Bapco Modernization Program

Critical Habitats Assessment (CHA)

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AOI	Area of Influence
BAP	Biodiversity Action Plan
BMP	Bapco Modernisation Programme
CBD	Convention on Biodiversity
CD	Chart Datum
CESMP	Construction Environmental and Social Management Plan
CHA	Critical habitat Assessment
CHD	Critical Habitat Determination
CITES	Convention on International Trade in Endangered Species
CR	Critically Endangered
DMU	Discrete Management Unit
EACS	Environment Arabia Consultancy Services WLL
EN	Endangered
E&S	Environmental and Social
ESIA	Environmental and Social Impact Assessment
GCC	Gulf Cooperation Council
GIS	Geographic Information Systems
GN	Guidance Note
IBA	Important Bird Area
IFC	International Finance Corporation
IUCN	International Union for Conservation of Nature
Km	Kilometre
LC	Least Concern
LHS	Left Hand Side
m^3	Cubic Metre
MPA	Marine Protected Area
NT	Near Threatened
NOAA	National Oceanographic Association
OWS	Oily Water Sewer
PATS	Permanent Auditory Threshold Shift
PS6	Performance Standard 6
RHS	Right Hand Side
RRLA	Regional Red List Assessment
TATS	Temporary Auditory Threshold Shift
TTSJV	Joint Venture led by TechnipFMC (Technip Italy S.p.A. and Technip USA:TP) with Tecnicas Teunidas S.A. (TR) and Samsung Engineering Co. Ltd (SECL)
TSS	Total Suspended Solids
UTM WGS 84	Universal Transverse Mercator World Geodetic System 1984
VU	Vulnerable
WBG	World Bank Group

1 INTRODUCTION

Environment Arabia Consultancy Services WLL (EACS) has been appointed by TTSJV to undertake a Critical Habitats Assessment (CHA) for the Bapco Modernization Program (BMP) project. The BMP comprises a package of developments to update and expand the capacity of the existing 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. An environmental permit was received from the SCE in December 2016. A Critical Habitats Assessment (CHA) was not included in the original ESIA and has been required by the lenders according to the International Performance Standard 6 on Biodiversity Conservation and Sustainable Management of Living Natural Resources (IFC PS6, January 1, 2012).

A Critical Habitat Determination (CHD) was undertaken by EACS[1] prior to this study. The outcome of the CHD exercise is presented in **Section 3** and **4** and has resulted in the requirement for this CHA. Some modifications have been made following internal review since the time of its first submission.

This CHA study comprises two activities, one entailed conducting additional primary baseline survey and secondary data collection, and two is the CHA itself. With respect to the additional collection of data, a further study to determine impact of the marine thermal plume, arising from the BMP discharge of effluents to sea, on the Critical Habitat (CH) of Fasht Al Adhm is currently being prepared and will be presented in due course.

1.1.1 Introduction to PS6

As stated in PS6:

PS6 recognizes that protecting and conserving biodiversity, maintaining ecosystem services, and sustainably managing living natural resources are fundamental to sustainable development. The requirements set out in PS6 have been guided by the Convention on Biological Diversity, which defines biodiversity as "*the variability among living organisms from all sources including, inter alia, terrestrial, marine and other aquatic ecosystems and the ecological complexes of which they are a part; this includes diversity within species, between species, and of ecosystems*."

1.2 Project Description - Overview

The main elements of the BMP will be located to the south and east of the existing Refinery process units. The BMP will involve the construction of several new process units and auxiliary plants, and also revamp some 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 BMP will also require changes and development of Sitra Tank Farm, Sitra Wharf and the transfer pipelines between the Refinery and the Sitra facilities.

[1] Environment Arabia, 1B064305 Bapco Modernisation Programme – Determination of Critical Habitat. Rev 00 dated 5th August 2018.

The Refinery uses seawater for cooling and desalination; desalinated seawater is used as process water and boiler feedwater. Due to efficiency improvements, following implementation of the BMP, the quantity of water used (915,179 m^3/day), and its quality, will be approximately the same as the current Refinery (1,004,074 m^3/day). Discharges to sea will be made via the existing sea outfall; subsequently no significant change to the current status of the marine environment will be registered.

The reader is directed to the EACS (2016) BMP ESIA for a full project description, activities during construction and operational regime.

1.3 Scope of this Document

This document has Nine Sections as follows:

Section 1 Provides an introduction to the report and project history and the requirement for a Critical Habitats Assessment (CHA).

Section 2 Presents legislation and guidance relevant to the project (International, Regional and National).

Section 3 Presents the procedure for identification Critical Habitats (CH) and identifies the Discrete Management Units (DMU) that has been used in this CHA.

Section 4 Presents the method of critical habitat determination. Where necessary secondary data presented within EACS (2016) ESIA has been augmented following renewed secondary data collection and/or consultation with specialists with extensive national and regional experience.

Section 5 Presents new (2018) baseline data for the Ma'ameer Channel DMU.

Section 6 Presents the assessment methodology for impact assessment including significance criteria.

Section 7 Provides the results of the impact assessment of CH with respect to the identified DMU and key features.

Section 8 Provides appropriate mitigation and environmental management for the project in relation to the identified impacts upon CH to ensure that there is no-net-loss of biodiversity value. This is to be achieved using the "like-for-like" or better principle of biodiversity offsets in line with the requirements of IFC performance standard 6.

