligible
10 to 13	Minor beneficial impact
14 to 17	Moderate beneficial impact
18 to 20	Major beneficial impact

5 STEP 1 - DETERMINATION OF SPATIAL AND TEMPORAL BOUNDARIES

5.1 Temporal Project Boundaries

Temporal boundaries for the analysis were set considering the following info:

- Construction phase (includes commissioning): 4 year period 2018-2022;
- Operations phase: 50 years from 2022 to 2072;
- Decommissioning and demolition of process units and equipment superseded by BMP at Bapco Refinery: 3 years from 2022-2025;
- Bahrain 2030: The National Plan.

Cumulative impacts of decommissioning of the BMP units have not been considered as this would occur after 2072.

The assessment includes planned developments up to 2030 as the current national plan runs to that date. It is reasonably certain that the majority of developments identified within the 2030 national plan will have commenced or be completed by that date. Beyond 2030 details of further developments are not available.

5.2 Spatial Project Boundaries

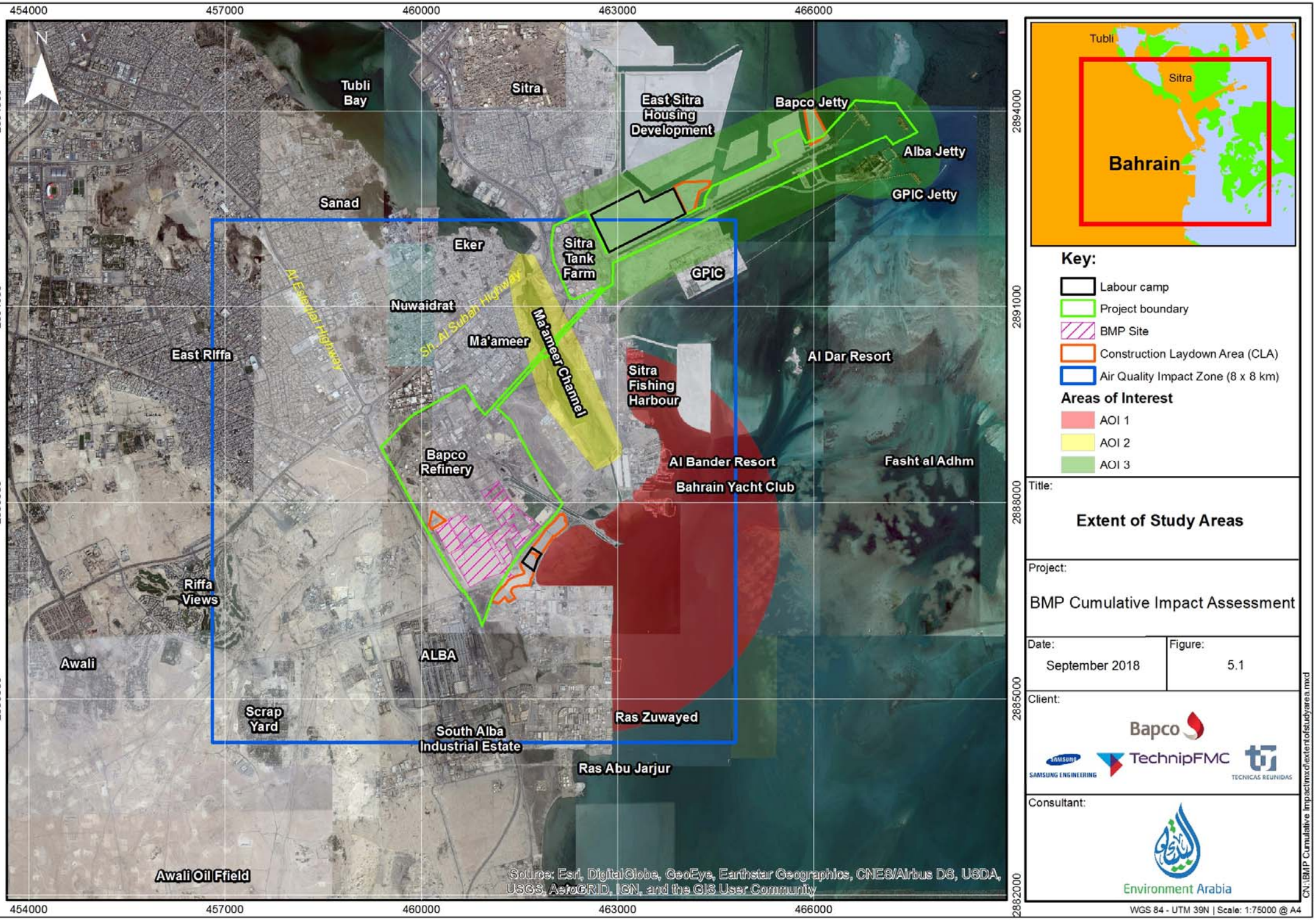
The spatial scope of the assessment is based on the AOIs identified in the ESIA. AOI3 was be updated to account for the presence of the labour camp on the NOGA plot. The main spatial boundaries of the CIA are shown in **Figure 5.1**.

The air quality impact zone is an 8km by 8km square centered on the Refinery. This is based on the dimensions of the central modelling grid used in the BMP air quality assessment. Impacts on ambient air quality due to the BMP will occur beyond this zone but the BMPs main influence on air quality will be within this zone. Emissions to air from other industrial sources within the east of Bahrain will overlap with the BMP emissions to create cumulative impacts on ambient air quality. In most cases these other sources are located outside the air impact zone defined for the BMP.

Emissions of dust will have localized areas of influence, as will emissions from road vehicles. The UK Institute of Air Quality Management (IAQM, 2014) sets a screening limit of 350m for emissions of dust from construction sites. This limit was used in the BMP ESIA and in this CIA. For the impact of road traffic emissions, the UK Highway Agency guidance (Highway Agency, 2007) indicates that road traffic emissions reduce to background values within 200m from the road centre and this distance has been used to screen for cumulative impacts. Similarly noise emissions are limited to localized impacts as noise emissions reduce with distance according to the inverse square law. Hence, the area of influence for the consideration of noise impacts has been confined to receptors around the BMP sites considered within the ESIA. The AOIs for water quality and marine ecology impacts are defined within the BMP ESIA and are shown in **Figure 5.1**. The BMP ESIA also includes wider study areas (extended 7km radius AOIs) with respect to identification of marine ecological receptors.

The spatial boundaries with respect to social impacts comprise the whole of Bahrain with respect to economic and employment impacts. With respect to other social impacts such as demand on public services these may have local as well as national impacts.

With respect to road users impacts have been considered on local roads, specifically King Hamad Highway, Highway 96, Um Al Saad Avenue and Sheikh Jaber A. Al Subah Highway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N
Tubli Bay
Sitra
East Sitra Housing Development
Bapco Jetty
Alba Jetty
GPIC Jetty
Sanad
Eker
Sitra Tank Farm
GPIC
Al Estiqlal Highway
Sh. Al Subah Highway
Nuwaidrat
Ma'ameer
Ma'ameer Channel
East RIffa
Al Dar Resort
Sitra Fishing Harbour
Bapco Refinery
Al Bander Resort
Fasht al Adhm
Bahrain Yacht Club
Riffa Views
Awali
ALBA
Scrap Yard
South Alba Industrial Estate
Ras Zuwayed
Ras Abu Jarjur
Awali Oil Ffield
Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, and the GIS User Community
Tubli
Sitra
Bahrain
Key:
Labour camp
Project boundary
BMP Site
Construction Laydown Area (CLA)
Air Quality Impact Zone (8 x 8 km)
Areas of Interest
AOI 1
AOI 2
AOI 3
Title:
Extent of Study Areas
Project:
BMP Cumulative Impact Assessment
Date:
September 2018
Figure:
5.1
Client:
Bapco
SAMSUNG ENGINEERING
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WGS 84 - UTM 39N | Scale: 1:75000 @ A4

6 STEP 2A IDENTIFICATION OF VECS

6.1 Stakeholder Input

Section 5 of the ESIA summarizes the stakeholder engagement activities previously undertaken. With respect to preparation of the CIA an additional meeting was held with Head of the CPO to obtain information of planned developments that may interact with the BMP. A copy of the Minutes of the Meeting is contained in **Appendix 6A**.

Further stakeholder meetings were held with non-governmental organizations (NGOs) as part of the social impact assessment. A summary of the stakeholder consultations undertaken is included in **Appendix 6B**. The summary includes identification of future projects that may interact with the BMP and VECs associated with potential direct and indirect environmental and social impacts of the BMP raised by stakeholders.

Future projects identified by stakeholders are:

1. East Sitra Housing Development;
2. Widening the entrance and exit of Ma'ameer Channel (also referred to as widening and deepening Ma'ameer Channel);
3. Railway near refinery along Sh Jabber a Al Subah Highway or East Sitra Link Road (no further information provided);
4. Bahrain to Qatar causeway;
5. A/B pipeline;
6. Improvements to Sh. Jaber A Al Subah Highway from Um Al Hassam Interchange to Nuwaidrat roundabout ;
7. East Sitra Link Road;
8. Alba and Nuwaidrat roundabout upgrades;
9. Proposed TSE pipeline from Ma'ameer STP;
10. Discharge from STP on East Sitra Housing;
11. Demolition of decommissioned Bapco process units;
12. Highway 96 upgrade;
13. Alba port capacity upgrade;
14. Plot 2.

VECs associated with BMP or the other projects directly identified by the stakeholders or inferred by EACS are:

1. Capture fisheries –impact of BMP
2. Ma'ameer Channel – Its hydrodynamic capacity to drain Tubli Bay – impact of BMP.
3. Groundwater resources –impact of BMP.
4. Cultural heritage - Presence of artefacts to south of Refinery in foreshore area (these have been identified and preserved) –impact of BMP.
5. Local communities – East Sitra Housing Development – impact of BMP.
6. Marine environment – potential for oil spills or discharges from vessels- BMP Sitra Wharf operations.
7. Air Quality (public health) – impact of BMP.
8. Employment– impact of BMP.
9. Visual impact– impact of BMP.

10. Road users – cumulative impact of BMP construction traffic and road upgrade schemes.
11. Major accident hazards – impacts of other developments on BMP labour Camp 2 on NOGA plot.
12. Workers' human rights – impact of BMP.
13. Occupational health and safety – impact of BMP.
14. Occupational health and safety (women) – impact of BMP.
15. Equal opportunities – impact of BMP.

6.2 VECs Impacted by BMP

Project impacts that have been scoped out of the CIA based on the criteria in **Section 4.3.2** are summarized in **Table 6.1**. Project residual impacts that have been scoped in and will be carried forward for consideration in the CIA are summarized in **Table 6.2**. The relevant VECs are noted in each case.

The impact classifications in both tables relate to those used in the relevant sections of the ESIA report.

Table 6.1 Impacts Scoped Out or Not Applicable

Design Phase Impact	Residual Impact	Reason / Comments	VEC
General Requirements			
Inclusion of ESIA Mitigation and Management requirements into contracts.	N/A		N/A
Design specification.	N/A		N/A
Cultural Heritage			
Impact during construction on sites of archaeological significance.	Negligible	No residual impact. Coastal area within Bapco land area so no development so no other development can go ahead.	Cultural heritage
Chemicals			
Storage of MTBE at Sitra Tank Farm	Negligible	No residual impact.	Groundwater resources
Social and Community Impacts			
Social Infrastructure.	Negligible	No residual impact.	Public services
Labour and Working Conditions			
Use of forced and child	Negligible	No residual impact.	Workers' rights

Design Phase Impact	Residual Impact	Reason / Comments	VEC
labour.			
Labour camp design.	Negligible	No residual impact.	Workers' rights, Public services,

Construction Phase Impact	Residual Impact	Reason / Comments	VEC
Soil and Groundwater			
Pitch Ponds - Presence of residual pitch on Pitch Ponds	Major Beneficial	The pitch ponds have been capped with clean fill.	Groundwater resources
Pitch Ponds - Waste oil contaminated soil – no validation of earlier remediation	Negligible	This is a local contamination issue within the BMP site	Groundwater resources
Pitch Ponds / All BMP - VOC vapour intrusion BH1056 into built structures	Negligible	This is a local contamination issue within the BMP site.	Groundwater resources
All BMP – Contaminated soils	N/A		Groundwater resources
All BMP – Construction Workers, protection of health	N/A	This is a local contamination issue within the BMP site.	Occupational health and safety
All BMP sites – Update Contamination Assessment	N/A		N/A
Noise and Vibration			
Construction Vibration	Negligible		Local communities Occupational health and safety
Marine Impacts			
Marine Sediment Loading and Resuspension – AOI 1, Farasiyah Bay	Negligible		Marine environment – water quality and marine ecology
Spillages of Fuels, Chemicals and Wastes – AOI 1, Farasiyah Bay	Negligible		Marine environment – water quality and marine ecology

Construction Phase Impact	Residual Impact	Reason / Comments	VEC
Spillages of Fuels, Chemicals and Wastes – AOI 2, Ma'ameer Channel	Negligible		Marine environment – water quality and marine ecology
Spillages of Fuels, Chemicals and Wastes – AOI 3, Sitra Wharf	Negligible		Marine environment – water quality and marine ecology
Marine Sediments - AOI 2, Ma'ameer Channel	Negligible	Additional sampling of sediments in Ma'ameer Channel for Organo-Tin compounds.	Marine environment – water quality and marine ecology
Terrestrial Ecology			
Loss of terrestrial habitat - coastal fringe	Negligible		Avifauna
Loss of terrestrial habitat - site west of Alba	Negligible	No longer relevant	N/A
Loss of terrestrial habitat - Ma'ameer Channel	Negligible		Avifauna
Traffic and Access			
Site Preparation	Significant - Short periods of increased congestion.	Construction work is complete with regard to site preparation	Road users
Construction Plant, Equipment and Materials	Not Significant		Road users
Waste			
Construction and commissioning wastes	Negligible		Landfill capacity
Decommissioning wastes	Negligible		Landfill capacity
Chemicals			
Contractor to update chemicals risk assessment prior to commencement of construction and then review and update it as needed.	N/A		Occupational health and safety Soil and groundwater resources
Storage of Fuels	Negligible	This is a local issue	Soil and groundwater

Construction Phase Impact	Residual Impact	Reason / Comments	VEC
		within the BMP site only.	resources
Social and Community Impacts			
Economic Development/ Employment	Moderate Beneficial		National wealth
Communicable Diseases	Negligible		Health of citizens
Labour and Working Conditions			
Human Resources policy and procedures	Negligible		Workers' rights
Grievance mechanism	Negligible		Workers' rights
Use of forced and child labour	Negligible		Workers' rights
Labour camp operations	Negligible		Workers' rights
Occupational Health and Safety			
General Construction Activities	Negligible		Occupational health and safety
Pitch Ponds Site – Exposure to contamination during construction	Negligible		Occupational health and safety
Refinery and Sitra Tank Farm Sites – Exposure to contamination during construction	Negligible		Occupational health and safety
Ma'ameer Channel and Sitra Wharf	Negligible		Occupational health and safety
Commissioning	Negligible		Occupational health and safety
Decommissioning and Demolition	Negligible		Occupational health and safety

Operational Phase Impact	Residual Impact	Reason / Comments	VEC
Air Quality			

Operational Phase Impact	Residual Impact	Reason / Comments	VEC
Greenhouse Gas Emissions	N/A		Global environment
Waste			
Operational wastes	Negligible		Landfill capacity
Chemicals			
Contractor to provide a list of new chemicals and MSDS to be used in operations to SCE for approval.	N/A		Occupational health and safety Soil and groundwater resources
New storage tanks to meet BAT (and Bahraini legal requirements).	Negligible		Soil and groundwater resources
Process chemicals, cleaning chemicals and anti-scaling chemicals.	Negligible		Soil and groundwater resources
Social and Community Impacts			
Economic Development/ Employment	Major Beneficial		National wealth
Communicable Diseases	Negligible		Health of citizens
Labour and Working Conditions			
Human Resources policy and procedures	Negligible		Workers' rights
Occupational Health and Safety			
Operation –General requirements	Negligible		Occupational health and safety

Table 6.2 Impacts Scoped In

Construction Phase Impacts	Residual Impact	Reason / Comments	VEC
Air Quality			
Construction Phase Dust	Negligible	Negligible but could interact with other projects in close proximity.	Air quality
Construction Vehicle Emissions	Negligible	Negligible but could interact with other projects in close proximity.	Air quality

Construction Phase Impacts	Residual Impact	Reason / Comments	VEC
Soil and Groundwater			
Pitch Ponds - Presence of LNAPL in BH1056 and dissolved hydrocarbon contamination in BH1060	Minor Adverse	It is possible, but unlikely, that the contamination could extend off site.	Groundwater resources
All BMP – Groundwater contamination	N/A	It is possible, but unlikely that groundwater contamination could extend off site (at BH1056)	Groundwater resources
Noise and Vibration			
Construction Noise Day	Negligible to Minor Adverse		Local communities
Construction Noise Evening	Negligible to Minor Adverse		Local communities
Construction Noise Night	Negligible to Minor Adverse		Local communities
Marine Impacts			
Marine Sediment Loading and Resuspension – AOI 3, Sitra Wharf	Minor Adverse		Marine environment – water quality and marine ecology
Terrestrial Ecology			
Loss of feeding and roosting grounds for birds during construction - coastal fringe.	Minor Adverse		Avifauna
Disturbance to feeding and roosting grounds for birds during construction - Ma'ameer Channel	Minor Adverse		Avifauna
Traffic and Access			
Transport of Construction Workers	Significant - Short periods of increased		Road users
Transport of Oversized Loads			Road users

Construction Phase Impacts	Residual Impact	Reason / Comments	VEC
	congestion.		
Social and Community Impacts			
In-Migration / Social Cohesion	Minor Adverse		Local communities

Operational Phase Impacts	Residual Impact	Reason / Comments	VEC
Air Quality			
Direct (stack) Emissions	Negligible for NO_2, PM_{10} and CO and beneficial for SO_2	Air emissions can easily interact with similar emissions from other developments.	Air quality
Fugitive/ Evaporative Emissions	Negligible	Air emissions can easily interact with similar emissions from other developments.	Air quality
Soil and Groundwater			
All BMP – Groundwater contamination	N/A	Groundwater contamination can potentially migrate off site and impact other developments.	Groundwater resources
Noise and Vibration			
Operational Plant/Machinery Noise	Negligible to Minor Adverse		Local communities
Marine Impacts			
Hydrodynamics and Water Quality – AOI 1 – Farasiyah Bay	Negligible	Emissions to water can easily interact with emissions from other developments.	Marine environment – water quality and marine ecology
Terrestrial Ecology			
Impact of operational noise on feeding and roosting birds – coastal fringe	Minor Adverse		Avifauna

Operational Phase Impacts	Residual Impact	Reason / Comments	VEC
Occupational Health and Safety			
Major Accident Hazard	Negligible	It is possible that other developments in the area could require alterations of plans or reassessment of impacts.	Occupational health and safety Local communities
Crisis and Emergency Response Plan	Negligible	It is possible that other developments in the area could require alterations of plans or reassessment of impacts.	Occupational health and safety Local communities
Oil Spill Contingency Plan	Negligible	It is possible that other developments in the area could require alterations of plans or reassessment of impacts.	Occupational health and safety Local communities Marine environment

6.3 Identification of VECs

Based on the issues raised by stakeholders and the residual impacts of the BMP, the VECs identified are summarized in **Table 6.3** and **6.4** for the construction and operational phases of the BMP, respectively.

Table 6.3 VECs Identified for BMP Construction Phase

VEC	BMP Impact	Location				
		AOI1	AOI2	AOI3	BMP Site	Other
Air quality	Construction phase dust emissions				x	
	Construction vehicle emissions				x	
Groundwater resources	Pitch Ponds - Presence of LNAPL in BH1056 and dissolved hydrocarbon contamination in BH1060				x	
	All BMP – Groundwater contamination				x	
Marine environment	Marine sediment loading and resuspension – AOI 3, Sitra Wharf			x		
Hydrodynamic capacity of Ma'ameer Channel	Maintaining the hydrodynamic capacity of the Channel to drain Tubli Bay		x			
Avifauna	Loss of feeding and roosting grounds for birds during construction - coastal fringe				x	
	Disturbance to feeding and roosting grounds for birds during construction - Ma'ameer Channel		x			
Local communities	Construction noise Day		x		x	
	Construction noise Evening		x		x	
	Construction noise Night		x		x	
	In-migration / social cohesion				x	
	Impact of BMP East Sitra Housing Development			x		
Road users	Transport of construction workers					Road network
	Transport of oversized loads					Road network
Cultural heritage	Impact of BMP on artefacts to south of Refinery in foreshore area				x	
Employment	Impact of BMP				x	
Workers rights	Impact of BMP				x	
	Equal opportunities – impact of BMP				x	
Occupational health and safety	Major accident hazards – impacts of other developments on BMP labour Camp 2 on NOGA plot			x		
	Impact of BMP				x	
	Impact on female workers				x	

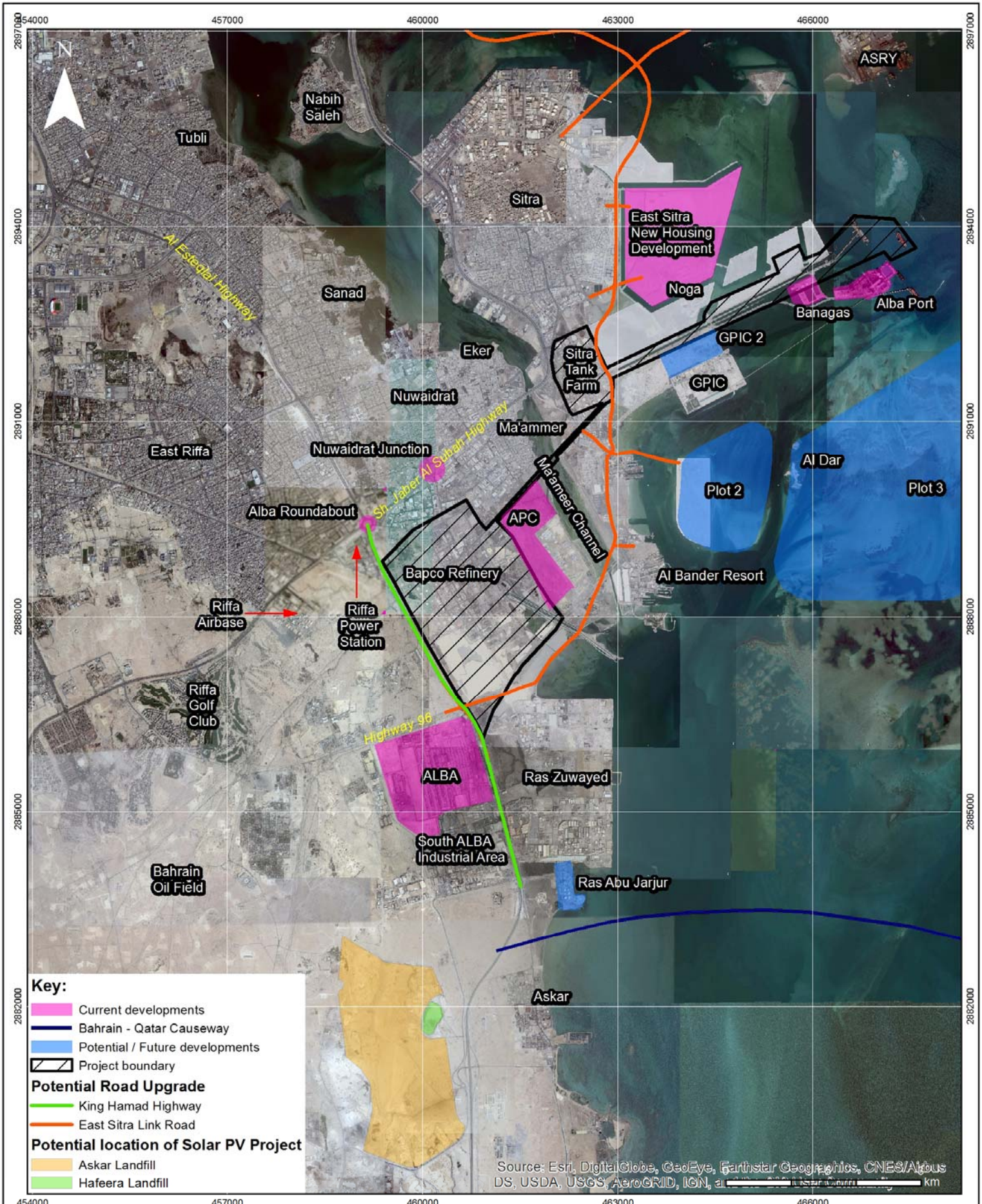
Table 6.4 VECs Identified for BMP Operational Phase

VEC	BMP Impact	Location				
		AOI1	AOI2	AOI3	BMP Refinery location	Other
Air quality	Direct (stack) emissions				x	
	Fugitive/ evaporative emissions				x	
Groundwater resources	Potential for groundwater contamination				x	
Marine environment	Hydrodynamics and water quality	x				
	Potential for oil spills or discharges from vessels- BMP Sitra Wharf operations			x		
Hydrodynamic capacity of Ma'ameer Channel	Maintaining the hydrodynamic capacity of the Channel to drain Tubli Bay		x			
Capture fisheries	Impact of BMP discharge to Farasiyah Bay	x				
Avifauna	Impact of operational noise on feeding and roosting birds – coastal fringe				x	
Local communities	Operational plant/machinery noise				x	
	Impact of major accident hazards inc. oil spills				x	
Visual impact	Impact of BMP				x	
Occupational health and safety	Major accident hazard				x	
	Crisis and Emergency Response Plan				x	
	Oil Spill Contingency Plan			x		
	Impact of BMP				x	
	Impact on female workers				x	
Workers rights	Impact of BMP				x	
	Equal opportunities – impact of BMP				x	
Employment	Impact of BMP				x	

7 STEP 2B - IDENTIFICATION OF DEVELOPMENTS AND EXTERNAL NATURAL AND SOCIAL STRESSORS AFFECTING THE VECS

7.1 Past and Existing Developments

Past and existing developments in the area that have known point source emissions to VECs are identified in **Table 7.1** and shown in **Figure 7.1**. VECS have been selected based on the known emissions of the specific developments or industry type.



Title: Current and Potential / Future Developments		Client: Bapco, TechnipFMC
Project: BMP Cumulative Impact Assessment		
Date: September 2018	Figure No.: 7.1	Consultant: Environment Arabia
Datum: WGS 84 - UTM 39 N	Scale: 1:50,000 (A4)	

CN:\BMP Cumulative Impact\mxd\current&future.mxd

Table 7.1 Previous and Existing Developments and Emissions to VECs

	Valued Environmental Components				
Facility / Activity	**Air Quality**	**Marine Environment**	**Road Users**	**Groundwater**	**Local Community - Noise**
Bapco Oil Refinery, Sitra Tank Farm and Wharf	Emissions to air from gas-fired power stations and process units (nitrogen oxides, sulphur dioxide). Fugitive emissions of VOCs	Abstraction / discharge of cooling, process water discharge of wastewater from STP	Road tankers, employees, contractors	Minor abstraction from Aquifer C Localised soil and groundwater contamination	Process noise
Alba aluminium smelter	Emissions to air from gas-fired power stations (nitrogen oxides, sulphur dioxide) Emissions to air from reduction process (nitrogen oxides, particulates, hydrogen fluoride) Emissions to air from carbon plant (sulphur dioxide, VOCs)	Minor emissions of process water and wastewater from STPs	Product distribution, employees, contractors	Minor abstraction from Aquifer C	Process noise
Alba Port – import of alumina, pitch, petroleum coke	Emissions to air from petroleum coke calciner (nitrogen, oxides, sulphur dioxide)	Abstraction / discharge of cooling water	Transfer of alumina, pet coke and pitch from port to Alba smelter, employees, contractors	None	Process noise
Riffa Power Station – electricity generation	Emissions to air from gas-fired power station (nitrogen oxides, sulphur dioxide)	None	Employees, contractors	None	Process noise
Ras Abu Jajur Desalination Plant – supply of potable water	Emissions to air from gas-fired power stations (nitrogen oxides, sulphur dioxide)	Emissions of cooling water, reject water, process water	Employees, contractors	Major abstraction from Aquifer C	Process noise
GPIC – production of methanol and urea	Emissions to air from gas-fired process units (nitrogen oxides, sulphur dioxide)	Abstraction and discharge of cooling water, process water	Employees, contractors	None	Process noise
Riffa Airbase – military helicopter base	Combustion emissions from helicopters	None	Employees, contractors	None	Process noise

	Valued Environmental Components				
Facility / Activity	**Air Quality**	**Marine Environment**	**Road Users**	**Groundwater**	**Local Community - Noise**
Askar Landfill – non hazardous and municipal landfill	Emissions of landfill gas	None	Deliveries of waste by truck	Possible emissions of leachate	Vehicle noise
Hafeera landfill – hazardous waste landfill	Emissions of landfill gas and VOCs?	None	Employees, contractors	None	Vehicle noise
Ras Zuwayed Industrial Area – industrial area	Emissions from contractors yards - dust, generator emissions	None	Employees, contractors	None	Vehicle noise, construction noise
South Alba Industrial Estate – industrial area	Emissions from process combustion (nitrogen oxides and sulphur dioxide)	Emissions from South Alba STP	Employees, contractors	None	Process noise
Bahrain oil and gas field – oil and gas exploration and extraction.	Emissions from process combustion (nitrogen oxides and sulphur dioxide), emissions volatile organic compounds, emissions of hydrogen sulphide	None	Employees, contractors	Yes - discharge of produced water, mainly at great depth Localised soil and groundwater contamination	Process noise

7.2 Future Developments

The following planned developments have been identified in the project AOIs. The list of developments is based on information provided by stakeholders and EACS records. The location of the developments is shown in **Figure 7.1**.

7.2.1 ALBA Line 6 Expansion Project

The project is for the addition of a further potline (Line 6) at ALBA aluminium smelter that will increase the production from approximately 1,000,000 to 1,500,000 tonnes of aluminum per year. The project also includes construction of an 1800MW gas-fired combined cycle power plant to provide power to the site (Power Station 5). The construction of the new power station will result in the closure of older, less efficient open cycle gas turbine power plant units at the ALBA site – Power Station 1 and some units in Power Station 2. The net result is that the power generation capacity will remain the same but the power station emissions will reduce (mainly nitrogen oxides emissions). The increase in aluminium production will lead to an increase sulphur dioxide emissions from the aluminium production process. As part of planning of the project Bapco were consulted by ALBA regarding the development and its possible interaction with the BMP.

The project construction commenced in autumn 2016 and will be complete in August 2019.

The project is in part internationally funded and is therefore aligned to IFC Environmental and Social Sustainability Performance Standards 2012.

7.2.2 ALBA Port Capacity Upgrade

This project is related to the ALBA Line 6 Upgrade Project. It is proposed to increase the capacity of the ALBA port facility at Sitra Wharf to meet the demands of the smelter capacity increase for alumina and petroleum coke. The project is in the planning stage and is expected to obtain approval in Autumn 2018 and for construction to be completed by Mid 2019. The project is medium-scale and will involve extension of jetties and construction of new storage silos. Consultations have already been undertaken between ALBA and Bapco.

The project is in part internationally funded and is therefore aligned to IFC Environmental and Social Sustainability Performance Standards 2012.

7.2.3 GPIC II

Gulf Petrochemical Industries Company (GPIC) located in Sitra Wharf manufactures methanol and urea. It is proposing to double its capacity by construction of a second phase on land adjacent to the existing plant. The project is presently at concept stage and does not having planning permission or an environmental permit. It is our understanding that at this stage there is no reasonable prospect of the project being developed at present and has been put on indefinite hold.

7.2.4 East Sitra Housing Development

East Sitra Housing Development is a new government housing development comprising 5000 homes and supporting infrastructure: roads, sewage treatment plant, healthcare facilities, schools, shops retail and commercial developments. The housing development will be constructed on reclaimed land located to the east of Sitra island. The land reclamation has been completed and construction of the housing has commenced. The construction completion date is not known but it can be expected that construction will be continuing for several years due to the scale of the project.

7.2.5 NOGA plot

The National Oil and Gas Authority (NOGA) commissioned the reclamation of land at Sitra Wharf as part of a long term strategic development for the oil and gas industry in Bahrain. The reclamation work was completed in 2016 but there is no firm plan for the long term development of the plot, except for the BMP requirements for construction of three Liquefied Petroleum Gas (LPG) storage tanks and temporary use of part of the plot as a labour accommodation camp during the BMP construction.

7.2.6 Aromatics Production Complex (APC)

The APC is designed to produce benzene and xylene for supply to the petrochemical industry. It is proposed that the plant is located on land to the north east of Bapco Refinery. The project is at the outline planning stage but has no planning or environmental permit. The project will need the BMP for supply of its feedstock and therefore cannot operate before the BMP is completed.

7.2.7 East Sitra Link Road

East Sitra Link Road is designed to provide connectivity to East Sitra housing Development and to provide additional bridges connecting Hidd and South East Manama with Sitra. The proposed route will pass through the Sitra Wharf area and then will pass south of the Bapco Refinery to the junction with Highway 96 and King Hamad Highway. The project is at concept stage and does not have planning permission or an environmental permit. The route has yet to be finalized. The planned construction commencement date is not known and the construction schedule is not known. Initial consultations have been undertaken between the scheme designer and Bapco representatives. Given the route alignment, through Sitra Wharf and the NOGA plot, south of the Refinery and adjacent to the Temporary Construction Facility it is considered that construction of the road during construction of the BMP is unfeasible.

7.2.8 Highway 96 Upgrade

It is proposed to upgrade Highway 96 from a single carriage probably to a dual carriage way. The project is at concept phase and does not have planning permission or an environmental permit. The planned construction commencement date is not known and the construction schedule is not known.

7.2.9 Alba and Nuwaidrat Interchanges

The Alba and Nuwaidrat roundabouts on Sheik Jabber A. Al Subah Highway are being improved to create flyovers for through traffic on the Highway. The work is resulting in diversions and temporary road alignments along the northern part of King Hamad Highway, parts of Sh. Jabber A. Al Subah Highway, the east part of Al Muaskar Highway and the southern part of Al Esteglal Highway. This work is on-going and is due for completion in 2019.

7.2.10 Ras Abu Jajur Phase II

Ras Abu Jajur (RAJ) is a desalination plant located on the East coast of Bahrain approximately 4km south of the Refinery. The existing desalination plant uses groundwater from Aquifer C (the Rus-Umm er Radhuma) as its raw water supply. It is intended to construct Phase II which will use seawater as its raw water supply. The project is at concept phase and does not have planning permission or an environmental permit. The planned construction commencement date is not known and the construction schedule is not known.

7.2.11 Plot 2 and 3

Two large land reclamation plots are proposed to be located to the south of Sitra Wharf in the 2030 National Plan: Plots 2 and 3. Part of plot 2 has already been reclaimed speculatively under the same contract that reclaimed land for East Sitra Housing and the NOGA plot. When complete it is proposed the plots will be occupied by heavy and light industrial facilities and commercial buildings. The planning and permitting status for reclamation of Plot 3 and the reclamation of the remainder of Plot 2 is not known but they are within the 2030 National Plan.

7.2.12 Banagas Expansion

The Bahrain National Gas Company (Banagas) is expanding its production of LPG at its plant in the Awali Oilfield. The LPG product will be piped to the Banagas facility at Sitra Wharf for storage prior to export. To accommodate the increased production capacity three additional LPG storage tanks are being constructed on reclaimed land. The project construction will be completed by the end of 2018.

7.2.13 Ma'ameer Channel Widening and Deepening

The Government of Bahrain has a concept proposal to widened and deepen Ma'ameer Channel as means of increasing water flushing through Tubli Bay which will act to improve water quality in the Bay which is impacted by long term sewage discharges. As far as we are aware there is no formal proposal in existence for this work and no assessment of its benefits has been undertaken.

Given that there are road bridges at either end of Ma'ameer Channel which would need to be rebuilt if the Channel were widened, and the dredging works would likely have significant impacts on a critical habitat, we believe these works do not have realistic prospect of being undertaken.

7.2.14 Qatar – Bahrain Causeway

There has been a long standing proposal to develop a causeway between Bahrain and Qatar. The proposed location is south of Ras Abu Jajar desalination plant. Due to the current political and financial circumstances the project is not considered to have a reasonable prospect of development in the foreseeable future.

7.2.15 Summary of Future Developments Applicable to the BMP

Table 7.2 provides a summary of the planned developments within the spatial and temporal boundaries considered for the BMP. The table summarizes the key environmental and social impacts of these projects and the likely timescales for their implementation. Where there is no significant temporal overlap with the BMP or the projects are not reasonably certain to proceed they have been scoped out.

On this basis, the following project phases and projects have been scoped out:

1. Alba Line 6 Expansion Project construction phase – This is to be completed by mid 2019 and so there will be no significant interaction with the BMP construction phase.

2. GPIC II – There is no reasonable level of certainty that this project will be developed further.

3. NOGA plot – No details of the plans for this site have been developed or are available and it is therefore not possible to assess its potential impact. As it will be occupied by BMP Labour Camp 2 it is not possible that development will commence during construction of the BMP.

4. East Sitra Link Road – There is no timescale available for this project and it is at concept design stage. It is assumed that this will not be constructed during the period of the BMP construction as this appears to be unfeasible.

5. Ras Abu Jajur Desalination Plant Phase II – There is no timescale available for this project. It is possible that other desalination plant project in Bahrain may take precedence over this project. For these reasons the project has been scoped out.

6. Alba and Nuwidrat Interchanges – It is expected that these projects will be complete in 2019 and there will not be a significant overlap with the BMP construction.

7. Plot 2 and 3 development – there is no information available regarding the likely developments and their possible emissions.

8. Banagas Expansion – Construction of the new LPG storage tanks at Sitra Wharf will be completed in late 2018 and will not overlap with the BMP construction phase.

9. Ma'ameer Channel Widening and Deepening – There is no formal plan for this project. Also in the view of EACS there is no reasonable prospect of the project proceeding due to costs and unacceptable environmental impacts. For these reasons the project has been scoped out.