Section 9 Provides a list of references and literature sources.

2 LEGISLATION AND GUIDANCE

Bahrain is party to international and regional environmental agreements and protocols, in addition to possessing national environmental legislation, which either directly or indirectly has influence on the management and/or protection of the marine environment.

The following sections identify key agreements/legislation, which have relevance to the project.

2.1 International

2.1.1 Convention on Biological Diversity

The Protocol Concerning the Conservation of Biological Diversity and the Establishment of Protected Areas (2002) aims to preserve environmental systems and wildlife, especially endangered species and those that migrate through the territorial waters. Bahrain signed the Convention in 1992 and it was subsequently ratified in 1996.

2.1.2 Ramsar Convention on Wetlands, 1975

In Bahrain, this international treaty was ratified by Royal Decree No. 3 on the 26th February 1997. The nomination of two Ramsar 'Wetlands of International Importance' followed on the 27th October 1997, namely:

- *The Hawar Islands* – this island archipelago, situated approximately 20 km off the south-east coast of Bahrain, was primarily designated owing to the fact it comprises undisturbed marine and coastal habitats which provide sanctuary for numerous species of breeding seabirds, a significant proportion of which are either threatened, rare or endangered.
- *Tubli Bay* – This enclosed water body, located in the north-east of Bahrain, supports the largest area of mangroves in Bahrain. One type of mangrove exists which is the Grey Mangrove; *Avicennia marina*. The area is one of the main sites for migratory and breeding waterbirds in the country. The mangroves are also an important nursery ground for the commercially important Green Tiger Prawn (or shrimp) *Penaeus semisulcatus*, as well as certain marine fishes.

2.1.3 Important Bird Areas (IBA)

There are four Important Bird Areas (IBAs) in Bahrain as designated by BirdLife International, a global partnership of conservation organisations which aim to conserve avifauna, their habitats and global biodiversity. These are: Tubli Bay, Hawar Islands, Maqabah and the South West Coast. Since designation, the Maqabah site has been lost due to housing development.

2.1.4 Wildlife and Natural Habitat Convention GCC

Convention on the Conservation of Wildlife and Natural Habitats in GCC Countries (2003) focuses on the conservation of ecosystems and wildlife, especially those species at risk from extinction, and aims to raise the standards of conservation of flora, fauna and natural habitats.

Table 2.1[2] provides a list of all of the protected areas in the Kingdom of Bahrain, and the distance of each of the Discrete Management Units[3] studied (DMUs – see **Section 3.1.2**) as part of the CHA. Note distances are 'as the crow flies[4]' and many of the areas are physically separated from the DMUs not only be the large geographic distances, but also by land (e.g. the Ras Mumtallah IBA is on the opposite coast of the mainland).

Table 2.1 Protected Marine Areas in Bahrain, and IBAs

Protected Areas in Bahrain		Distance from DMUs		
		Fasht Al Adhm	**Tubli Bay**	**Ma'ameer**
Tubli Bay MPAand Ramsar site - Tubli Bay and Ma'ameer were declared as protected area by Decree No. (53) of 2006*		~5 km	Inside	Immediately adjacent to and connected to Tubli Bay
Hawar Islands was declared as a protected area in 1996 and designated as a RAMSAR site in 1997		>28 km	>45 km	>43 km
Dohat Arad (Arad Bay) is a Marine Protected Area under Ministerial Order (4) of 2003*.		>13 km	>7.5 km	>13 km
Reef Bul Thamah was declared a protected area following Ministerial Decree (9) of 2007*.		>85 km	>85	>90 km
Mashtan Island is Protected Area by Ministerial Order (1) of 2002*.		>19 km	>35 km	>30 km
Important Bird Areas[5]				
In addition Bahrain has 4 marine Important Bird Areas (IBA):	South West Coast IBA (Ras Mumtallah)[6]	>29 km	>36 km	> 33 km
	Hawar Islands IBA	>28 km	>45 km	>43 km
	Tubli Bay IBA*	~5 km	Inside	Immediately adjacent to and connected to Tubli Bay
	Maqabah	~18 km	~7 km	~2.7 km

2.1.5 IFC Performance Standard 6, Biodiversity Conservation and Sustainable Management of Living Natural Resources, 2012

IFC Performance Standard 6 concerning Biodiversity Conservation and Sustainable Management of Living Natural Resources recognises that protecting and conserving

[2] Note this table also includes nationally protected areas (highlighted with an *).
[3] A DMU is defined as an area with a clearly demarcated boundary within which the biological communities and or management issues have more in common with each other than they do with those in adjacent areas.
[4] An idiom for the most direct path between two points.
[5] These are not all protected, by default, under Bahrain legislation.
[6] IBA criteria A4i, B1i, B3.

biodiversity, maintaining ecosystem services, and sustainably managing living natural resources are fundamental to sustainable development.

It states that the impact identification process should consider direct and indirect project-related impacts on biodiversity and ecosystem services and identify any significant residual impacts. The project proponent should seek to avoid impacts on biodiversity and ecosystem services, and, where avoidance is not possible, measures to minimise impacts and restore biodiversity and ecosystem services should be implemented.

Where natural habitat is involved, project proponents should retain competent professionals to assist in conducting the risks and impact identification process. If Critical Habitat (CH) is involved, external experts with appropriate regional experience should be retained to develop a mitigation hierarchy.