10. Qatar – Bahrain Causeway – There is no reasonable likelihood of this project progressing in the foreseeable future.

Table 7.2 Planned Future Developments and Potential Emissions to VECs

Project	Company Organization	Activities	Project Description	Start/End Date	Key Predicted Environmental and Social Impacts	VECs Impacted	Reference
Alba Line 6	Alba	Aluminium smelting / Power generation	Expansion of the ALBA aluminium smelter to increase aluminium production to around 1.5 million tonnes per annum. This will comprise construction of a new potline - Potline 6 and a new power station - PS5.	Construction ongoing- to end in Mid 2019	Scoped out as no significant temporal overlap with BMP	N/A	Project ESIA available on www.albasmelter.com
				Operation from Jan 2019	• There will be no significant increase in emissions to air over present operations due to the replacement of old equipment with new, coupled with production efficiency gains.	• Air quality	
					• Increased water consumption will be met by water from Alba calciner which will be piped to the smelter site.	• Groundwater resources (reduced abstraction, beneficial impact)	
					• Operational noise emissions	• Local communities	
					• Increased traffic.	• Road users	
Alba Port Capacity Upgrade	Alba	Shipping / logistics	Installation of a new ship unloader for alumina, additional offloading of calcined petroleum coke (CPC)	Construction 2018-19	• Traffic including transportation of workforce, construction materials and abnormal loads.	• Road users	Draft project ESIA prepared by EACS
					• Dust.	• Air quality	
					• Marine sediment from dredging and piling.	• Marine environment – water quality and marine ecology	
				Operation from Mid 2019	• Increased frequency of alumina and pet coke road tankers travelling to and from Alba Smelter site	• Road users	
					• Increased shipping rates	• Marine navigation	
					• Increased emissions to air from ships.	• Air quality	
GPIC II	GPIC	Petrochemicals	Expansion of Urea and Methanol manufacturing	Not known	Scoped out as it is not reasonably certain this project will be developed.	N/A	
East Sitra Housing	Ministry of Housing	Housing development	Construction of 5000 new homes and associated infrastructure including a STP	Construction to commence in 2018 on reclaimed plot	• Increased traffic	• Road users	Consultation with Ministry of Housing
					• Noise	• Local communities	
					• Dust	• Air quality	
				Occupation from 2020?	• Discharge to marine environment from STP	• Marine environment – water quality and marine ecology	
					• Increased traffic	• Road users	
					• Noise	• Local communities	
NOGA Plot	NOGA	Oil and Gas	Not known	Not known	Not known	N/A	
Aromatics Production Complex APC	NOGA/PIC	Petrochemicals	Production of aromatic compounds, most notably benzene and paraxylene (p-xylene) using naphtha from the adjacent Bapco Refinery	Construction likely after 2022?	• Traffic including transportation of workforce, construction materials and abnormal loads.	• Road users	Draft project ESIA prepared by EACS
					• Noise.	• Local communities	
					• Dust.	• Air quality	
				Operation from 2024/5	• Emissions to air from point source stacks (NO_x, SO_2)	• Air quality	
					• Emissions to air of VOCs from non point sources - fugitive emissions	• Air quality	
					• Intake of seawater for cooling and process uses	• Marine environment –	

Project	Company Organization	Activities	Project Description	Start/End Date	Key Predicted Environmental and Social Impacts	VECs Impacted	Reference
					• Emissions to water - cooling water, process water	water quality and marine ecology	
					• Contamination of groundwater	• Groundwater resources	
					• Noise emissions	• Local communities	
					• Major accident hazard	• Local communities	
East Sitra Link Road	Ministry of Works	Transport	New road providing connectivity from Hidd and South East Manama to south of Sitra and access to East Sitra Housing Development.	After construction of BMP	• Construction traffic	• Road users	From consultations with CPO
					• Noise	• Local communities	
					• Dust	• Air quality	
					• Impact of route on ecology	• Avifauna	
				Operation after 2024?	• Increased noise from traffic	• Local communities	
					• Increased vehicle emissions locally	• Air quality	
					• Reduced traffic congestion	• Road users	
Highway 96 Upgrade	Ministry of Works	Transport	Road improvement to improve access from east of Bahrain across country to industrial area south of Sitra.	Not known but it is unlikely that construction will commence before 2020	• Construction traffic	• Road users	From consultations with CPO
					• Noise	• Local communities	
					• Dust emissions	• Air quality	
				Operation after 2022?	• Increased noise from traffic	• Local communities	
					• Increased vehicle emissions locally	• Air quality	
					• Reduced traffic congestion	• Road users	
Alba and Nuwaidrat Interchanges	Ministry of Works	Transport	Road improvements to improve traffic flow through Sitra.	On-going to be completed in 2019	Scoped out as no significant temporal overlap with BMP.	N/A	
				Full operation after 2019	• Reduced traffic congestion	• Road users	
Ras Abu Jajur Power and Desalination Plant Phase II	Electricity and Water Authority	Desalination and Power Generation	Capacity of about 1700MW and 50MGD potable water.	Construction start date is not known Operation start date is not known	Scoped out as it is not reasonably certain this project will be developed.	N/A	
Plots 2 and 3	Government of Bahrain	Land reclamation	Land reclamation using marine sand	Not expected before 2020	• Emissions of sediment to water.	• Cooling water intakes • Marine environment – water quality and marine ecology	2030 National Plan
					• Emissions from marine dredging equipment.	• Air quality	
					• Direct impacts at dredge sites.	• Marine environment – water quality and marine ecology	

Project	Company Organization	Activities	Project Description	Start/End Date	Key Predicted Environmental and Social Impacts	VECs Impacted	Reference
	Private developers	Development of reclaimed plots	Industrial and commercial land uses	Not expected before 2022	Scoped out. No information available for the development.	N/A	
Banagas Expansion	Banagas	Development of additional LPG storage tanks at Sitra Wharf	Land reclamation Construction of LPG storage tanks and associated pipelines	Construction to be completed at the end of 2018	Scoped out as no significant temporal overlap with BMP	N/A	Project EIA prepared by EACS
			Operation of storage tank facilities	Operation from start 2019	• Potential change to major accident hazards within Sitra Wharf	• Local communities	
Ma'ameer Channel widening and deepening	Government of Bahrain	Dredging of Ma'ameer Channel	Dredging	Not known	Scoped out as it is not reasonably certain this project will be developed.	N/A	SCE
Qatar – Bahrain Causeway	Government of Bahrain	Causeway and road/railway construction	Construction of causeway in the marine environment. Construction of highway and railway on land and on the causeway.	Not known	Scoped out as it is expected this project will be constructed in the foreseeable future.	N/A	

7.3 Natural and Social Stressors Affecting VECS

Table 7.3 provides a summary of the natural and social stressors affecting VECs. These have been taken from the responses from stakeholders, the BMP ESIA and SIA reports.

Table 7.3 Natural and Social Stressors Acting on VECs

	Valued Environmental Components						
Stressors	**Public Services**	**Air Quality**	**Land**	**Road Users**	**Noise**	**Marine Environment**	**Groundwater Resources**
Increasing population	Increased demand for housing, healthcare, education facilities and employment	Increased vehicle and industrial emissions	Increased demand for land for construction, increased urbanization	Increased traffic density	Increased noise	Increased land reclamation and impact to marine ecosystems	Increased abstraction, over abstraction, degradation of aquifer quality
Expansion of road network		Emissions from vehicle exhausts (nitrogen oxides, particulates, carbon monoxide, VOCs)		Increased vehicle use	Vehicle noise		
Commercial fishing						Overfishing	
Arid sub-tropical climate		Natural high dust levels exceed WHO air quality standards				High summer time water temperatures in the Arabian Gulf lead to coral die back	High demand on groundwater resources

8 ENVIRONMENTAL AND SOCIAL BASELINE

8.1 Baseline Surveys

A series of environmental and baseline surveys were undertaken for the BMP ESIA and subsequent reports listed in **Section 1.2**. The content of these surveys are summarized in the following sections. Full details are contained in the source reports.

8.2 Site Setting

The Bapco Refinery is located on the east coast of Bahrain in a mainly industrial area. **Figure 8.1** shows the land uses in the vicinity of the site. **Table 8.1** provides a brief description of the sensitive receptors identified in the BMP ESIA. The only receptors which have been added since the ESIA was completed are the labour accommodation location in the NOGA plot and receptors on Um Al Saad Avenue.

Table 8.1 Sensitive Receptors

Reference No. from Figure 5.1	Description	Notes
1	Al Noor International School	School to the north of the proposed site on Sitra Island
2	East Sitra Housing Development	Large proposed residential area to the north of the wharf, and north east of Sitra Tank Farm.
3	Sitra Residential Area	Closest residential area to Sitra Tank Farm.
4	Nuwaidrat Residential Area	Closest village to the north of the BMP site.
5	Al Eker	Village approximately equidistant to Sitra Tank Farm and the BMP site.
6	Umm Alqura Primary Girls School	Representative of a school receptor within residential areas to the north of the BMP site.
7	Ma'ameer Village	Residential area between Sitra Tank Farm and the BMP site.
8	Labour Accommodation	Closest residential units to BMP site.
9	Bahrain Yacht Club/Al Bandar	Representative recreation/tourist land use east of BMP site.
10	Labour Accommodation	Closest residential receptor to west of BMP site.
11	Labour Accommodation	Closest residential receptor to south of BMP site.
12	East Riffa Residential Area	Residential area to the north west of BMP site.
13	International Medical City Hospital	Representative of healthcare receptor in study area.
14	Riffa Views	Representative of recreation/residential receptor to the

Reference No. from Figure 5.1	Description	Notes
		west of the BMP site.
15	Um Al Saad Avenue	Businesses based on Al Saad Avenue
16	BMP Labour Accommodation Camps	Camp 2 – NOGA plot
17	BMP Labour Accommodation Camps	Camp 1 - South of Bapco Refinery

Ma'ameer village, the nearest residential community to the Refinery, is located adjacent to the northern perimeter of Bapco, beyond which are the villages of Eker and Nuwaidrat over a kilometre away. The closest residential community to the south of the Refinery is Askar at approximately 5 km. The large residential community of Riffa lies approximately 1 km north west of the Refinery.

Labour accommodation blocks are scattered around the adjacent industrial areas to the north and south of the Refinery. Labour blocks have been observed within the Alba plant, the South Alba Industrial Estate, and the Ma'ameer and Sitra Industrial areas. There is also a labour accommodation block approximately 600 m to the west of the BMP site, across King Hamad Highway.

There are few remaining areas of natural coastal strip in the study area as they have been significantly affected by industrial development. However, there is a strip to the south east of the Pitch Ponds and Refinery which is still in a relatively natural state. This area has been surveyed as part of the terrestrial ecological survey.

In the wider area there are two important marine conservation areas:

1) Tubli Bay - a nationally designated Marine Protected Area (MPA) under Law No. 53 of 2006 and is also internationally recognized as a RAMSAR site (no. 921). The Bay includes three protected areas namely:

   a. Tubli Bay wetlands (RAMSAR 1b-2c-3b-4b) –
   b. Ras Sanad Mangrove Reserve; and
   c. Tubli National Park (covers the whole Tubli Bay including Ma'ameer Channel).

   Tubli Bay includes open sea habitat, forest habitat (subtropical and tropical mangrove comprising the sole species *Avicennia marina*) and coastline habitat (intertidal lagoon with marshes, mud, sand and salt flats, rocky shoreline, shallow waters with sea grass and subtidal aquatic beds). Tubli Bay is an important staging and wintering area for birds (up to 45 species have been recorded)[1] and is identified as an Important Bird Area (IBA) by BirdLife International[2]. Tubli Bay is approximately 3.5 km north of the Bapco Refinery but is physically linked to Ma'ameer Channel.

2) Fasht Al Adhm – is a shallow water reef comprising mixed habitats including seagrass (*Halodule uninervis*, *Halophila* spp.), macro algae (including key species,

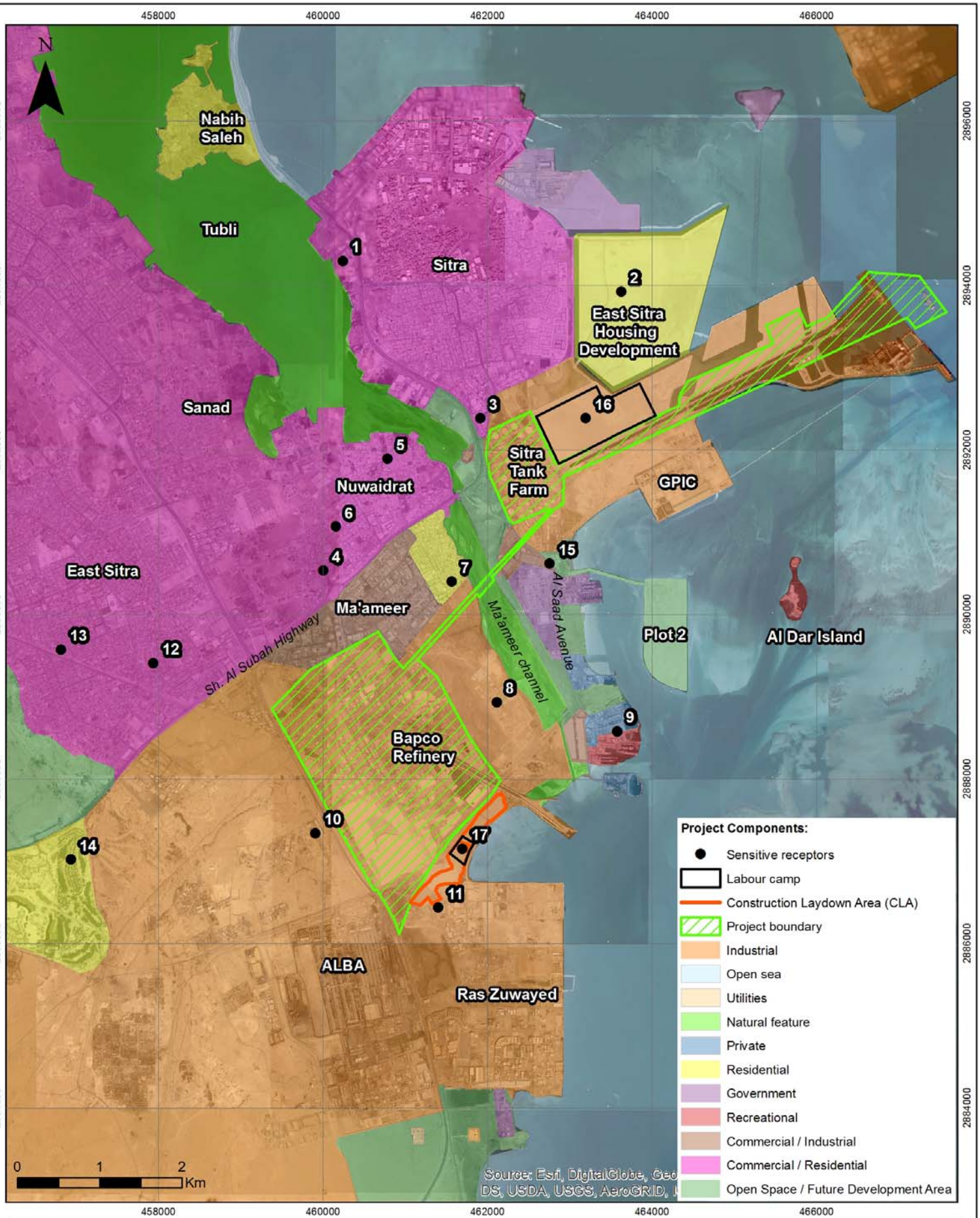
[1] https://www.ramsar.org/taxonomy/term/69/all?page=2.
[2] IBA criteria met A4i, B1i (1994).

Hormophysa cuneiformis, *Cystoseira trinodis*, *Sargassum* spp.), soft substrate (sand) and, in low coverage, hard corals (key coral areas are located along the north eastern fringe). The diversity and geographical extent of habitats present contributes to the biodiversity of the system (and its supporting role with regards harbouring biota and fish) and as such *Fasht Al Adhm* is recognised as the country's main fishing ground.

In the 1980s the reef was considered rich with a high coverage of live reef building corals and with a coverage of 50–75% in most measured locations (Alkuzai et al., 2009); today it supports almost no living coral at all (Shepherd et. al, 2010). Much of the coral coverage of *Fasht Al Adhm* was severely damaged during the global bleaching events, due to increased water temperatures, of 1998 (Shams, 2002) and increased suspended solids within the water column due to coastal development. In 2009, coral cover in *Fasht Al Adhm* was found to comprise less than 5% of the reef areas (Alkhuzai et al., 2009) and the reef is believed to support minimal living coral recently (Riegl and Purkis, 2012).

Subsequent years had seen the limited localised growth of some more hardier species e.g. *Cyphastrea* spp., *Porites* spp. *Favia* spp. and *Platygyra* spp. although the branching corals of the *Acropora* spp. are not to be seen[3].

[3] Personal observations Michael Arora, 2018.



Title: **Adjacent Land Use and Sensitive Receptors**		Client: Bapco, TechnipFMC
Project: BMP Cumulative Impact Assessment		
Date: September 2018	Figure No.: 8.1	Consultant: Environment Arabia
Datum: WGS 84 - UTM 39N	Scale: 1:60,000 (A4)	

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8.3 Air Quality

As part of the ESIA for the BMP, an air quality monitoring station (AQMS1) was established in January 2016, approximately 2km north-west of the refinery (see **Figure 8.2**). The AQMS was established to provide continuous ambient measurements of air pollutant concentrations to inform the baseline air quality assessment. The AQMS was operated for 3 months from 25th January to 27th April 2016. The AQMS was located at the northern extent of the Bahrain National Transportation Yard, East Riffa, Bahrain. This location is in an area representative of background air quality upwind of the Bapco Refinery to characterise conditions at residential receptor locations.

An additional air quality monitoring survey was undertaken as part of the Health Impact Assessment (HIA) of the Camp 2 site. The Camp 2 site is located on an area of reclaimed land at Sitra Wharf known as the NOGA plot (see AQMS2 in **Figure 8.2**). A mobile AQMS (the same AQMS used for the BMP ESIA) was also use for this survey. The AQMS was located on the site and operated from the 4th December 2017 to the 4th January 2018.

The results for both surveys are shown in **Table 8.2** and are compared to relevant national and international standards. Results in bold indicate an exceedence of the standard.

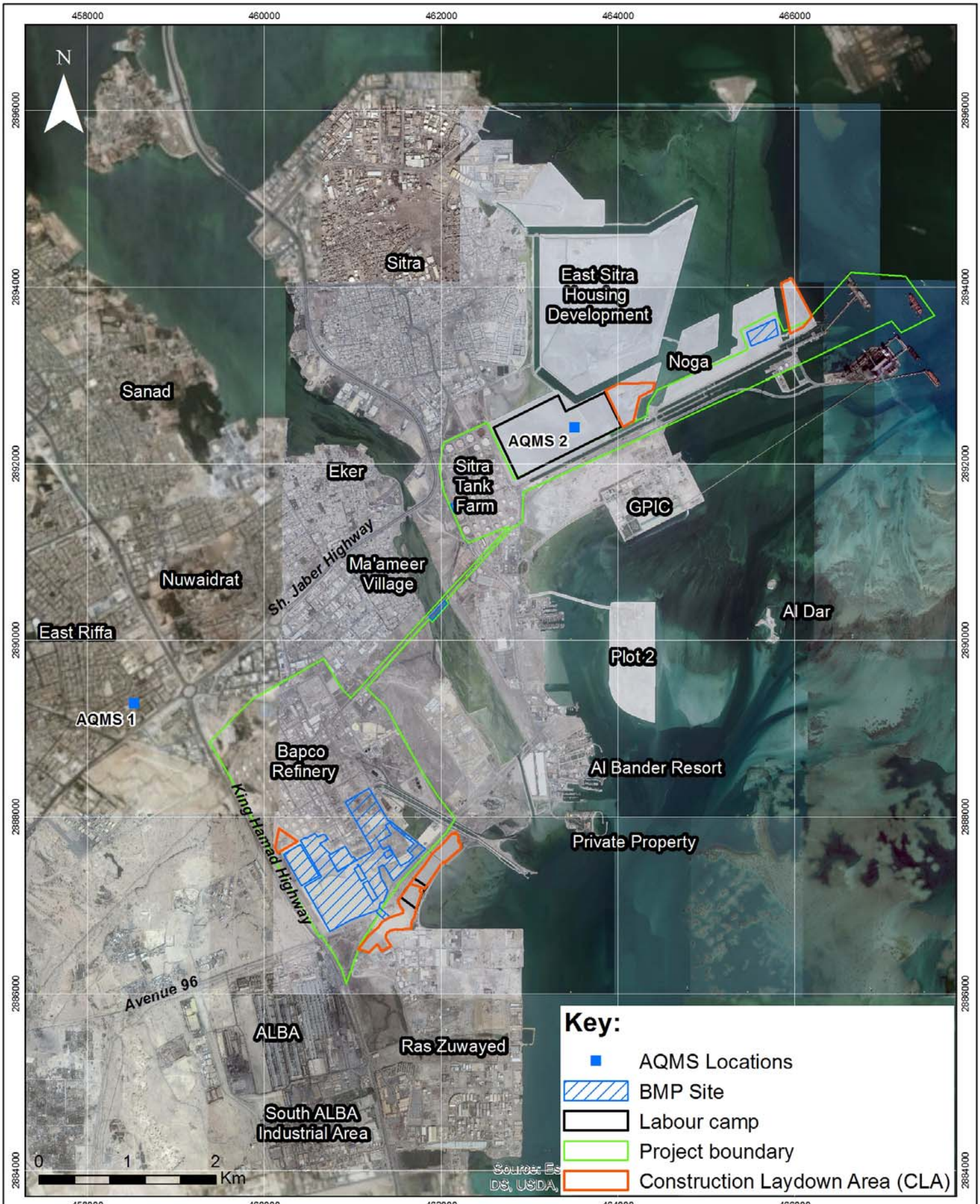
In summary the air quality monitoring results show that in East Riffa, which is representative of the urban background, air quality was compliant with all national standards. At the NOGA plot in Sitra Wharf, short and long term standards for nitrogen dioxide were indicated to be exceeded. At both locations, WHO standards for particulate matter were exceeded. This is due to the natural arid conditions in the region and these standards are not considered achievable in Bahrain for this reason.

The results also show that there are elevated concentrations of hydrogen sulphide above the odour threshold which indicates there are likely to be noticeable odours from time to time. The levels of hydrogen sulphide are below the level where there would be any health concerns. The elevated hydrogen sulphide concentrations are likely to be mainly due to operations in the Bahrain oil and gas field located to the south west of the Refinery.

Table 8.2 Summary of Automatic Air Quality Monitoring

Pollutant	Period	Unit	East Riffa	NOGA Plot	Bahrain	WHO
SO_2	Max Hourly Value	µg/m^3	234.9	128.48	350(1)	-
	Max Daily Value	µg/m^3	89.4	33.36	125	20(4)
	Mean	µg/m^3	18.9	11.24	50	-
NO_2	Max Hourly Value	µg/m^3	83.8	**417.15**	200	200
	Max Daily Value	µg/m^3	26.2	**154.41**	150	-
	Mean	µg/m^3	13.1	**61.41**	40	40
CO	Max Hourly Value	µg/m^3	6.3	1.12		-
	Max Daily Value (8 hourly mean)	µg/m^3	5.5	0.17	10000	
	Mean	µg/m^3	0.78			

Pollutant	Period	Unit	East Riffa	NOGA Plot	Bahrain	WHO
PM10	Max Hourly Value	µg/m^3	1671.2	447.10	-	-
	Max Daily Value	µg/m^3	295.5	240.15	340	50
	Mean	µg/m^3	120.0	111.15	-	20
H_2S	Max Hourly Value Health guide value	µg/m^3	36.3	67.95	-	150
	Odour threshold (30min mean)	µg/m^3			-	7
NMVOC*	Max Hourly Value	ppm	12.1	-	-	-
	Mean	µg/m^3	0.70	-	-	-



Title: Baseline Air Quality Monitoring Locations			Client: Bapco, TechnipFMC
Project: BMP Cumulative Impact Assessment			
Date: September 2018	Figure No.: 8.2		Consultant: Environment Arabia
Datum: WGS 84 - UTM 39 N	Scale: 1:55,000 (A4)		

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8.4 Noise

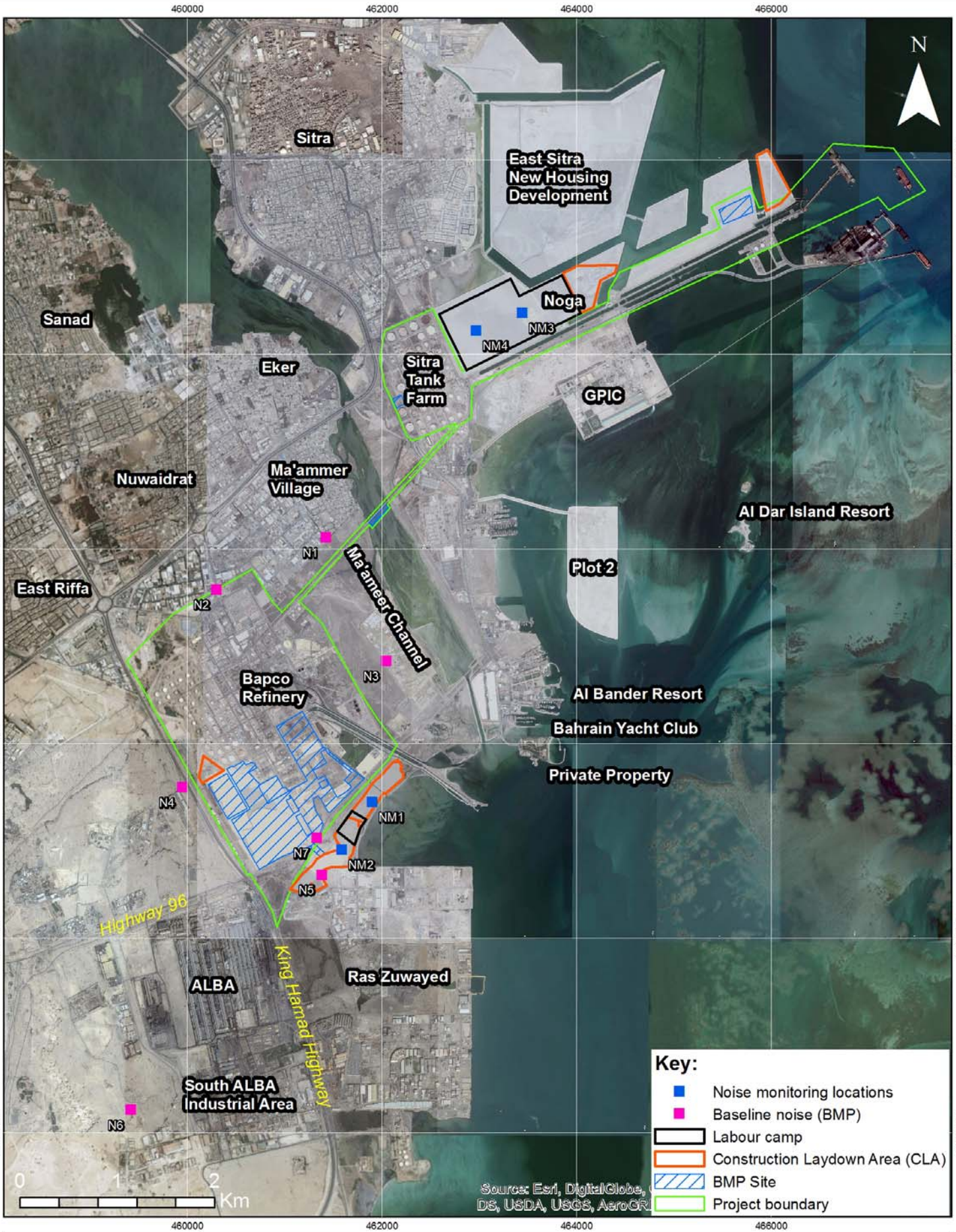
As part of the BMP ESIA, a baseline noise study was undertaken in 2016. Baseline conditions have been established from short-term day and night-time noise monitoring at the nearest noise sensitive receptors identified (N1-N7 shown on **Figure 8.3**).

Additional baseline noise measurements were undertaken at two locations within the Camp 1 and at two locations within the Camp 2 site in November 2017 (NM1-NM4 shown on **Figure 8.3**). The survey comprised 15 minute noise measurements in the day and night-time.

A summary of the baseline noise levels measured at these locations is shown in **Table 8.3** below. The noise levels have been compared to the standard for noise at residential receptors given in Section 1.7 of the General EHS Guidelines, World Bank Group, 2012 (55dBA daytime and 45dBA night-time). Exceedences are shown in bold text in the table. Although the land uses at the receptor locations is classified as industrial, because of the presence of labour camps within these areas the survey results have been compared to the residential standard. It can be noted that in several cases the existing noise levels already exceed the applicable noise standard. This includes the night-time noise limit at all locations monitored

Table 8.3 Baseline Noise Measurement Summary, Noise Level, dB(A)

Receptor Location	Daytime	Evening	Night-time
N1 - APC1	**57.4**	52.6	**49.9**
N2 - APC2	**67.8**	**57.0**	**58.6**
N3 - APC3	**60.6**	**56.8**	**53.0**
N4	**65.1**	**60.8**	**58.9**
N5 - APC4	52.6	52.0	**61.6**
N6	**55.8**	50.7	**53.7**
N7 - APC5	**61.7**	54.1	**54.5**
APC6	58.0	54.1	**54.5**
NM1	54.3	-	**48.3**
NM2	**57.0**	-	**47.6**
NM3	50.6	-	**51.3**
NM4	47.4	-	**48.9**
World Bank Standard	55	55 (daytime standard)	45



Title:	Baseline Noise Monitoring Locations		Client: Bapco, TechnipFMC
Project:	BMP Cumulative Impact Assessment		
Date:	September 2018	Figure No.: 8.3	Consultant: Environment Arabia
Datum:	WGS 84 - UTM 39 N	Scale: 1:50,000 (A4)	

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8.5 Terrestrial Ecology

The existing Refinery, Sitra Tank Farm and Sitra Wharf do not have any areas of terrestrial ecological interest and hence were excluded from the assessment. There will be no direct impacts on any protected or designated areas, such as Tubli Bay. The two areas of interest for the parameter of terrestrial ecology identified during the ESIA are:

1. the coastal strip south of the BMP site; and
2. the Ma'ameer Channel.

8.5.1 Coastal Zone South of BMP Site

A habitat map for the areas surveyed is provided in **Figure 8.4**. Sabkha habitat was observed within the site, with damp and salt-encrusted soil. In the western side of the site, patches of low bushes such as *Sueda sp.* with a few trees such as Mesquite (*Prosopis juliflora* and *Tamarix sp.* were observed. Near the coast and towards the east, more saltmarsh plants such as *Halocnemum* and *Sueda* were observed, with small, shallow water bodies present during high tide where many seabirds were observed.

The area contained a large amount of waterborne rubbish such as plastic and wood, but despite this, the coastal area attracts a large amount of seabirds. Furthermore, there were a few patches of *Phragmites* reeds and *Juncus* recorded in some depressions near the Bapco intake channels.

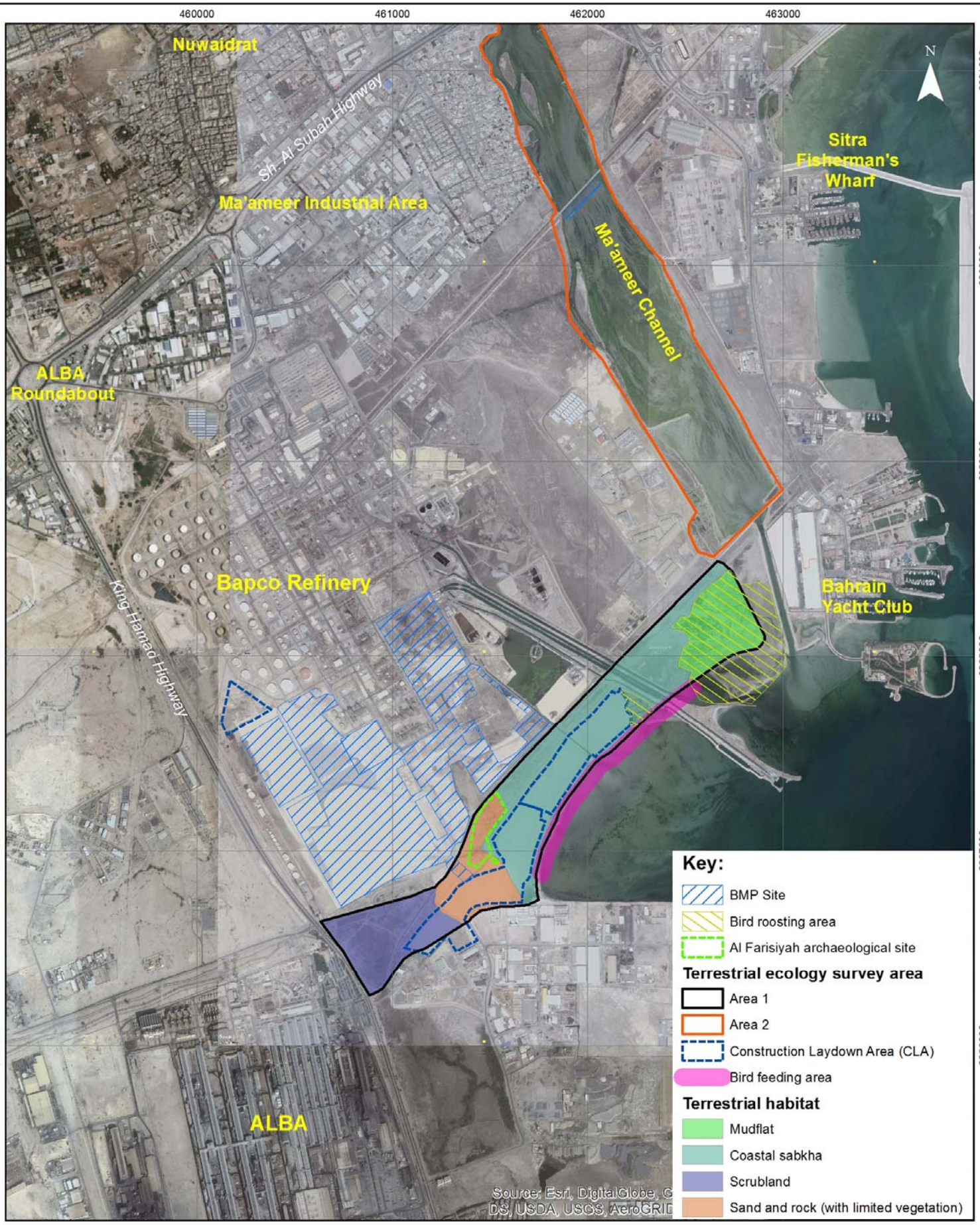
The shallow water along the coastline is an important bird feeding and roosting area. Bird species observed during a terrestrial ecological survey in 2016 are shown in **Table 8.4** together with their status in Bahrain and the region. The area is host to many migratory bird species, and although the birds are common, the habitat available for over-wintering birds in Bahrain is in decline due to on-going reclamation activities in coastal areas.

Table 8.4 List of Birds and Their Status

Scientific Name	Common Name	Status in Bahrain	Status in the Region
Phoenicopterus roseus	Greater Flamingo	Migratory/common	Common
Egretta gularis	Western reef Heron	Resident breeder/ common	Common
Ardea cinerea	Grey Heron	Migratory/common	Common
Larus barabensis	Baraba Gull	Migratory/common	Very common
Larus ridibundus	Black-headed Gull	Migratory/common	Very common
Chroicocephalus genei	Slender-billed Gull	Migratory/common	Common
Phalacrocorax carbo	Great Cormorant	Migratory/common	Very common
Hydroprogne caspia	Caspian Tern	Migratory/breeding	Common
Streptopelia decaocto	Collared Dove	Resident breeder/ v. common	Very common
Galerida cristata	Crested Lark	Resident breeder/	Very common

Scientific Name	Common Name	Status in Bahrain	Status in the Region
		v. common	
Passer domesticus	House Sparrow	Resident breeder/ v. common	Very common

In 2017 the site has been cleared, leveled and infilled with a rock and sand base to create a development ready platform for the TCF. A coastal buffer zone has also been created as part of the recommended BMP ESIA mitigation, to minimise disturbance to roosting and feeding birds in the coastal fringe area. The area is securely fenced off to minimise the impact of the Temporary Construction Facility occupants on bird populations within the coastal buffer zone.



Title: **Coastal Zone Habitat Map**		Client: Bapco, TechnipFMC
Project: BMP Cumulative Impact Assessment		
Date: September 2018	Figure No.: 8.4	Consultant: Environment Arabia
Datum: WGS 84 - UTM 39N	Scale: 1:22,000 (A4)	

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8.5.2 Ma'ameer Channel

The Ma'ameer Channel, with its shallow water, represents a suitable feeding ground for many wintering seabirds and shorebirds. To the north of the existing pipe bridge approximately 350 m from the bridge there are three small islets. To the south of the pipe bridge, there is a further islet approximately 300 m from the bridge. Black mangrove trees (*Avicennia marina*) were found on all islets and along the shoreline of Ma'ameer Channel. The shallow water in the Channel attracts large numbers of over-wintering seabirds such as Greater flamingos, herons and gulls. Hundreds of flamingos, tens of western reef herons were observed feeding around the islets during the terrestrial ecological survey for the BMP ESIA. Gulls were also observed roosting on the islets. Although there is no documentation regarding breeding on the islets, it is possible that in the spring and summer (from April to August), some species may use the shore and mangroves to breed. Birds such as black winged stilt, moor hen, kentish plover regularly breed in the Sanad mangrove within Tubli Bay. As the three northern islets are not far from Shaikh Jaber A Al Subah Highway, traffic noise is discernible. There is a public walkway running along the shoreline close to the islets and a children's park. The presence of the birds indicates that they are undisturbed by the present level of noise.