2.2 Regional

Regional Protocols to protect the Arabian Gulf's marine resources include the Regional Organization for the Protection of the Marine Environment (ROPME); Bahrain is a member state. Of note is the Kuwait Regional Convention (adopted on 24th April 1978 and which entered into force on 1st July 1979); its protocols and action plans include the following:

- Action Plan for the Protection of the Marine Environment and the Coastal Areas of Bahrain, Iran, Iraq, Kuwait, Oman, Qatar, Saudi Arabia and the United Arab Emirates;
- Protocol concerning Regional Co-operation in Combating Pollution by Oil and other Harmful Substances in Cases of Emergency;
- Protocol concerning Marine Pollution resulting from Exploration and Exploitation of the Continental Shelf;
- Protocol for the Protection of the Marine Environment against Pollution from Land-Based Sources;
- Protocol on the Control of Marine Transboundary Movements and Disposal of Hazardous Wastes and other Wastes; and
- The Convention on the Conservation of Wildlife and Natural Habitats in GCC Countries (2002), focuses on the conservation of ecosystems and wildlife, especially those species at risk from extinction, and aims to raise the standards of conservation of flora, fauna and natural habitats.

2.3 National

2.3.1 Legislative Decree No. 21 of 1996, Kingdom of Bahrain

Legislative Decree No. 21 of 1996 with Respect to the Environment aims to protect the environment from polluting sources and factors, and put an end to its deterioration by drawing up the required plans and policies to preserve it from the harmful effects resulting from activities causing damage to human health, agricultural crops, marine life, wildlife, other natural resources and the climate. Article 6 states "It shall not be permitted for any person or project to use the environment in any environment polluting activity, contributing to its deterioration activity, causing damage to the natural resources, living beings, breach, prevent the utilisation, use and the proper and

reasonable exploitation of the environment". The law allows the designation of protected areas which must not be utilised by any person or project.

2.3.2 Law No. 53 of 2006

This law designates Tubli Bay and Ma'ameer Channel as a protected area (**Table 2.1**).

2.3.3 Ministerial Resolution No. 70 of 2011 on Defining the Reclamation Boundary of the Protected Area

This Resolution provides the reclamation limit lines in Tubli Bay and Ma'ameer Channel.

3 DETERMINATION OF CRITICAL HABITAT

3.1 Definition of Critical Habitat

As per paragraph 16 of WBG (2012) IFC Performance Standard 6 Biodiversity Conservation and Sustainable Management of Living Natural Resources, Critical Habitat is defined as Areas with high biodiversity value, including:

I. Habitat of significant importance to Critically Endangered (CR) and/or Endangered (EN) species;
II. Habitat of significant importance to endemic and/or restricted-range species;
III. Habitat supporting globally significant concentrations of migratory species and/or congregatory species;
IV. Highly threatened and/or unique ecosystems; and/or
V. Areas associated with evolutionary processes.

Further, and as per GN56 (Guidance Note #56), CH can also be determined on a case by case basis and where other recognised high biodiversity values apply such as:

- Areas required for the reintroduction of CR and EN species and refuge sites for these species (habitat used during periods of stress).
- Ecosystems of known special significance to EN or CR species for climate adaptation purposes.
- Concentrations of Vulnerable (VU) species in cases where there is uncertainty regarding the listing, and the actual status of the species may be EN or CR.
- Areas of primary/old-growth/pristine forests and/or other areas with especially high levels of species diversity.
- Landscape and ecological processes (e.g., water catchments, areas critical to erosion control, disturbance regimes (e.g., fire, flood)) required for maintaining critical habitat.
- Habitat necessary for the survival of keystone species.
- Areas of high scientific value such as those containing concentrations of species new and/or little known to science.

Finally as per GN57, internationally and/or nationally recognised areas of high biodiversity value will qualify as critical habitat; this would include, amongst others, for example, Important Bird Areas (IBAs) and Ramsar Sites.

3.1.1 Guidance by Criterion and Gradients

Table 3.1 presents the categories of critical habitat based on relative vulnerability and irreplaceability. For Criteria 1-3 quantitative thresholds are provided to assign critical habitat into Tier 1 or Tier 2 and as per IFC PS6.

Table 3.1 Quantitative Thresholds for Tiers 1 and 2 and for Criterion 1 Through 3

Criteria	Tier 1	Tier 2
1. Critically Endangered (CR)/ Endangered (EN) Species	(a) Habitat required to sustain ≥ 10 percent of the global population of a CR or EN species/subspecies where there are known, regular occurrences of the species and where that habitat could be considered a discrete management unit	(c) Habitat that supports the regular occurrence of a single individual of a CR species and/or habitat containing regionally- important concentrations of a Red-listed EN species where that habitat could be considered a discrete

Criteria	Tier 1	Tier 2
	for that species. (b) Habitat with known, regular occurrences of CR or EN species where that habitat is one of 10 or fewer discrete management sites globally for that species.	management unit for that species/ subspecies. (d) Habitat of significant importance to CR or EN species that are wide-ranging and/or whose population distribution is not well understood and where the loss of such a habitat could potentially impact the long-term survivability of the species. (e) As appropriate, habitat containing nationally/regionally important concentrations of an EN, CR or equivalent national/regional listing.
2. Endemic/ Restricted Range Species	(a) Habitat known to sustain ≥ 95 percent of the global population of an endemic or restricted-range species where that habitat could be considered a discrete management unit for that species (e.g., a single-site endemic).	(b) Habitat known to sustain ≥ 1 percent but < 95 percent of the global population of an endemic or restricted-range species where that habitat could be considered a discrete management unit for that species, where data are available and/or based on expert judgment.
3. Migratory/ Congregatory Species	(a) Habitat known to sustain, on a cyclical or otherwise regular basis, ≥ 95 percent of the global population of a migratory or congregatory species at any point of the species' lifecycle where that habitat could be considered a discrete management unit for that species.	(b) Habitat known to sustain, on a cyclical or otherwise regular basis, ≥ 1 percent but < 95 percent of the global population of a migratory or congregatory species at any point of the species' lifecycle and where that habitat could be considered a discrete management unit for that species, where adequate data are available and/or based on expert judgment. (c) For birds, habitat that meets BirdLife International's Criterion A4 for congregations and/or Ramsar Criteria 5 or 6 for Identifying Wetlands of International Importance. (d) For species with large but clumped distributions, a provisional threshold is set at ≥5 percent of the global population for both terrestrial and marine species. (e) Source sites that contribute ≥ 1 percent of the global population of recruits.

3.1.2 Unit of Analysis – Discrete Management Units

A DMU is defined as an area with a clearly demarcated boundary within which the biological communities and or management issues have more in common with each other than they do with those in adjacent areas. A DMU may or may not have an actual management boundary but can also be defined by some other sensible ecologically definable boundary (e.g. seagrass habitat, coral habitat, modified etc). The delineation of the management unit will depend on the species of concern.

The relationship between the DMUs identified in the following sections and the Areas of Interest (AOI) for the project and as identified in the BMP ESIA is shown in **Table 3.2**.

Table 3.2 Identification of DMU from BMP ESIA AOI

AOI	Description	DMU
AOI1	Located near the two refinery outfalls (#6 Oily Water Separator (OWS) outfall, and the main Bapco outfall) including an area extending in an arc 3 km from the coastline at the midpoint of the two outfalls[7]. AOI 1 is graphically represented on **Figure 3.2** as this was the location of the original marine survey for the BMP ESIA. It can be seen that AOI 1 overlaps into the Fasht Al Adhm DMU. The coastal zone fronting the shoreline of the project and extending north and south. Defined as water habitats featuring water depths between 1-9 m and of mixed subtidal habitats adjoining Fasht Al Adhm.	1. Fasht Al Adhm 2. Coastal Zone
AOI2	Defined in the BMP ESIA as the entire Ma'ameer channel (in respect of the reconstruction of the pipe bridge). Tubli Bay DMU is connected to AOI2 at the north end of Ma'ameer Channel and is graphically represented on **Figure 3.3**.	1. Ma'ameer channel.
AOI3	Defined in the BMP ESIA as a distance of up to 1 km from the T-head of the Sitra wharf relating to the installation of sealines (see **Figure 3.2**).	1. Deep water

The following sections present applicable baseline data for the identified DMUs. The location of these is illustrated in **Figure 3.2** and **Figure 3.3**. The data sets presented are a summary of features pertinent to the determination of the presence of critical habitat, as per PS6, but also from which the CHA is subsequently made.

3.2 Baseline - Fasht Al Adhm DMU

3.2.1 General description

At approximately 210 km^2, the shallow water reef of Fasht Al Adhm (**Figure 3.2**) comprises mixed habitats including seagrass (*Halodule uninervis*, *Halophila* spp.), macro algae (including key species, *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[8]).

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.

The following is an extract from GEOMATEC (2006) MARGIS II:

[7] The size of 3 km radius was chosen for AOI 1 as the largest probable area of influence of effluent from the outfalls based on knowledge of the area as defined by HR Wallingford.

[8] Located approximately 15 km east of the BMP outfall.

Fasht Al Adhm is marked as a high value area mainly due to the diversity of its habitats and the high productivity and diversity of its fishing grounds. Fasht Al Adhm is well-known as the biggest fishing grounds in Bahrain and used by a large number of local fishermen (Abdulqader et al, 2004). The fisheries resources survey reported a large quantity of commercial fish catch from this area especially the Rabbit fish (locally known as Saffi). As with other fashts, the dominant habitat on the reef flat is hard rock substrate covered by sand and algae. There are patches of scattered seagrass as well, with a stretch of live corals existing along the northeast slopes of the fasht.

Although falling outside the direct influence[9] of the proposed BMP, Fasht Al Adhm is considered applicable due to the interconnectivity of adjacent habitats and the movement of key species over geographic areas.

No primary surveys[10] have been conducted within Fasht Al Adhm DMU as part of this CHA, hence the information provided below has been collated from a number of secondary sources and as referenced throughout.

3.2.2 Coral cover

In the 1980s the north eastern leading edges of the reef (approximately 15 km east of the existing Refinery outfall) 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, notably at the north eastern leading edge, (e.g. *Cyphastrea* spp., *Porites* spp. *Favia* spp. and *Platygyra* spp.) although the branching corals of the *Acropora* spp. are not to be seen[11]. Baseline surveys conducted as part of the EACS (2016) BMP ESIA identified only one survey site where coral cover of ≤20 % was present. This site, station 18, is located at the outer edge of the identified thermal plume affected area and where predicted project related elevated temperatures are estimated at 0.1 °C above baseline.