A baseline survey was carried out on October 2016 by a specialist ecologist. During the survey, mangroves were identified and were singled-out for survey due to their national importance. A rapid mangrove assessment was also undertaken in December 2016 by EACS and updated in 2018 with the aim of further assessing the mangroves. These surveys are reported in more detail in the Critical Habitat Assessment (CHA) Report. Based on the CHA, the Ma'ameer Channel is classified as a Tier 2 critical habitat with respect to the presence of mangroves.

8.6 Marine Environment - Water Quality

8.6.1 Baseline Survey

Water quality was surveyed by EACS in 2016 as part of the BMP ESIA baseline. The marine environment was divided into 3 Areas of Interest (AOI) corresponding to:

- AOI1 – Farasiyah Bay – the receiving water for the outfalls from the Bapco Refinery;
- AOI2 – Ma'ameer Channel – the water that will be impacted by construction of the new pipe bridge;
- AOI3- Sitra Wharf- the water that will be impacted by construction of the new product sealines and other construction at the Wharf.

The work is fully reported in the BMP ESIA. Previously, water quality was also surveyed by Bapco in 2011 and the results of this survey are also summarized in the BMP ESIA report. Sample locations are shown in **Figure 8.5**.

There are no relevant Water Quality Objectives (WQO) or standards in Bahrain and hence water quality survey results were compared to international standards. Standards used comprised:

- The Kingdom of Saudi Arabia (KSA) Environmental Quality Objectives (EQOs) for Ambient Marine Water Quality, Presidency of Meteorology and Environment (PME),

2012. These ambient water quality standards are for 3 classifications of marine waters; Coastal Marine, Coastal High Value and Coastal Industrial[4].

- United States Environmental Protection Agency (USEPA) National Recommended Water Quality Criteria (USEPA, 2014). The US EPA have 2 guideline values, the Criteria Maximum Concentration (CMC), and the Criterion Continuous Concentration (CCC).
- Canadian Council of the Ministers of the Environment – Canadian Water Quality Guidelines for the Protection of Aquatic Life (CCME, 2014).
- UK Environment Agency – Environmental Quality Standards (EQS) − based upon substances detailed in the European Union's Dangerous Substances Directive (76/464/EEC and Daughter Directives).
- Dubai Municipality - Marine Water Quality Objectives (Dubai Municipality, 2003).
- Australian Government - Department of Environment and Resource Management – Queensland Water Quality Guidelines (DERM, 2009).

8.6.2 Summary of Marine Water Quality within AOI 1

Within AOI 1 the water quality results were, for most parameters tested for, considered uncontaminated when compared to international standards. The following provides a summary of the exceedences:

- Aluminium values were consistent across the study area, with a minimum of 0.6 mg/l recorded at stations BMP 33, 43 and 45, and a maximum value of 0.63 mg/l recorded at BMP 26; these breach the Dubai Marine WQO (0.2 mg/l) and the KSA EQO ambient water (C1 and C2 class waters) quality guideline (0.2 mg/l). When comparing the results to those recorded in Bapco (2011), EACS values are significantly lower (by a factor of > 10 fold).
- The KSA EQO for (total) phosphorus is 0.25 mg/l (C2) and 1.0 mg/l (C3 class waters). The values recorded in the study area ranged from 0.13 mg/l to 0.47 mg/l. Half of the stations surveyed were within the guideline value set for C2 classed (coastal) waters.

In situ water quality parameters were all within anticipated ranges for this location of Bahrain and time of year (i.e. January and February); with the exception of temperature readings at stations BMP 22a, 22b and 22c located approximately 250m from the Bapco Refinery main outfall. The temperature differential between locations a, b and c was 9.96 ºC with 19.42 ºC recorded at BMP 22a and 29.38 ºC recorded at BMP 22c with temperature reducing with distance from the outfall.

At the remainder of the stations, the temperature ranged from 18.23 ºC (~ 1 m from the seabed at BMP 43)) to a maximum of 20.82 ºC (~ 1m from the surface at BMP 33) with an average of 19.27 ºC across all stations and depths.

8.6.3 Summary of Marine Water Quality within AOI 2

For most parameters tested for AOI 2, the results showed that the water is uncontaminated in comparison to the international standards used. *In situ* water quality

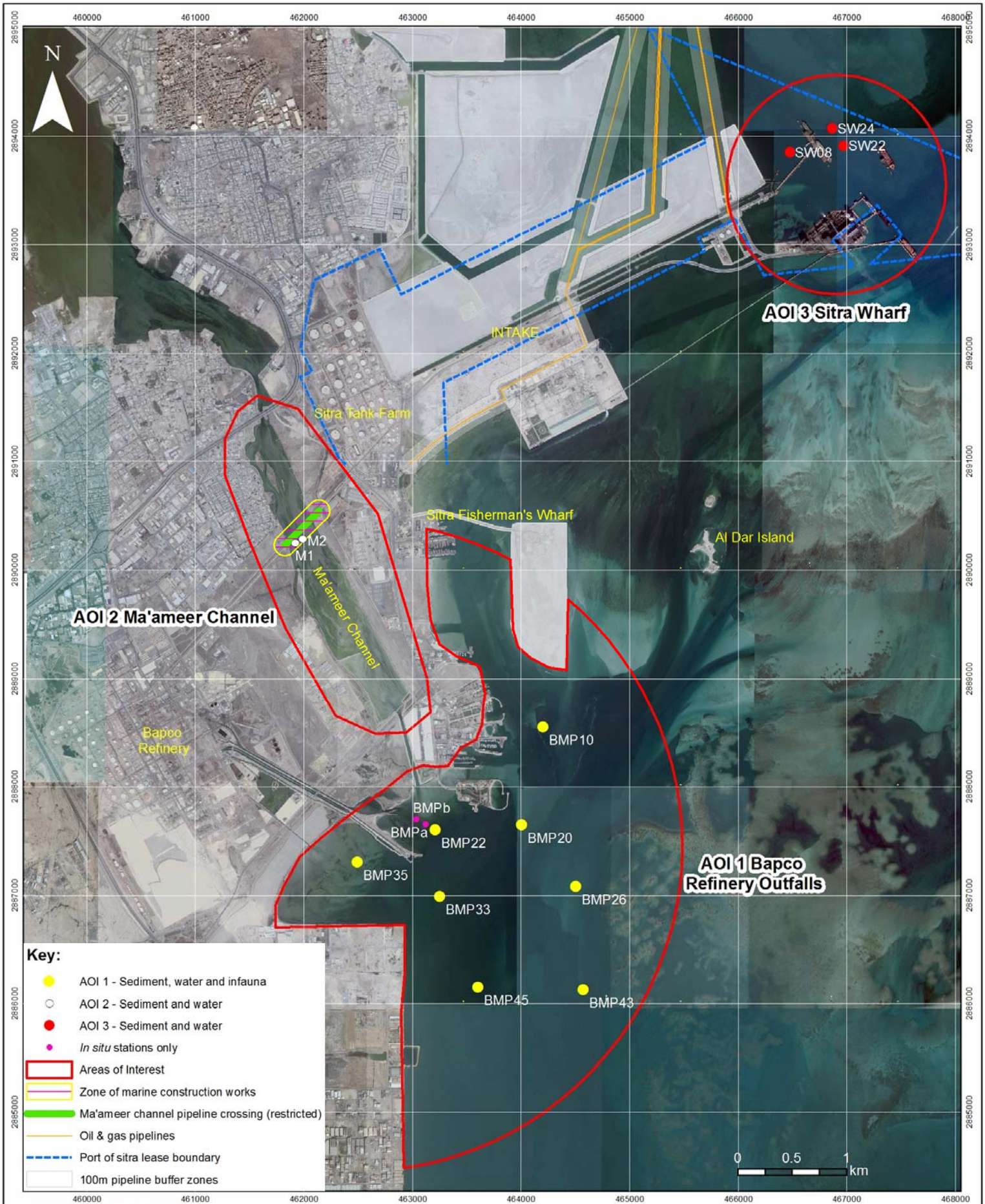
[4] For the purpose of the ESIA only Coastal Marine and Coastal High Value guidelines are considered.

parameters were not recorded at AOI 2 due to shallow water depths. The following bullet points highlight exceedences of the standards used.

- The value recorded for copper was 0.062 mg/l and 0.059 mg/ for station M1 and M2 respectively. These values are in breach of the KSA PME ambient water quality standards for C1 and C2 waters (coastal and high value), the UK EQS, and Dubai WQO. It is however compliant with the KSA PME ambient water quality standard (industrial waters) and both the US EPA CMC and CCC value for this parameter.
- 0.054 mg/l zinc was recorded from the water sample M1 and 0.05 mg/l at M2. These values are above the UK EQS (set at 0.04 mg/l) and the Dubai WQO (0.02 mg/l). The values recorded are however compliant with all of the KSA EQS (for all classifications of water bodies), the US EPA CMC and CCC and US EPA CMC and CC values for this parameter.
- Reactive phosphorus was recorded as 0.01 mg/l for both stations (M1 and M2) in AOI 2. This exceeds the Australian DERM (0.006 mg/l) but is compliant with the Dubai WQO (0.05 mg/l).

8.6.4 Summary of Marine Water Quality within AOI 3

Water quality recorded from the 3 locations in AOI 3 can be considered largely uncontaminated at the time of sampling when comparing the results to the international standards used. Furthermore, in situ water quality results were all within ranges considered to be 'normal' for the geographical area and time of year.



Title: **Location of Infauna, Sediment Sampling and Water sampling Locations (AOI 1, 2 & 3)**			Client: Bapco, TechnipFMC
Project: BMP Cumulative Impact Assessment			
Date: September 2018	Figure No.: 8.5		Consultant: Environment Arabia
Datum: WGS 84 - UTM 39N	Scale: 1:45,000 (A4)		

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8.7 Marine Environment - Sediment Quality

8.7.1 Baseline Survey

A baseline survey was undertaken as part of the BMP ESIA comprising sampling sediments from AOI1-3 at eight locations within AOI 1, two locations within AOI 2 and three locations within AOI 3. Sample locations are shown in **Figure 8.5**. As there are no relevant sediment quality standards in Bahrain, the survey results were compared to international standards as detailed below:

- Australian Government National Assessment Guidelines for Dredging (NAGD) (Commonwealth of Australia, 2009) and ANZECC/ARMCANZ 2000 The Screening Levels used (or 'ISQG Trigger Value') are threshold concentrations below which the frequency of adverse biological effects is expected to be very low.
- The Interim Marine Sediment Quality Guidelines (ISQGs) issued by CCME (Canadian Council of Ministers of the Environment, 2007). The Canadian ISQGs include Threshold Effect Levels (TELs) and Probable Effect Levels (PELs).
- The UK Centre for Environment, Fisheries and Aquaculture Science (CEFAS) guideline 'action levels' for the disposal of dredged material at sea (DEFRA, 2012).
- Dutch Target and Intervention Values, 2000.
- Swedish Environmental Protection Agency (EPA) Environmental Quality Criteria (EQC) for seabed sediments as referenced in Bapco, 2011[5].

8.7.2 Summary of Marine Sediment Quality within AOI 1

Within AOI 1, the sediment quality was, for most parameters tested for, considered uncontaminated when compared to international standards.

Exceedences of the standards were only identified at station BMP 22 (**Figure 8.5**) for the following parameters:

- Copper (value recorded - 87.0 mg/kg): the Australian NAGD ISQG (65.0 mg/kg), Canadian Threshold Effects Level (TEL) (18.7 mg/kg for copper), CEFAS Action Level (AL) 1 (30.0 mg/kg), Dutch Threshold Value (TV) (36.0 mg/kg) and Swedish Environment Quality Criteria (EQC) (80.0 mg/kg) for copper.
- Lead ranged from 'not detected' at 5 of 8 of the locations sampled (< 5.0 mg/kg) to a maximum of 89.00 mg/kg at BMP 22. The aforementioned result breaches the Australian NAGD ISQG (50.0 mg/kg), the Canadian PEL (30.2 mg/kg), CEFAS AL 1 (50.0 mg/kg), and Dutch IV (85.0 mg/kg). However, BMP 22 recorded a value for lead that was lower than the Canadian PEL, CEFAS AL 2, Dutch IV and Swedish EPA EQC.
- The values recorded for zinc ranged from 6.0 mg/kg (BMP 26) to 171 mg/kg at BMP 22. BMP 22 breached the Canadian TEL (124 mg/kg) but was under all of the remaining guideline values reported (Australian NAGD ISQG, Canadian PEL, CEFAS AL 1 and AL 2, Dutch TV and IV, and Swedish EPA EQC).

The results of the Particle Size Analysis (PSA) indicated that the majority of the survey locations were described as either 'gravelly sand' or 'slightly gravelly sand' with a

[5] Swedish standards have been referred to as they were used in Bapco, 2011.

relatively low silt content (<12 %). Silt content ranged from 2% at station BMP 20 (in the middle of the channel) to 88% at BMP 22 closest to the Refinery main outfall. The second siltiest station was BMP 33 situated in the vicinity of the Refinery intake (32 % silt).

8.7.3 Summary of Marine Sediment Quality within AOI 2

Within AOI 2, two sediment samples were taken close to the existing pipe bridge - within the footprint of the proposed construction works. For most parameters tested the sediment quality results were considered uncontaminated. The only exceedences of the international standards were:

- The copper value (26 mg/kg) recorded at M1 breached the Canadian TEL (set at 18.7 mg/kg); however, it is in line with all of the other guideline values for this parameter.
- The CEFAS AL 2 was breached for the parameters MBT (2.55 mg/kg) and TBT (1.92 mg/kg) in the sample collected from station M2. The NAGD was breached at both M1 and M2 for all parameters, with the exception of those which were recorded at <1 mg/kg; the detection limit is higher than the NAGD standard.

Both M1 and M2 contained 5% gravel. M1 (closer to the western shoreline of the channel) contained a significantly higher silt content (66%) than station M2 situated closer to the centre of the channel (23%). M1 is classified as 'slightly gravelly mud' whilst M2 is classified as 'slightly gravelly muddy sand'.

8.7.4 Summary of Marine Sediment Quality within AOI 3

Within AOI 3, for most parameters tested the sediment quality results are considered uncontaminated. Exceedences of the international standards were, however, recorded as follows:

- The copper values recorded ranged from 26 mg/kg (SW 24) to 35 mg/kg (SW 22). These values are all in breach of the Canadian TEL, which is set at 18 mg/kg. In addition, the values recorded at SW 08 and SW 22 were equal to or breached the CEFAS AL 1 (30 mg/kg). However, the values recorded were within the other international standards referenced.
- The sum of PAH was 1.8 mg/kg for SW 22. This value is above the Dutch TV (set at 1.0 mg/kg), but is in line with the Dutch IV and Australian NAGD ISQG trigger value.
- The values for DBT, MBT and TBT at all 3 stations sampled breached the Australian NAGD ISQG value of 1.0 µg/kg, and the CEFAS AL 1 (0.1 mg/kg) and CEFAS AL 2 (1.0 mg/kg). In addition, the values recorded for DOT and MOT breached the Australian NAGD ISQG at all 3 stations and the Australian NAGD ISQG was breached at SW 08 for the parameters TeBT and TPhT.

All 3 samples collected within AOI 3 were very similar with regard to composition, with each recording 1% gravel, sand content ranged from 50 – 55% and silt content ranged from 44 – 49%. Each sample was classified as 'sandy mud'.

8.8 Marine Environment - Ecology

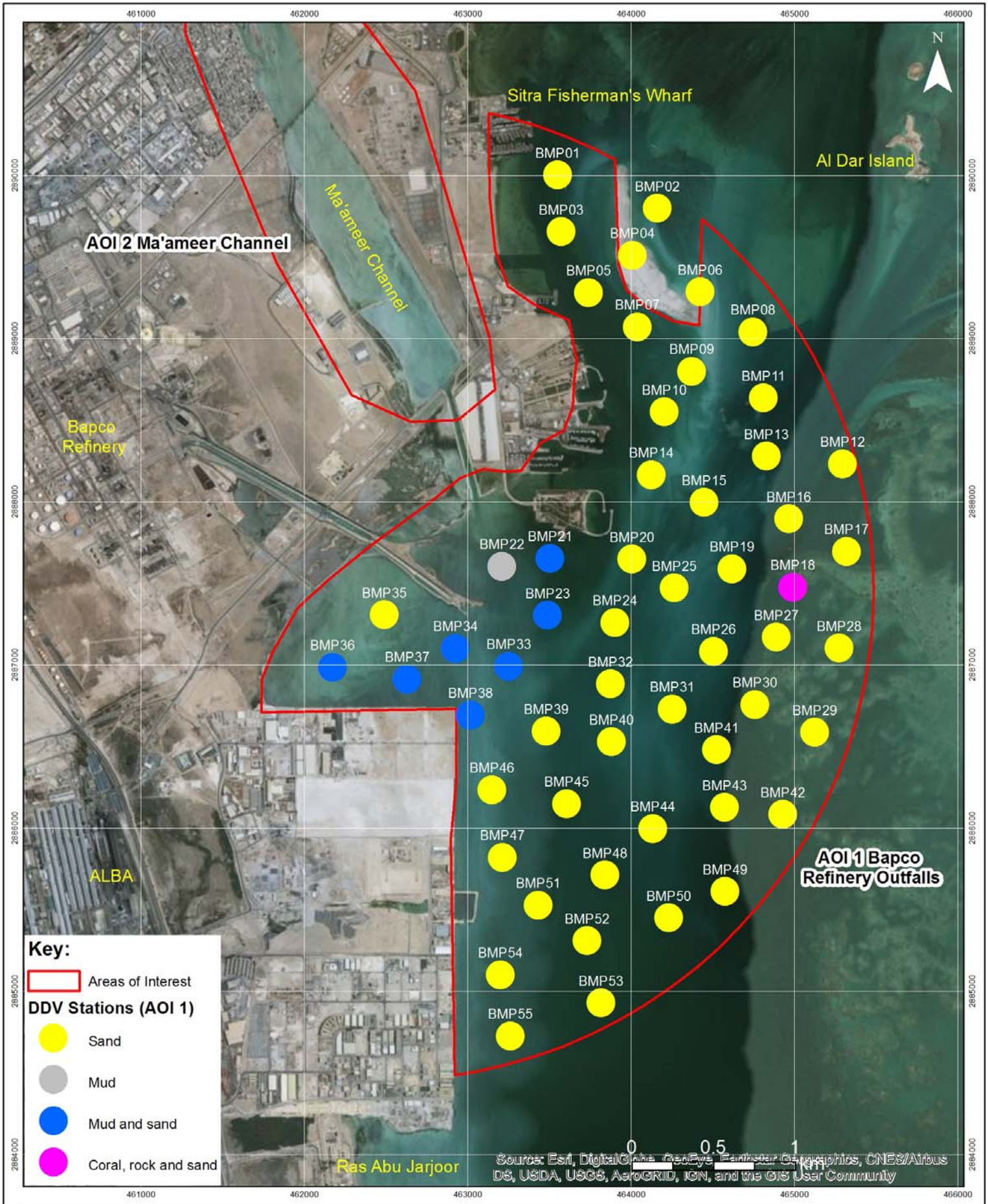
8.8.1 AOI 1

The marine habitat was surveyed using drop down video and SCUBA. The survey identified four broadscale marine habitat types within AOI 1. These are summarised in **Table 8.5**. and **Figure 8.6**. A total of 70 taxa were identified throughout the study area, of which fish, flora and fauna accounted for 5, 20 and 45 taxa respectively.

Table 8.5 Marine Habitats Identified Within the Study Area

Habitat	Summary Description
Sand	Well-mixed sediment dominated by sand (fine-coarse). Topography varies from flat to undulating plain. Some green filamentous algae and mixed macroalgae present (~<5%). Some scouring evident on sediment surface in places.
Mud and sand	Muddy / sandy seabed, pits and burrows on the surface of the sediment. Some areas may have a thin layer of algal biofilm.
Mud	Muddy seabed with frequent distinctive pits and burrows on the surface. Some areas may have a thin layer of algal biofilm. Typically no conspicuous flora or fauna.
Coral, rock & sand[6]	Large rocky outcrops with areas with sand in between. Rocky areas have a mixture of epibiota including macroalgae, mixed bivalves, and scleractinian corals (coral cover variable and up to 60 % in places).

[6] Identified from the survey and SCUBA surveys.



Title: **Marine Habitat Map (AOI 1)**			Client: Bapco, TechnipFMC
Project: BMP Cumulative Impact Assessment			
Date: September 2018	Figure No.: 8.6		Consultant: Environment Arabia
Datum: WGS 84 - UTM 39N	Scale: 1:50,000 (A4)		

CN:\BMP Cumulative Impact\mxd\Habitat map AOI 1.mxd

8.8.2 AOI 2

The marine habitat within the Ma'ameer Channel consists of shallow (typically less than 1m) subtidal areas comprising a silty / muddy seabed with limited flora and fauna. With the exception of the fringing mangrove trees (Avicennia marina), only 9 epifaunal species were recorded within three phyla and four classes. The majority of the specimens were molluscs (6 taxa). The most commonly encountered gastropods were the ceriths (Cerithium) and Pirenella sp. typically associated with the mud/sand flats. Only a single crustacean taxa was recorded in the area close to the existing pipeline crossing; the abundant small hermit crabs of the Family Paguridae which inhabited assorted empty gastropod shells (Paguridae). Barnacles (Balanus sp.) and Spirobranchus kraussii (Serpulid worms) were also observed, both of which were almost exclusively associated with palm trunks or other hard surfaces of debris deposited in the Channel.

Several shoals of small fish were observed during the survey, on the shallow subtidal areas and it is likely that the Channel plays an important role as nursery habitat for juvenile fish. The presence of goby burrows also indicates the use of the Channel as a permanent habitat for these fishes. At least 10 flora species were observed during the survey, from three phyla and seven orders, including the fringing mangrove trees. The most notable type of algal specimens on site were large filamentous strands of robust green algae, most of which was most likely a mix of several species including Chaetomorpha sp., Cladophora sp. and Ulva Spp. (2) in varying proportions.

8.8.3 AOI 3

Only 2 habitat types were identified in AOI 3 - 'sand' and 'mud and sand'. The 'sand' habitat was identified at only 5 of the 38 locations surveyed (13 %) whilst the 'mud and sand' habitat was identified at the remaining 33 (87 %). Both habitat types are characterised as having little or no conspicuous flora or fauna due dredging and port operations causing disturbance to the sea bed.

8.9 Cultural Heritage

A cemetery used by inhabitants of the historical village of Al Farasiyah, and dating to the 16/17th century, falls within the existing Refinery footprint / southern boundary of the BMP. This is fenced off from the operational Refinery and will not be affected by the Refinery operation or BMP construction or operation.

A further three sites were identified in the foreshore area to the south east of the Refinery site (noted as 191, 192 and 193 in Section 13 of the ESIA) comprising remnants of mosques and the village of Al Farasiyah. The areas of interest were fenced off during the BMP site preparation works in 2018 as agreed with Bahrain Authority for Culture and Antiquities (BACA) and will not be impacted by the BMP construction or operation.

8.10 Road Users

Traffic accesses the current Bapco Refinery from the Nuwaidrat and ALBA roundabouts. Traffic is often congested in both of these areas. The BMP site is located to the east of King Hamad Highway, within the current Bapco boundary. Access to the BMP site and

the Pitch Ponds is via the King Hamad Highway at the junction with ALBA. The King Hamad Highway is a major dual carriageway.

As of early 2016, road improvement construction work has commenced on the ALBA and the Nuwaidrat roundabouts. When complete, the ALBA roundabout will consist of a 3-level interchange and the Nuwaidrat roundabout will be a 2-level interchange. The works are expected to be completed in 2019 and are expected to greatly reduce congestion in the area.

The Roads Directorate also plans to upgrade Shaikh Jaber A Al Subah Highway at unspecified dates in the future to 3-4 lanes in each direction together with grade separated junctions.

Traffic volumes for 2010, 2016 and 2020 have been provided from the MWMAUP National Planning and Development Strategy 2030 (NPDS) Model created by W.S Atkins for the section of King Hamad Highway which adjoins the ALBA roundabout and passes ALBA and Bapco sites. The volumes are presented in **Table 8.6**.

Table 8.6 Traffic Flows on King Hamad Highway

Duration	2010 (measured)		2016 (measured)		2020 (predicted)	
	From ALBA R/A	To ALBA R/A	From ALBA R/A	To ALBA R/A	From ALBA R/A	To ALBA R/A
	Numbers of Vehicles					
24 hrs	19,737	22,462	35,662	38,607	46,279	49,370
Morning 06.30-07.30	1,487	1,173	3,475	2,186	4,800	2,861
Afternoon 13.00-14.00	1,448	1,345	2,129	2,738	2,583	3,667
Evening 16.30-17.30	1,357	1,391	2,061	2,868	2,531	3,852

Traffic volumes on King Hamad Highway are relatively high and averaged 160 vehicles per hour in 2016. Given the industrial nature of the area, the traffic comprises a large proportion of HGVs and worker transportation (minibuses, coaches).

The BMP construction phase will also use Um Al Saad Avenue and Alba Road to allow construction workers to be transported by bus from Labour Camp 2 on the NOGA plot to the BMP site. Um Al Saad Avenue is a single lane each way road which feeds a mainly industrial area. No traffic figures are available but the road is relatively quiet and under used. Alba Road is a private road which runs to the south of the Refinery and provides connectivity from Um Al Saad Avenue to the Alba smelter. The road is mainly used by road tankers transporting alumina, petroleum coke and pitch from Alba port to the smelter.

8.11 Social Baseline

8.11.1 National

Bahrain comprises a growing population of 1,501,116 in 201. Growth is driven by immigration and natural growth of the native population. Average life expectancy is

increasing due to advances in health care and higher living standards, increasing from 73.7 years in 2000, 74.9 years in 2010 to 77.1 years in 2016 (Source: United Nations). The Bahraini population is predominately Muslim, both Sunni and Shi'a denominations.

The average literacy rate (both sexes expressed as percentage aged 15 years and above) was 85.5% in the year 2000, and 87.9% in the year 2005. However, in the year 2010 the average increased to 90%.

Approximately 72.4% of the labour force in Bahrain is comprised of non Bahraini workers (mostly male) engaged in the private sector while the Bahraini work force is employed in the public sector. Unemployment rates have slightly gone up from 3.6% in 2010 to 4.3% in 2016. Only 1% of the population is in the retirement age group (60-65). (CIO Website).

Economic activity in the economy of the Kingdom of Bahrain is diverse. The oil and natural gas sector is the largest contributor to the nation's Gross Domestic Product (GPD) followed by the manufacturing sector, which contribute 19.21% and 14.92% respectively in 2016. Although total revenue from the oil and gas sector dropped from 2,600.16 Million BD in 2013 to 1436.46 Million BD in 2016, this is expected to change in the coming years with the most recent discovery of large oil reserves in Bahrain where 80 billion barrels of shale oil were discovered in 2018. (CIO Website).

8.11.2 Southern Governorate

The Southern Governorate is the largest of the four governorates and most diverse. Much of the Southern Governorate is open space and undeveloped land but there are also significant areas of industrialization, subrban development, educational and lesuire facilities.

There are a number of important industrial sites within the Southern Governorate including Bapco, Alba, GPIC, Banagas (natural gas purification and processing), Al Dur (integrated desalination and power plant), South Alba Industrial Area and the Bahrain oil and gas field.

The Bahrain oil and gas field occupies much of the centre of the island and residential areas occupy the coastal zone (Hamad Town, Zallaq on the west coast, Jaww and Askar on the east coast and the new development of Durrat Al Bahrain to the south). The Southern Governorate also hosts important leisure and educational resources in the western area including Bahrain International Circuit, Bahrain University and equestrian facilities.

The Southern Governorate is growing residential area where 51.2% of establishments are residential units which are relatively new (34.4% of the establishments are under 14 years of age). Local residents mostly occupy apartments and private villas (40.7% and 44.5% respectively).

The population in the Governorate was estimated to be 301,058 in 2017 (20% of the total Bahraini population).

8.11.3 Local Area

The Refinery and main BMP development site is located on the eastern coast of Bahrain within an industrial area. Industrial facilities in the area include Alba smelter, Gulf Petrochemical Industries Company (GPIC), Riffa Power Station, Ras Abu Jajur desalination plant, South Alba Industrial Estate and Alba port including a petroleum coke calciner. To the south of the Refinery there is Ras Zuwayed which is an industrial area comprising numerous small factories, contractors' storage and fabrication facilities, a jetty and several labour accommodation blocks.

To the north of the Bapco Refinery there are several residential areas comprising: Ma'ameer; Nuwaidrat; Al Eker; East Riffa and Sanad. These were originally distinct villages that have become linked to form part of the suburban sprawl.

8.11.4 Marginal Groups

The social impact assessment identified the following vulnerable social groups:

1) Disabled persons;
2) Youth;
3) The elderly.

8.11.5 Marine Environment Users

Fasht Al Adham is the country's most productive fishing ground and is consequently important to the livelihoods of local fishermen.

8.11.6 Workers

According to the Labour Market Regulatory Authority (LMRA), non-Bahraini nationals make up 78.8% of the labour force in 2017. In 2016, 516,474 expatriate workers were reported to be working in the private sector while 8,260 were employed in the public sector (Source CIO). Expatriate workers are mainly from Asian countries such as India, Pakistan, Bangladesh and the Philippines.

8.11.7 Businesses on Um Al Saad Avenue

Bahrain Yacht Club and Al Bander Resort Hotel are the nearest tourism and recreation facilities which are located approximately 2 km east of Refinery, at the end of Um Al Saad Avenue. Also along Um Al Saad Avenue there are a number of private businesses and government directorate offices and storage facilities as well as the entrance to Sitra fishing port.

9 STEP 4 - ASSESSMENT OF CUMULATIVE IMPACTS ON VECS

9.1 Identification of Potential for Cumulative Impacts – BMP Construction Phase

The identified key impacts for VECS for past, present and planned developments and social and environmental stressors have been assessed against scoped in impacts for the BMP to identify where there is potential for cumulative impacts to occur. The assessment for the BMP construction phase is summarized in **Table 9.1.** Where potentially significant cumulative impacts are identified they are described and assessed further in the following sections.

Table 9.1 Identification of Potential Cumulative Impacts of BMP Construction Phase

			Valued Environmental Components												
			Air Quality		Soil and Groundwater		Noise			Marine Environment	Terrestrial Ecology		Traffic and Access		Social and Community Impacts
Project / Stressor	Start/End Date	VECs Impacted by Project or Stressor	Construction Phase Dust	Construction Vehicle Emissions	Pitch Ponds - Presence of LNAPL in BH1056 and dissolved hydrocarbon contamination in BH1060	All BMP – Groundwater contamination	Construction Noise Day	Construction Noise Evening	Construction Noise Night	Marine Sediment Loading and Resuspension – AOI 3, Sitra Wharf	Loss of feeding and roosting grounds for birds during construction - coastal fringe.	Disturbance to feeding and roosting grounds for birds during construction – Ma'ameer Channel	Transport of Construction Workers	Transport of Oversized Loads	In-Migration / Social Cohesion
Previous and Existing Developments															
Bapco Oil Refinery, Sitra Tank Farm and Wharf		Air Quality	Y	Y	N	N	N	N	N	N	N	N	N	N	N
		Marine Environment	N	N	N	N	N	N	N	N	N	N	N	N	N
		Road Users	N	N	N	N	N	N	N	N	N	N	Y	Y	N
		Groundwater	N	N	Y	Y	N	N	N	N	N	N	N	N	N
		Noise	N	N	N	N	Y	Y	Y	N	N	N	N	N	N
Alba aluminium smelter		Air Quality	N	N	N	N	N	N	N	N	N	N	N	N	N
		Marine Environment	N	N	N	N	N	N	N	N	N	N	N	N	N
		Road Users	N	N	N	N	N	N	N	N	N	N	Y	N	N
		Groundwater	N	N	N	N	N	N	N	N	N	N	N	N	N
		Noise	N	N	N	N	N	N	N	N	N	N	N	N	N
Alba Port –		Air Quality	N	N	N	N	N	N	N	N	N	N	N	N	N

			Valued Environmental Components												
			Air Quality		Soil and Groundwater		Noise			Marine Environment	Terrestrial Ecology		Traffic and Access		Social and Community Impacts
Project / Stressor	Start/End Date	VECs Impacted by Project or Stressor	Construction Phase Dust	Construction Vehicle Emissions	Pitch Ponds - Presence of LNAPL in BH1056 and dissolved hydrocarbon contamination in BH1060	All BMP – Groundwater contamination	Construction Noise Day	Construction Noise Evening	Construction Noise Night	Marine Sediment Loading and Resuspension – AOI 3, Sitra Wharf	Loss of feeding and roosting grounds for birds during construction - coastal fringe.	Disturbance to feeding and roosting grounds for birds during construction – Ma'ameer Channel	Transport of Construction Workers	Transport of Oversized Loads	In-Migration / Social Cohesion
import of alumina, pitch, petroleum coke		Marine Environment	N	N	N	N	N	N	N	N	N	N	N	N	N
		Road Users	N	N	N	N	N	N	N	N	N	N	Y	N	N
Riffa Power Station – electricity generation		Air Quality	N	N	N	N	N	N	N	N	N	N	N	N	N
		Road Users	N	N	N	N	N	N	N	N	N	N	Y	N	N
Ras Abu Jajur Desalination Plant – supply of potable water		Air Quality	N	N	N	N	N	N	N	N	N	N	N	N	N
		Marine Environment	N	N	N	N	N	N	N	N	N	N	N	N	N
		Road Users	N	N	N	N	N	N	N	N	N	N	N	N	N
		Groundwater	N	N	N	N	N	N	N	N	N	N	N	N	N
		Noise	N	N	N	N	N	N	N	N	N	N	N	N	N
GPIC – production of methanol and		Air Quality	N	N	N	N	N	N	N	N	N	N	N	N	N
		Marine Environment	N	N	N	N	N	N	N	N	N	N	N	N	N
		Road Users	N	N	N	N	N	N	N	N	N	N	Y	N	N

			Valued Environmental Components												
			Air Quality		Soil and Groundwater		Noise			Marine Environment	Terrestrial Ecology		Traffic and Access		Social and Community Impacts
Project / Stressor	Start/End Date	VECs Impacted by Project or Stressor	Construction Phase Dust	Construction Vehicle Emissions	Pitch Ponds - Presence of LNAPL in BH1056 and dissolved hydrocarbon contamination in BH1060	All BMP – Groundwater contamination	Construction Noise Day	Construction Noise Evening	Construction Noise Night	Marine Sediment Loading and Resuspension – AOI 3, Sitra Wharf	Loss of feeding and roosting grounds for birds during construction - coastal fringe.	Disturbance to feeding and roosting grounds for birds during construction – Ma'ameer Channel	Transport of Construction Workers	Transport of Oversized Loads	In-Migration / Social Cohesion
urea		Noise	N	N	N	N	N	N	N	N	N	N	N	N	N
Riffa Airbase – military helicopter base		Air Quality	N	N	N	N	N	N	N	N	N	N	N	N	N
		Road Users	N	N	N	N	N	N	N	N	N	N	Y	N	N
		Noise	N	N	N	N	Y	Y	Y	N	N	N	N	N	N
Askar Landfill – non hazardous and municipal landfill		Air Quality	N	N	N	N	N	N	N	N	N	N	N	N	N
		Road Users	N	N	N	N	N	N	N	N	N	N	Y	N	N
		Groundwater	N	N	N	N	N	N	N	N	N	N	N	N	N
		Noise	N	N	N	N	N	N	N	N	N	N	N	N	N
Hafeera landfill – hazardous waste landfill		Air Quality	N	N	N	N	N	N	N	N	N	N	N	N	N
		Road Users	N	N	N	N	N	N	N	N	N	N	Y	N	N
		Groundwater	N	N	N	N	N	N	N	N	N	N	N	N	N
		Noise	N	N	N	N	N	N	N	N	N	N	N	N	N
Ras Zuwayed Industrial Area –		Air Quality	Y	Y	N	N	N	N	N	N	N	N	N	N	N
		Road Users	N	N	N	N	N	N	N	N	N	N	Y	N	N

			Valued Environmental Components												
			Air Quality		Soil and Groundwater		Noise			Marine Environment	Terrestrial Ecology		Traffic and Access		Social and Community Impacts
Project / Stressor	Start/End Date	VECs Impacted by Project or Stressor	Construction Phase Dust	Construction Vehicle Emissions	Pitch Ponds - Presence of LNAPL in BH1056 and dissolved hydrocarbon contamination in BH1060	All BMP – Groundwater contamination	Construction Noise Day	Construction Noise Evening	Construction Noise Night	Marine Sediment Loading and Resuspension – AOI 3, Sitra Wharf	Loss of feeding and roosting grounds for birds during construction - coastal fringe.	Disturbance to feeding and roosting grounds for birds during construction – Ma'ameer Channel	Transport of Construction Workers	Transport of Oversized Loads	In-Migration / Social Cohesion
industrial area		Noise	N	N	N	N	Y	Y	Y	N	N	N	N	N	N
South Alba Industrial Estate – industrial area		Air Quality	N	N	N	N	N	N	N	N	N	N	N	N	N
		Road Users	N	N	N	N	N	N	N	N	N	N	Y	N	N
		Noise	N	N	N	N	N	N	N	N	N	N	N	N	N
Bahrain oil and gas field – oil and gas exploration and extraction.		Air Quality	N	N	N	N	N	N	N	N	N	N	N	N	N
		Road Users	N	N	N	N	N	N	N	N	N	N	Y	N	N
		Groundwater	N	N	N	N	N	N	N	N	N	N	N	N	N
		Noise	N	N	N	N	N	N	N	N	N	N	N	N	N
Planned Future Developments															
Alba Line 6	Operation from Jan 2019	Air quality	N	N	N	N	N	N	N	N	N	N	N	N	N
		Groundwater resources (reduced abstraction, beneficial impact)	N	N	N	N	N	N	N	N	N	N	N	N	N
		Waste management capacity	N	N	N	N	N	N	N	N	N	N	N	N	N