To our knowledge there are no recent studies to catalogue and document the presence, distribution and coverage of corals on Fasht Al Adhm as a whole, however of those recognised by the IUCN as being present in Bahrain it is considered possible that some or all may be present within Fasht Al Adhm. These may include, but not limited to *Pavona cactus*, *Porites harrisoni*, *Porites lobata*, *Platygyra lamellina* and *Acropora clathrata*[12].

[9] Plume dispersion modelling conducted as part of the EACS (2016) BMP ESIA indicated negligible thermal plume interaction.

[10] Following review of EACS (2016) ESIA by the lenders environmental and social (E&S) advisors, it was recommended that further study is undertaken to address thermal impacts of the BMP upon sensitive faunal receptors including those associated with Marine Protected Areas (MPA's). Part of the additional works includes field investigations which shall be presented in a stand alone document.

[11] Personal observations Michael Arora, 2018.

[12] Species identified in RRLA (2017).

3.2.3 Megafauna

Bahrain is known to host a number of megafaunal species including marine mammals and turtles. **Table 3.3** identifies these and comments on their likely presence/distribution within Fasht Al Adhm (Geomatec, 2006, Michael Arora pers obs).

Table 3.3 Potential presence of megafauna within Fasht Al Adhm

Scientific name	Common Name	IUCN Conservation Status	Potential Occurrence
Dugong dugon	Dugong	VU	Individuals rarely
Neophocaena phocaenoides	Finless porpoise	VU	
Tursiops aduncus	Indian Ocean bottlenose dolphin	DD	Moderate
Sousa plumbea	Indo-Pacific humpback dolphin	EN	High
Delphinus capensis	Long-beaked common dolphin	DD	Moderate
Orcinus orca	Killer whale	DD	Sighted once in 2004
Chelonia mydas	Green turtle	EN	Individuals sighted, however main distribution is south of Fasht Al Adhm
Eretmochelys imbricata	Hawksbill turtle	CR	
Caretta caretta	Loggerhead turtle	VU	Most unlikely

Key: DD – Data Deficient, EN-Endangered, VU – Vulnerable, CR – Critically Endangered, VU - Vulnerable

Of marine mammals, *Tursiops aduncus, Sousa plumbea*[13] *and Delphinus capensis* are frequently sighted within Fasht Al Adhm whereas the distribution of *Dugong dugon* is mainly reported (Preen *et al*, 1989) in areas falling outside and predominantly:

- Between Bahrain and Qatar, south of Fasht Al Adhm;
- North of the *Hawar* Islands; and
- Between Saudi Arabia and Bahrain, south of the Saudi Arabia-Bahrain (King Fahd Causeway) and north of *Uqair* (in the eastern province of Saudi Arabia).

The most common turtle species to occur in Bahraini waters are the green (*Chelonia mydas*) and the hawksbill turtle (*Eretmochelys imbricata*) which occur as foraging populations in shallow waters (Miller *et al,* 1989; Al Zayani, 2003). The loggerhead turtle (*Caretta caretta*) also occurs, though with less frequency and presumably in much lesser abundance (Miller 1989). There appears to be little data on the spatial and seasonal distribution of turtles in Bahrain though various reports suggest concentrations in shallow seagrass areas (presumably mostly green turtles) to the east and west of Bahrain, more or less mirroring primary dugong distribution (Abdulqader, 2000; Geomatec, 2006).

[13] *Sousa plumbea* has been recognized as a species since taxonomic revision of the genus *Sousa* in 2014 (Committee on Taxonomy 2014, Jefferson and Rosenbaum 2014). Previously this species was lumped with the Indo-pacific humpback dolphin (*Sousa chinensis)* but animals occurring in the Indian Ocean from South Africa to India are now recognized as taxonomically distinct from those that occur further east (Jefferson and Rosenbaum, 2014).

3.2.4 Fish

Given the diversity of habitats within Fasht Al Adhm it is no surprise that it is recognised as the country's best fishing ground. Of species noted by the IUCN as falling within the geographical range of Bahrain and of which are of CR or EN status, only the Longcomb sawfish (*Pristis zijsron* – **Figure 3.1**) may potentially be present within its waters.

National distribution data sets for this species do not exist however a specimen was caught by local fishermen earlier in 2018 (at Fasht Al Jarim located some 40 km north of the study area) and a large individual was sighted off the west coast in the late 1980's[14]. During this time the combs of such fish were regularly sighted washed up along the coastline[15] indicating their presence was greater than recent times.

Figure 3.1 The Longcomb Saw fish sighted off the west coast of Bahrain in the late 1980s[16]

3.3 Baseline - Coastal Zone[17] DMU

3.3.1 General description

This DMU extends approximately 15 km in a north to south direction and a maximum of 10 km to the east, and buffering Fasht al Adhm. This area has been defined based on water depths but also as an originally productive marine habitat with direct biological interaction with the neighbouring DMU of Fasht al Adhm. The waters fronting the eastern shoreline of Bahrain (**Figure 3.2**), and within the vicinity of the Bapco existing marine outfall have, to varying degrees, experienced significant coastal development over the past decade including both dredging and reclamation works. Consequently much of the shallow water habitat, has been significantly impacted and/or removed altogether.

[14] Personal observations by Mr Lothar Tschersich (Bapco employee 1976-2012).
[15] Pers comms, Michael Arora (Bahrain resident 1979 – current).
[16] Photo credit; Lothar Tschersich.
[17] Note the coastal zone DMU in the context of this project is all of the sea areas within a certain depth range. A *representative* proportion has been physically demarked on **Figure 3.2** within this document extending to the southernmost tip of the Fasht Al Adhm DMU.

Water depths in this area range between 1-9 m in depth and, as per GEOMATEC (2006), comprise mix habitat containing sea grass, algae, rock, sand and mud, in varying proportions, with each never exceeding 75% cover (this amount is used to define a pure habitat stand). The area does, therefore, retain an ecological importance with regards a feeding area for fish and biological productivity.

3.3.2 Bapco (2011) Marine Assessment

Studies commissioned by Bapco since the 1980's allows for the periodic (every 5 years) assessment of marine ecology within the waters fronting the Refinery outfall. The Bapco 2011 marine environment assessment, carried out by Olof Lindén, PhD. and Ulf Larsson, PhD, encompasses AOI 1 (i.e. waters fronting the Bapco outfall), and a larger area to the north, east and south of the Refinery; the report notes the following:

The shallow coastal area in front of the Bapco Refinery has a maximum depth of less than 10 meters. The sub-tidal ecosystem consists of a mixed soft bottom and coral rock/lime stone habitat. Relatively dense sea grass beds cover the areas with soft substrate where fish, shrimps and crabs are common. In the areas covered by rock, a few single colonies of coral are found.

The results of the Bapco 2011 marine environment assessment show a richer fauna in several of the stations in 2011 than in the earlier studies. In most of the stations, the number of species increased significantly, at some stations with a factor two or three. The results from the investigations of the benthic fauna in 2011 showed significantly more fauna, both in terms of number of species, diversity and abundance.

3.3.3 EACS (2016) BMP Marine Baseline Study

A total of 70 taxa were identified throughout the study area[18], using SCUBA, of which fish, flora and fauna accounted for 5, 20 and 45 respectively. Four broadscale marine habitat types were identified within AOI 1 (i.e. that fronting the existing Bapco outfall and within an area determined by hydrodynamic modelling as a plume affected area). These have been summarised in **Table 3.4**.

Table 3.4 Marine habitats identified within the study area

Habitat[19]	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.

[18] Within AOI 1 as defined in **Table 3.2**. No primary studies have been conducted for the CHA within the main area of Fasht Al Adhm. The station identified as Coral Rock and Sand (CRS) within AOI 1 may be representative of certain areas of the Fasht al Adhm DMU.

[19] These habitat codes are in line with those used in MARGIS 2. The reader is referred to the EACS BMP ESIA for full details of the marine baseline including maps, data sets and photographs.

Habitat[19]	Summary Description
Coral, rock & sand[20]	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).

The baseline surveys conducted as part of EACS (2016) ESIA indicated that much of the defined study area comprised flat homogenous sand (with sparse (≤1%) sporadic seagrasses of *Halodule uninervis* and *Halophila ovalis*) and mud with limited conspicuous epibiota. One small discrete area of rocky habitat with sparse (locally <10% cover) coral communities (primarily *Cyphastrea* sp. and *Porites* sp.) was noted towards the eastern extreme of the EACS (2016) ESIA study area (AOI1).

The Coastal Zone includes isolated pockets of intertidal mudflats, particularly immediately south of the main Bapco outfall, which according to GEOMATEC (2006), provides suitable habitat for several species of feeding and roosting birds.

Of fish species noted by the IUCN as falling within the geographical range of Bahrain[21], and hence potentially within the waters of the Coastal Zone, is that of the Longcomb sawfish (*Pristis zijsron*). The reader is directed to **Section 3.2.4**.

3.4 Baseline - Tubli Bay DMU

No primary surveys have been conducted within the Tubli Bay DMU. With a size of approximately 24 km² in the 1950's[22], Tubli Bay was known internationally for its unique ecology. Past reclamation has significantly reduced the size of the bay to 13 km^2.

The Bay represented an important nursery area for many species of fish (some of commercial value) and shrimp[23] (*Penaeus semisulcatus* and *Metapenaeus stebbingi*) as well as an essential site for thousands of migratory and resident bird species[24].

Located towards the centre of the Bay, the island of Nabih Saleh provided an idyllic setting with dense palm groves, a rocky coastline on the west coast, and natural freshwater springs providing water for irrigation and bathing. The coastline along Tubli fronted significant agricultural areas, with many vegetables and fruits grown beneath the canopy of once significant date palm plantations. Intertidal areas hosted significant floral communities and mangroves were dotted along the western side of the bay (extending towards the south-western coast of Sitra island), with the largest stand located at Ras Sanad. The reeds, *Phragmites australis,* and the rushes, *Juncus* sp., were also common, inhabiting the many drainage ditches that fed the bay with fresh water from the farm areas. However, since that time, anthropogenic activities have severely affected the ecology and geomorphology of the bay and this once ecologically unique ecosystem has been significantly degraded.

[20] Identified from the survey and SCUBA surveys.

[21] And within habitats that constitute much of the coastal zone.

[22] Ghanem *et al* (2004) Biological & Sociological Study on Tubli Bay, Bahrain. Unpublished.

[23] Abdulqader, E.A.A. (1995) Fisheries and Aspects of Penaeid Shrimps of Bahrain, Ph.D thesis, University of North Wales, Bangor.