			Valued Environmental Components												
			Air Quality		Soil and Groundwater		Noise			Marine Environment	Terrestrial Ecology		Traffic and Access		Social and Community Impacts
Project / Stressor	Start/End Date	VECs Impacted by Project or Stressor	Construction Phase Dust	Construction Vehicle Emissions	Pitch Ponds - Presence of LNAPL in BH1056 and dissolved hydrocarbon contamination in BH1060	All BMP – Groundwater contamination	Construction Noise Day	Construction Noise Evening	Construction Noise Night	Marine Sediment Loading and Resuspension – AOI 3, Sitra Wharf	Loss of feeding and roosting grounds for birds during construction - coastal fringe.	Disturbance to feeding and roosting grounds for birds during construction – Ma'ameer Channel	Transport of Construction Workers	Transport of Oversized Loads	In-Migration / Social Cohesion
		Road users	N	N	N	N	N	N	N	N	N	N	N	N	N
Alba Port Capacity Upgrade	Construction 2018-19	Road users	N	N	N	N	N	N	N	N	N	N	Y	N	N
		Air quality	N	N	N	N	N	N	N	N	N	N	N	N	N
		Marine environment – water quality and marine ecology	N	N	N	N	N	N	N	N	N	N	N	N	N
Alba Port Capacity Upgrade	Operation from Mid 2019	Air quality	N	N	N	N	N	N	N	N	N	N	N	N	N
		Road users	N	N	N	N	N	N	N	N	N	N	Y	N	N
		Marine navigation	N	N	N	N	N	N	N	N	N	N	N	N	N
East Sitra Housing	Construction from 2018	Air quality	Y	Y	N	N	N	N	N	N	N	N	N	N	N
		Road users	N	N	N	N	N	N	N	N	N	N	Y	N	N
		Noise	Y	Y	N	N	Y	N	N	N	N	N	N	N	N
East Sitra Housing	Occupation from 2020?	Marine environment – water quality and marine ecology	N	N	N	N	N	N	N	N	N	N	N	N	N

			Valued Environmental Components												
			Air Quality		Soil and Groundwater		Noise			Marine Environment	Terrestrial Ecology		Traffic and Access		Social and Community Impacts
Project / Stressor	Start/End Date	VECs Impacted by Project or Stressor	Construction Phase Dust	Construction Vehicle Emissions	Pitch Ponds - Presence of LNAPL in BH1056 and dissolved hydrocarbon contamination in BH1060	All BMP – Groundwater contamination	Construction Noise Day	Construction Noise Evening	Construction Noise Night	Marine Sediment Loading and Resuspension – AOI 3, Sitra Wharf	Loss of feeding and roosting grounds for birds during construction - coastal fringe.	Disturbance to feeding and roosting grounds for birds during construction – Ma'ameer Channel	Transport of Construction Workers	Transport of Oversized Loads	In-Migration / Social Cohesion
		Road users	N	N	N	N	Y	N	N	N	N	N	Y	N	N
		Noise	N	N	N	N	N	N	N	N	N	N	N	N	N
Aromatics Production Complex APC	Construction from 2022?	Air quality	N	N	N	N	N	N	N	N	N	N	N	N	N
		Road users	N	N	N	N	N	N	N	N	N	N	N	N	N
		Noise	N	N	N	N	N	N	N	N	N	N	N	N	N
Aromatics Production Complex APC	Operation from 2024/5?	Air quality	N	N	N	N	N	N	N	N	N	N	N	N	N
		Marine environment – water quality and marine ecology	N	N	N	N	N	N	N	N	N	N	N	N	N
East Sitra Link Road	Construction after completion of BMP	Road users	N	N	N	N	N	N	N	N	N	N	N	N	N
		Noise	N	N	N	N	N	N	N	N	N	N	N	N	N
		Air quality	N	N	N	N	N	N	N	N	N	N	N	N	N
		Avifauna	N	N	N	N	N	N	N	N	N	N	N	N	N
East Sitra Link Road	Operation after 2024?	Noise	N	N	N	N	N	N	N	N	N	N	N	N	N
		Air quality	N	N	N	N	N	N	N	N	N	N	N	N	N

			Valued Environmental Components												
			Air Quality		Soil and Groundwater		Noise			Marine Environment	Terrestrial Ecology		Traffic and Access		Social and Community Impacts
Project / Stressor	Start/End Date	VECs Impacted by Project or Stressor	Construction Phase Dust	Construction Vehicle Emissions	Pitch Ponds - Presence of LNAPL in BH1056 and dissolved hydrocarbon contamination in BH1060	All BMP – Groundwater contamination	Construction Noise Day	Construction Noise Evening	Construction Noise Night	Marine Sediment Loading and Resuspension – AOI 3, Sitra Wharf	Loss of feeding and roosting grounds for birds during construction - coastal fringe.	Disturbance to feeding and roosting grounds for birds during construction – Ma'ameer Channel	Transport of Construction Workers	Transport of Oversized Loads	In-Migration / Social Cohesion
		Road users	N	N	N	N	N	N	N	N	N	N	N	N	N
Highway 96 Upgrade	Construction after 2020	Road users	N	N	N	N	N	N	N	N	N	N	N	N	N
		Noise	N	N	N	N	N	N	N	N	N	N	N	N	N
		Air quality	N	N	N	N	N	N	N	N	N	N	N	N	N
Highway 96 Upgrade	Operation after 2022?	Noise	N	N	N	N	N	N	N	N	N	N	N	N	N
		Air quality	N	N	N	N	N	N	N	N	N	N	N	N	N
		Road users	N	N	N	N	N	N	N	N	N	N	N	N	N
Plot 2 & 3 Reclamation	Not expected before 2020	Cooling water intakes	N	N	N	N	N	N	N	Y	N	N	N	N	N
		Marine environment – water quality and marine ecology	N	N	N	N	N	N	N	Y	N	N	N	N	N
		Air quality	N	N	N	N	N	N	N	N	N	N	N	N	N
Banagas Expansion	Operation from start 2019	Local communities - Major Accident Hazard	N	N	N	N	N	N	N	N	N	N	N	N	N

			Valued Environmental Components												
			Air Quality		Soil and Groundwater		Noise			Marine Environment	Terrestrial Ecology		Traffic and Access		Social and Community Impacts
Project / Stressor	Start/End Date	VECs Impacted by Project or Stressor	Construction Phase Dust	Construction Vehicle Emissions	Pitch Ponds - Presence of LNAPL in BH1056 and dissolved hydrocarbon contamination in BH1060	All BMP – Groundwater contamination	Construction Noise Day	Construction Noise Evening	Construction Noise Night	Marine Sediment Loading and Resuspension – AOI 3, Sitra Wharf	Loss of feeding and roosting grounds for birds during construction - coastal fringe.	Disturbance to feeding and roosting grounds for birds during construction – Ma'ameer Channel	Transport of Construction Workers	Transport of Oversized Loads	In-Migration / Social Cohesion
Natural and Social Stressors															
Increasing population		Public Services	N	N	N	N	N	N	N	N	N	N	N	N	Y
		Air Quality	Y	Y	N	N	N	N	N	N	N	N	N	N	N
		Land	N	N	N	N	N	N	N	N	N	N	N	N	Y
		Road Users	N	N	N	N	N	N	N	N	N	N	Y	N	N
		Noise	N	N	N	N	Y	Y	Y	N	N	N	N	N	N
		Marine Environment	N	N	N	N	N	N	N	N	N	N	N	N	N
		Groundwater Resources	N	N	N	N	N	N	N	N	N	N	N	N	N
Expansion of road network		Air Quality	Y	Y	N	N	N	N	N	N	N	N	N	N	N
		Road Users	N	N	N	N	N	N	N	N	N	N	Y	N	N
		Noise	N	N	N	N	Y	Y	Y	N	N	N	N	N	N
Commercial fishing		Marine Environment	N	N	N	N	N	N	N	N	N	N	N	N	N

			Valued Environmental Components												
			Air Quality		Soil and Groundwater		Noise			Marine Environment	Terrestrial Ecology		Traffic and Access		Social and Community Impacts
Project / Stressor	Start/End Date	VECs Impacted by Project or Stressor	Construction Phase Dust	Construction Vehicle Emissions	Pitch Ponds - Presence of LNAPL in BH1056 and dissolved hydrocarbon contamination in BH1060	All BMP – Groundwater contamination	Construction Noise Day	Construction Noise Evening	Construction Noise Night	Marine Sediment Loading and Resuspension – AOI 3, Sitra Wharf	Loss of feeding and roosting grounds for birds during construction - coastal fringe.	Disturbance to feeding and roosting grounds for birds during construction – Ma'ameer Channel	Transport of Construction Workers	Transport of Oversized Loads	In-Migration / Social Cohesion
Arid sub-tropical climate		Air Quality	Y	N	N	N	N	N	N	N	N	N	N	N	N
		Marine Environment	N	N	N	N	N	N	N	N	N	N	N	N	N
		Groundwater Resources	N	N	N	N	N	N	N	N	N	N	N	N	N

9.2 Impact Assessment - BMP Construction Phase

9.2.1 Air Quality

There will be emissions to air from the Bapco Refinery operations which will occur alongside the BMP construction work. There may also be additional emissions of dust from industrial activities at Ras Zuwayed, associated with vehicle movements. The cumulative interaction with Refinery emissions was considered within the BMP ESIA report, as the baseline conditions include current Refinery operations. It was concluded that the impact of construction dust and vehicle emissions is negligible. With respect to potential cumulative interaction with dust emissions in Ras Zuwayed, it is considered that the impact is negligible as the distances between potential sources are relatively large and dust and construction vehicles only have localized impacts (IAQM, 2014) and so there is no possibility of interaction.

The construction of the East Sitra housing development and its associated infrastructure has the potential to produce dust emissions that could impact the BMP labour camp on the NOGA plot. However, the southern part of the East Sitra housing plot will be devoted mainly to open space uses such as storage. Hence the construction works required will be limited. Also during the day time period the labour camp will be virtually unoccupied and during the evening and weekend when the camp is occupied, there is not likely to be significant construction work taking place on the East Sitra housing development. Hence, the impact is considered negligible.

Emissions of construction dust and construction vehicle emissions from the Highway 96 upgrade may interact with dust emissions and vehicle emissions from the BMP construction. In this area there are no sensitive receptors in the immediate vicinity. There are potential receptors in terms of labour accommodation buildings, but these are likely to be too distant (+500m) to be impacted by any cumulative impacts caused by locally poor air quality due to cumulative impacts of construction works. This impact is considered negligible.

From time to time due to the local arid climate it is likely there will be short-term episodes of very poor air quality where dust levels may exceed 1000µg/m^3. In such circumstances, the natural dust levels will far exceed the worst case emissions of dust from the project and will be the dominant impact on air quality. This is considered a potentially minor adverse cumulative impact. In such circumstances the project health and safety officer will require that outside workers wear dust masks to mitigate the impact and in extreme circumstances may require outside work to be suspended. These mitigation measures should reduce the residual impact to negligible. This impact will also be relevant to the BMP during operation, but during operation it will be much easier to manage the issue as there will be far less outside work required which will generally be able to be scheduled to avoid dust storms. Therefore, in the case of BMP operations the impact is considered negligible.

9.2.2 Soil and Groundwater

The BMP construction locations within the Refinery are, in some cases, located close to and within existing Refinery process units. Given these circumstances there is likely to be some pre-existing groundwater contamination associated with previous Refinery operations that may interact with the BMP construction works. This was identified within

the BMP ESIA and it is proposed that groundwater quality is monitored during the construction phase to confirm that BMP construction is not having a significant adverse impact on groundwater quality. The monitoring will include all areas of BMP construction within the Refinery. The residual impact is assessed as negligible.

9.2.3 Noise

The impact of construction noise from the BMP with operational noise emissions from the Refinery has been assessed in the BMP ESIA. The noise impact of the existing Refinery is considered within the baseline monitoring. The baseline also includes the noise emissions from Alba smelter and other local noise sources including roads. The BMP ESIA identified a minor adverse residual impact on a neighbouring labour accommodation block, located to the south of the Refinery, during the daytime.

Riffa military helicopter base is located approximately 2.4km to the south west of the Refinery site but the helicopters usually fly to the south west over the Bahrain oil field for training exercises, away from the Refinery, and hence the cumulative impact is assessed as negligible.

East Sitra housing development is being constructed on land to the north of the NOGA plot which may be used as a location for a BMP labour camp. Construction of East Sitra housing will be a source of noise in the general vicinity. However, as noted above, the southern part of the East Sitra housing plot will be devoted mainly to open space uses such as storage. Hence the construction works required will be limited. Also during the day time period the BMP labour camp will be virtually unoccupied and during the evening and weekend when the camp is occupied, there is not likely to be significant construction work taking place on the East Sitra housing development. Hence, the impact of construction noise from East Sitra housing on the possible labour camp location is considered negligible. There are no other sensitive noise receptors in the vicinity of the labour camp on the NOGA plot that could be affected by cumulative noise impacts.

Noise emissions from construction of Highway 96 upgrade may interact with noise emissions from the BMP construction. Within the ESIA, the BMP construction works were identified to have a potentially minor adverse noise impact on a labour accommodation block to the south of the BMP site identified as receptor N5 in the BMP ESIA (see **Figure 9.1**). It is expected that road construction would occur mainly during the daytime. Also there is only potential for additional noise emissions from construction at the eastern end of Highway 96 to act cumulatively to increase noise emissions at receptor N5. The additional increase in noise at N5 is expected to be slight and short term. Therefore the cumulative impact is assessed as negligible.

Figure 9.1 Location of Labour Accommodation - N5

9.2.4 Marine Environment

Reclamation of the residual area of Plot 2 and reclamation of Plot 3 may have cumulative impacts with the construction of the new sealines at Sitra Wharf. Both projects would have the potential to release sediments to the water column and through interaction could intensify or extend the area of sea impacted. Sediments have the potential to smoother marine life and can also affect industrial seawater intakes by clogging or reducing process efficiency.

The Plot 2 and 3 projects are large scale projects, the BMP sealine construction is a relatively small scale aspect of the BMP. Also, it is far from certain whether both works would take place at the same time. Both projects are expected to have mandatory suspended solids mitigation and monitoring plans in place in line with SCE requirements. For the BMP, these requirements were included as mitigation in the ESIA. Given these conditions it is not expected that the BMP construction will have a significant cumulative impact with the Plot 2 and 3 reclamation works and the impact is assessed as negligible.

9.2.5 Road Users

9.2.5.1 Transportation of Construction Workers

It is proposed that the vast majority of construction workers (up to 13,500 persons) may be accommodated in a purpose built labour camp on the NOGA plot (Camp 2). The workers will be transported to the BMP site along Um Al Saad Avenue and Alba Road in buses.

Um Al Saad Avenue is an under-utilized access road to industrial, commercial and leisure facilities (the Yacht Club and Al Bander Resort). There are no sensitive receptors on the stretch of road that will be used by the buses from Camp 2.

The Alba port upgrade construction will require the movement workers, materials and equipment to and from site and access will also be via Um Al Saad Avenue.

The two projects will interact to increase traffic on this road. However the during the Alba port upgrade construction, the additional traffic is not expected to be highly significant as the project is of only moderate scale and it will only overlap with the BMP during the first year of construction when the numbers of workers accommodated at Camp 2 will be well below capacity. For these reasons the cumulative impact of the BMP with the Alba pot capacity upgrade construction is considered negligible.

Once the additional capacity at the port is operational, the frequency of road tankers transferring alumina and pet coke to the Alba smelter will increase from 1 per 6 minutes (243 per day) to 1 per 3.5 minutes (405 per day). The tankers use the Um Al Saad and Alba Road route, the same route that the BMP construction workers from Camp 2 will be using. This will lead to a cumulative impact on these roads. The impacts may include reduction in the efficiency of Alba operations, congestion on the impacted roads and reduced access and parking for businesses along Um Al Saad Avenue.

This impact is assessed to be moderate adverse and there will be a requirement to implement mitigation measures to manage the impact. These will comprise:

- Further stakeholder engagement with Alba to coordinate transportation logistics;
- Further stakeholder engagement with business owners along Um Al Saad Avenue;
- Development of a Transport Management Plan (TMP) for the BMP construction.

With these mitigation measures in place it is assessed that the impact will be reduced to minor adverse.

Many other industrial sites and businesses in the area contribute to road traffic (as identified in **Table 9.1**) and the BMP ESIA provided an assessment of the impacts of the BMP construction and operation on road traffic and road users which included these. Beyond the cumulative impacts highlighted above no other cumulative impacts are identified beyond the general increase in traffic volumes on local roads as a result of economic development during the period of the BMP construction. Given that the local road network has recently been improved and further improvements are planned during the period of the BMP construction the cumulative impact of the increase in road traffic is assessed as negligible.

9.2.5.2 Transportation of Oversized Loads

There are not expected to be any cumulative impacts. The impact of the transportation of oversized loads on the road network was considered in the BMP ESIA.

9.2.6 In-Migration / Social Cohesion

There are not expected to be any cumulative impacts. The labour camps that will be constructed for the BMP will provide all the services required by their residents including food, leisure, shops, banking and medical facilities and places of worship. There are no direct links to local communities for workers leaving the camps on foot during their free time. The nearest shop or places of interest are over 4km from the Camp 2 site on the NOGA plot. Workers will be provided with buses to commercial centres during periods of free time.

The BMP is being developed entirely on land that is proposed for industrial development and is not utilizing land that could be used for other purposes; hence it has minimal effect on increasing the stress on land resources within Bahrain.

9.3 Identification of Potential for Cumulative Impacts – BMP Operational Phase

The identified key impacts on VECS for past, present and planned developments and social and environmental stressors have been assessed against scoped in impacts for the BMP to identify where there is potential for cumulative impacts to occur. The assessment for the BMP operational phase is summarized in **Table 9.2.** Where potential cumulative impacts are identified they are described and assessed further in the following sections.

Table 9.2 Identification of Potential Cumulative Impacts of BMP Operational Phase

			Valued Environmental Components								
			Air Quality		Soil and Groundwater	Community Noise	Marine Environment	Terrestrial Ecology	Occupational Health and Safety		
Project / Stressor	**Start/End Date**	**VECs Impacted by Project or Stressor**	Direct (stack) Emissions	Fugitive/ Evaporative Emissions	All BMP – Groundwater contamination	Operational Plant/Machinery Noise	Hydrodynamics and Water Quality – AOI 1 – Farasiyah Bay	Impact of operational noise on feeding and roosting birds – coastal fringe	Major Accident Hazard	Crisis and Emergency Response Plan	Oil Spill Contingency Plan
Previous and Existing Developments											
Bapco Oil Refinery, Sitra Tank Farm and Wharf		Air Quality	Y	Y	N	N	N	N	N	N	N
		Marine Environment	N	N	N	N	Y	N	N	N	N
		Road Users	N	N	N	N	N	N	N	N	N
		Groundwater	N	N	Y	N	N	N	N	N	N
		Noise	N	N	N	Y	N	N	N	N	N
Alba aluminium smelter		Air Quality	Y	N	N	N	N	N	N	N	N
		Road Users	N	N	N	N	N	N	N	N	N
		Groundwater	N	N	Y	N	N	N	N	N	N
		Noise	N	N	N	Y	N	N	N	N	N
Alba Port – import of alumina, pitch,		Air Quality	Y	N	N	N	N	N	N	N	N
		Marine Environment	N	N	N	N	Y	N	N	N	N

			Valued Environmental Components								
			Air Quality		Soil and Groundwater	Community Noise	Marine Environment	Terrestrial Ecology	Occupational Health and Safety		
Project / Stressor	**Start/End Date**	**VECs Impacted by Project or Stressor**	Direct (stack) Emissions	Fugitive/ Evaporative Emissions	All BMP – Groundwater contamination	Operational Plant/Machinery Noise	Hydrodynamics and Water Quality – AOI 1 – Farasiyah Bay	Impact of operational noise on feeding and roosting birds – coastal fringe	Major Accident Hazard	Crisis and Emergency Response Plan	Oil Spill Contingency Plan
petroleum coke		Road Users	N	N	N	N	N	N	N	N	N
Riffa Power Station – electricity generation		Air Quality	Y	N	N	N	N	N	N	N	N
		Road Users	N	N	N	N	N	N	N	N	N
Ras Abu Jajur Desalination Plant – supply of potable water		Air Quality	Y	N	N	N	N	N	N	N	N
		Marine Environment	N	N	N	N	Y	N	N	N	N
		Road Users	N	N	N	N	N	N	N	N	N
		Groundwater	N	N	Y	N	N	N	N	N	N
		Noise	N	N	N	N	N	N	N	N	N
GPIC – production of methanol and urea		Air Quality	Y	N	N	N	N	N	N	N	N
		Marine Environment	N	N	N	N	Y	N	N	N	N
		Road Users	N	N	N	N	N	Y	N	N	N
		Noise	N	N	N	N	N	N	N	N	N

			Valued Environmental Components								
			Air Quality		Soil and Groundwater	Community Noise	Marine Environment	Terrestrial Ecology	Occupational Health and Safety		
Project / Stressor	**Start/End Date**	**VECs Impacted by Project or Stressor**	Direct (stack) Emissions	Fugitive/ Evaporative Emissions	All BMP – Groundwater contamination	Operational Plant/Machinery Noise	Hydrodynamics and Water Quality – AOI 1 – Farasiyah Bay	Impact of operational noise on feeding and roosting birds – coastal fringe	Major Accident Hazard	Crisis and Emergency Response Plan	Oil Spill Contingency Plan
Riffa Airbase – military helicopter base		Air Quality	Y	N	N	N	N	N	N	N	N
		Road Users	N	N	N	N	N	N	N	N	N
		Noise	N	N	N	Y	N	N	N	N	N
Askar Landfill – non hazardous and municipal landfill		Air Quality	Y	N	N	N	N	N	N	N	N
		Road Users	N	N	N	N	N	N	N	N	N
		Groundwater	N	N	N	N	N	N	N	N	N
		Noise	N	N	N	N	N	N	N	N	N
Hafeera landfill – hazardous waste landfill		Air Quality	Y	N	N	N	N	N	N	N	N
		Road Users	N	N	N	N	N	N	N	N	N
		Groundwater	N	N	N	N	N	N	N	N	N
		Noise	N	N	N	N	N	N	N	N	N
Ras Zuwayed Industrial Area – industrial area		Air Quality	N	N	N	N	N	N	N	N	N
		Road Users	N	N	N	N	N	N	N	N	N
		Noise	N	N	N	N	N	N	N	N	N

			Valued Environmental Components								
			Air Quality		Soil and Groundwater	Community Noise	Marine Environment	Terrestrial Ecology	Occupational Health and Safety		
Project / Stressor	**Start/End Date**	**VECs Impacted by Project or Stressor**	Direct (stack) Emissions	Fugitive/ Evaporative Emissions	All BMP – Groundwater contamination	Operational Plant/Machinery Noise	Hydrodynamics and Water Quality – AOI 1 – Farasiyah Bay	Impact of operational noise on feeding and roosting birds – coastal fringe	Major Accident Hazard	Crisis and Emergency Response Plan	Oil Spill Contingency Plan
South Alba Industrial Estate – industrial area		Air Quality	Y	N	N	N	N	N	N	N	N
		Road Users	N	N	N	N	N	N	N	N	N
		Noise	N	N	N	N	N	N	N	N	N
Bahrain oil and gas field – oil and gas exploration and extraction.		Air Quality	Y	Y	N	N	N	N	N	N	N
		Road Users	N	N	N	N	N	N	N	N	N
		Groundwater	N	N	N	N	N	N	N	N	N
		Noise	N	N	N	N	N	N	N	N	N
Planned Future Developments											
Alba Line 6	Operation from Jan 2019	Air quality	Y	N	N	N	N	N	N	N	N
		Groundwater resources (reduced abstraction, beneficial impact)	N	N	N	N	N	N	N	N	N
		Waste management capacity	N	N	N	N	N	N	N	N	N
		Road users	N	N	N	N	N	N	N	N	N
Alba Port	Construction	Road users	N	N	N	N	N	N	N	N	N

			Valued Environmental Components								
			Air Quality		Soil and Groundwater	Community Noise	Marine Environment	Terrestrial Ecology	Occupational Health and Safety		
Project / Stressor	**Start/End Date**	**VECs Impacted by Project or Stressor**	Direct (stack) Emissions	Fugitive/ Evaporative Emissions	All BMP – Groundwater contamination	Operational Plant/Machinery Noise	Hydrodynamics and Water Quality – AOI 1 – Farasiyah Bay	Impact of operational noise on feeding and roosting birds – coastal fringe	Major Accident Hazard	Crisis and Emergency Response Plan	Oil Spill Contingency Plan
Capacity Upgrade	2018-19	Air quality	N	N	N	N	N	N	N	N	N
		Marine environment – water quality and marine ecology	N	N	N	N	N	N	N	N	N
Alba Port Capacity Upgrade	Operation from Mid 2019	Air quality	N	N	N	N	N	N	N	N	N
		Road users	N	N	N	N	N	N	N	N	N
		Marine navigation	N	N	N	N	N	N	N	N	N
East Sitra Housing	Construction from 2018	Air quality	N	N	N	N	N	N	N	N	N
		Road users	N	N	N	N	N	N	N	N	N
		Noise	N	N	N	N	N	N	N	N	N
East Sitra Housing	Occupation from 2020?	Marine environment – water quality and marine ecology	N	N	N	N	N	N	N	N	N
		Road users	N	N	N	N	N	N	N	N	N
		Noise	N	N	N	N	N	N	N	N	N

			Valued Environmental Components								
			Air Quality		Soil and Groundwater	Community Noise	Marine Environment	Terrestrial Ecology	Occupational Health and Safety		
Project / Stressor	**Start/End Date**	**VECs Impacted by Project or Stressor**	Direct (stack) Emissions	Fugitive/ Evaporative Emissions	All BMP – Groundwater contamination	Operational Plant/Machinery Noise	Hydrodynamics and Water Quality – AOI 1 – Farasiyah Bay	Impact of operational noise on feeding and roosting birds – coastal fringe	Major Accident Hazard	Crisis and Emergency Response Plan	Oil Spill Contingency Plan
Aromatics Production Complex APC	Construction from 2022?	Air quality	Y	Y	N	N	N	N	N	N	N
		Road users	N	N	N	N	N	N	N	N	N
		Noise	N	N	N	Y	N	N	N	N	N
Aromatics Production Complex APC	Operation from 2024/5?	Air quality	Y	N	N	N	N	N	N	N	N
		Marine environment – water quality and marine ecology	N	N	N	N	Y	N	N	N	N
		Groundwater	N	N	Y	N	N	N	N	N	N
		Noise	N	N	N	Y	N	N	N	N	N
East Sitra Link Road	Construction after completion of BMP	Road users	N	N	N	N	N	N	N	N	N
		Noise	N	N	N	Y	N	Y	N	N	N
		Air quality	N	N	N	N	N	N	N	N	N
		Avifauna	N	N	N	N	N	N	N	N	N
East Sitra Link Road	Operation after 2024?	Noise	N	N	N	Y	N	Y	N	N	N
		Air quality	Y	N	N	N	N	N	N	N	N

			Valued Environmental Components								
			Air Quality		Soil and Groundwater	Community Noise	Marine Environment	Terrestrial Ecology	Occupational Health and Safety		
Project / Stressor	**Start/End Date**	**VECs Impacted by Project or Stressor**	Direct (stack) Emissions	Fugitive/ Evaporative Emissions	All BMP – Groundwater contamination	Operational Plant/Machinery Noise	Hydrodynamics and Water Quality – AOI 1 – Farasiyah Bay	Impact of operational noise on feeding and roosting birds – coastal fringe	Major Accident Hazard	Crisis and Emergency Response Plan	Oil Spill Contingency Plan
		Road users	N	N	N	N	N	N	N	N	N
Highway 96 Upgrade	Construction after 2020	Road users	N	N	N	N	N	N	N	N	N
		Noise	N	N	N	Y	N	N	N	N	N
		Air quality	N	N	N	N	N	N	N	N	N
Highway 96 Upgrade	Operation after 2022?	Noise	N	N	N	Y	N	N	N	N	N
		Air quality	Y	N	N	N	N	N	N	N	N
		Road users	N	N	N	N	N	N	N	N	N
Plot 2 & 3 Reclamation	Not expected before 2020	Cooling water intakes	N	N	N	N	Y	N	N	N	N
		Marine environment – water quality and marine ecology	N	N	N	N	Y	N	N	N	Y
		Air quality	N	N	N	N	N	N	N	N	N
Banagas Expansion	Operation from start 2019	Local communities - Major accident hazard	N	N	N	N	N	N	Y	Y	N

			Valued Environmental Components								
			Air Quality		Soil and Groundwater	Community Noise	Marine Environment	Terrestrial Ecology	Occupational Health and Safety		
Project / Stressor	**Start/End Date**	**VECs Impacted by Project or Stressor**	Direct (stack) Emissions	Fugitive/ Evaporative Emissions	All BMP – Groundwater contamination	Operational Plant/Machinery Noise	Hydrodynamics and Water Quality – AOI 1 – Farasiyah Bay	Impact of operational noise on feeding and roosting birds – coastal fringe	Major Accident Hazard	Crisis and Emergency Response Plan	Oil Spill Contingency Plan
Natural and Social Stressors											
Increasing population		Public Services	N	N	N	N	N	N	N	N	N
		Air Quality	Y	N	N	N	N	N	N	N	N
		Land	N	N	N	N	N	N	N	N	N
		Road Users	N	N	N	N	N	N	N	N	N
		Noise	N	N	N	Y	N	N	N	N	N
		Marine Environment	N	N	N	N	Y	N	N	N	Y
		Groundwater Resources	N	N	Y	N	N	N	N	N	N
Expansion of road network		Air Quality	Y	N	N	N	N	N	N	N	N
		Road Users	N	N	N	N	N	N	N	N	N
		Noise	N	N	N	Y	N	Y	N	N	N
Commercial fishing		Marine Environment	N	N	N	N	Y	N	N	N	Y
Arid sub-tropical		Air Quality	Y	Y	N	N	N	N	N	N	N

			Valued Environmental Components								
			Air Quality		Soil and Groundwater	Community Noise	Marine Environment	Terrestrial Ecology	Occupational Health and Safety		
Project / Stressor	**Start/End Date**	**VECs Impacted by Project or Stressor**	Direct (stack) Emissions	Fugitive/ Evaporative Emissions	All BMP – Groundwater contamination	Operational Plant/Machinery Noise	Hydrodynamics and Water Quality – AOI 1 – Farasiyah Bay	Impact of operational noise on feeding and roosting birds – coastal fringe	Major Accident Hazard	Crisis and Emergency Response Plan	Oil Spill Contingency Plan
climate		Marine Environment	N	N	N	N	Y	N	N	N	Y
		Groundwater Resources	N	N	Y	N	N	N	N	N	N

9.4 Assessment of Impacts - BMP Operational Phase

9.4.1 Air Quality

9.4.1.1 Direct Stack Emissions – Alba Line 6, APC and Other Emissions Sources

The cumulative impact of combustion emissions from the Alba Line 6 Expansion Project with the BMP operation was considered in the BMP ESIA and identified to be negligible.

It is likely that in the future the APC will also be developed, on land adjacent to the Bapco Refinery

The cumulative impact of the BMP with the APC facility and the Alba Line 6, was considered in the APC ESIA using dispersion modelling for the cumulative impact of the Bapco Refinery post-BMP and APC ESIA. The combined process contributions were then added to the process contributions stated in the Alba Line 6 ESIA. The background air quality was represented by the air quality monitoring data collected in 2016 for the BMP ESIA baseline.

When considering the cumulative impacts it must be noted that:

- The individual assessments do not consider the same receptor locations;
- The location of maximum impacts of any two or more significant industrial development will vary;
- The modelling software, meteorological dispersion data and other assessment tools may be different;
- The Alba Line 6 and APC projects models use different time periods and hence the model input data is different;
- It is not considered appropriate to compare maximum short term (hourly) conditions from the two developments. As the two facilities are located more than 2.5km apart it is considered very unlikely that peak source emissions and associated maximum hourly ground level concentrations would coincide. Therefore long-term (annual average) cumulative effects are considered.

A comparison of predicted annual mean SO_2 and NO_2 concentrations at East Riffa, the area likely to be most affected by the combined emissions from the Bapco BMP, Alba and APC facilities, is provided in **Table 9.3**. The assessment has assumed that the Alba Scenario 3 will be implemented, which incorporates the impact of proposed mitigation measures.

Table 9.3 Cumulative Air Quality Impacts at East Riffa for SO_2 and NO_2

Pollutant	Standard	Background	Process Contribution (PC)			Total
			BMP	APC	Alba	
SO_2 - Annual Mean ($\mu g/m^3$)	50	18.9	2.9	<0.01	4.7	26.5
NO_2 - Annual Mean ($\mu g/m^3$)	40	13.1	7.24	0.66	0.4	21.4

The comparison indicates that the combined APC and BMP emissions are anticipated to give rise to a greater contribution to annual mean NO_2 concentrations at East Riffa, whereas implementation of the Alba Line 6 project would have a greater effect on SO_2

levels in this location. At the East Riffa receptors, which are predicted to have the highest predicted environmental concentration, emissions from the Alba expansion would also contribute to ambient NO_2 and SO_2 concentrations. However, when also accounting for the existing background concentrations, the combined maximum effect would remain well below the respective Bahrain National Standards for annual mean SO_2 and NO_2. The cumulative emissions were therefore assessed as negligible.

The BMP ESIA also included consideration of background emissions from Riffa Power Station, GPIC, Ras Abu Jajur and other industrial and vehicle sources of emissions within the background air quality survey. The BMP ESIA air quality assessment included consideration of the impact of these existing background sources and the BMP emissions together and concluded that the impact on air quality was negligible.

9.4.1.2 Fugitive and Evaporative Emissions

The APC will be constructed on land next to the Bapco Refinery. Both plants, but particularly the APC are capable of producing fugitive emissions of volatile compounds from leaks from pumps, flanges and storage vessels. Leaks can lead to odours which can be short term or persistent. In the case of benzene, it can also be toxic at low concentrations and so can have health effects as well as nuisance impacts. As part of the BMP ESIA, the impact of fugitive emissions from the BMP was assessed to be negligible, but as the APC will be on the adjacent plot and will also have the potential for fugitive VOC emissions; there is the potential for cumulative impacts. The cumulative impact is considered likely to comprise short term odours that may give rise to complaints. This is assigned a minor adverse impact. Through implementation of Leak Detection and Repair (LDAR) programmes and through benzene fence line monitoring[7], the impact can be reduced to negligible.

9.4.1.3 East Sitra Link Road and Highway 96 Upgrade

East Sitra Link Road will pass by the south of the Bapco Refinery to access King Hamad Highway. The road will likely be a dual carriageway or six lane highway. The road will result in additional emissions of nitrogen oxides, particulates and carbon monoxide from vehicle exhausts. This may have a cumulative impact with stack emissions from the BMP, in particular nitrogen oxides. Immediately to the south of the Refinery annual average nitrogen dioxide concentrations exceed the national standard, as identified in the Camp 1 Health Impact Assessment Report, EACS, 2018. Vehicle emissions will have a cumulative impact and further increase nitrogen dioxide concentrations in the area. However, the impact of vehicle emissions reduces rapidly with distance from the roadside until at a relatively short distance (<200m) the contribution to the ambient concentration is relatively small. Thus, due to the likely absence of receptors within this envelope, the cumulative impact on air quality of the East Sitra Link Road operation is assessed as negligible.

The same situation is relevant to the Upgrade of Highway 96 expect the project is to an upgrade an existing road which will not lead to a significant change in traffic levels in itself. In any case there are no sensitive receptors within 200m of the road and the cumulative impact is therefore considered negligible.

[7] As part of the Word Bank Group Environmental Health and Safety Guidelines for Petroleum Refining, 2016, the Refinery is required to undertake benzene monitoring at the fence line and the maximum guideline value is 9µg/m^3.

9.4.1.4 Alba Port Upgrade

The Alba port upgrade will increase shipping traffic to Alba by about 1/3 which will lead to a proportionate increase in emissions to air from shipping. The BMP will also increase shipping traffic and associated emissions, presumably by around 35% which is proportionate to the increase in the capacity of the Refinery post-BMP. These emissions will have a cumulative impact on air quality in the marine environment to the east of Bahrain and at Sitra Wharf. In this area there are no sensitive receptors in the vicinity and hence the cumulative impact is considered negligible.

9.4.2 Soil and Groundwater

Both the BMP and APC process hydrocarbons and leaks and seepages during operation may lead to soil and groundwater contamination. When the quantity of contamination is significant this can lead to off-site migration of contamination and impacts on natural resources including ground and surface water as well as neighbouring land. As both facilities are adjacent to each other there is the potential for cumulative impacts arising from contamination. As the contaminant types are similar the potential cumulative impacts would be additive. Overall, it is assessed that the potential cumulative impact would be negligible as the impacts are not likely to be truly cumulative. In reality instances of soil or groundwater contamination are likely to remain localized to their respective sites. Bapco Refinery already operates a groundwater monitoring programme and this will be expanded to include the BMP, during operation (and during the construction period). The APC would also have a similar groundwater monitoring programme which is identified as a requirement in the APC ESIA.

Alba smelter and its associated gas-fired power stations is a potential source of industrial contamination of soil and groundwater. Aluminium production can cause soil and groundwater contamination with aluminium, fluorides, heavy metals, cyanides and hydrocarbons. There is some potential for cumulative impacts to local groundwater with the BMP. However, the shallow groundwater in the vicinity (Aquifer B) is impacted by saline intrusion and does not represent an exploitable resource. Also the groundwater quality of the BMP and Refinery sites will be monitored during construction and operation. The potential cumulative impact is considered negligible.

Ras Abu Jajur desalination plant abstracts approximately 110,000m^3 per day of groundwater from the deeper groundwater, Aquifer C, at approximately 150m below ground level. Aquifer C is isolated from Aquifers A and B by overlying confining strata. There is therefore no significant interaction between the aquifers and it is not expected that any groundwater contamination at Bapco Refinery or the BMP could significantly impact groundwater quality at the Ras Abu Jajur abstraction. The BMP will not change the approximately 5,500m^3 per day abstraction rate of the Bapco Refinery from Aquifer C. In summary the cumulative impact of the BMP and Ras Abu Jajur desalination plant on groundwater quality is assessed as negligible.