[24] Abdulrahman (1997) A Management Plan for the Viable and Sustainable Development of Tubli Bay, Bahrain. Unpublished.

Physically and intrinsically linked to Ma'ameer Channel (**Section 3.5**), Tubli Bay is 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 (**Figure 3.3**) namely:

1. Tubli Bay wetlands (RAMSAR 1b-2c-3b-4b) – Tubli Bay as shown in **Figure 3.3**.;
2. Ras Sanad Mangrove Reserve; and
3. Tubli National Park (covers the whole Tubli Bay as shown in **Figure 3.3** including Ma'ameer Channel).

Tubli Bay includes open sea habitat, forest habitat (subtropical and tropical mangrove comprising the sole species *Avicennia marina*[25]) 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)[26] and is identified as an Important Bird Area (IBA) by BirdLife International[27] (**Table 3.6**). Tubli Bay is approximately 7 km North West of the project area but is included due to its physical and historic link to Ma'ameer Channel.

3.5 Baseline - Ma'ameer Channel DMU

Historically, Ma'ameer Channel acted as a drainage wetland for Tubli Bay although in recent decades the imposition of bridges and culverts has somewhat demarked the Channel from Tubli although remains physically connected. It remains an ecologically sensitive site and is nationally protected as a nature reserve under law No. 53 of 2006 and its amendment of 2011.

The waters of the Channel are shallow, typically 1 m or less and do not host conspicuous biota other than algae, juvenile fish and invertebrates associated with the muddy sediments; the latter providing a valuable food source for many species of avifauna. Stands of *Avicennia marina* are sporadically present in varying sparse coverage, but locally more dense, along the flanks of the Channel.

During the 2016 BMP baseline surveys, nine epifaunal invertebrate 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; the abundant small hermit crabs of the Family Paguridae which inhabited assorted empty gastropod shells (Paguridae Latreille, 1802). 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.

Table 3.5 lists all of the epibiota recorded during the walkover survey.

[25] The largest aggregate of mangroves in Bahrain is located at *Ras Sanad*, with additional stands located throughout the bay. Al Zayani & Loughland (2009) report that around 300 ha were lost due to reclamation activities in 1975; furthermore it states that only around 80 hectares of mangroves remain.
[26] https://www.ramsar.org/taxonomy/term/69/all?page=2.
[27] IBA criteria met A4i, B1i (1994).

Table 3.5 List of Epibiota (Faunal and Floral Taxa) Encountered (AOI 2)

Fauna (Phylum: Class)	Flora (Phylum: Order)
Annelida: Polychaeta	Chorophyta: Bryopsidales
Spirobranchus kraussii (Baird, 1865)	*Caulerpa sertularioides* (S.G.Gmelin) M.A.Howe, 1905
Chordata: Pisces (Superclass)	Chorophyta: Cladophorales
Superclass Pisces indet. (juvenile fish)	*Chaetomorpha* Kützing, 1845
Crustacea: Malacostraca	*Cladophora* Kützing, 1843
Paguridae Latreille, 1802	Chorophyta: Ulvales
Crustacea: Maxillopoda	*Ulva* Linnaeus, 1753 Spp. (2)
Balanus Costa, 1778	Rhodophyta: Ceramiales
Mollusca: Gastropoda	*Ceramium* Roth, 1797
Cerithium Bruguière, 1789	Rhodophyta: Gigartinales
Lunella Röding, 1798	*Sarconema* Zanardini, 1858 Spp. (2)
Mitrella blanda (G. B. Sowerby I, 1844)	Rhodophyta: Gracilariales
Planaxis sulcatus (Born, 1778)	*Gracilaria* Greville, 1830
Pirenella Gray, 1847	Tracheophyta: Lamiales
Trochus Linnaeus, 1758	*Avicennia marina* (Forssk.) Vierh

Several shoals of small fish were observed during the survey; the channel plays an important role as a 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 (*Avicennia marina* (Forssk.) Vierh); a recent walk over survey to assess the mangrove populations within the proposed pipeline crossing was undertaken in 2018. The findings are presented within **Section 5**.

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* Kützing, 1845, *Cladophora* Kützing, 1843 and *Ulva* Linnaeus, 1753 Spp. (2) in varying proportions.

Extensive mudflats of the Channel provide an excellent feeding and roosting habitat for waterbirds. SCE & ARCWH (2018) indicated that more than 650 individual waterbirds of 28 species were observed including the Socotra cormorants (*Phalacrocorax nigrogularis*), herons, flamingos, gulls and terns.

An avifuanal survey was undertaken by a specialist ecologist, Dr. Saeed Abdulla Al Khuzai in October 2016 for the BMP ESIA. The survey area encompassed the entire Western bank of the channel in the area to the south of the pipeline crossing study area and is therefore considered representative of the area. During this survey, a large flock of flamingos (between 100 and 200 flamingos) was observed feeding in the shallow water along the coastline which is a common occurrence in the area.

Table 3.6 provides a list of birds which were recorded[28].