9.4.3 Noise

9.4.3.1 APC

The APC will be constructed on land adjacent to the Bapco Refinery, hence they can both be expected to have noise impacts on nearby receptors. In the BMP ESIA, the

predicted operational noise impacts of the BMP at sensitive receptors are shown in **Table 9.4**. The location of the receptors is shown in **Figure 9.2**. Location N6 is no longer relevant as it relates to a previous potential location of a temporary construction facility which will no longer be used. N7 is the BMP Temporary Construction Facility which is not relevant to the operational phase of the BMP.

Table 9.4 Operational BMP Noise Levels, L_{den} dB(A)

Receptor	Predicted Noise Level	Target Noise Level, $L_{Aeq,T}$ dB		
	L_{den} dB(A)	Day	Evening	Night
N1	34	60	55	50
N2	38	60	55	50
N3	40	60	55	50
N4	51	60	55	50
N5	54	60	55	50
N6	33	60	55	50
N7	61	60	55	50

Lden : Day-evening-night equivalent level: This is the A weighted Leq noise level, over a 24 hour period, with a 10 dB penalty added to the levels between 23.00 and 07.00 hours and a 5 dB penalty added to the levels between 19.00 and 23.00 hours to reflect people's extra sensitivity to noise during the night and the evening.

Table 9.4 shows that the night-time noise limits will be exceeded at N4 and N5 which are labour accommodation blocks located to the west and south of the BMP site respectively.

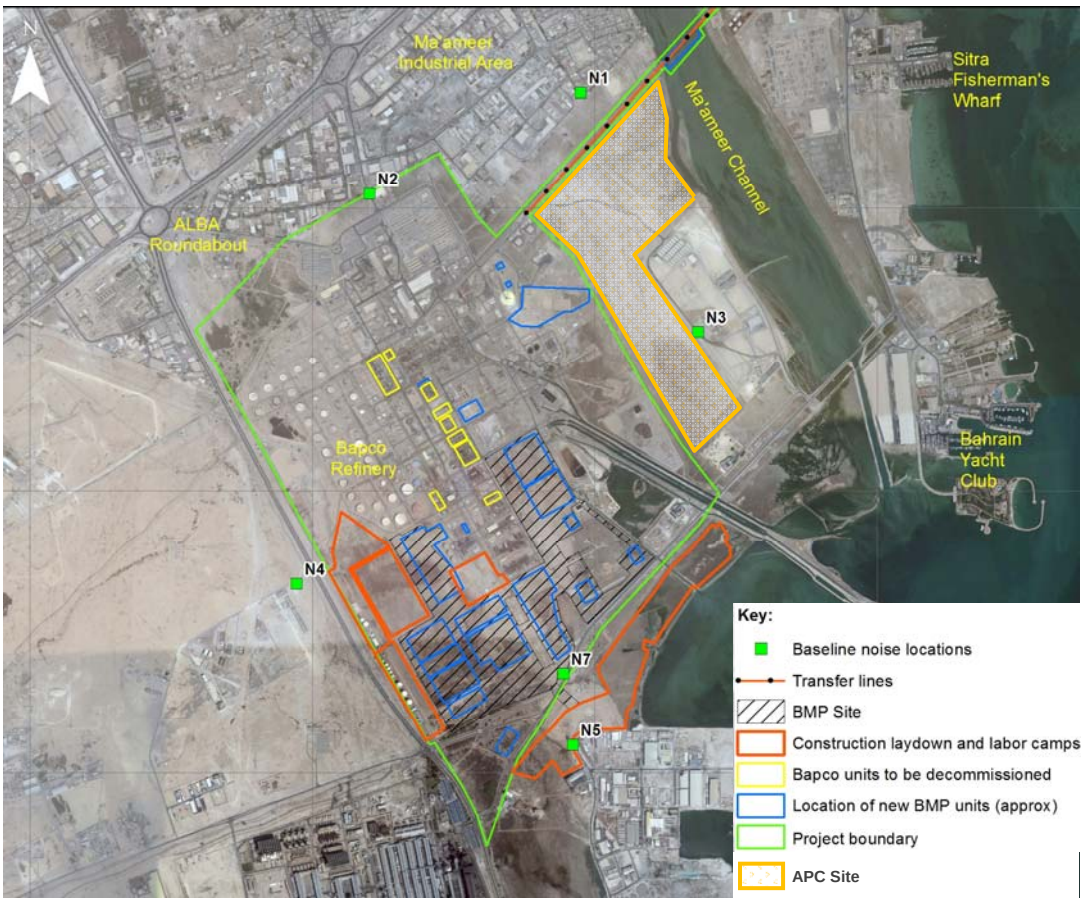
The APC will be a significant distance away from these receptors (2km for N4 and 1.8km for N5) and will be much closer to N1 and N3 where it may have a significant impact. Conversely, the BMP will be a significant distance from N1 and N3. In short there is not much scope for significant cumulative noise impacts at the nearest sensitive receptors for each project. Based on this qualitative assessment is not expected that the APC will change the impact classification of the BMP at N4 and N5 and hence the cumulative impact is assessed to be negligible.

9.4.3.2 East Sitra Link Road

During construction of the section of road to the south of the Refinery, the construction would increase daytime noise levels at receptor N5, the labour accommodation block. However, the block would be expected to be empty during the day and the impact is therefore considered to be negligible.

In respect of operational noise impacts, the East Sitra Link Road would mainly act to increase noise levels during the day and evening. The impact at night-time would be reduced in line with reduced traffic volumes at night. Based on the noise levels in **Table 9.4** in can be expected that the East Sitra Link Road would increase night-time noise levels at N5 and this would lead to exacerbation of the minor adverse impact of the BMP for night-time noise at this receptor. This impact is considered as a potential minor adverse cumulative impact. During the design of the road scheme it would be expected to pass through the national EIA process which would include requirements for the assessment of noise impacts and mitigation of any adverse impacts identified.

Figure 9.2 BMP – Location of Sensitive Noise Receptors



9.4.3.3 Highway 96 Upgrade

There is likely to be increased daytime noise levels associated with the project construction which would impact receptors N4 and N5. As these receptors are labour accommodation facilities, they would be expected to be empty during the day so the impact is assessed as negligible.

As the project is to upgrade an existing road the operational impacts are not likely to be significantly changed from the existing scenario and the impact is considered negligible.

9.4.4 Marine Environment

The APC will utilize sea water for cooling and process water. The water will be taken from the Bapco cooling water intake. The returned cooling water and process effluents will be discharged to the Bapco cooling water flume and will combine with the Bapco discharge. **Table 9.5** shows the increase in volume of the Bapco main outfall as a result of APC operation. The APC is predicted to increase the volume of the outfall by around 15%. The quality and temperature of the effluent is expected to remain the same.

Table 9.5 Changes in Effluent Volume for APC

Effluent Source	Normal Volumes of Effluents Discharged to Sea at Bapco Main Outfall (m^3 /day)	
	Refinery Post BMP	APC
Desalinated brine	-	101,563
WWTP	-	3,325
Process water to Bapco Refinery WWTP	-	11.5
Total	**716,132**	**104,899.5**
Total main outfall	**821,032**	

The combined outfall of the BMP and APC was modeled as part of the APC ESIA. The relevant extract of the ESIA report is included as **Appendix 9A**. The ESIA study also includes the cumulative impact of the following:

1. Plot 2 and 3 reclamation impact on dispersion of the Bapco / APC cooling water outfall plume – this includes bridges to the main land from Plots 2 and 3.

2. GPIC plume.

3. Ras Abu Jajur Phase I and II intake protection zone – The Electricity and Water Authority (EWA) have proposed the development of intake protection zones as a planning tool to protect its seawater intakes for existing and proposed power stations and desalination plant. At Ras Abu Jajur a preliminary protection zone has been define to protect the cooling water intake of Ras Abu Jajur Phase I and the desalination water intake for Phase II.

The modelling study concludes that the APC will extend the extent of the thermal plume around the Bapco main outfall by 300m in worst case conditions comprising neap tides and weak winds. The increase will be primarily at the sea surface and in deeper waters (at the seabed) there will be no discernible increase in temperature. The cumulative impact is classified as minor adverse. Cumulative impacts with other developments listed above were considered negligible for both the thermal and water chemistry impact of the plume.

9.4.5 Terrestrial Ecology

The proposed East Sitra Link Road will pass south of the Refinery along the foreshore of Farisiyah Bay. Noise from the road would likely have a minor adverse effect on roosting and feeding bird populations in the foreshore area. In the BMP ESIA, the impact of the BMP itself on this receptor is assessed as minor adverse. These impacts would combine to increase the magnitude of the noise impact. Without mitigation the cumulative impact is assessed as moderate adverse as the road development would increase the magnitude and extent of the noise impact. With implementation of mitigation measures such as route optimization and use of acoustic barriers, the cumulative impact should be able to be reduced to minor adverse.

It should be noted the route for the road is only at concept stage; the road project still has to pass through the Bahrain EIA and planning control processes to obtain approval this includes further stakeholder engagement with Bapco and other stakeholders. So presently the project and its potential impacts are somewhat speculative.

9.4.6 Occupational Health and Safety

Other developments in the vicinity of the BMP may impact the major accident hazards scenarios for the updated refinery. In turn this may lead to requirements to update the Crisis and Emergency Response Plan (CERP) and Oil Spill Contingency Plans (OSCP). The potential effects of developments are described below:

1. Construction of additional LPG storage tanks at Sitra Wharf may alter the major accident hazard scenarios requiring update of the CERP.

2. APC – This will be located adjacent to the BMP and may alter the major accident hazard scenarios requiring updating of the CERP. As the APC will also lead to the storage and export of new products (e.g. benzene and xylene) at Sitra Wharf the OSCP may need to be updated.

3. Plot 2 and 3 reclamation – The development of Plots 2 and 3 may change the expected dispersion of any oil spills at Sitra Wharf. This may require changes to the scenarios considered in the OSCP and the planned responses.

The impact of these changes is predicted to be minor adverse without mitigation. In all cases hazard assessments and response plans exist that are backed by management systems that are periodically tested and reviewed. The developments listed may result in some revisions to these plans which can be reasonably expected to reduce the cumulative impact to negligible.

10 SUMMARY

The BMP will result in few significant cumulative impacts. This is because in most cases, the potential cumulative impacts have been considered in the BMP design and avoided or otherwise mitigated by design measures. **Table 10.1** summarises the predicted cumulative impacts for the BMP. The table only shows impacts that have at least a minor adverse impact prior to mitigation. Impacts that are predicted to have negligible impacts prior to mitigation are not shown.

Table 10.1 Summary of Residual Cumulative Impacts

		Without Mitigation							With Mitigation					
VEC	**Cumulative Impact**	**Magnitude**	**Extent**	**Sensitivity**	**Duration**	**Impact Score**	**Pre-Mitigation Impact**	**Mitigation**	**Magnitude**	**Extent**	**Sensitivity**	**Duration**	**Impact Score**	**Residual Impact**
BMP Construction Phase														
Air quality	Natural dust storms	-1	-2	-3	-1	-7	Minor Adverse	Provide dust masks to staff required to work outside. Health and Safety Manager to have power to suspend outside work in dust storms.	0	0	-3	-1	-4	Negligible
Noise	Cumulative impact of noise from existing Refinery with BMP construction noise on labour accommodation block to south of BMP site.						Minor Adverse	Assessed in BMP ESIA						Minor Adverse
Road users	Cumulative impact of Alba Port Capacity Upgrade operation with transport of BMP construction workers from Labour Camp 2 on NOGA plot.	-1	-2	-1	-1	-5	Moderate Adverse	Further stakeholder engagement with Alba and occupants of Um Al Saad Avenue. Development and implementation of a TMP.	0	0	-3	-1	-4	Minor Adverse
BMP Operational Phase														
Air quality	Cumulative impact of fugitive and evaporative emissions from BMP and APC.	-1	-2	-3	-5	-11	Minor Adverse	As per BMP ESIA - No additional measures required	-0	-0	-3	-5	-8	Negligible
Noise	Cumulative impact of noise of BMP and other industrial sources with additional noise from East Sitra Link Road to labour accommodation to south of BMP site.	-2	-2	-2	-5	-11	Minor Adverse	Possible additional mitigation required by EIA for East Sitra Link Road.	-2	-2	-2	-5	-11	Minor Adverse

		Without Mitigation							With Mitigation					
VEC	**Cumulative Impact**	**Magnitude**	**Extent**	**Sensitivity**	**Duration**	**Impact Score**	**Pre-Mitigation Impact**	**Mitigation**	**Magnitude**	**Extent**	**Sensitivity**	**Duration**	**Impact Score**	**Residual Impact**
Terrestrial Ecology	Cumulative impact of noise from BMP/Refinery and road noise on feeding and roosting bird – Coastal Fringe.	-3	-3	-3	-5	-14	Moderate Adverse	As per BMP ESIA. Route optimization. EIA process for road development to identify if additional mitigation is required.	-2	-2	-3	-5	-12	Minor Adverse
Occupational Health and Safety	Impact of other developments on post-BMP Refinery CERP and OSCP.	-2	-3	-3	-5	-13	Minor Adverse	Update BMP CERP and OSCP periodically in line with introduction of new hazard scenarios due to other developments.	-1	-1	-3	-5	-10	Negligible

11 REFERENCES

Alba Line 6 Expansion Project ESIA documentation available at www.albasmelter.com

Bapco, 2011 - Marine Environment Assessment. Olof Lindén and Ulf Larsson, 2011.

IFC PS1, 2012 - International Performance Standard 1 on Environmental and Social Sustainability. International Finance Corporation 2012.

IAQM, 2014 - Guidance on the Assessment of Dust from Demolition and Construction. 2014, Institute of Air Quality Management.

IFC, August 2013 - Good Practice Handbook Cumulative Impact Assessment and Management: Guidance for the Private Sector in Emerging Markets. International Finance Corporation 2012.

Highways Agency, 2007 - Design Manual for Roads and Bridges. Volume 11 Environmental Assessment Section 3 Environmental Assessment Techniques. Part 1. HA207/07 Air Quality. UK Highways Agency, 2007.

IFC & EBRD 2009 - Workers' Accommodation: Processes and Standards, International Finance Corporation and European Bank for Reconstruction and Development, 2009.

EACS, June 2016 - Bapco Modernization Program, Environmental and Social Impact Assessment, Environment Arabia Consultancy Services, June 2016

Appendix 6A

Minutes of Meeting with Central Planning Office

Meeting Minutes

Project Title	Bapco Modernization Program (BMP)
Venue	Central Planning Office (CPO)
Date and time	06 June 2018
Attendees	Dominic McPolin, Chief Planning Officer, CPO Andy Booth, Technical Director, Environment Arabia Consultancy Services (EACS) Eman Rafea, Environmental Consultant, EACS Mohammed Asim, Environmental Specialist, Worley Parsons/BMP
Subject	Cumulative Impact of BMP

No.	Item	Action by
1	EACS briefed CPO of the purpose of the meeting and the supplementary studies EACS were undertaking for the BMP, including the cumulative impact assessment.	
2	EACS noted the project included the building of Ma'ameer pipe bridge which would include temporary reclamation. CPO inquired about the possibility of dredging Ma'ameer Channel. EACS stated that widening and deepening of the channel was not likely to be a realistic possibility due to the presence of bridges at either end of the channel which would probably need rebuilding if flows are significantly increased or the channel widened. This would likely be prohibitively expense. An Environmental Impact Assessment shall be conducted by the EPC as per SCE requirements.	
3	EACS inquired about the East Sitra Link Road. CPO advised that the road has been granted cabinat approval for the southern section, from the newly reclaimed plot 2 "Mumtalakat plot" to the King Hamad Highway; however, it is unlikely that construction will commence in the near future. The project still requires further planning consultation and agreement from Bapco, Noga and Alba. CPO also highlighted that the upgrade of Highway 96 and King Hamad Highway has been granted approval for construction and may impact on the BMP construction.	
4	CPO informed that the hydrodynamic modelling for the East Sitra Housing reclamation did not take into account the impact of reclamation on turbulence. Furthermore, CPO indicated that there is an increase in water temperature at the GPIC intakes, flooding in the Mumtalakat Plot (south of the Noga plot) and sediment deposits at the Sitra port. Finally, CPO advised that the design of the Alba port must be done in coordination with the BMP.	
5	CPO expressed safety concerns over the location of the BMP Labour Camp 2 on the Noga Plot, suggesting use of the Mumtalakat Plot instead. EACS noted that NOGA 1 & 2 plots are allocated for Bapco to use for BMP and a QRA had been completed for the Camp 2 site and found that the site was acceptable in terms of risk to the camp occupants.	
6	CPO also pointed that the current proposed BMP construction access road from King Hamad is considered inadequate and suggested an additional one way exit to the King Hamad Highway might help traffic flows.	
7	Finally, CPO suggested putting in place a technical interface officer for the BMP that will liaise with relevant authorities regarding all necessary permits. Technical interface meetings for major projects are held weekly by CPO.	

Appendix 6B

Summary of Stakeholder Consultations

Organisation	Notes	Projects Identified	VECs Identified
Agricultural Affairs and Marine Resources (AAMR)	*Consultation undertaken on 14th October 2015 at AAMR, Old Juffair, Manama* *Response received 26.10.2015:* • The designated area is surrounded by major fishing grounds. • Information is required regarding the technologies to be used to minimise levels of pollution in the marine environment. • If any aspects of the BMP affect sedimentation in the Ma'ameer channel, mitigation measures would need to be provided. • The AAMR requested copies of historical work undertaken by Dr Olof Linden. These have been issued by Bapco. The AAMR attended a presentation on the 2015 survey in March 2016. • The AAMR must be informed of any reclamation activities.		Capture fisheries Ma'ameer Channel – Its capacity as an outlet for Tubli Bay.
Agriculture, Engineering and Water Resources Directorate (AEWRD)	*Consultation undertaken on 9th October 2015 at AEWRD, Budaiya* • The AEWRD enquired how long AGAS has been working on the Pitch Ponds, and EACS stated that it was approximately 15 years. Most of the pitch has been removed but more pitch needs to be recovered from ponds adjacent to the BMP site. Residual pitch remains on the site which will be covered with clean material with a depth of 3-4m to raise the height of the site to be in-line with the existing Refinery. • AEWRD requested hydrogeological data from previous site investigations undertaken at the Refinery and Sitra Tank Farm by EACS on behalf of Bapco • SI data will be provided to the AEWRD as part of the ESIA from historical and more recent investigations. • A geotechnical survey has just been completed of the Pitch Ponds sites and the AEWRD had requested a copy as part of permitting the work. • The AEWRD stated that there are no production wells in the vicinity of the BMP site, but Bapco itself abstracts from Aquifer C. • No abstraction is proposed as part of the BMP, but seawater will be used for cooling purposes following desalination. • The AEWRD will require long-term monitoring of the BMP site. At least two wells should be provided near the Pitch Ponds site. These should be located in areas which allow the AEWRD direct access.		Groundwater resources

Organisation	Notes	Projects Identified	VECs Identified
	• The AEWRD requested that a site visit be conducted to the Pitch Ponds site during the ESIA. • The AEWRD asked whether there would be any piling for the tanks and reminded EACS that a permit would be required for any piling operations. *Site Visit undertaken on 20th October 2015 with representatives from the AERWD, Bapco and Environment Arabia.*		
Bahrain Authority for Culture and Antiquities	*Consultation letter sent on 20th September 2015.* Shaikha Azza received letter and advised EACS that she is waiting for advisor to the Authority to respond. Response received via e-mail on 10th of January requesting a walkover survey to be undertaken to the part of the BMP site which was of interest to the authority. The survey was undertaken on 12th January 2015 with the presence of EACS staff.		Cultural heritage - Presence of artefacts to south of Refinery in foreshore area (these have been identified and preserved)
Central Planning Office (CPO), Ministry of Works	*Consultation letter sent on 20th September 2015* The CPO verbally stated on 7th October 2015 (telecom between Ali Bucheery and Halel Engineer) that they had no comments and did not need a consultation meeting. No written response received to date.		No VECs identified
Coastguard Directorate, Ministry of Interior (CG)	*Consultation undertaken on 30th September 2015, Coastguard Headquarters, Sitra* • Colonel Subaie indicated that the area where the Bapco Wharf is currently located is considered a sensitive area in terms of security due to the existence of nationally important industrial facilities and Sitra port, and the navigation of vessels within that area. • Colonel Subaie expressed the need to inform the Ministry of Interior, the National Guard, the CID, Alba and Bapco security Departments of this project with coordination by NOGA. He suggested that a joint stakeholder meeting should be set up so that the concerns of all parties could be addressed. Bapco has sent letters to all aforementioned parties informing them of the project. • A contact for Bapco was requested. • The Coastguard should be provided with details of marine operations as soon as they become available (e.g. date & time of operation, type of boat, crew, etc.).		National security issues - No VECs identified

Organisation	Notes	Projects Identified	VECs Identified
Electricity and Water Authority (EWA)	• EWA stated that they have been in discussion with Bapco regarding the BMP project for the past six months. • EWA requested details of the project so that they can incorporate any requirements into their 2015-2030 Development Plan. • EWA asked whether the expansion of the Refinery will require additional water and power supplies from Government supplies or will it be internally generated? EACS responded that they would direct this question to Bapco. • EWA indicated that there is a site allocated to them for a water distribution station within the safety zone of the East Sitra Housing Reclamation Plot. They enquired whether Bapco would reject proposals for such a development within the safety zone. • EWA requested to be provided with a detailed master plan of the BMP project when it becomes available and meet with Bapco at a later stage. • Finally, EWA inquired if the assessment will address the impacts on the East Sitra Housing plot and EACS responded that a list of sensitive receptors will be established during this scoping phase of the project to include local residential areas.	East Sitra Housing Development	Local communities – East Sitra Housing Development
General Directorate of Civil Defence	*Consultation undertaken on 7th October 2015, Block 313* • CDD expressed that they have no comments or concerns regarding the BMP project at this stage, and that they are happy with Bapco safety standards and regulations that will be followed.		No VECs identified
Ministry of Municipalities Affairs and Urban Planning (MMAUP) (General Directorate of Urban Planning (GDUP))	*Consultation undertaken on 8th October 2015, GDUP, Zayed Town* • GDUP indicated that they are concerned with the possible reclamation associated with the transfer pipelines from the Refinery to Sitra Tank Farm within the Ma'ameer channel and that it is unlikely that such an element of the project will obtain approval. They suggested looking at alternative methods of pipe crossing. They also indicated that there is a committee tasked with providing a solution to the existing issues with flushing and retention time of water within Tubli Bay. Widening of both the northern and southern extents of the Ma'ameer channel is being discussed.	Reclamation in Ma'ameer Channel Widening the entrance and exit of Ma'ameer Channel	Ma'ameer Channel – Its capacity as an outlet for Tubli Bay.

Organisation	Notes	Projects Identified	VECs Identified
Ministry of Transport and Telecommunications (MoTT)	*Consultation undertaken on 12th October 2015, Bahrain Financial Harbour, 9th Floor East Tower* • The MoTT stated that there may be a railway in the vicinity of the Refinery and that they would provide a drawing showing an indicative route. The route currently indicated follows the Sh. Jaber Highway and crosses the Ma'ameer channel just north of the existing transfer pipes. If the East Sitra Road Link is provided by the Roads Directorate, opportunities for the railway along this corridor would be investigated. The development of the railway is dependent on the construction of the Bahrain to Qatar Causeway. • A planning application was circulated for the railway following Shaikh Jaber Highway approximately 18 months ago. The MoTT stated that they will check their records to see whether Bapco responded with comments on the application. A response can be expected in a few weeks time. • The MoTT stated that they had no concerns with the tabled plans for the BMP.	Railway near refinery along Sh Jabber a Al Subah Highway or East Sitra Link Road (no further information provided) Bahrain to Qatar causeway	Road users (road improvements) Marine environment and capture fisheries (Bahrain to Qatar causeway)
Ports and Maritime Affairs (PMA)	*Consultation undertaken on 6th October 2015, PMA in Hidd* • The PMA enquired whether the BMP project was linked to the A/B pipeline and it was explained that both projects are part of the overall expansion of Bapco. • The PMA enquired of the Bapco Pitch Ponds were cleared and how deep the residue was. It was explained that approximately 80% of the pitch has been removed and two recent site investigations have been undertaken to determine site conditions, the results of which will be reported in the ESIA. • The PMA expressed that their interest lies in the marine element of the project more specifically regarding any changes in the wharf equipment, pipelines and navigational channels. It was explained that 19 new loading arms will be provided at the wharf and a new pipeline will be required at the end of the wharf. • PMA stated that all ships must comply with the requirements of the Marpol convention. • The PMA expressed their concern for any increase in discharge or oil spill in the marine environment. EACS noted that that discharges	A/B pipeline	Marine environment – potential for oil spills or discharges from vessels.

Organisation	Notes	Projects Identified	VECs Identified
	from the Refinery outfalls will be within the design limits of the existing treatment plants.		
Roads, Planning & Design Directorate (RPDD), Ministry of Works	*Consultation undertaken on 6th October 2015, Ministry of Works, Government Avenue* • The Roads Directorate has appointed a consultant to undertake the design of improvements to Sh. Jaber Highway from Um Al Hassam Interchange to Nuwaidrat roundabout. The improvements will include more lanes and grade separated junctions. A plan was provided. • The Roads Directorate intends to construct a new road linking Mina Salman to King Hamad Highway via East Sitra, known as East Sitra Link Road. This project is at the feasibility stage and they have invited consultants to bid for studying the potential impact of the road on concerned stakeholders in the area such as NOGA, GPIC, Bapco & Alba. • Construction work is about to commence on the Alba and Nuwaidrat roundabouts. Some preliminary work is underway on moving the affected utilities. Plans for the roundabouts were provided. • The Roads Directorate also plans to upgrade King Hamad Highway in the future. There will be 3-4 lanes in each direction together with grade separated junctions. • The Roads Directorate has no concerns regarding the BMP project, but they wish to know whether the AGAS plant will be removed in the future.	Improvements to Sh. Jaber A Al Subah Highway from Um Al Hassam Interchange to Nuwaidrat roundabout East Sitra Link Road Improvements to King Hamad Highway. Alba and Nuwaidrat roundabout upgrades.	Road users
Sanitary Engineering Projects and Planning Directorate (SEPPD), Ministry of Works	Consultation was undertaken on 11th November 2015 during a meeting which was held in the SEPPD offices in Salmabad. The following points were raised: • SEPPD presented EACS with the plan for a proposed TSE pipeline from the Ma'ameer STP. SEPPD does not feel that this proposed line would conflict with the BMP project. However, SEPPD indicated	Proposed TSE pipeline from Ma'ameer STP. Discharge from STP on East Sitra Housing.	Marine environment – Proposed TSE pipeline from Ma'ameer STP – reduction in discharge to marine environment.

Organisation	Notes	Projects Identified	VECs Identified
	that they have plans to construct a STP on the East Sitra Housing project with outfalls potentially parallel to the Sitra Wharf. • SEPPD suggested that Bapco use the TSE from Ma'ameer STP for landscaping or beautification purposes as it is high quality TSE. The current plan is to use this TSE for landscaping the King Hamad Causeway.		Marine environment – Discharge from STP on East Sitra Housing.
Supreme Council for Environment (SCE)	The SCE have been consulted throughout the ESIA process and the consultations are recorded in Section 5 of the ESIA. A permit with conditions was granted for the project on 4th December 2016. The residual impacts in the ESIA therefore comprise the impact of the BMP on VECs as agreed by SCE.	Demolition of decommissioned Bapco process units	As per scoped in BMP impacts (see **Section 6.1.2**)
Bahrain Women Association (BWA)	*Consultation undertaken on the 6th of June 2018* • BWA expressed concern about the potential impacts of the project on public health, especially emissions from industrial activities in the area. EACS assured BWA that the BMP will result in improved emissions level from the refinery relative to existing conditions. • BWA highlighted the importance of engaging with the local communities, especially Ma'ammeer and introducing them to the project through local social councils and NGOs. BWA also suggested providing job opportunities to Ma'ameer locals. • BWA suggested the implementation of green buffers around potentially affected communities to reduce visual impact.		Air Quality (public health) Employment Visual impact
Central Planning Office (CPO)	*Consultation undertaken on the 6th June 2018* • EACS inquired about the East Sitra Link Road. CPO advised that the road has been granted cabinet approval for the southern section, from the newly reclaimed plot 2 "Mumtalakat plot" to the King Hamad Highway; however, it is unlikely that construction will commence in the near future. The project still requires further planning consultation and agreement from Bapco, Noga and Alba. CPO also highlighted that the upgrade of Highway 96 and King Hamad Highway has been granted approval for construction and may impact on the BMP construction. • CPO informed that the hydrodynamic modelling for the East Sitra Housing reclamation did not take into account the impact of	East Sitra Link Road Upgrade of Highway 96 and King Hamad Highway East Sitra Housing Development Alba Port Capacity upgrade	Road users Major accident hazards

Organisation	Notes	Projects Identified	VECs Identified
	reclamation on turbulence. Furthermore, CPO indicated that there is any increase in water temperature at the GPIC intakes, flooding in the Mumtalakat Plot (south of the Noga plot) and sediment deposits at the Sitra port. Finally, CPO advised that the design of the Alba port must be done in coordination with the BMP. • CPO expressed safety concerns over the location of the BMP Labour Camp 2 on the Noga Plot, suggesting use of the Mumtalakat Plot instead. EACS noted that NOGA 1 & 2 plots are allocated for Bapco to use for BMP and a QRA had been completed for the Camp 2 site and found that the site was acceptable in terms of risk to the camp occupants. • CPO also pointed that the current proposed BMP construction access road from King Hamad is considered inadequate and suggested an additional one way exit to the King Hamad Highway might help traffic flows. • CPO suggested putting in place a technical interface officer for the BMP that will liaise with relevant authorities regarding all necessary permits. Technical interface meetings for major projects are held weekly by CPO.		
Migrant Workers Protection Society (MWPS)	*Consultation undertaken on the 5th June 2018* • MWPS spoke about the general issues and challenges facing expatriate workers such as delayed wages, poor accommodations, difficulty in communication, withholding of travel documentation, lack of awareness regarding safety and grievance mechanisms and so on. • Bapco assured MWPS that stringent measures will be put in place to ensure proper requirement and adequate training of workers. Bapco also explained that the labour camp will be designed to international standards and equipped with medical and recreational facilities and in line with the local relevant local regulations. MWPS emphasized that maintenance of new labour camps is essential to the well being of the workers • MWPS suggested that safety instructions must be made available in multiple language (English, Hindi, Bengali, Malyalim, etc) and pictures as to be understood by all workers • MWPS offered to share safety videos (in Hindi, Bengali, Malyalim		Workers' rights Occupational health and safety

Organisation	Notes	Projects Identified	VECs Identified
	and Tiligo) that can be presented to the workers at the labour camp. • MWPS identified BD 120-140 per month plus accommodations is generally considered as a fair rate pay for unskilled construction labourers. • MWPS noted that literacy competencies can be quite poor so the grievance mechanism should be explained to the workers.		
Supreme Council for Women (SCW)	*Consultation undertaken on the 5th June 2018* • SCW expressed concern regarding women's health in the workplace, citing that they had recently participated in a health and safety event organized by Bapco. • SCW indicated that they interface with various ministries and government bodies to achieve their goals and programs. • SCW stated that they have an ongoing relationship with Bapco, providing guidance and advice regarding the safety of women in the workplace as well as promoting equal job opportunities for women.		Occupational health and safety (women) Equal opportunities
Fisherman's Society	• EACS inquired about the fishing activity around Sitra Port. SFS informed that historically, Sitra was a rich Saffi ground; however, catch is now quite scarce and the fishermen need to sail about an hour away to find fish. • EACS inquired about the nature of fishing ground around the Bapco outfall. The SFS responded that the shrimp occurring in that area was found to of poor quality. Bapco pointed that under the new BMP, water quality is expected to improve. • SFS expressed concern over the discharge of chemical used for cleaning the outfall pipe. Bapco responded that all Refinery effluents and cooling water return are treated properly into various waste water treatment facilities and tested regularly through the outfalls to the marine environment.		Capture fisheries
Expat Protection Centre and Shelter (under LMRA)	• A representative of the site was met, Shereen Khalil Saati, was met on site briefly. She provided the contact details of the relevant person to organise a meeting. Following this, EACS tried to organise a meeting several times however no response was received.		
Environment Friends Society	• They were contacted on numerous occasions however no response was received and it was not possible to organise a meeting.		

Environment Arabia

Appendix 9A

Extract of APC ESIA

Aromatics Production Complex

Environmental and Social Impact Assessment

Marine Water Quality Section

10 MARINE WATER QUALITY

10.1 Introduction

Once a pollutant enters a water body it is difficult to remove; its direct effect upon the physical, chemical and biological properties of seawater can have deleterious indirect impacts not only on marine ecology, but also indirectly upon the operational efficiency of industrial facilities (e.g. seawater intakes), and the social interface with populations residing on bounding land masses (e.g. effects of eutrophication).

The operation of the APC will require an increase in the abstraction of seawater from the exising Bapco Refinery seawater intakes. The APC outfall will discharge into the Bapco Refinary main outfall, it is estimated to discharge 104,899.5 m^3/day. This volume represents an approximate increase of 15% compared to post BMP estimates. The quality of effluent arising from the APC is not predicted to significantly alter from that currently experienced from either the existing Bapco Refinery or post BMP scenario and hence, under normal operating scenarios, the key pollutant has been determined as thermal with increased flow.

Although predominantly a terrestrial based development, aspects of both APC construction works (e.g. terrestrial dewatering, surface water runoff from laydown areas, installation and construction of sealines and loading arms at the Sitra Wharf area), and its operational regime (i.e. discharge of effluents to sea) will, to varying extent, degrade marine water quality either on a temporary or long term basis. **Table 10.1** and **Figure 10.1** identifies three potentially affected geographical areas, which are discussed in later sections.

Table 10.1 Definition of Study Area

Location	Area of Interest (AOI)	Phase	Impacting activities
Waters extending east, north and south of the existing Bapco main outfall	AOI 1	Operations	Discharge of effluents to sea
Ma'ameer channel	AOI 2	Construction	Surface water runoff, terrestrial dewatering
Sitra wharf area	AOI 3	Construction	Subsea pipeline installation

10.2 Legislation and Guidance

10.2.1 National legislation

Bahrain has in place a number of Ministerial Orders which specifically refers to the protection of marine waters. Those which are applicable to the project are outlined in **Table 10.2**.

Table 10.2 Relevant National Legislation

Source	Description
Ministerial Order (21) of 1996	Provides general environmental guidance for Projects development and operation within the Kingdom of Bahrain specifically: – Article 6 prohibits the permitting of any project with the potential to cause environmental pollution, contribute to degradation of natural resources or exploitation of the environment. – Articles 8, 16, 24 & 25 forbids emission or leaks of substances into the environment exceeding their corresponding National limits. Projects are required to incorporate mitigation measures to prevent emission or leakage of substances above allowable national limits. Appropriate engineering controls, following consultation with applicable regulatory bodies, are to be incorporated to prevent pollution or environmental degradation. – Article 11 makes mandatory for projects to incorporate necessary measures to prevent environmental effect of excavation, demolition, or transportation of earth or debris. – Article 13 prohibits the discharge of waste or conducting activities that can cause pollution/degradation of the marine environment.
Ministerial Order (2) of 2001	Amends some provisions of Ministerial Order (10) of 1999 with Respect to Environmental Standards (Air and Water). It states that the use of water for industrial purposes must not affect the chemical balance of ground or surface water sources, and requires that all effluent released into the environment from industrial sources complies with the limits stated in the Ministerial Order (10) of 1999 with Respect to Environmental Standards and amended in Ministerial Orders (2) of 2001 and (3) of 2001. It also defines mixing zones of receiving waters to be a circular area adjacent to the point source that has a radius of 100 m (may be more or less based on quality of effluents and location of discharge) measured from the point of discharge. Water temperature change at the boundary of this zone should not exceed ±3°C when compared to ambient unless there are sensitive ecological systems in that area. The order defines the point of discharge as the meeting point between the effluent and receiving water at the centre of the mixing zone. Article 22 also states(bis): "*The Environment Authority may define the mixing area of certain projects with more or less than a circle or semi-circle with a diameter of one hundred (100) metres, as the case may be, and in view of the location, type and characteristics of the discharged water. The Environment Authority map compel the projects which do not accept such definition or wishes to modify their mixing area or have been defined before, to carry out such task and at their own expenses to conduct a study or more by a specialised firm of consultants approved by the Environment Authority to define the mixing point for such projects and determine the effect of discharging the waste water is such area. The definition resulting from this study shall be final*."

Source	Description
Ministerial Order No. 3 of 2001	Amendments to Tables in Ministerial Order No. 10 of 1999 with Respect to Environmental Standards (Air and Water) and its Amendments in Ministerial Order No. 2 of 2001. These are defined in **Table 10.4**.

10.2.2 International

Regional

The Kuwait Regional Convention was adopted on 24th April 1978 and represents the key regional legislation governing marine water quality with a requirement to prevent, abate and combat pollution caused by discharges from land reaching the Sea Area. It entered into force in 1979 with the creation of the Regional Organisation for the Protection of the Marine Environment (ROPME). A number of protocols were established with the *Protocol for the protection of the marine environment against pollution from land based sources* of relevance (entered into force 21st February 1990).

Introduced in February 1990, the *Protocol for the protection of the marine environment against pollution from land based sources* protocol commits the member states of Kuwait Convention, and in alignment to the UNCLOS (1982) and the Montreal Guidelines for the Protection of the Marine Environment, against Pollution from Land Based Sources (1985), to ensure that discharges to water bodies (e.g. that arising from industrial processes) are controlled via regulation, this including detailed studies to assess, control and abate adverse impacts via acceptable treatments processes.

International

The United Nations Convention on the Law of the Sea (UNCLOS, 1982) was ratified by Bahrain on the 30th May 1985, and refers to "the protection and preservation of the marine environment"; from this one could infer that controlling polluting sources to water bodies is relevant.

Although the following refers to ecological receptors, they have been included due to the direct influence water quality has upon marine ecology.

- Convention on Biological Diversity was signed by the Kingdom of Bahrain[36] on the 9th June 1992, ratified on the 30th August 1996 and came into party on the 28th November 1996; and
- Protocol Concerning the Conservation of Biological Diversity and the Establishment of Protected Areas (2002). This aims to preserve environmental systems and wildlife, especially endangered species and those that migrate through the territorial waters.

In addition to the above, the Bahrain is a contracting party[37] of The Convention on Wetlands (RAMSAR), which was adopted in the Iranian city of Ramsar in 1971 and came into force in 1975. This is an intergovernmental treaty that presents the framework for cooperation on a national and international level for the conservation and

[36] Is addressed within Legislative Decree No. 9.
[37] Bahrain ratified the agreement on the 26th February 1997 (Amiri Decree 3, 1997).

appropriate use of wetlands. Bahrain has two RAMSAR sites, *Tubli* Bay (located to the north of AOI 2) and the *Hawar* Islands.

10.2.3 Guidance

Water Quality Objectives (WQO), derived by many countries internationally, indicate a preferred water quality based on key criteria (e.g. sustenance of marine ecology, industrial use, recreational bathing, etc.). Although not necessarily supported by legislation, such guidance provides a valuable tool in assessing both baseline and predicted water quality (for chemical, biological and physical parameters) following anthropogenic input.

We have identified water quality standards/objectives, which are pertinent to the development; these are derived from a variety of sources including national, regional, and international (including the International Finance Corporation (IFC) of the World Bank). Two categories exist:

1. Those which refer to water quality objectives (i.e. quality of water which is required to maintain acceptable levels for ecological and human use). Reference is made to the standard within later sections of this document, but also summarised within **Table 10.3**.
2. Effluent quality standards[38] (**Table 10.4**).

Standards for Water Quality Objectives

As Bahrain does not have its own national ambient marine water quality standards, reference is made to other regions/countries that do. Standards between countries will vary and indeed some may not have values for all parameters, hence the following identifies those standards which have been used to define ambient water quality within the study area.

- The KSA Environmental Quality Objectives (EQOs) for Ambient Marine Water Quality (Presidency of Meteorology and Environment, 2012). The KSA guidelines (Arabian Gulf) may be considered relevant to Bahrain based on the similarity of their marine environments; these two countries are very similar biogeographically. These ambient water quality standards are for 3 classifications of marine waters; Coastal Marine, Coastal High Value and Coastal Industrial
- United States Environmental Protection Agency (USEPA) National Recommended Water Quality Criteria (USEPA, 2014). The US EPA have 2 guideline values, the Criteria Maximum Concentration (CMC), and the Criterion Continuous Concentration (CCC). The CMC ('acute' scenario) is an estimate of the highest concentration of a material in surface water, which an aquatic community can be briefly exposed to without resulting in an unacceptable effect. The CCC ('chronic' scenario) is an estimate of the highest concentration of a material in surface water which an aquatic community can be exposed indefinitely to without resulting in an unacceptable effect.
- Canadian Council of the Ministers of the Environment – Canadian Water Quality Guidelines for the Protection of Aquatic Life (CCME, 2014).

[38] Excludes those relevant to MARPOL.

- UK Environment Agency – Environmental Quality Standards (EQS) − based upon substances detailed in the European Union's Dangerous Substances Directive (76/464/EEC and Daughter Directives). The EQS have been developed for the protection of aquatic life.
- Dubai Municipality - Marine Water Quality Objectives (Dubai Municipality, 2003).
- Australian Government - Department of Environment and Resource Management – Queensland Water Quality Guidelines (DERM, 2009).

Industrial discharge standards[39]

- Kingdom of Bahrain Ministerial Order No. 3 of 2001 – Amendments to Tables in Ministerial Order No. 10 of 1999 with Respect to Environmental Standards (Air and Water) and its Amendments in Ministerial Order No. 2 of 2001[40].
- WBG (2016) EHS Guidelines for Petroleum Refining.
- WBG (2007) EHS Guidelines for Large Volume Petroleum-Based Organic Chemicals Manufacturing.
- Ministry of Works (MoW) "TSE standards for agriculture unrestricted reuse and discharge to sea – sensitive areas".
- Ministry of Works Sanitary Engineering Affairs - Trade Effluent Conditions of Discharge.
- SCE (2010) EIA-9 Guidelines on TSS Monitoring Program of Large Scale Projects Involving Intensive Dredging and Reclamation Operations.
- The International Convention for the Prevention of Pollution from Ships (MARPOL).

Ministerial Order No. 3 of 2001 presents standards to which industrial effluents within the Kingdom of Bahrain must adhere. However, as the APC project is to be financed by international finance corporations, reference to IFC standards, World Bank, (2007) EHS Guidelines, Large Vol. Petroleum Based Organic Chemicals Manufacturing, are required. The WBG (2007) EHS Guidelines are technical reference documents with industry specific guidance.

They contain the performance levels and measures that are generally considered to be achievable in new facilities by existing technology at reasonable costs. When host country regulations differ from the levels and measures presented in the EHS Guidelines, projects are expected to achieve whichever is more stringent. If less stringent levels or measures than those provided in these EHS Guidelines are appropriate, in view of specific project circumstances, a full and detailed justification for any proposed alternatives is needed as part of the site-specific environmental assessment. This justification should demonstrate that the choice for any alternate performance levels is protective of human health and the environment.

Based on the above, **Table 10.4** presents the Bahrain Standards for Industrial Effluents BSIE, World Bank (2007), and APC Project Accepted Limits (PAL). Note, the most stringent apply and are presented in the PAL column.

[39] Including ship-borne.

[40] Note that SCE has revised these as a Draft V3.0 dated 29th September 2015. However as these have not been passed into law, they are not applicable to this project.

To represent the discharge from the Bapco Refinery, post BMP, the 2016 World Bank EHS guidelines for Petroleum Refining, together with the BSIE have been used to represent worst case emissions from the Refinery.

Table 10.3 Water Quality Objective Guidelines (all values in mg/l)

Parameter		Saudi Arabian PME			USEPA		CCME	UK EQS	Australia DERM	Dubai WQO
		C1[a]	C2[a]	C3[a]	CMC	CCC				
Inorganic Non-metals	Ammonium as N	-	-	-			-	-	-	-
	Silica	-	-	-			-	-	-	-
Metals - Total	Aluminium	0.2	0.2	1.0	-	-	-	-	-	0.2
	Barium	0.5	0.5	1.0	-	-	-	-	-	-
	Cadmium	0.005	0.005	0.05	0.04	0.0088	0.00012 (long term)	0.0025	-	0.003
	Chromium	0.05	0.05	0.1	-	-	-	-	-	0.01
	Cobalt	0.05	0.05	1.0	-	-	-	-	-	-
	Copper	0.05	0.05	0.15	0.0048	0.0031	-	0.005	-	0.005
	Iron	0.5	0.1	1.0	-	-	-	-	-	0.2
	Lead	0.05	0.005	0.2	0.21	0.081	-	0.025	-	-
	Manganese	0.01	0.01	2.0	-	-	-	-	-	-
	Mercury	0.0004	0.0004	0.001	0.0018	0.00094	0.000016	0.0003	-	0.001
	Molybdenum	-	-	-	-	-	-	-	-	-
	Nickel	0.05	0.05	0.2	0.074	0.0082	-	0.03	-	-
	Strontium	-	-	-	-	-	-	-	-	-
	Vanadium	-	-	-	-	-	-	-	-	-
	Zinc	0.8	0.2	2.0	0.090	0.081	-	0.040	-	0.02
Nutrients	Nitrate as N	1.5	1.2	2.0	-	-	1500 mg/l (short-term), 200 mg/l (long-term)	-	-	0.5

Parameter		Saudi Arabian PME			USEPA		CCME	UK EQS	Australia DERM	Dubai WQO
		C1[a]	C2[a]	C3[a]	CMC	CCC				
	Nitrite as N	1.5	1.2	2.0	-	-	-	-	-	-
	Reactive Phosphorus as P	-	-	-	-	-	-	-	0.006	0.05
	Total Phosphorus as P	0.5	0.25	1.0	-	-	-	-	0.025	-
Major Cations and Anions	Calcium	1,200	1,200	1,200	-	-	-	-	-	-
	Magnesium	-	-	-	-	-	-	-	-	-
	Potassium	-	-	-	-	-	-	-	-	-
	Sodium	14,000	14,000	14,000	-	-	-	-	-	-
Total Petroleum Hydrocarbons (TPH)	Sum of C10 – C40 Fraction	0.3	0.2	0.5	-	-	-	-	-	-

[a] **C1 = Coastal waters** - those that are under the jurisdiction of KSA (the territorial coastal waters being 12 international nautical miles (22.2 kilometres) of the shoreline). The subdivision 'marine' is the default when the coastal water body does not meet the criteria for 'high-value' or 'industrial'.

C2 = High value - areas of coastal water shall be classified as 'high value' if they are designated as locally, nationally or internationally protected areas by any Concerned Agency (this includes but is not limited to the Competent Agency, ROPME, NCWCD and PERGSA).

C3 = Industrial - water bodies shall be classified as industrial if they are adjacent to terrestrial zones or surrounding fixed offshore platforms that that are classified as industrial through local or national planning regulation. The extent of the aquatic environment classified as industrial will represent a seaward extension of the terrestrial boundary provided that it does not impinge upon high areas classified as C1 or C2. Furthermore, industrial ambient conditions will extend no more than a 500 meter radius from the edge of any mixing zone.

Table 10.4 Applicable Effluent Discharge Standards Including Those for the APC Entering Bapco Outfall Flume (i.e. PAL)

Parameter	Units	WBG (2016)[41]	WBG (2007)	Bahrain Standards for Industrial Effluents		Project Accepted Limits (PAL)
				Monthly Average	Maximum	
Physico-chemical pollutants						
Floating particles	mg/l	-		0	0	0
pH	-	6-9	6-9	6-9	6-9	6-9
Temperature	°C	<3[42]	=3	3°C Δ T		3°C Δ T
Total Suspended Solids	mg/l	30	30	20	35	20^{A} 30^{M}
Turbidity	NTU	-	-	25	75	25^{A} 75^{M}
Inorganic Pollutants						
Ammoniacal Nitrogen as N	mg/l	-	-	1	3	1^{A} 3^{M}
Sulphide as H_2S	mg/l	-	-	0.5	1	0.5^{A} 1^{M}
Sulphides	mg/l	0.2	-	-	-	
Chlorine residual	mg/l	-	-	0.5	2	0.5^{A} 2^{M}
Cyanide (Total)	mg/l	Total: 1	-	Total: 0.05	Total:0.1	0.05^{A} 0.1^{M}
Cyande (Free)		Free: 0.1	-	-	-	0.1
Nitrate (NO_3)	mg/l	-	-	-	1	1
Nitrite (NO_2)	mg/l	-	-	-	10	10
Nitrogen total	mg/l	10[43]	10	-	-	10
Phosphate total	mg/l	-	-	1	2	1^{A} 2^{M}
Phosphorous total	mg/l	2	2	-	-	2

[41] These are relevant only as a definition of exiting effluent quality from the BMP and do not feature in determining the PAL.

[42] At the edge of a scientifically established mixing zone which takes into account ambient water quality, receiving water use, potential receptors and assimilative capacity.

[43] The effluent concentration of nitrogen (total) may be up to 40mg/l in processes that include hydrogenation

Parameter	Units	WBG (2016)[41]	WBG (2007)	Bahrain Standards for Industrial Effluents		Project Accepted Limits (PAL)
				Monthly Average	Maximum	
Organic Pollutants						
Biological Oxygen Demand (BOD)	mg/l	30	25	25	50	25
Chemical Oxygen Demand (COD)	mg/l	125	150	150	350	150
Total Kjeldahl Nitrogen	mg/l	-	-	5	10	5^{A} 10^{M}
Benzene	mg/l	0.05	0.05	-	-	0.05
Benzo(a)pyrene	mg/l	0.05	-	-	-	-
Oil and grease	mg/l	30	10	8	15	8^{A} 10^{M}
Phenol	mg/l	0.2	0.5	0.5	1	0.5
Vinyl Chloride (VCM)	mg/l	-	0.05	-	-	0.05
1,2 Dichloroethane (EDC)	mg/l	-	1	-	-	1
Adsobable Organic (AOX)	mg/l	-	1	-	-	1
Fluorescent Petroleum Matter	mg/l	-	-	0.1	0.1	0.1
Total coliforms	No./100ml	-	-	1000	10000	1000^{A} 10000^{M}
Total Organic Carbon (TOC)	mg/l	-	-	50	-	50
Trace metals						
Arsenic	mg/l	0.1	-	0.1	0.5	0.1^{A} 0.5^{M}
Cadmium	mg/l	-	0.1	0.01	0.05	0.01^{A} 0.05^{M}
Chromium total	mg/l	0.5	0.5	0.1	1	0.1^{A} 0.5^{M}
Chromium hexavalent	mg/l	0.05	0.1	-	-	0.1
Copper	mg/l	0.5	0.5	0.2	0.5	0.2^{A} 0.5^{M}
Iron	mg/l	-	-	5	10	5^{A} 10^{M}
Lead	mg/l	0.1	0.5	0.2	1	0.1^{A} 0.5^{M}
Mercury	mg/l	0.003	0.01	0.001	0.005	0.001^{A} 0.005^{M}
Nickel	mg/l	0.5	0.5	0.2	0.5	0.2^{A} 0.5^{M}
Zinc	mg/l		2	2	5	2

10.3 Assessment Methodology

The assessment methodology employed follows that commonly employed for water pollution assessments and was informed by review of secondary data (i.e. EACS, 2016 Environmental and Social Impact Assessment: Bapco Modernization Programme) and specialist studies (i.e. plume dispersion modelling). A systematic approach of defining impacts, following review of the project construction programme/methodologies and operational project design, and applying defined significance criteria (**Section 10.3.3**) was employed to quantitatively assess impacts.

10.3.1 Baseline water quality

Primary surveys were not conducted as part of this ESIA, rather reference is made to EACS (2016) Environmental and Social Impact Assessment: Bapco Modernization Programme.

EACS (2016) Environmental and Social Impact Assessment: Bapco Modernisation Programme

Data sets obtained from EACS (2016) present a comprehensive assessment of water quality across three study areas (**Table 10.5** and **Table 10.6**). A total of 13 water samples were taken; 8 fronting the main Bapco outfall, 2 within Ma'ameer Channel and 3 at the Sitra wharf area; *in situ* water readings were taken at the same locations (**Figure 10.1**).

The following provides a brief summary of the parameters that were tested and analysed as part of the primary baseline surveys. The survey took place in January and February 2016 (winter). Where a standard identified in **Table 10.3** is breached this is referenced.

Within AOI 1 (**Figure 10.1**) the water quality results were, for most parameters tested for, considered uncontaminated when considering the WQO guidelines highlighted in **Section 10.2.3**. The following provides a summary of the few minor breaches noted:

- Aluminium values were consistent across the study area, with a minimum of 0.6 mg/l recorded at stations BMP 33, 43 and 45, and a maximum value of 0.63 mg/l recorded at BMP 26; these breach the Dubai Marine WQO (0.2 mg/l) and the Kingdom of Saudi Arabia (KSA) EQO ambient water (C1 and C2 class waters) quality guideline (0.2 mg/l).
- The KSA EQO for total phosphorus is 0.25 mg/l and 1.0 mg/l (for C2 and C3 class waters). The values recorded in the study area ranged from 0.13 mg/l (BMP 33) to 0.47 mg/l (BMP 20). Half of the stations surveyed were within the guideline value set for C2 classed (coastal) waters.

In situ water quality parameters (pH, temperature, salinity, dissolved oxygen) were all within anticipated ranges for this location of Bahrain and time of assessment (i.e. January and February); with the exception of temperature readings at stations BMP 22a, 22b and 22c (see **Figure 10.1**). The temperature differential between locations a, b and c was 9.96 ºC with 19.42 ºC recorded at BMP 22a and 29.38 ºC recorded at BMP 22c. At the remainder of the stations, the temperature ranged from 18.23 ºC (~ 1 m from the seabed at BMP 43) to a maximum of 20.82 ºC (~ 1m from the surface at BMP 33) with an average of 19.27 ºC across all stations and depths.

For most parameters tested for AOI 2 (**Figure 10.1**), the results showed that the water is uncontaminated when considering the guidelines highlighted in **Section 10.2.3**. *In situ* water quality parameters were not recorded at AOI 2 due to shallow water depths. The following bullet points highlight the few minor breaches in guideline values:

- The value recorded for copper was 0.062 mg/l and 0.059 mg/ for station M1 and M2 respectively. These values are in breach of the KSA PME ambient water quality standards for C1 and C2 waters (coastal and high value), the UK EQS, and Dubai WQO. It is however compliant with the KSA PME ambient water quality standard (industrial waters) and both the US EPA CMC and CCC value for this parameter.
- 0.054 mg/l zinc was recorded from the water sample M1 and 0.05 mg/l at M2. These values are above the UK EQS (set at 0.04 mg/l) and the Dubai WQO (0.02 mg/l). The values recorded are however compliant with all of the KSA EQS (for all classifications of water bodies), the US EPA CMC and CCC and US EPA CMC and CC values for this parameter.
- Reactive phosphorus was recorded as 0.01 mg/l for both stations (M1 and M2) in AOI 2. This exceeds the Australian DERM (0.006 mg/l) but is compliant with the Dubai WQO (0.05 mg/l).

Water quality recorded from the 3 locations in AOI 3 (**Figure 10.1** can be considered largely uncontaminated at the time of sampling when comparing the results to the guideline values highlighted in **Section 10.2.3** (i.e. no breaches recorded). Furthermore, in *situ* water quality results were all within ranges considered to be 'normal' for the geographical area and time of year.

Effluents from Bapco Refinery

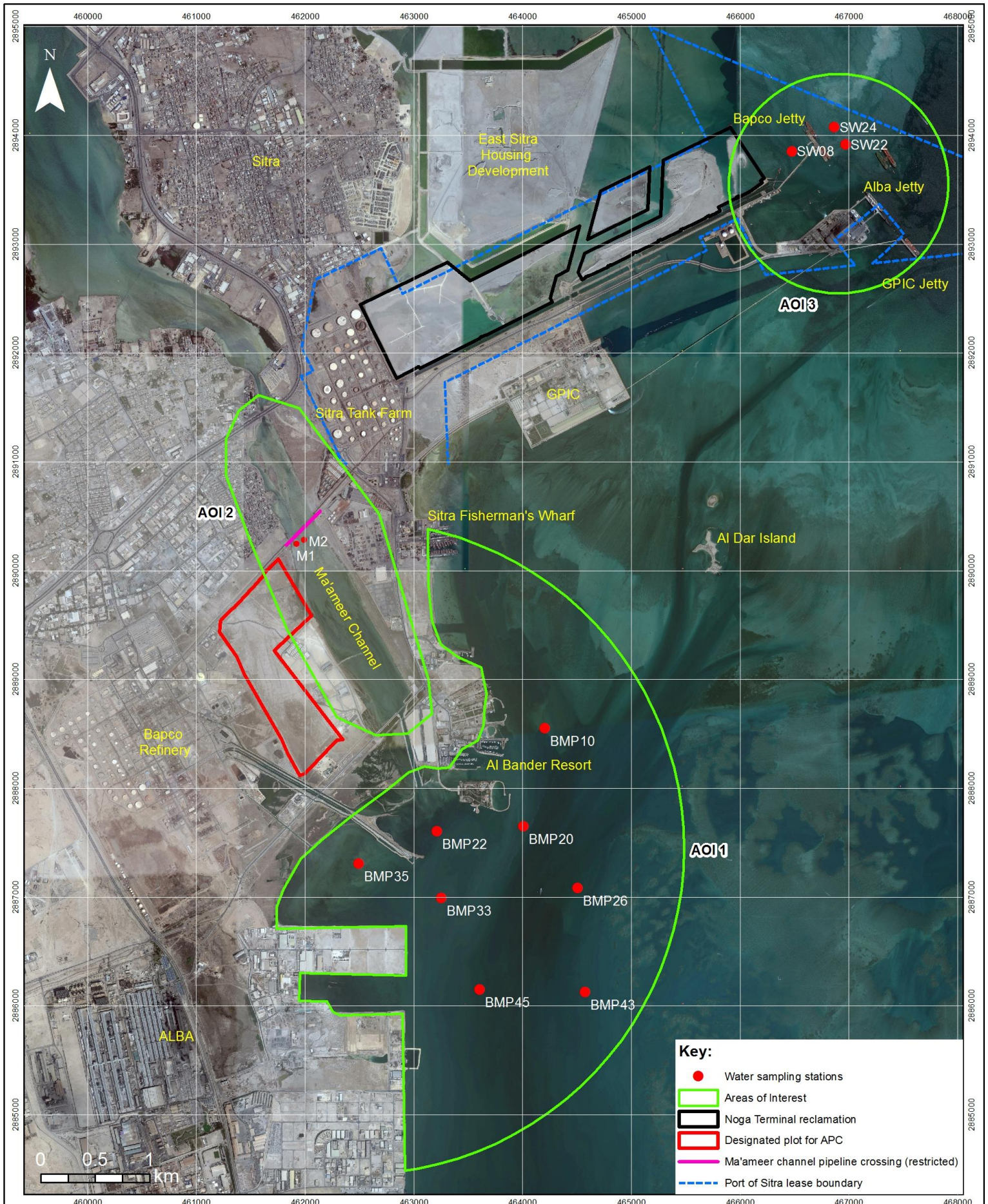
For the purposes of this assessment, it has been assumed that the discharge from the Bapco Refinery meets the most stringent values from:

1. WBG (2016) EHS Guidelines for Petroleum Refining.
2. Ministerial Order No. 3 of 2001, Ministerial Order No. 10 of 1999 and its amendments[44] Bahrain Standards for Industrial Effluents.

As such those values presented in **Table 10.4**[45] can be considered as representing the 'baseline' effluent condition assumed for this ESIA. The addition of the APC effluents to the BMP effluent stream is unlikely to result in a change in the effluent quality of the BMP, rather slightly increase the volume of effluent.

[44] Ministerial Order 10 of 1999 is amended by Ministerial Order No. 2 of 2001 and Ministerial Order No. 3 of 2001

[45] This refers to the columns in Table 10.4 which present the WBG (2016) and BSIE only.



	Title: **Location of EACS (2016) Water Sampling Stations**		Client: nogaholding; PETROCHEMICAL INDUSTRIES COMPANY K.S.C.
	Project: APC ESIA		
	Date: April 2017	Figure No.: 10.1	Consultant: Environment Arabia
	Datum: WGS 84 - UTM 39N	Scale: 1:45,000 (A4)	

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Table 10.5 Summary of Water Quality Results (AOI 1, 2 & 3) [46]

Parameter		LOR	Unit	Station and AOI													
				AOI 1								AOI 2		AOI 3			
				BMP 10	BMP 20	BMP 22	BMP 26	BMP 33	BMP 35	BMP 43	BMP 45	M1	M2	SW 08	SW 22	SW 24	
Inorganic Non-metals	Ammonium as N	0.01	mg/l	0.05	0.05	0.06	0.06	0.04	0.05	0.06	0.03	0.08	<5.0	0.52	0.08	0.07	
	Silica	0.1	mg/l	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<1.0	<0.1	<0.1	<0.1	
Metals - Total	Aluminium	0.01	mg/l	0.61	0.61	0.63	0.63	0.60	0.61	0.60	0.60	<0.01	11.0	<0.01	<0.01	<0.01	
	Barium	0.001	mg/l	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	0.148	<2.0	<0.001	<0.001	<0.001	
	Cadmium	0.0001	mg/l	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	30.0	<0.0001	<0.0001	<0.0001	
	Chromium	0.001	mg/l	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	5.0	<0.001	<0.001	<0.001	
	Cobalt	0.001	mg/l	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.1	<0.001	<0.001	<0.001	
	Copper	0.001	mg/l	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	0.062	12.0	<0.001	<0.001	<0.001	
	Iron	0.01	mg/l	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	3,300.0	<0.01	<0.01	<0.01	
	Lead	0.001	mg/l	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	15.0	<0.001	<0.001	<0.001	
	Manganese	0.001	mg/l	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	45.0	<0.001	<0.001	<0.001	
	Mercury	0.0001	mg/l	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.5	<0.0001	<0.0001	<0.0001	
	Molybdenum	0.001	mg/l	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	0.162	<0.5	<0.001	<0.001	<0.001	
	Nickel	0.001	mg/l	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.5	<0.001	<0.001	<0.001	
	Strontium	0.001	mg/l	9.18	9.37	9.47	9.32	9.29	9.28	9.23	9.38	98.7	<0.5	9.5	9.78	9.46	
	Vanadium	0.01	mg/l	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.5	<0.01	<0.01	<0.01	
	Zinc	0.005	mg/l	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	0.054	<0.5	<0.005	<0.005	<0.005	
Nutrients	Nitrate as N	0.01	mg/l	0.02	0.02	0.01	<0.01	<0.01	0.02	0.04	0.01	<0.01	<0.5	<0.01	<0.01	<0.01	
	Nitrite as N	0.01	mg/l	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.5	<0.01	<0.01	<0.01	
	Reactive	0.01	mg/l	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	0.01	<0.5	<0.01	<0.01	<0.01	

[46] Results highlighted in red indicate a breach of one or more of the guideline values highlighted in **Section 10.3.1**. Results in green indicate compliance. Results with no highlight indicate that no guideline has been identified for the parameter.

Parameter		LOR	Unit	Station and AOI												
				AOI 1								AOI 2		AOI 3		
				BMP 10	BMP 20	BMP 22	BMP 26	BMP 33	BMP 35	BMP 43	BMP 45	M1	M2	SW 08	SW 22	SW 24
	Phosphorus as P															
	Total Phosphorus as P	0.01	mg/l	0.42	0.47	0.19	0.19	0.13	0.19	0.34	0.38	0.22	<0.5	0.10	0.21	0.01
Major Cations and Anions	Calcium (Ca)	0.0	mg/l	568.0	581.0	571.0	565.0	576.0	570.0	579.0	568.0	593.0	<0.5	543.0	562.0	562.0
	Magnesium (Mg)	1.0	mg/l	1,810	1,840	1,830	1,800	1,830	1,840	1,830	1,820	1680	<0.5	1,540	1,590	1,600
	Potassium (K)	1.0	mg/l	738.0	786.0	751.0	768.0	784.0	752.0	751.0	737.0	770.0	<0.5	720.0	753.0	752.0
	Sodium (Na)		mg/l	15,300	15,600	15,500	15,300	15,600	15,600	15,500	15,200	15,200	<0.5	13,200	13,600	13,700
Total Petroleum Hydrocarbons (TPH)	C6-C9	20.0	µg/l	<20.0	<20.0	<20.0	<20.0	<20.0	<20.0	<20.0	<20.0	<20.0	<0.5	<20.0	<20.0	<20.0
	C10-C14	50.0	µg/l	<50.0	<50.0	<50.0	<50.0	<50.0	<50.0	<50.0	<50.0	<50.0	<0.5	<50.0	<50.0	<50.0
	C15-C8	100.0	µg/l	<100.0	<100.0	<100.0	<100.0	<100.0	<100.0	<100.0	<100.0	<100.0	<0.5	<100.0	<100.0	<100.0
	C29-C36	50.0	µg/l	<50.0	<50.0	<50.0	<50.0	<50.0	<50.0	<50.0	<50.0	<50.0	<0.5	<50.0	<50.0	<50.0
	C37-C40	50.0	µg/l	<50.0	<50.0	<50.0	<50.0	<50.0	<50.0	<50.0	<50.0	<50.0	<10.0	<50.0	<50.0	<50.0
	C10 – C40	100.0	µg/l	<100.0	<100.0	<100.0	<100.0	<100.0	<100.0	<100.0	<100.0	<100.0	<50.0	<100.0	<100.0	<100.0

Table 10.6 *In Situ* Water Quality Data (EACS, 2016)

Station	Maximum depth (m BSL)	Depth of reading (m BSL)	Depth of reading (m)	Sal.(ppt)	Cond. (mS/cm)	pH	D. oxygen (mg/l)	Temp (°C)	Secchi depth (m)
BMP 10	1.8	0.9	0.9	45.88	67.5	8.40	6.92	20.09	Seabed
BMP 18	1.5	0.75	0.7	45.73	67.2	8.50	6.75	19.58	Seabed
BMP 20	2.7	1.4	1.3	45.63	67.1	8.00	6.29	19.36	Seabed
BMP 22	1.6	0.8	0.8	47.13	66.6	8.30	6.63	19.42	Seabed
BMP 22a	<1.0	0.5	0.5	46.17	68.4	8.40	6.50	25.91	Seabed
BMP 22b	<0.8	0.4	0.5	46.08	68.7	8.41	6.29	29.38	Seabed
BMP 23	5.5	1	1.0	45.70	67.3	8.10	6.16	19.00	Seabed
		2.5	2.2	45.70	67.2	8.06	6.17	18.94	
		4.5	4.5	45.67	67.2	7.98	6.22	18.91	
BMP 26	4.2	1.	1.0	45.66	67.2	8.31	6.18	19.02	Seabed
		2	2.1	45.66	67.2	8.31	6.20	19.02	
		3.2	3.2	45.66	67.2	8.37	6.19	19.02	
BMP 33	4.1	1	1.0	46.00	67.2	8.22	6.31	20.82	Seabed
		2	2.0	45.80	67.3	8.13	6.19	19.13	
		3.1	3.1	45.79	67.4	8.12	6.22	19.22	
BMP 35	<1.0	0.5	0.5	45.92	67.5	8.34	6.84	20.25	Seabed
BMP 43	4.8	1	1.0	45.68	67.2	8.24	6.00	19.07	Seabed
		2.5	2.4	45.70	67.3	8.23	6.02	19.02	
		3.8	3.8	45.81	67.3	8.29	6.17	18.23	
BMP 45	4.5	1	1.0	45.33	67.4	8.24	6.18	19.47	Seabed
		2.5	2.2	45.84	67.4	8.22	6.20	19.11	
		3.5	3.5	45.78	67.3	8.24	6.39	18.84	
SW 08	11.8	1	1.0	45.68	67.2	8.39	6.55	18.94	6.0
		5	6.0	45.89	67.3	8.40	6.59	18.88	

Station	Maximum depth (m BSL)	Depth of reading (m BSL)	Depth of reading (m)	Sal.(ppt)	Cond. (mS/cm)	pH	D. oxygen (mg/l)	Temp (°C)	Secchi depth (m)
		10.8	10.8	45.71	67.3	8.39	6.54	18.38	
SW 22	15.5	1	1.0	45.56	67.2	8.33	6.57	18.10	6.0
		7.5	7.8	45.58	67.2	8.33	6.56	18.05	
		14.5	14.5	45.58	67.3	8.32	6.56	18.05	
SW 24	15.0	1	1.0	45.57	67.2	8.34	6.51	18.15	6.0
		7.5	7.5	45.66	67.2	8.33	6.55	18.03	
		14	14.0	45.66	67.3	8.31	6.55	18.03	

10.3.2 Hydrodynamic modelling

Operation of the APC will result in a discharge to the existing Bapco main outfall flume of approximately 104,899.5 m^3/day. This represents a relatively small volume, approximately 15% of post BMP volumes. Effluents from the APC arise from a various sources but are summarised in **Table 10.7**; these will be combined with that predicted from BMP (716,132 m^3 /day) and hence result in a total volume of 821,032 m^3 /day.

Table 10.7 Summary of Effluents From the APC

Source	Volume	Treatment	End point
Desalination	101,563 m^3/day	None	Bapco Refinery Final Outfall
APC waste water treatment	3,325 m^3/day	Wet case, including de oiling stream	
Process water	11.5 m^3/day	None	Bapco Refinery WWTP

Plume dispersion modelling was conducted as part of EACS (2016), however, consultation with key stakeholders (e.g. SCE[47], EWA, GDUP) have indicated a requirement to assess the cumulative impact of known discharges in the area and incorporating the latest version of the Bahrain 2030 Development Plan. This latest plan includes additional land masses which may affect dispersion, but also newly planned seawater intakes associated with EWA facilities (desalination plant) at Ras Abu Jar Jur (RAJ).

Consequently, HRW were commissioned to undertake specialist studies, to assess:

- Dispersion characteristics of the increased flow (includes combined thermal effluents from BMP and APC) from the BMP outfall with the inclusion of new land masses/coastal configuration associated with 2030. Importantly this includes crossing designs linking the mainland to the plot 2 reclamation (**Figure 10.2**).
- Incorporation within the model, of existing discharges arising from GPIC so as to assess cumulative impacts, and to assess the contribution (if any) of APC thermal pollution at the GPIC intake.
- Recirculation of combined BMP and APC effluents to the Bapco Refinery and BMP sea water intake.
- Any degradation of water quality at EWA, current and proposed, intakes (i.e. Ras RAJ and Al Dur intakes). This was achieved via both thermal and conservative non-decaying tracer modelling, the later to assess diluted contaminats.

Dispersion of the combined APC and BMP discharge, and those of GPIC, has been examined using the TELEMAC finite element modelling system (refer to **Appendix 10A** for standalone modelling report[48]). TELEMAC-3D, the three dimensional module of the TELEMAC system, was used to allow the simulation of the vertical transport and structure of the effluent plumes. Important atmospheric processes, including cooling of surface plumes to the atmosphere, are also represented. These processes are essential to obtain a good representation of thermal/saline plume dispersion. The model

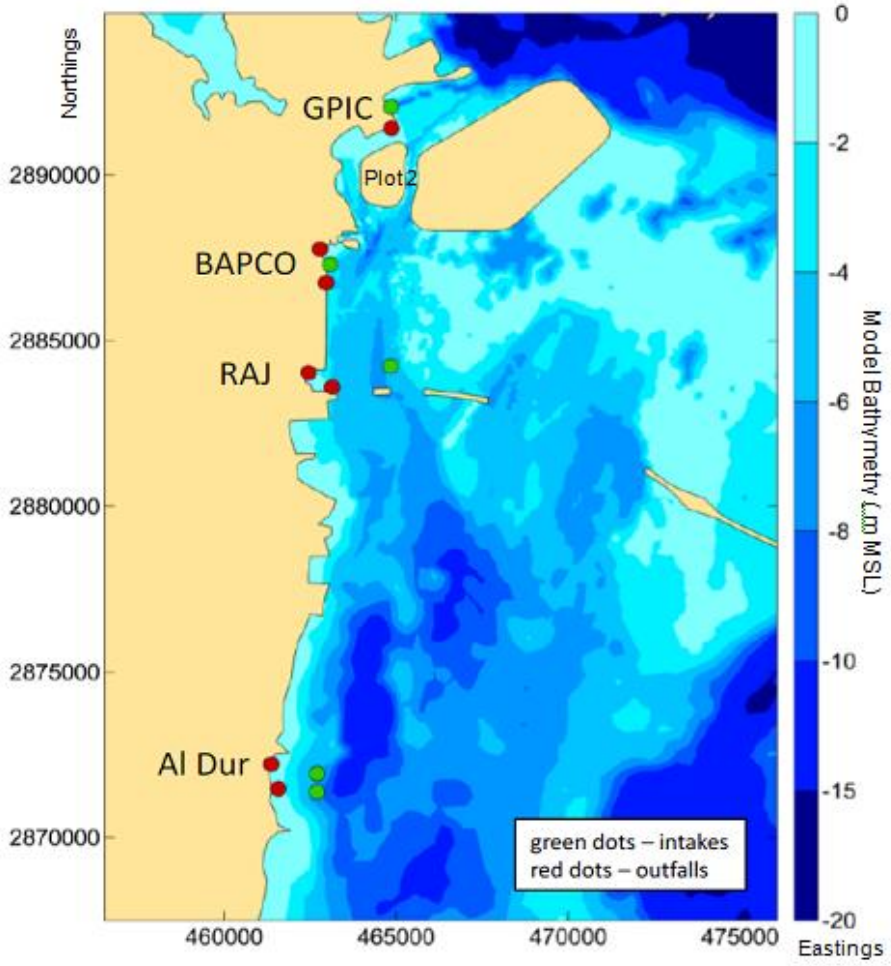
[47] The requirement for modelling was stipulated in the SCE response to the environmental scoping report.

[48] HR Wallingford (2017) APC Thermal Dispersion Modelling. DEM7922-RT001-R02-00.

configuration was updated following consultation with the GDUP and EWA; the layout of the model is shown in **Figure 10.2** and importantly includes identified criteria for bridges/causeways (i.e. porosity) where available[49].

The Bapco average discharge parameters derived in EACS (2016) were updated to include the intake and outfall flows that will be experienced during operation of the APC. The GPIC plant was also included using summer flow conditions. These represent the largest flows from GPIC and those most likely to affect dispersion of the joint BMP and APC cooling water discharge. The intake and outfall flows are presented in **Table 10.8** and locations[50] in **Figure 10.2**.

Figure 10.2 Key Receptors, Coastline Configuration (Including NPDS, 2030)



[49] Note despite consulting with GDUP and the Ministry of Works, we were unable to determine design plans for the sea crossings; consequently, the assumption was made that these would comprise bridge sections with negligible restriction of water flows.

[50] As in EACS (2016), the proposed reclamation covers the existing OWS#6 outfall and therefore, the outfall has been extended along its present alignment to a point on the new coastline.

Table 10.8 Model Inputs[51]

	Bapco including APC			GPIC	
	Main outfall	OWS#6	Intake	Outfall	Intake
Flow rate m^3/day	821,032	131,020	952,052	1,017,600	1,080,000
Flow rate m^3/second	9.5	1.5	11.0	11.8	12.5
Ambient temp (°C)	25.0	25.0	25.0	25.0	25.0
Discharge excess temp (°C)	11.0	8.5	-	10.0	-

The modelling was undertaken for the following conditions:

- Average ambient and discharge conditions (BMP + APC) with summer flows from GPIC;
- Typical and weak wind conditions.
- Complete spring to neap tidal cycle over 15-days.

The dispersion is assessed in terms of the excess temperatures as compared to the baseline (ΔT°C). All simulations were run for 18 days. This allowed for a spin-up time of 3 days, followed by a complete spring-neap tidal cycle over 15 days. Ambient temperature conditions were derived from HR Wallingford's experience of working in Bahrain, informed by historic data and long-term monitoring. The findings of the modelling works are presented within **Section 10.5** and in support of the operational impact assessment.

10.3.3 Assessment criteria and methodology

Impact significance is quantified as a product of the sensitivity of the parameter (**Table 10.10**) and the perceived magnitude of the impact (**Table 10.11**). The formula provides a better appreciation that as the sensitivity of the environment and the magnitude of the effect increases, so the significance of that effect increases (**Table 10.9**).

Table 10.9 Calculation of Impact Significance

MAGNITUDE	**High**	Moderate	Moderate/Major	Major
	Medium	Minor/Moderate	Moderate	Moderate/Major
	Low	Minor	Minor/Moderate	Moderate
	Negligible	Negligible	Negligible/Minor	Minor/Moderate
		Low	**Medium**	**High**
		VALUE AND SENSITIVITY		

Table 10.10 presents the sensitivity criteria employed by EACS for marine water quality. It takes into account the importance of water quality (biological, chemical, physical) and its influence on both the natural environment and human interface. It is determined based upon three classes[52] of water.

[51] Due to design mitigation (**Tabe 10.31**), dispersion of off-specification effluents has not been modeled.

[52] These conform to those classes identified in PME (2012).

Table 10.10 Sensitivity Criteria for the Parameter of Marine Water

Importance	Description
High	Coastal waters designated as locally, nationally or internationally protected areas by any Concerned Agency (e.g. National - SCE, International (e.g. RAMSAR). Ma'ameer Channel is an example. Furthermore, waters which serve industrial/utilities (e.g. power station intake) fall within this category or host exceptionally sensitive ecological receptors (e.g. coral reefs).
Medium	National marine waters which do not conform to either high or low classified waters. These may be indicative of open sea areas not holding exceptionally sensitive receptors/habitats.
Low	Waters adjacent to areas (either marine or terrestrial) which are classified as industrial through local or national planning regulation. The extent of these waters do not impinge upon higher classification of water bodies. The waters of the Wharf area, could be considered as low importance.

Quantifying the magnitude of an impact is defined via a number of sub-criteria. Typically, these may be informed following specialist studies (e.g. hydrodynamic modelling), expert opinion, review of contractor's methodologies, and reference to published data (e.g. water quality guidelines). Criteria include:

- **Extent:** whether the impact would occur onsite, in a limited (Li) area (within 1 km of the site); local (Lo) area (within, say, 5 km of the site or within the relevant Municipality); nationally (na) or internationally (in).
- **Duration:** whether the impact would be short-term (ST- ≤1 year), medium term (MT- 1 - 5 years), long-term (LT- 5 - 20 years), or permanent (P - ≥20 years).
- **Intensity:** the quantifiable effects of impacts, measured where appropriate against an appropriate environmental standards (national, regional or international) or based on expert judgment.

For each impact assessed, some or all of the above criteria are used as applicable. In order to mitigate subjectiveness, EACS has developed a scoring system to which the magnitude of an impact is determined. This is shown in **Table 10.11**. When this is applied to a specific impact, the sum of the above features is used to determine the category of the magnitude (**Table 10.12**).

Table 10.11 Scale of Impact Magnitude

Feature	Scale of Magnitude			
Extent[53]	Limited	Local	National	International
Score	1	2	3	4
Duration	Short term	Medium term	Long term	Permanent
Score	1	2	3	4
Intensity	Negligible	Low	Medium	High
Score	1	2	3	4

[53] Note: Extent is not used for all impact assessment (e.g. where the impact falls directly on a receptor - seawater intake).

Table 10.12 Determining Impact Magnitude[54]

	Magnitude of impact			
	High	**Medium**	**Low**	**Negligible**
Score (3 features)	12	9	6	≤3
Score (2 features)	8	6	4	≤2

Additional criteria is used to further define features of the impact, although are not used in the quantification process, these include:

- **Likelihood/ Risk:** based on the best available information (primary and secondary data), the likelihood of an impact is assigned a classification based upon the probability of an event occurring (i.e. unlikely (U), likely (L), and definite (D)).
- **Direct** (D): impacts that result from direct interaction between a project activity and the receiving environment (e.g. direct source of pollution into a water body).
- **Indirect** (I): impacts that result from other activities as a consequence of the project (e.g. reduction in water quality affects fish and therefore impairs fisheries activities).

Using a combination of these factors, a consistent set of impact significance levels has been applied (**Table 10.13**).

Table 10.13 Significance of Impact

Impact significance	Impact characteristic
Negligible	Impact is virtually imperceptible over baseline
Minor Adverse	Impacts are of low intensity with short-term duration. The potential for recovery to existing conditions is good with return to baseline conditions over a short period of time.
Moderate Adverse	Activities are likely to result in significant physical/chemical/biological impacts in the medium term.
Major Adverse	Activities will result in significant long term/permanent change to existing physical, chemical or biological conditions of marine waters.

Where an impact significance is assigned, this is based on the perceived impact following successful implementation of the design incorporated mitigation (**Table 10.31**). Should additional mitigation be forwarded as part of this ESIA (i.e. originating from EACS), a residual impact of lesser significance may apply. Residual impact is quantified by quantifying the reduction in the impact magnitude and as per the scale presented in **Table 10.11** and **Table 10.12;** this may arise due to a decrease in impact extent, duration or intensity.

[54] Where a magnitude value falls between two categories, expert opinion is used to finalise the scale.

10.4 Impact Assessment - Construction

Sections 2.3 and 2.4 outline the proposed construction work activities at two locations (i.e. Ma'ameer Channel, Sitra Wharf) and which have the potential to result in adverse impacts upon water quality. The introduction of water borne contaminants (e.g. hydrocarbons), fine sediments and blown litter will have a direct adverse impact upon water quality and which may subsequently result in indirect impacts on ecological resources (e.g. fish, infaunal communities, fringing mangroves (*Avicennia marina*) and neighbouring industrial facilities (e.g. ALBA seawater intake). As the APC plant will utilise the existing Bapco Refinery outfall channel, no construction works are anticipated at this location. **Table 10.14** summarises potential construction related impacts.

Table 10.14 Potential Construction Related Impacts

Ma'ameer Channel	Sitra Wharf Area
– Discharge of groundwater to Ma'ameer Channel (which may exhibit un-quantified levels of hydrocarbons associated with past neighbouring activities) arising from terrestrial excavation works (e.g. trenching, excavation for civil works' foundations). SCE has indicated that discharge to Ma'ameer Channel is prohibited.	– Disturbance of marine sediments during the installation of sealines at the Wharf area, with potential impacts on nearby sensitive receptors (e.g. ALBA seawater intake);
– Spillages of fuels/chemicals – Litter (e.g. paper, plastic, packaging material, etc.) which may be blown from construction works	
– Release of contact water arising from work areas during rain events	– Discharges (routine and emergency) from marine vessels associated with installation of sealines at the wharf
– General construction works with the installation of transfer lines across the new pipe bridge at Ma'ameer	

10.4.1 Discharge of effluents from dewatering activities - Ma'ameer Channel

The SCE has indicated in their response to environmental scoping[55] that under no circumstances will discharges to the Ma'ameer Channel be permitted. Hence, any dewatering works associated with construction works (e.g. foundations), will need to be disposed of appropriately (i.e. to an existing waste water treatment facility or other). This is discussed in more detail within **Section 17.5.1 Waste)**. The client has indicated there will be no discharges to Ma'ameer Channel, **no impact** is assigned.

10.4.2 Marine sediment loading of Ma'ameer Channel - perimeter road construction

Whereas the direct footprint of the APC is fully contained within the exiting land mass, the outer perimeter road, required to access the site boundary, will follow the existing shoreline towards the southern section of the development. Whereas land reclamation

[55] Letter from SCE to Bapco dated 2nd November 2016 and Ref: EL-656-16.

will not take place, the extreme proximity of construction works to the main Ma'ameer water body carries a risk that limited sediment loading takes place.

Table 10.15 Impact Summary Table - Sediment Loading of Ma'ameer Channel

Sensitivity of receptor	Magnitude of impact			Features of impact		Impact significance	
	Extent	Duration	Intensity	Risk	Direct / indirect		
H	1	1	1	Unlikely	Direct	Design mitigation	Minor adverse
	Negligible (3)						
	1	1	0			Residual	Negligible
	Negligible (2)						
Mitigation (to achieve residual impact & best practice)							
– Ensure all workers exhibit care when working on the water's edge – Should works require direct contact with marine waters, consider the deployment of a silt curtain to contain works.							

10.4.3 Spillages of fuels or chemicals and littering - Ma'ameer Channel

Terrestrial construction works will require the operations of generators and other plant (e.g. excavator, loaders, etc.). These will require refueling on a regular basis with fuel possibly stored (estimated volume 5000 litres) strategically across the site, or delivered to plant via a mobile fuel tanker. Although considered unlikely, the compromise of fuel stores could result in the introduction of hydrocarbons (albeit indirectly via groundwater 'base flow') to the Ma'ameer Channel thus degrading water quality.

Table 10.16 Impact Summary Table - Spillages of Fuel, Chemicals and Littering - Ma'ameer Channel

Sensitivity of receptor	Magnitude of impact			Features of impact		Impact significance	
	Extent	Duration	Intensity	Risk	Direct / indirect		
H	2	1	3	Unlikely	Direct	Design mitigation	Moderate adverse
	Low (6)						
	1	1	1			Residual	Minor adverse
	Negligible (3)						
Mitigation (to achieve residual impact & best practice)							
– Store fuel away from water's edge. Consider extending GIIP guidance from 20 m to 50m. – Ensure fuel stored within a bund of 125% capacity and on impervious ground. – Re-fuelling to be carried out on drip trays. – Consider use of enviro-safe generators incorporating double skinned fuel tanks. – Ensure hazardous wastes are correctly managed and stored as per MSDS (See **Section 7 Chemicals** and **Section 17 Waste** for further information). – Ensure sufficient and appropriate waste collection facilities (e.g. closable skips) are stationed onsite.						

10.4.4 Release of contact water following storm event - Ma'ameer Channel

As construction works progress, increasing areas of exiting land will be concreted and tarmac access roads built. The current capacity of existing soil conditions to absorb rain water will be significantly reduced, hence, surface water runoff, during storm events may

result in localised flooding. Furthermore, this water may contain contaminants originating from fuel stores, spills etc. The frequency of events is considered low and restricted to winter periods (i.e. November - February) with the level of contaminants low, if any. The SCE has indicated that no discharge to Ma'ameer Channel is permitted, hence, appropriate mitigation will be incorporated within design.

Table 10.17 Impact Summary Table - Release Of Contact Water Following Storm Event - Ma'ameer Channel

<table>
<tr><td rowspan="2">Sensitivity of receptor</td><td colspan="3">Magnitude of impact</td><td colspan="2">Features of impact</td><td colspan="2" rowspan="2">Impact significance</td></tr>
<tr><td>Extent</td><td>Duration</td><td>Intensity</td><td>Risk</td><td>Direct / indirect</td></tr>
<tr><td rowspan="4">H</td><td>1</td><td>1</td><td>1</td><td rowspan="4">Unlikely</td><td rowspan="4">Direct</td><td>Design mitigation</td><td>Minor adverse</td></tr>
<tr><td colspan="3">Negligible (3)</td><td rowspan="3">Residual</td><td rowspan="3">Negligible</td></tr>
<tr><td>1</td><td>1</td><td>0</td></tr>
<tr><td colspan="3">Negligible (2)</td></tr>
<tr><td colspan="8">Mitigation (to achieve residual impact & best practice)</td></tr>
<tr><td colspan="8">– Ensure effective waste management procedures are in place (i.e. correct storage of chemicals/fuels).
– Ensure storage and use of fuels is according to best practice.
– Install a water collection system with oil interceptors at key locations (e.g. work yards).
– Any drainage points should be located away from Ma'ameer Channel.</td></tr>
</table>

10.4.5 Installation of transfer lines across Ma'ameer pipe bridge

The existing pipe bridge which crosses Ma'ameer Channel will be rebuilt as part of the BMP project and all lines originating from the APC works will be facilitated within the capacity of the bridge. As such no disturbance to the Ma'ameer Channel will be experienced. Adherence to general environmental guidelines, and as identified in the project CESMP is applicable. A **no impact** significance is assigned to these works.

10.4.6 Sediment loading due to installation of sealines at Sitra Wharf

Method statements addressing installation of subsea pipelines have not been developed; these are likely post FEED stage. However, at this time, it is assumed that installation will not require marine trenching. It is likely that pipes will be installed on pre-cast concrete mattresses which will have been pre-positioned prior to pipe installation. As such, sediment plume dispersion modelling has not been carried out.

Pipes may be covered with a protective shroud to minimise the risk of damage due to unlikely impact from vessels. . The potential for sediment resuspension is low and certainly localised to within 50 m of any works; given the industrial nature of the area a low receptor sensitivity is assigned; subsequently, a **minor adverse** impact is estimated.

Table 10.18 Impact Summary Table - Sediment Loading due to Installation of Sealines at Sitra Wharf

Sensitivity of receptor	Magnitude of impact			Features of impact		Impact significance	
	Extent	Duration	Intensity	Risk	Direct / indirect		
L	1	1	2	Unlikely	Direct	Design mitigation	Minor
	Low (4)						
	1	1	1			Residual	Negligible
	Negligible (3)						
Mitigation (to achieve residual impact & best practice)							
– If trenching works are required consult with the SCE to determine requirement for specialist studies (e.g. sediment dispersion modelling) . Based on modelling results carry out a environmental risk assessment (ERA) to determine threats to sensitive receptors (e.g. ALBA intake - **Section 10.4.7**). – Consider deployment of silt curtains around the ALBA intake. – Conduct TSS monitoring of waters as per CESMP.							

10.4.7 Elevated suspended solids at the ALBA seawater intake

Installation of sealines at the Sitra Wharf are unlikely to result in significant degradation of water quality if the construction methods defined in **Section 10.4.6** are employed (i.e. no dredging/excavation). The risk to the ALBA sea intake (located approximately 600 m away) is considered low despite a TSS threshold for operations defined at 6 mg/l[56] and given the relatively small amounts of seabed disturbance which could lead to suspension of sediments. It is not possible to quantitatively assess predicted suspension of solids arising from the proposed methodology, however, should dredging/excavation be required, it is possible that quantitative dispersion modelling be required to determine predicted TSS levels at the ALBA intake. This requirement would be made following further consultation with the SCE and ALBA at that time.

Best practice would, due to the sensitivity of the ALBA intake, include the installation of silt curtains around the ALBA intake, and to conduct regular monitoring with corrective measures (e.g. modify dredging method, cessation of works) in place should TSS levels rise significantly.

Table 10.19 Impact Summary Table - Elevated Suspended Solids at the ALBA Intake

Sensitivity of receptor	Magnitude of impact			Features of impact		Impact significance	
	Extent	Duration	Intensity	Risk	Direct / indirect		
H	1	1	1	Unlikely	Direct	Design mitigation	Minor adverse
	Negligible (3)						
	1	1	0			Residual	Negligible
	Negligible (2)						

[56] EACS (2015) Dredging Environmental Management Plan, East Sitra Housing Project Bahrain, Dredging, Reclamation and Shoreline Protection Works - Borrow Areas D and R.

Mitigation (to achieve residual impact & best practice)
– Adhere to the project TSS monitoring protocol (CESMP). The client should consider implementing this at the start of works to confirm the limited extent of sediment loading. – Should ground intrusive methods be utilised to install subsea pipelines, dispersion modelling may be required to assess risks to the ALBA intake; TSS levels not to exceed 6 mg/l @ 7m below water surface at the intake. – As a precaution, silt curtains should be installed around the ALBA intake to minimise egress of suspended solids.

10.4.8 Limited release of hydrocarbons from construction vessels at Sitra Wharf

The potential for hydrocarbons (fuels, oils) to be released during construction activities (e.g. installation of sealines and jetty loading arms) exists although the volumes of which are likely to be negligible (e.g. small spillage / run off from vessel decks). In the event of a major incident (e.g. vessel collision or sinking) significantly larger volumes are expected to be released. Such a scenario is considered most unlikely and has not been assessed further within this document. Should assessment be required, spill dispersion modelling may be required in order to determine the extent of resulting oil slicks.

Spills of hydrocarbons, and degradation of water quality poses a risk to both ecological receptors (e.g. fish, marine mammals) and nearby infrastructure (e.g. ALBA intakes).

Diesel fuel is a light, refined petroleum product with a relatively narrow boiling range, meaning that, when spilled on water, most of the oil will evaporate or naturally disperse rapidly. It has a very low viscosity and is readily dispersed into the water column/evaporated following agitation due to wave and wind action.

Operation of marine vessels associated with pipeline installation will be required to adhere to national and Bapco marine vessel regulations. Depending on vessel size (i.e. those >400 GT), adherence to MARPOL 73/78 convention and Ship Oil Pollution Emergency Plan (SOPEP) will be required, the later which addresses readiness in the event of an oil spill. Such management is considered appropriate mitigation in the event of large spills however additional measures can be implemented to address smaller, less significant events.

Table 10.20 Impact Summary Table - Limited Release of Hydrocarbons from Construction Vessels at Sitra Wharf

<table>
<tr><th rowspan="2">Sensitivity of receptor</th><th colspan="3">Magnitude of impact</th><th colspan="2">Features of impact</th><th colspan="2" rowspan="2">Impact significance</th></tr>
<tr><th>Extent</th><th>Duration</th><th>Intensity</th><th>Risk</th><th>Direct / indirect</th></tr>
<tr><td rowspan="4">L</td><td>1</td><td>1</td><td>1</td><td rowspan="4">Unlikely</td><td rowspan="4">Direct</td><td rowspan="2">Design mitigation</td><td rowspan="2">Negligible</td></tr>
<tr><td colspan="3">Negligible (3)</td></tr>
<tr><td>1</td><td>1</td><td>1</td><td rowspan="2">Residual</td><td rowspan="2">Negligible</td></tr>
<tr><td colspan="3">Negligible (3)</td></tr>
<tr><td colspan="8">Mitigation (design)</td></tr>
<tr><td colspan="8">– Adhere to MARPOL 73/78 and SOPEP as applicable
– Refuelling of vessels to take place at correct facilities.
– Fuel/oil stored on deck to be lashed to prevent spills.
– Fuel less than 200 l to be stored in drip trays.</td></tr>
</table>

- Clean spills immediately with absorbent material.
- Oily rags etc. to be disposed of appropriately (do not dispose in the sea).

10.5 Impact assessment - operation

Operation of the APC plant, and its support facilities will typically include the following liquid waste streams which will undergo necessary treatment (see project description for further information **Section 2.6.5)** and be discharged to sea via the existing Bapco Refinery outfall:

- Desalination (i.e. brine);
- domestic sewage;
- process and cooling water;
- storm water; and
- other specific discharges (e.g. hydrotesting, washing and cleaning mainly during facility start up and turnaround).

Process water within aromatics plants is generally operated in closed loops. The main wastewater sources are process water recovered from condensates of the steam jet vacuum pumps and overhead accumulators of some distillation towers. These streams contain small quantities of dissolved hydrocarbons.

Wastewater containing sulfide and COD may also be generated from caustic scrubbers. Other potential sources are unintentional spillages, purge of cooling water, rainwater, equipment wash-water, which may contain extraction solvents and aromatics and water generated by tank drainage and process upsets.

During operation waste effluents will be diverted, as necessary, to dedicated waste water treatment facilities via a network of water drainage and collection facilities; strategic sampling and testing points will be incorporated within liquid waste stream flows to ensure they are diverted to the correct treatment/process infrastructure. **Table 10.31** summarises sources of liquid effluents and the processes and facilities incorporated within the APC design to ensure compliance to PAL. **Figure 2.6** presents a flow diagram of all effluent waste streams.

Under normal operation of the APC plant, the quality of effluents discharged to the marine environment will equal, or better, the BSIE. APC effluents will mix with those from the BMP within the Bapco Refinery outfall flume prior to discharge to sea. The combined effluents can be considered to also equal or better the BSIE.

Given the mitigation included within design of the proposed APC (**Table 10.31**), only normal operational discharges are assessed within the following sections; emergency scenarios are not anticipated to result in any discharge to sea. Furthermore, the rupture of sealines during operation is not addressed.

10.5.1 Degradation of Ma'ameer waters due to release of surface water run off

All surface water runoff including that arising from washing down, fire water and storm runoff will be directed via the APC drainage system (i.e. clean water and clean storm water sewers, oily water sewer, contaminated storm water sewer) to the Treated Water Observation Pond (TWOP) and then to Bapco Refinery outfall for subsequent discharge

to sea. Where treatment is required (e.g. waters arising from oily water effluents, contaminated storm water), effluents will be directed to the necessary treatment plants and then to the TWOP prior to discharge to sea. Process Oily Water will be accumulated in a basin inside the APC and then sent to Bapco Refinery WWTP for treatment.

Table 10.21 Impact Summary Table - Release Of Runoff To Ma'meer Channel

<table>
<tr><td rowspan="2">Sensitivity of receptor</td><td colspan="3">Magnitude of impact</td><td colspan="2">Features of impact</td><td colspan="2" rowspan="2">Impact significance</td></tr>
<tr><td>Extent</td><td>Duration</td><td>Intensity</td><td>Risk</td><td>Direct / indirect</td></tr>
<tr><td rowspan="4">H</td><td>1</td><td>1</td><td>0</td><td rowspan="4">Unlikely</td><td rowspan="4">Direct</td><td>Design mitigation</td><td>Negligible</td></tr>
<tr><td colspan="3">Negligible (2)</td><td rowspan="3">Residual</td><td rowspan="3">Negligible</td></tr>
<tr><td>1</td><td>1</td><td>0</td></tr>
<tr><td colspan="3">Negligible (2)</td></tr>
<tr><td colspan="8">Mitigation (to achieve residual impact & best practice)</td></tr>
<tr><td colspan="8">– No additional mitigation required.</td></tr>
</table>

10.5.2 Impacts on marine water quality due to APC discharge

10.5.2.1 Thermal plume footprints

Table 10.22 and **Table 10.23** show the areas and distances of thermal plumes arising from the Bapco Refinery (including the BMP) outfall at the sea surface and seabed, where the average and maximum excess temperatures are predicted to be above 3°C. The areas and distances from the outfall are slightly increased by the APC flows as compared to that assessed in EACS (2016) and conducted for the BMP ESIA. In each case, the predicted mixing zone size is greater than 100 m and thus exceeds default national and WBG standards[57].

The largest changes from that identified in EACS (2016) are seen at the sea surface, in the maximum extents during neap tides, where affected areas are increased by up to 0.16 km^2 and distances from the outfall by up to 300 m. Significantly smaller changes are predicted at the sea bed.

Table 10.22 Areas and Distances From Outfall Where Excess Temperature Is Predicted To Exceed 3°C, Average Discharge Including APC, 2030 Layout, Weak Wind

		area (km^2)		distance from outfall (m)			
		mean	**max**	**mean**	**direction**	**max**	**direction**
sea surface	spring	0.38	0.87	1000	east	1600	south
	neap	0.41	1.06	1100	east	1800	south
sea bed	spring	0.20	0.24	700	east	700	east
	neap	0.22	0.27	700	east	700	east

[57] Note this scenario has been inherited from both existing (i.e. Bapco) and proposed (i.e. BMP) discharge scenarios and is not as a result of the addition of APC effluent.

Table 10.23 Areas And Distances From Outfall Where Excess Temperature Is Predicted To Exceed 3°C, Average Discharge Including APC, 2030 Layout, Typical Wind

		area (km^2)		distance from outfall (m)			
		mean	max	mean	direction	max	direction
sea surface	spring	0.30	0.78	700	east	1800	south
	neap	0.41	1.04	1100	east	1700	south
sea bed	spring	0.18	0.26	500	east	700	east
	neap	0.22	0.26	700	east	700	east

Figure 10.3 and **Figure 10.4** present the thermal dispersion plots for a discharge at the sea surface and for a weak and typical wind respectively. Both plots represent neap and spring tide conditions.

Figure 10.3 Dispersion Patterns BMP & APC, Average Discharge, Weak Wind at the Sea Surface (Mean Values)

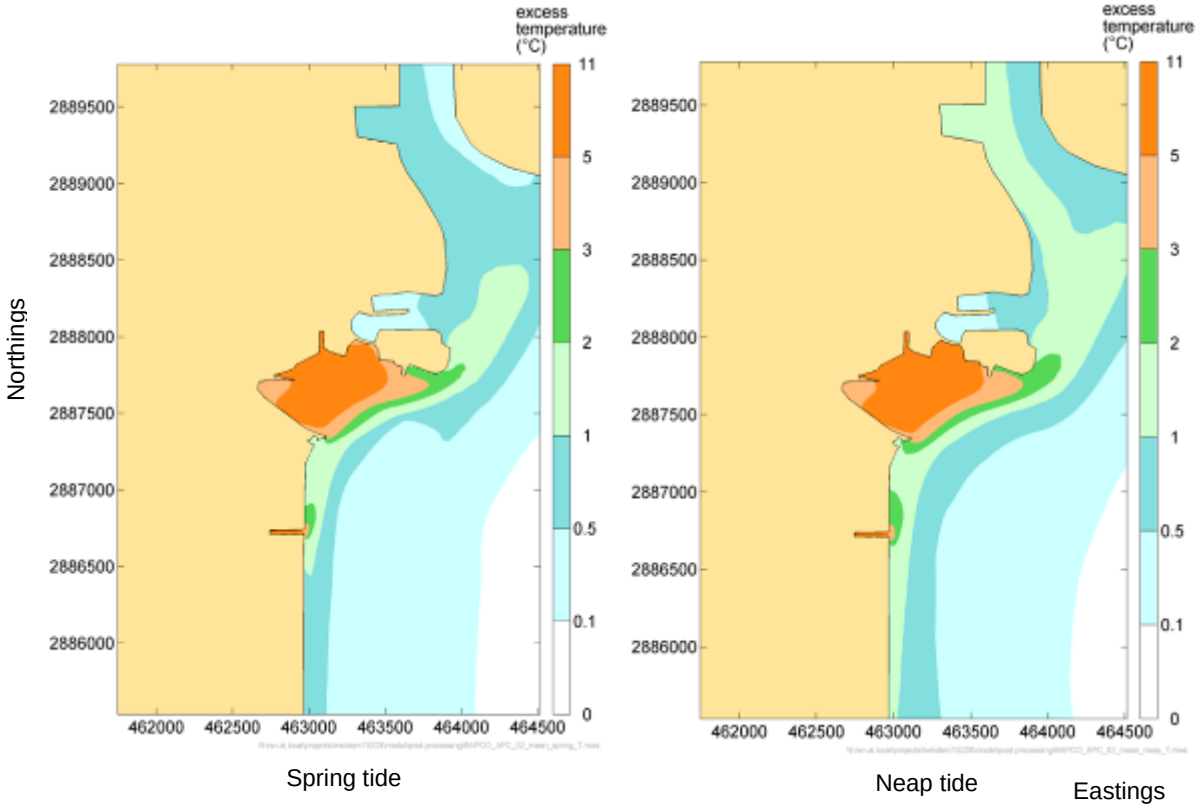
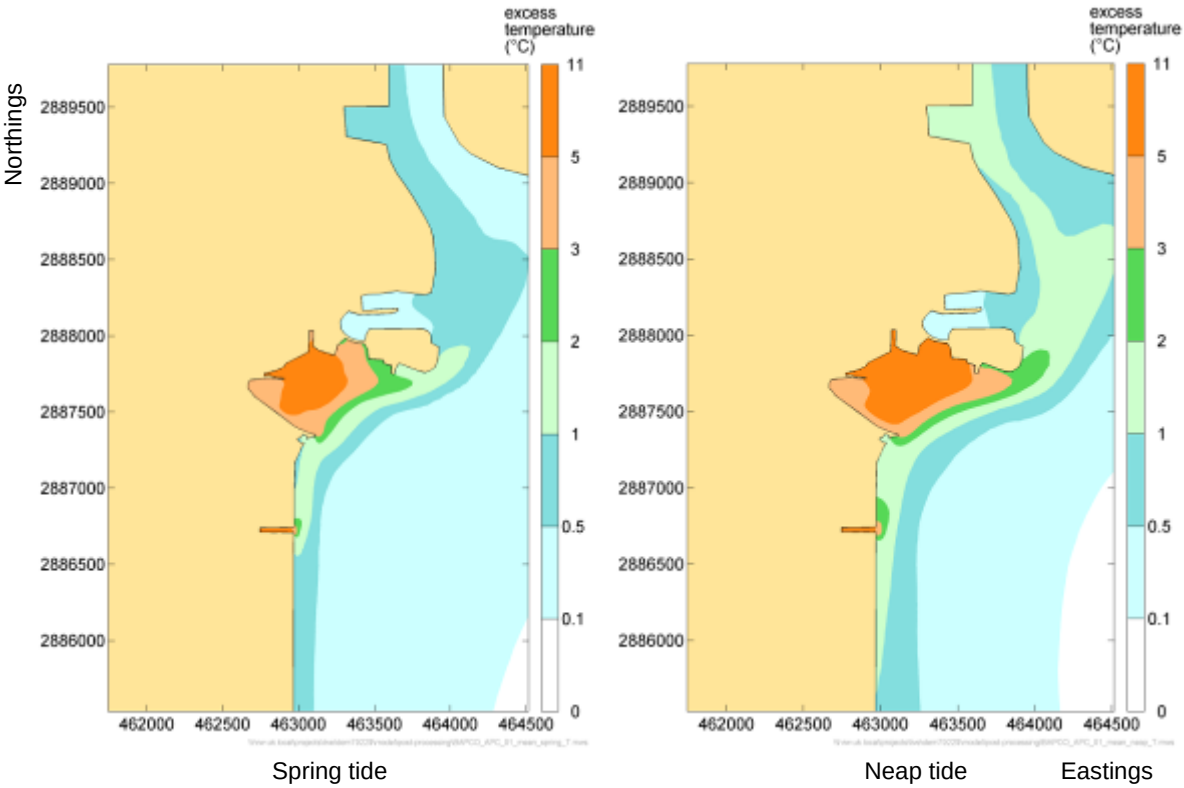


Figure 10.4 Dispersion Patterns BMP & APC, Summer Discharge, Typical Wind At Sea Surface (Mean Values)



10.5.2.2 Recirculation of thermal plumes at the Bapco Refinery/ BMP intake

The potential of recirculation of thermal effluents to the Bapco Refinery/ BMP intake was also examined; **Figure 10.5** and **Figure 10.6** show the predicted excess temperatures at the intake and for surface, mid, bed and depth averaged; the results are very similar to those of EACS (2016) with the APC contributing a marginal increase of up to 0.2°C.

Excess temperature at the Bapco Refinery/ BMP intake is dominated by short period peaks of up to around 5°C. There are generally two peaks per day and they correspond to the south-going (flood) phase of the semi-diurnal tide. Between these peaks the excess temperatures are generally less than 1°C.

Figure 10.5 Intake Excess Temperature, Average Discharge, Weak Wind

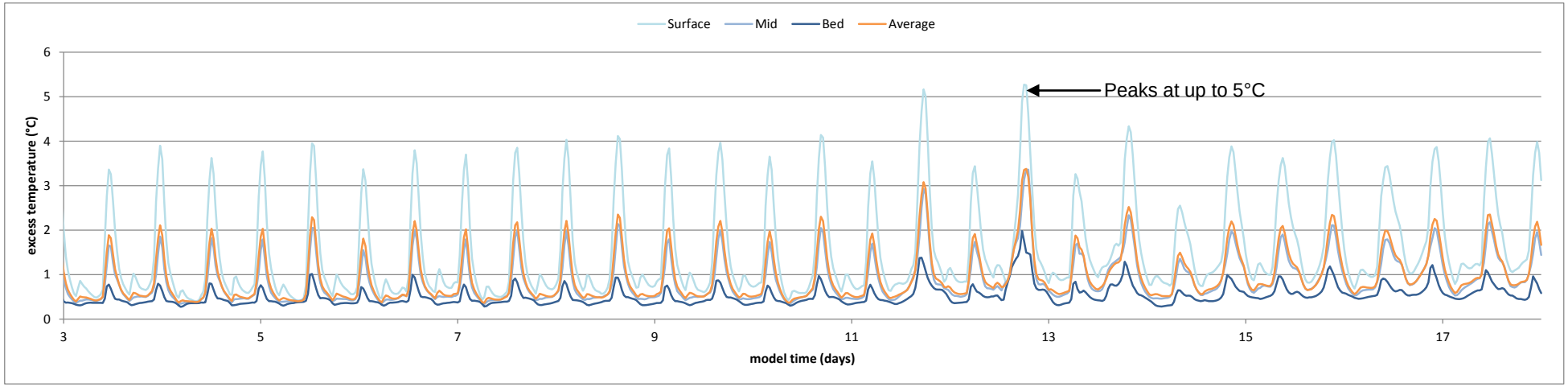
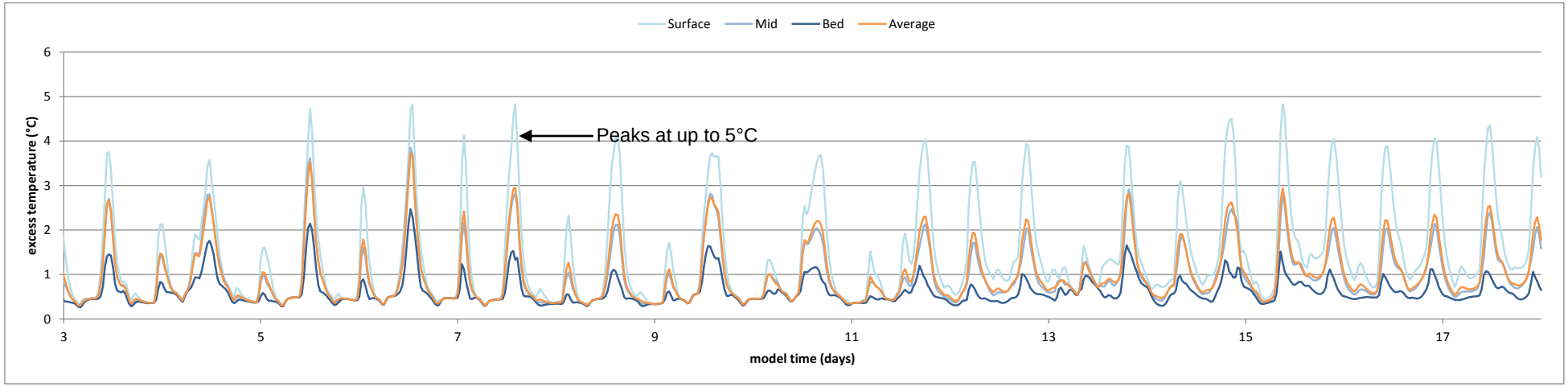


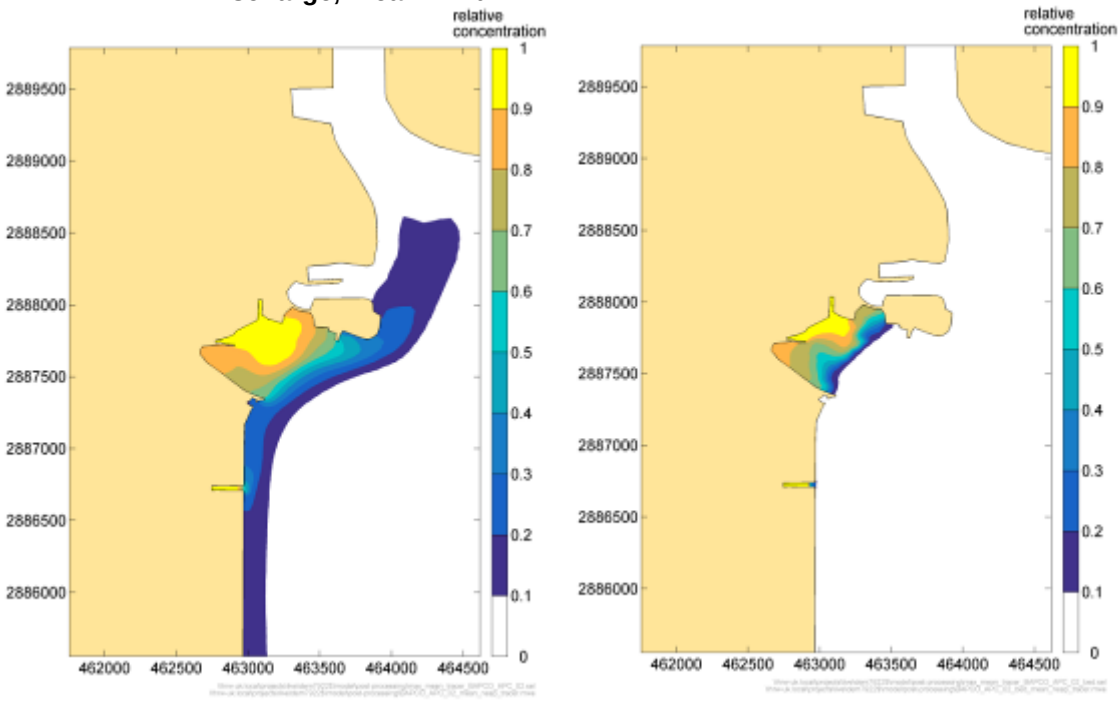
Figure 10.6 Intake Excess Temperature, Average Discharge, Typical Wind



10.5.2.3 Dispersion of diluted contaminants via use of a conservative tracer

To assess impacts on non thermal pollutants (i.e. dissolved chemical contaminants), the simulations of a conservative (non-decaying) tracer discharged at known unit concentrations from the Bapco Refinery including the BMP outfall was conducted. **Figure 10.7** presents the average footprints and assumes the background contaminant constituent is zero. Plots indicate a % value of tracer. Key sensitive sites were identified (e.g. EWA, existing and proposed facilities) and assessed. The location of these sites is shown in **Figure 10.9**.

Figure 10.7 Average Footprints of Tracer Relative Concentration for Average Discharge, Weak Wind



Neap tide surface values

Neap tide seabed values

For all model scenarios, the maximum extent of a 0.5 (i.e. 50 %) conservative tracer is 1.4 km from the BMP outfall, and with a mean extent in the order of 0.5 - 0.9 km.

Concentrations predicted further afield are estimated at less than 5% and typically in the order of 1%. Given the high dilution ratio and the distances of sensitive receptors (i.e. current and proposed EWA intakes) from the Bapco Refinery /BMP outfall, it is not anticipated that significant changes in water quality will occur at these sites.

Table 10.24 and **Table 10.25** present the conservative tracer dilution for the BMP with APC effluents at identified sensitive receptors, and for a weak and typical wind respectively. For all sites, tracer dilution is estimated at <5% discharge concentration.

Table 10.24 Relative Conservative Tracer Concentration at Sensitive Receivers, Average BMP Discharge Including APC, 2030 Layout, Weak Wind

	GPIC intake		RAJ-2 intake		Al Dur intake		Al Dur Ph3-4 intake	
	mean	max	mean	max	mean	max	mean	max
surface	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05
mid-depth	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05
bed	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05
depth-average	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05

Table 10.25 Relative Tracer Concentration at Sensitive Receptors, Average BMP Discharge Including APC, 2030 Layout, Typical Wind

	GPIC intake		RAJ-2 intake		Al Dur intake		Al Dur Ph3-4 intake	
	mean	max	mean	max	mean	max	mean	max
surface	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05
mid-depth	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05
bed	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05
depth-average	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05

Table 10.26 presents the predicted concentration of example contaminants at sensitive receptors with a starting concentration equivalent to those associated from the combined BMP/APC effluents (as defined in **Table 10.4**[58]). The diluted factor (using a tracer value of 0.01) is then compared against international WQO and as outlined in **Table 10.3 and Table 10.26**.

At a 1 % value, and for those parameters where standards exist, most are fully met; the USEPA CCC value is slightly breached for copper, however it should be remembered that the approach used is conservative and in reality, values are likely to be significantly lower.

Table 10.26 Effluent Values, Diluted Values and WQO

Contaminant	Max effluent (mg/l)	Value (mg/l) at 1% (dilution of 0.01)	Australia DERM (mg/l)	USEPA (mg/l)		CCME (µg/l)	UK
				CMC	CCC		
Nitrogen - total	10	0.1	-	-	-	-	-
Phosphorous -total	2	0.02	0.025	-	-	-	-
BOD	30	0.3	-	-	-	-	-
COD	125	1.25	-	-	-	-	-
Arsenic	0.1	0.001	-	-	-	-	-

[58] The starting values are the more stringent between WBG (2016) and the BSIE.

Contaminant	Max effluent (mg/l)	Value (mg/l) at 1% (dilution of 0.01)	Australia DERM (mg/l)	USEPA (mg/l)		CCME (µg/l)	UK
Chromium -total	0.5	0.005	-	-	-	-	-
Copper	0.5	0.005	-	0.0048	0.0031	-	0.005
Lead	0.1	0.001	-	0.21	0.081	-	-
Mercury	0.003	0.00003	-	0.0018	0.00094	0.000016	-

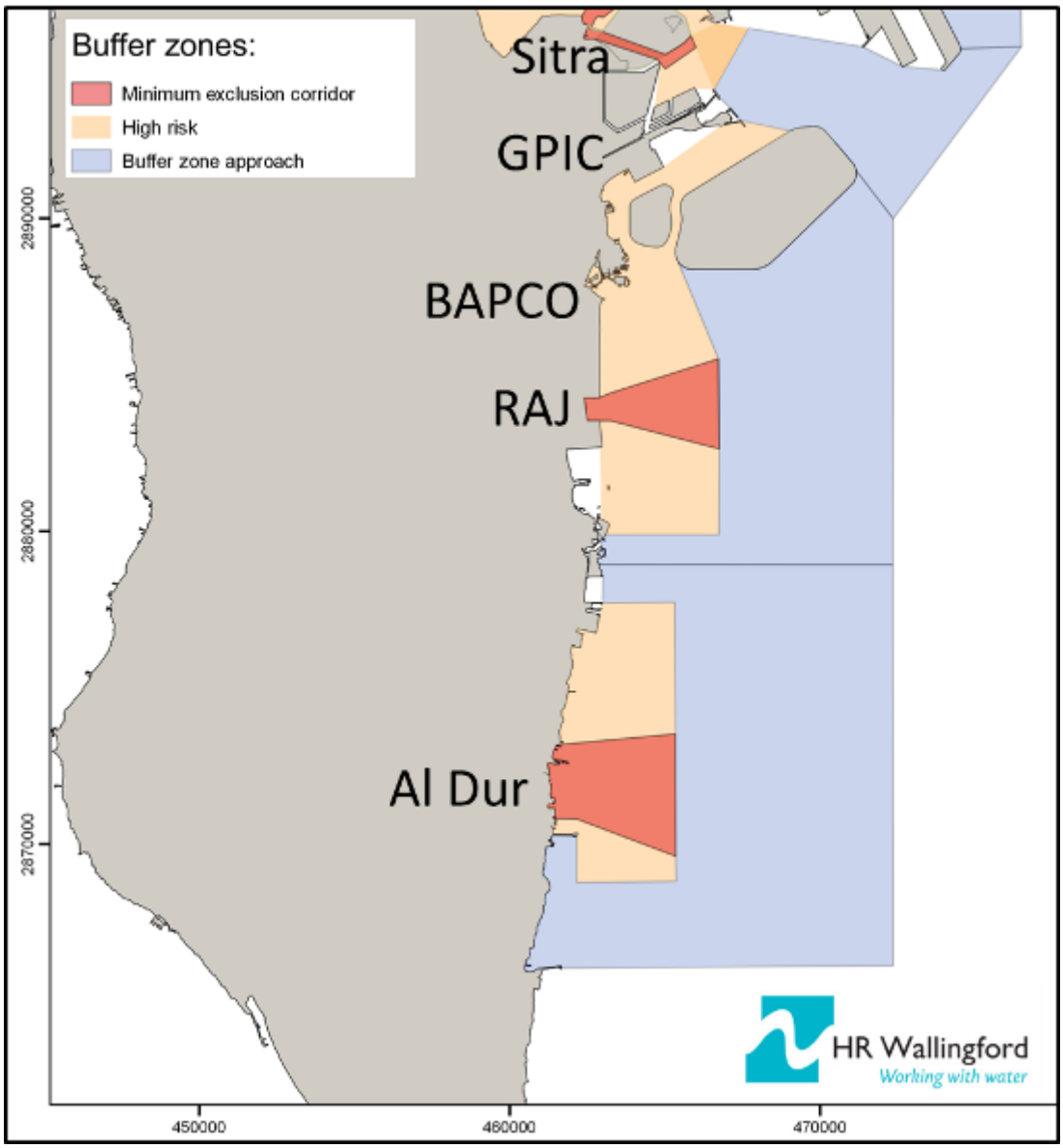
10.5.2.4 Thermal interaction with EWA and GPIC intakes and cumulative assessment

HR Wallingford is currently engaged by the EWA in a wide-ranging study to protect water quality at its power and water plants. Key objectives of the study are to identify water bodies and sections of coastline that are high risk in terms of the potential for impact on EWA's plants, and to establish buffer zones to protect against adverse effects from future developments. As part of the ongoing study for EWA, two key buffer zone types are currently being established:

1. High risk zones, within which any proposed development will require detailed study to assess any effects on the plants;
2. Minimum exclusion corridors, which are essential to maintain successful operation of EWA's intakes and outfalls, and which will be protected from all but essential (e.g. emergency or remedial) developments and activities.

The buffer zones (**Figure 10.8**) are currently being finalised and awaiting approval by the relevant stakeholders.

Figure 10.8 Preliminary Buffer Zones

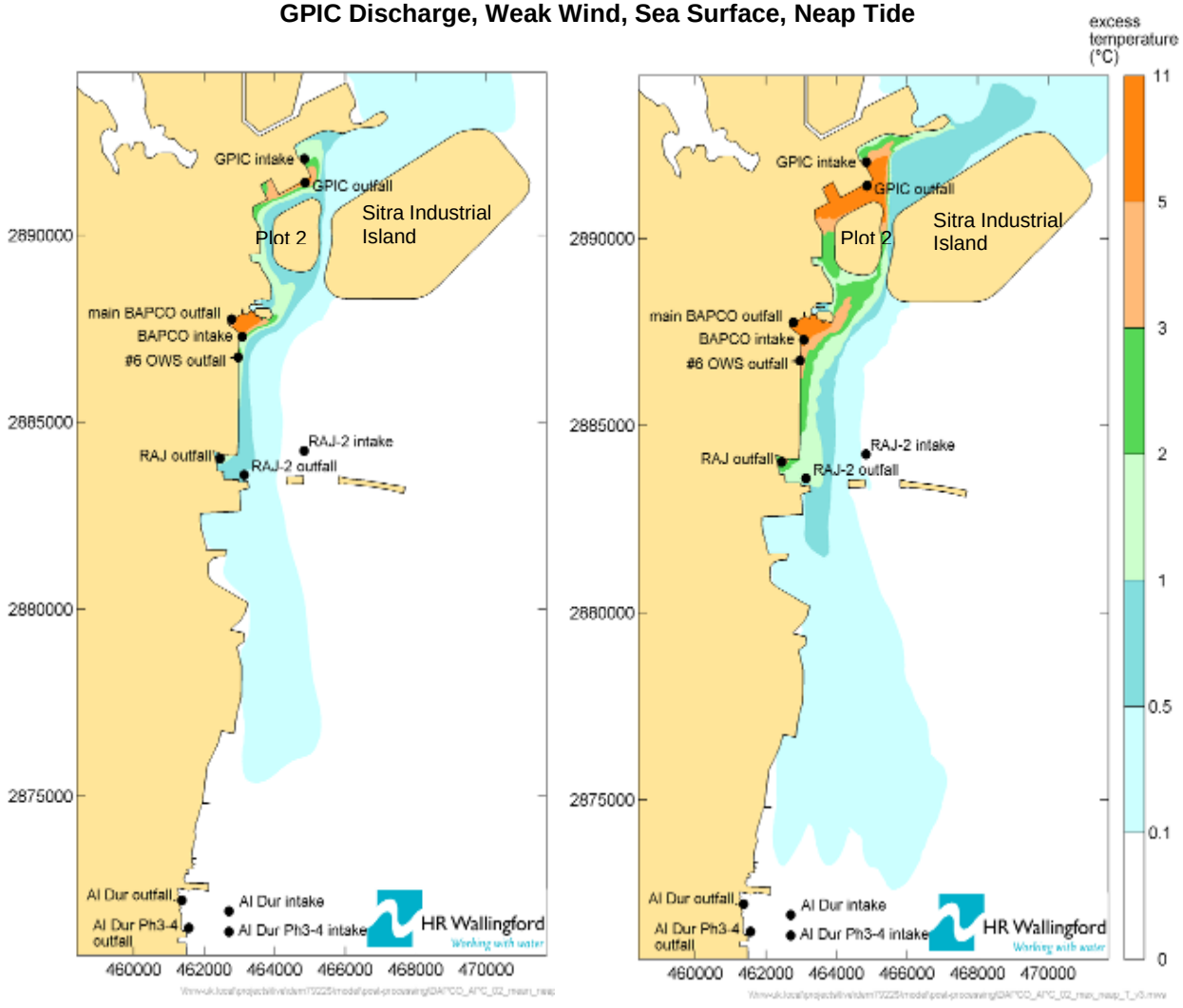


The Bapco Refinery outfall lies within the preliminary high risk zone for the Ras Abu Jarjur (RAJ) desalination plant which is located approximately 3 km south. RAJ currently has no seawater intakes, as water is drawn from an aquifer, but it does requires a supply of cool seawater to and from the location of its outfall, to preserve its mixing zone and to adhere to applicable national standards. Interaction with thermal discharges from the combined GPIC, BMP & APC could compromise this via a cumulative impact.

Figure 10.9 and **Figure 10.10** show the predicted maximum and average sea surface excess temperature footprints for the conditions that were predicted to give the largest and smallest footprints (combined GPIC and BMP & APC). The locations of all nearby existing and proposed intakes and outfalls are marked in the figures. An approved 2030 development layout plan was used for completeness.

The RAJ-2 plant and the Al Dur Phase 3-4[59] expansion are proposed developments and the locations of their intakes and outfalls may be subject to change.

Figure 10.9 Excess Temperature Footprint for Average BMP/APC and Summer GPIC Discharge, Weak Wind, Sea Surface, Neap Tide



Mean extent Maximum extent

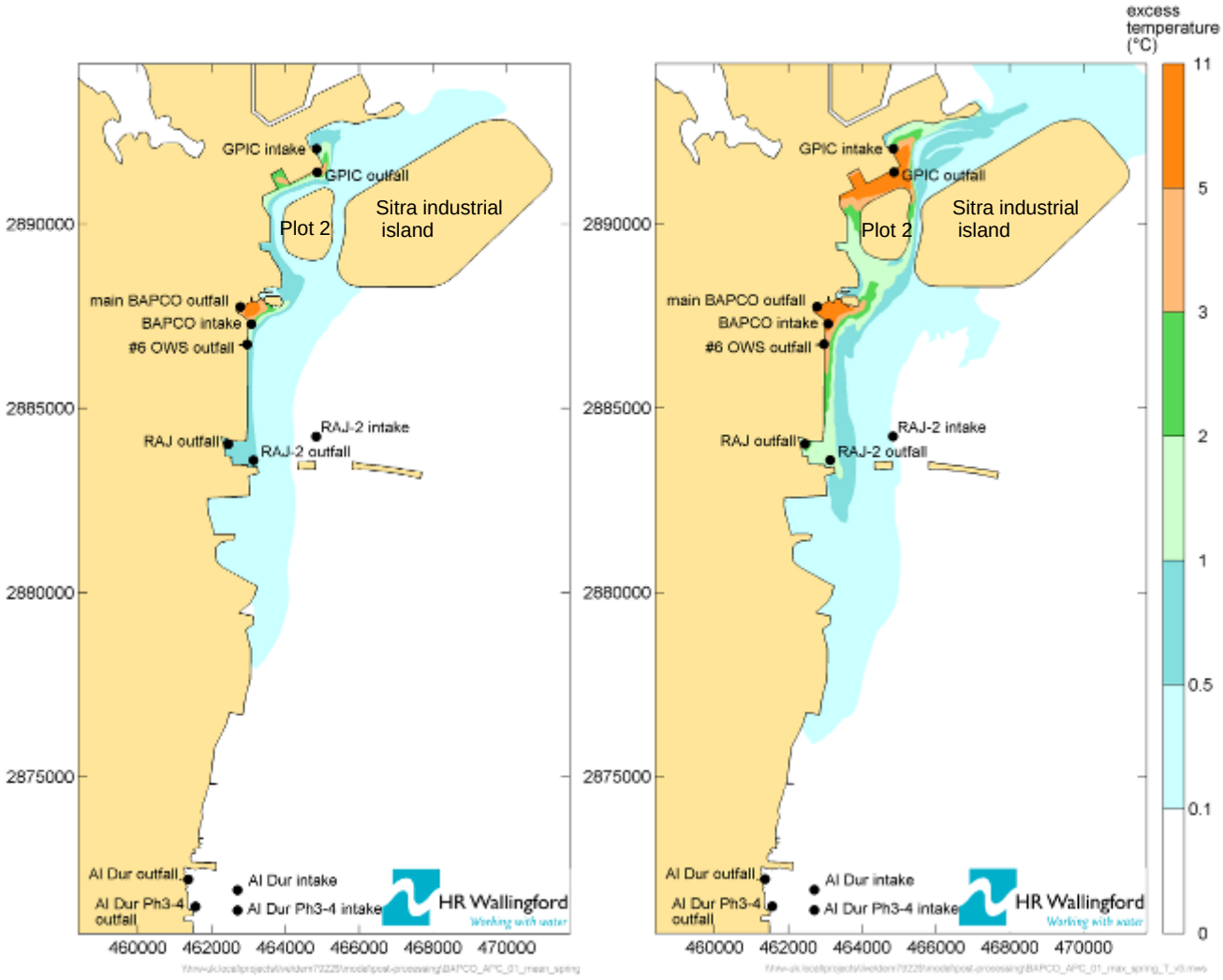
The GPIC and Bapco (i.e. BMP and APC) discharges are transported around both sides of the western Sitra Industrial Island, and will merge around it, with combined, cumulative, excess temperatures up to 2°C. The combined effect is predicted to increase the size of the region where excess temperatures are up to 2°C. However, the regions where temperatures exceed +3°C are similar to those predicted in EACS (2016).

The BMP and APC discharge plume passes close to the RAJ discharge at times, and the plumes merge with combined excess temperatures up to +2°C. This interaction is not predicted to cause any significant changes to the +3°C mixing zone at RAJ. There are currently no seawater intakes at the site to be affected, however, any future outfalls and intakes at RAJ (e.g. RAJ (2)) must be designed accounting for the presence of the

[59] These proposed expansions of existing facilities will require additional seawater intakes and at the proposed locations shown.

BMP & APC combined plume to ensure operational efficiency and regulatory compliance.

Figure 10.10 Excess Temperature Footprint For Average BMP/APC and Summer GPIC Discharge, Typical Wind, Sea Surface, Spring Tide



Mean extent

Maximum extent

Predicted excess temperatures at all nearby current and proposed EWA, and GPIC, plant intakes are shown in **Table 10.27** and **Table 10.28**.

Table 10.27 Excess Temperatures (°C) At Sensitive Receptors, Average Bmp Discharge Including APC, 2030 Layout, Weak Wind

	GPIC intake		RAJ-2 intake		Al Dur intake		Al Dur Ph3-4 intake	
	mean	max	mean	max	mean	max	mean	max
surface	1.3	3.9	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
mid-depth	0.7	1.7	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
bed	0.5	1.5	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
depth-average	0.8	2.0	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1

Table 10.28 Excess Temperatures (°C) At Sensitive Receptors, Average Bmp Discharge Including APC, 2030 Layout, Typical Wind

	GPIC intake		RAJ-2 intake		Al Dur intake		Al Dur Ph3-4 intake	
	mean	max	mean	max	mean	max	mean	max
surface	1.0	3.0	<0.1	0.2	<0.1	<0.1	<0.1	<0.1
mid-depth	0.6	1.4	<0.1	0.2	<0.1	<0.1	<0.1	<0.1
bed	0.4	1.0	<0.1	0.2	<0.1	<0.1	<0.1	<0.1
depth-average	0.7	1.5	<0.1	0.2	<0.1	<0.1	<0.1	<0.1

The predicted excess temperatures at the EWA plant intakes are considered negligible. . Relatively high excess temperatures at the GPIC intake are predicted due to recirculation of its own effluent and likely due to the influence of new land masses (plot 2 and Sitra Industrial Island) to the south and east of the GPIC outfall. Predicted increases in temperatures at the GPIC intake are not attributable to the Bapco Refinery BMP & APC effluents.

10.5.2.5 Impacts Summary

Extension of Bapco Refinery / BMP thermal plume due to APC inclusion

With reference to adherence to WBG (2016) and the BSIE effluent temperature standards (i.e. adherence to a temperature increase of 3°C 100 , from the outfall), it was determined by the SCE, following review of EACS (2016), that an extended mixing zone be determined in order to accommodate effluents arising from the BMP as these exceeded the existing 100 m mixing zone by over 1.5 km. As such, and based on Article 22 of Ministerial Order (2) of 2001 (**Table 10.2**), the extent of the mixing zone was identified following specialist hydrodynamic modelling and subsequently approved by the SCE.

The imposition of the APC to BMP effluents will increase the extent of thermal plumes, primarily at the surface, up to 300 m[60] during neap tides and weak winds. No discernible increases are expected for deeper waters (i.e. at seabed).

[60] This represents the worse case scenario and only for limited periods.

Table 10.29 summarises the impact of the APC effluents on the physical thermal extent of BMP effluents.

Table 10.29 Impact Summary Table - Contribution of APC Effluents to the Existing BMP Mixing Zone

Sensitivity of receptor	Magnitude of impact			Features of impact		Impact significance
	Extent	Duration	Intensity	Risk	Direct / indirect	
M	1	3	2	Likely	Direct	Minor adverse
	Low (6)					
Mitigation						
– Consult and liaise with the SCE to extend the combined outfall mixing zone.						

Impact on general water quality (temp and contaminants) and identified receptors

Table 10.30 provides a summary of identified potential impacts arising from the addition of the APC effluent to the Bapco Refinery/BMP effluent stream. Where impacts upon intakes are addressed, these are classed as indirect (i.e. due to a direct change in water quality); the 'extent' criterion of magnitude (**Section 10.3.3**) is not included within the assessment (as the impact is assessed at a single geographical point as opposed to a wider geographic area).

Table 10.30 Impact Summary Table - BMP & APC Intake Facilities

	Sensitivity of receptor	Magnitude of impact			Features of impact		Impact significance
		Extent	Duration	Intensity	Risk	Direct / indirect	
Recirculation at BMP intake	H	na	1	2	Likely	Indirect	Minor adverse
		Negligible-low (3)					
Elevated temp at RAJ (2)	H	na	0	1	Likely	Indirect	Negligible
		Negligible (1)					
Elevated temp at Al Dur	H	na	0	1	Likely	Indirect	Negligible
		Negligible (1)					
Elevated temp at GPIC	H	na	0	1	Likely	Indirect	Negligible
		Negligible (1)					
Contaminants at RAJ (2)	H	na	0	1	Likely	Indirect	Negligible
		Negligible (1)					
Contaminants at Al Dur	H	na	0	1	Likely	Indirect	Negligible
		Negligible (1)					
Mitigation							
– If experienced intake temperatures (at Bapco refinery BMP) are found to be excessive, an engineering solution may be required and as determined by specialist dispersion studies. – Operator of the APC will be required to monitor APC effluents prior to mixing with those of BMP within the Bapco refinery outfall flume. – It is suggested that both Bapco and the operator of the APC agree of a joint responsibility for the monitoring of marine waters at sensitive sites (refer to OESMP). – Dispersion modelling may be required to further assess the mixing zones of RAJ (2) outfalls prior to development. This would be the responsibility of EWA and conducted prior to final design phases of RAJ (2).							

Table 10.31 Design Mitigation - Operational Effluents

Plant/Process		Management / Design Mitigation
Desalination plant (u285)		• Discharged to sea via existing Bapco main sea outfall.
Cooling water system (u287)	• Cooling tower basin	• Basin overflow routing to the Oily Water Sewer (OWS).
	• Make up and blow down	• Blow-down routed to Treated Water Observation Pond (TWOP) in Waste Water Treatment Plant (WWTP) (Unit f294). In event of oily pollution, the blow-down will be routed to de-oiling treatment in WWTP Unit f294.
	• Side-stream filter system	• Side Stream Filter (SSF) Backwash Settling Basin, with settlement section (287BA0002) is provided to collect the backwash water (suspended solids) coming from Side Stream Filter Package (287U0001). • Water passes through a weir into a collecting pit and then is discontinuously discharged by means of the Backwash Water Pumps (287P0002A/B) to be sent to WWTP Unit f294.
BFW condensate recovery system (u290)	• Condensate treatment section	• Condensate from recovery drum is stored inside Condensate Storage Tanks (290D0001) provided with a skimming oil device to separate possible free oil, and then it is pumped to the polishing system. • Condensate Polishing Package (CPP-290U0004) consists of two sections (each allows redundancy backup): – Activated Carbon Filters (ACF), to remove possible traces of hydrocarbons; – Mixed Bed Filters (MBF), to reduce water conductivity at level suitable for demineralised water production. – Treated condensate is continuously monitored through a Total Organic Carbon (TOC) analyzer to detect any possible presence of hydrocarbons caused by filters malfunction. • A dumping line is provided upstream of the ACF: in case of high temperature or very high TOC, the flow can be directly to oily sewer without passing through the ACF. Diversion is activated also in case of high TOC detection after ACF to prevent Mixed Bed (MB) resins contamination. • The treated condensate leaving the CPP (290U0004) is reused as BFW production and other APC users. • Effluent water from ACF backwash is discharged to the OWS and to the WWTP (f294), while effluent water from MB regeneration is routed to neutralization system.
	• Neutralisation facilities	• The Neutralization Basin (290BA0001) neutralises effluent water from the CPP and Demineralization Packages. • Effluents are neutralized with Sulphuric Acid (H_2SO_4) and Caustic Soda. • The neutralized water is sent by means of Neutralized Water Pumps to TWOP (in unit f294).
Steam	• High pressure steam	• The destination of blow-down coming from blow-down drum (291V0002) is the Clean Storm Water Sewers. Alternative destinations (the TWOP (u294) or the Cooling Water Basin (u287)) shall be investigated during EPC

Plant/Process		Management / Design Mitigation
system (u291)		Phase.
	• Low pressure steam	• The condensate from Excess Steam Condenser (291E0001) is routed to the Excess Steam Condensate Drum (291V0003) and then sent to unit u290 by means of Excess Steam Condensate Pumps (291P0002A/B) to be recovered and treated.
Tank farm (u281)		• Closed drain system to collect and recover liquid drains from equipment and lines. Two closed drain sumps, By-products Recovered Sump (281V0002) and the Naptha and Final Products Recovered Sump (281V0001).
Sewer collection system (f293)	Segregated drainages sewers are provided for the APC Plant: • Clean Water and Clean Storm Water drainages: all drains and storm water not contaminated with hydrocarbon. Clean water may be discharged directly off-site without treatment. • Oily Water Effluents: drainages and washing water from Process and Utilities Areas; Contaminated Storm water: rainwater and/or fire water from paved areas of process and utilities units considered potentially contaminated with hydrocarbon; • Sanitary Effluents: collected and treated in Unit f294 by a dedicated package (i.e. 294U0005). Unit f293 provides different drainage systems to safely manage storm water and fire water run-off, spillage from hydrocarbon processing units, leaks and liquid wastes in order to support effective fire control, prevent flooding and to ensure effluent quality meets the environmental pollution limits. Three separate drainage collection systems are provided in Unit f293: • Clean Water Sewer indicated as CS, not including lifting station, as it is considered that the clean water is collected and discharged by gravity flow[61]; • Oily Water Sewer indicated as OWS, including basins and lift pumps to sent the effluents to proper destination in Unit f294; • Contaminated Storm water Sewer indicated as CSS; including basins and lift pumps to sent the effluent to proper destination in Unit f294.	
	Oily water sewers	• All areas of units handling hydrocarbon (aromatics unit, Naptha hydrotreating, CCR platforming) provided with an oily water sewer system for the safe removal of effluents and drainages from process area. Oily water is routed to this collection system and thus separated from storm water sewer. OWS collects other discharges (e.g. equipment handling hydrocarbon wash-out, steam generators blow-down in case of hydrocarbon contamination, feedstock, by-product and product tanks water draw-offs).

[61] If it is not feasible, clean water has to be collected in a dedicated lift stations. To be defined during FEED according to plot plan finalization.

Plant/Process		Management / Design Mitigation
		• Gravity sewers are routed to the closest Oily Water Basins[62] where collected oily water is pumped to the treatment facilities in Unit f294 for removal of oil.
	Contaminated storm water sewers	• Contaminated storm water sewer system collects rainwater and fire water run-off potentially contaminated by hydrocarbon from process paved areas and tank diked areas. The initial period, known as first flush, corresponds to the period when the bulk of contaminants are cleared by the flushing action of storm water[63]. This period has been fixed to half an hour, after which the surface run-off water can be considered clean. • Sewers serving areas subjected to potential risk of fire shall be designed to handle also the fire event. • Gravity sewers are routed to the closest Contaminated Storm Water Basins[64] where collected rain water is pumped to the treatment facilities in Unit f294.
Waste water plant f294	The objective of Waste Water Treatment Plant is to treat the oily water, storm water / fire water from lift stations (unit f293) and to collect and treat sanitary effluents. Unit f294 consists of the following sections: • De-oiling Section; • Sludge Thickening and Dewatering Section; • Clean Water Section; • Sanitary Effluents Collection and Treatment; • Chemicals Dosing Section; • Process Oily Water Collection System.	
	De-oiling	Contaminated storm water / fire water coming from dedicated lift stations in unit f293 is stored in the Oil Contaminated Storm Water Tank (294D0001). From here the water is pumped (centrifugal with minimum flow spill back) to the de-oiling section together with the oily water coming from the dedicated lift stations. The de-oiling section includes: • American Petroleum Institute (API) Separator Package (294U0001); • Dissolved Air Flotation (DAF) Package (294U0002); • Recovery Oil Drum (294V0001)

[62] Size and basis of design are preliminary and shall be confirmed according to layout and effluents routing.

[63] One inlet diversion box facility provided upstream of each CSS lift station to route the first flush to CSS lift stations, subsequent amount of rain water to CS.

[64] Size and basis of design are preliminary and shall be confirmed according to layout and effluents routing.

Plant/Process		Management / Design Mitigation
		The API Separator Package consists of two channels, each one designed to treat the contaminated storm water from 294D0001 plus the oily water flow rate coming from the oily water basins 293BA001 and 293BA0005, included in unit f293. The skimmed oil is routed by gravity to the Recovered Oil Drum (294V0001) and then it is pumped by means of the Recovered Oil Pumps (294P0002A/B), to the Slop Tank of the Tank Farm (f281). The separated oily sludge from the API Separator is collected in the bottom and sent to Sludge Thickening and Dewatering Package (294U0003). The clean effluent flows upward to the clean effluent compartment, then over the weir and out in the effluent chamber, from which it is sent to the DAF Package (294U0002), by gravity, in order to avoid emulsion formation. Before entering the DAF, API effluent is chemically conditioned. DAF Package is used to remove particulate materials by means of a flotation process based on the injection into the feed of pressurized water supersaturated with air. The oil and particulate materials are removed with a mechanical skimmer and sent to Sludge Thickening and Dewatering Package (294U0003). The DAF Package consists of two DAF Separators, each one designed for the same design capacity of the API Separator channels. The clarified water flows under a float retention baffle, then over an adjustable weir into the effluent chamber from where it is pumped (pumps included inside U0002 package) to the Treated Water Observation Pond (294BA0001). The Recovered Oil Drum is provided in order to collect oily stream from de-oiling packages; this stream is an oil/water mixture with an oil content in the range of 10 - 20%wt. Two vertical centrifugal s Recovered Oil Pumps (294P0002A/B) are provided, one intermittent and one spare, to pump the collected oily streams from de-oiling packages to the Slop Tank (281D0003). From the APC Slop Tank it is pumped to Refinery BMP Slop Tank.
	Sludge thickening	The oily sludge, separated by API Separator and DAF packages, is fed to the Sludge Thickening and Dewatering Package (294U0003); here it is thickened, increasing the solids content of the sludge, removing excess water by decanting and the concentration of solids by settling. Afterwards the sludge is sent to the Dewatering Section (press type) for sludge dewatering. In this section the solid content is increased to 20% wt. A polymer agent is added at package inlet to promote coagulation. The supernatant (i.e. the aqueous stream recovered) is sent to API Separator Package while the dewatered sludge, with a solid content of 20%wt, is discharged by gravity to a tank truck and transferred off-site for disposal[65] The supernatant from the Sludge Thickening and Dewatering Package is collected in the Oily Sludge Sump (294BA0002) and then recycled to the API Separator by means of the Oily Sludge Pumps (294P0004A/B). Two vertical centrifugal pumps are provided, one intermittent and one spare.
	Clean water	The clean water section consists of the Treated Water Observation Pond (294BA0001) and the chemical conditioning by means of Tertiary Treatment Package (294U0004)[66]. The clean effluents and treated water (both oily and sanitary) are

[65] To be confirmed during FEED.

Plant/Process		Management / Design Mitigation
	section	collected into the Treated Water Observation Pond (294BA0001) that is provided as a safeguard before discharging water to the outfall. Continuous monitoring of TOC concentration is provided on the clean water to outfall stream. BOD and COD laboratory analysis is required to ensure that water is in compliance with local regulation limits, and in case it does not comply with local regulation limits it will be recirculated back to the pond, by means of an automatic diversion, and an additional treatment is required, by means of the Tertiary Treatment Package (294U0004), to adjust water quality. Type of tertiary treatment to be finalized during FEED. Three Treated Water Pumps (294P0003 A/B/C), two operating and one spare, vertical type, are provided to pump the treated water to the outfall. The pumps are provided with minimum flow spillback to the observation pond.
	Sanitary effluents collection & treatment	The Sanitary Water Treatment Package [294U0005] collects and pumps waste water from toilets, showers and sink located in the APC Plant layout. The sanitary effluents are treated trough a biological system and then sent to the Treated Water Observation Pond (294BA0001).
	Chemical dosing section	Chemicals typically used in water de-oiling processes are: demulsifier, dewatering polymer, NaOH and H_2SO_4; (treatment program to be finalized). Chemical treatment is provided by means of Chemical Dosing Package (294U0006).
	Process wastes effluent collection system	The process waste effluents continuously generated inside the following process units are collected in a centralized basin, Process Waste Effluent Basin (294BA0003) and then pumped to the existing Waste Water Treatment System of BAPCO Refinery by means of the Process Waste Effluent Pumps (294P0005 A/B). Two pumps, vertical centrufugal type, are provided, one intermittent and one spare. • Parex Unit (PU), a276; • Isomar Unit (IU), a277; • Extractive Distillation Sulfolane Unit (EDSU), a278; and • Benzene – Toluene Fractionation Unit (BTFU), a279.

[66] The type of additional treatment to be provided as a safeguard, e.g. chemical injection or activated carbon filters, has to be finalized during FEED taking into account upset scenarios.

Table 10.32 Summary of Impacts

Issue / Impact	Potential Significance (Minor/Moderate/Major), (Beneficial/Adverse/Negligible)	Mitigation / Monitoring / Enhancement Measures	Residual Impacts (Minor/Moderate/Major), (Beneficial/Adverse/Negligible)
Construction			
Discharge of effluents from dewatering activities - Ma'ameer Channel	No Impact	– Client has confirmed that there are no planned discharges to Ma'ameer	No Impact
Marine sediment loading of Ma'ameer Channel - perimeter road construction	Minor Adverse	– Ensure all workers exhibit care when working on the water's edge – Should works require direct contact with marine waters, consider the deployment of a silt curtain to contain works.	Negligible
Spillages of fuels or chemicals and littering - Ma'ameer Channel	Moderate Adverse	– Store fuel away from water's edge. Consider extending GIIP guidance from 20 m to 50 m. – Ensure fuel stored within a bund of 125% capacity and on impervious ground. – Re-fuelling to be carried out on drip trays. – Consider use of enviro-safe generators incorporating double skinned fuel tanks. – Ensure all wastes are correctly managed (**Section 17**). – Ensure sufficient and appropriate waste collection facilities (e.g. closable skips) are stationed onsite.	Minor Adverse
Release of contact water following storm event - Ma'ameer Channel	Minor Adverse	– Ensure effective waste management procedures are in place (i.e. correct storage) – Ensure storage and use of fuels is according to best practice. – Install a water collection system with oil interceptors. – Any drainage points should be located away from	Negligible

Issue / Impact	Potential Significance (Minor/Moderate/Major), (Beneficial/Adverse/Negligible)	Mitigation / Monitoring / Enhancement Measures	Residual Impacts (Minor/Moderate/Major), (Beneficial/Adverse/Negligible)
		Ma'ameer Channel.	
Installation of transfer lines across Ma'ameer pipe bridge	No Impact	– The existing pipe bridge, built as part of BMP, will be used. No additional disturbance to the channel will be experienced.	No Impact
Sediment resuspension due to installation of sealines at Sitra Wharf	Minor Adverse	– If trenching works are required consult with the SCE to develop mitigation plans and requirement for specialist studies (e.g. sediment dispersion modelling) . Based on modelling results carry out an environmental risk assessment (ERA) to determine threats to sensitive receptors (e.g. ALBA intake). – Consider deployment of silt curtains around the ALBA intake. – Conduct TSS monitoring of waters as per the CESMP.	Negligible
Elevated suspended solids at the ALBA seawater intake	Minor Adverse	– Adhere to the project TSS monitoring protocol (CESMP). The client should consider implementing this at the start of works to confirm the limited extent of sediment loading. – Should ground intrusive methods be utilised to install subsea pipelines, dispersion modelling may be required to be undertaken by the EPC contractor to assess risks to the ALBA intake; TSS levels not to exceed 6 mg/l @ 7m below water surface at the intake. – As a precaution, silt curtains should be installed around the ALBA intake to minimise egress of suspended solids.	Negligible
Release of hydrocarbons from construction vessels	Negligible	– Refuelling of vessels to take place at correct facilities. – Fuel/oil stored on deck to be lashed to prevent spills.	Negligible

Issue / Impact	Potential Significance (Minor/Moderate/Major), (Beneficial/Adverse/Negligible)	Mitigation / Monitoring / Enhancement Measures	Residual Impacts (Minor/Moderate/Major), (Beneficial/Adverse/Negligible)
		– Fuel less than 200l to be stored in drip trays. – Oil spill response plan to be established, including to clean spills immediately with absorbent material. – Oily rags etc. to be disposed of appropriately (do not dispose in the sea).	
Operation			
Extension of thermal plume from BMP due to APC	Minor Adverse	– Consult and liaise with the SCE to extend the combined outfall mixing zone.	Negligible
Recirculation at Bapco Refinery/ BMP seawater intake	Minor Adverse	– If intake temperatures (at Bapco Refinery/ BMP) are found to be excessive, an engineering solution may be required and as determined by specialist dispersion studies.	Negligible
Increased temperature at RAJ	Negligible	– Operator of the APC will be required to monitor APC effluents prior to mixing with those of BMP within the Bapco refinery outfall flume. – It is suggested that both Bapco and the operator of the APC agree of a joint responsibility for the monitoring of marine waters at sensitive sites (refer to OESMP). – Dispersion modelling may be required to further assess the mixing zones of RAJ (2) outfalls prior to development. This would be the responsibility of EWA and conducted prior to final design phases of RAJ (2).	
Elevated temperature at Al Dur	Negligible		
Elevated temperature at GPIC	Negligible		
Diluted contaminants at RAJ	Negligible		
Diluted contaminants at Al Dur	Negligible		