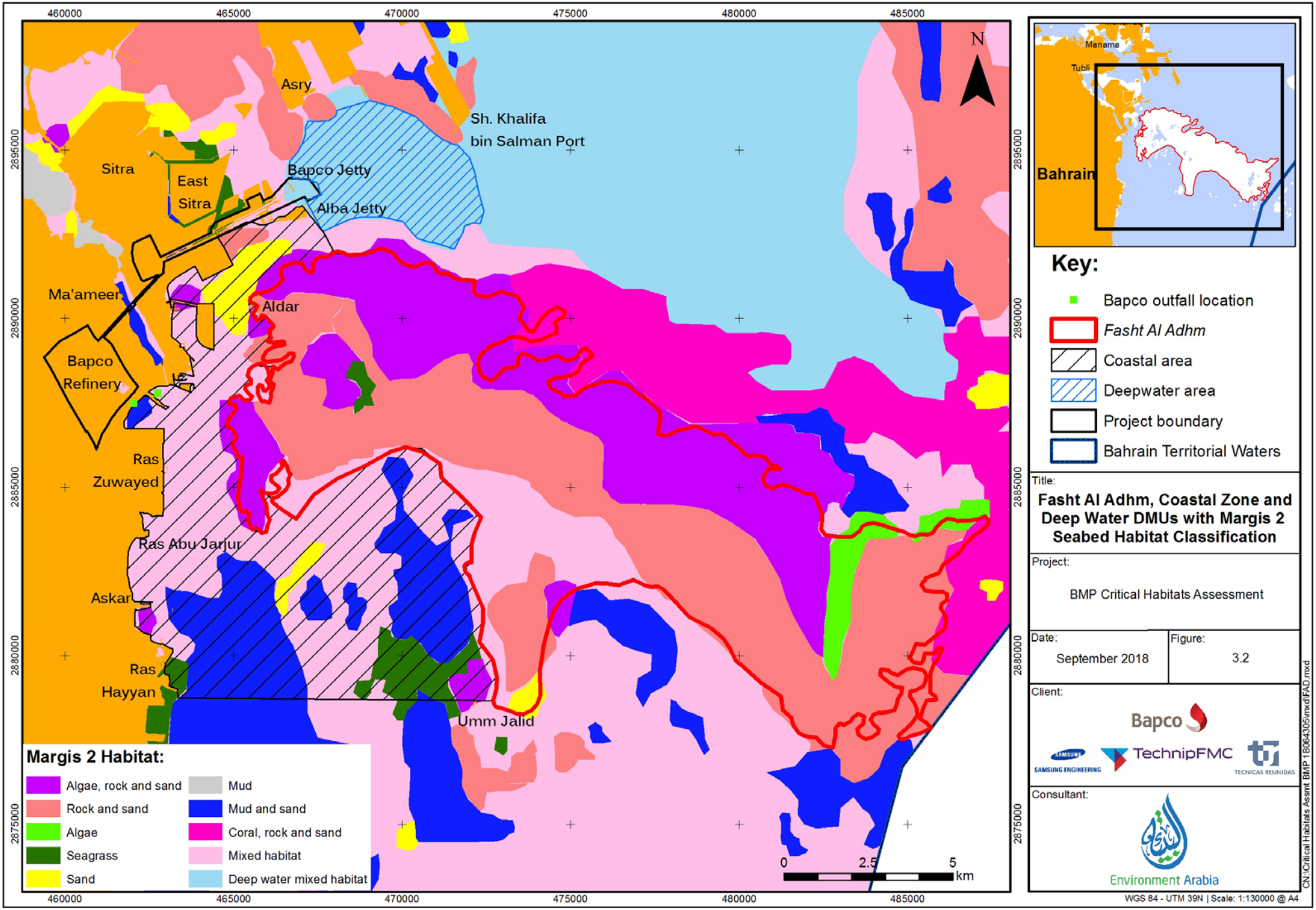
Table 3.6 List of Birds and their Status

Scientific name	Common name	Status in Bahrain	The Region	IUCN Category
Phoenicopterus roseus	Greater Flamingo	migratory/ common	common	least concern
Egretta gularis	Western Reef Heron	resident breeder/ common	common	least concern
Ardea cinerea	Grey Heron	migratory/ common	common	least concern
Sterna sp	Tern (undet.)	migratory		unknown
Larus ridibundus	Black-headed Gull	migratory/ common	common	least concern
Charadrius alexandrinus	Kentish plover	resident breeder/ common	common	least concern
Charadrius mongolus	Lesser sand plover	migratory/ common	common	least concern
Calidris minuta	Little stint	migratory/ common	common	least concern
Calidris alpina	Dunlin	migratory/ common	very common	least concern
Calidris ferruginea	Curlew sandpiper	migratory/ common	common	Near Threatened
Tringa totanus	Redshank	migratory/ common	common	least concern
Xenus cinereus	Terek sandpiper	migratory/ common	common	least concern
Himantopus himantopus	Black-winged stilt	Resident breeder/common	common	least concern
Streptopelia decaocto	Collared Dove	Resident breeder/ common	common	least concern
Oenanthe sp.	Wheatear	migratory		unknown
Passer domesticus	House Sparrow	resident breeder/ common	common	least concern

3.6 Baseline - Deep Water DMU

The industrial zone (**Figure 3.2**) located within and around the Sitra Wharf area of the BMP project, comprises dredged seabed with depths ranging from -10 to -15 m Chart Datum (CD). The area is the site of many heavy industries and commercial shipping lanes/jetties/wharfs. EACS (2016) indicates that limited conspicuous epibiota present and that this DMU is representative of a low ecological value.

[28] Three of the five CH species identified in **Table 4.2** were observed during the aforementioned survey and are highlighted in **Table 3.6.**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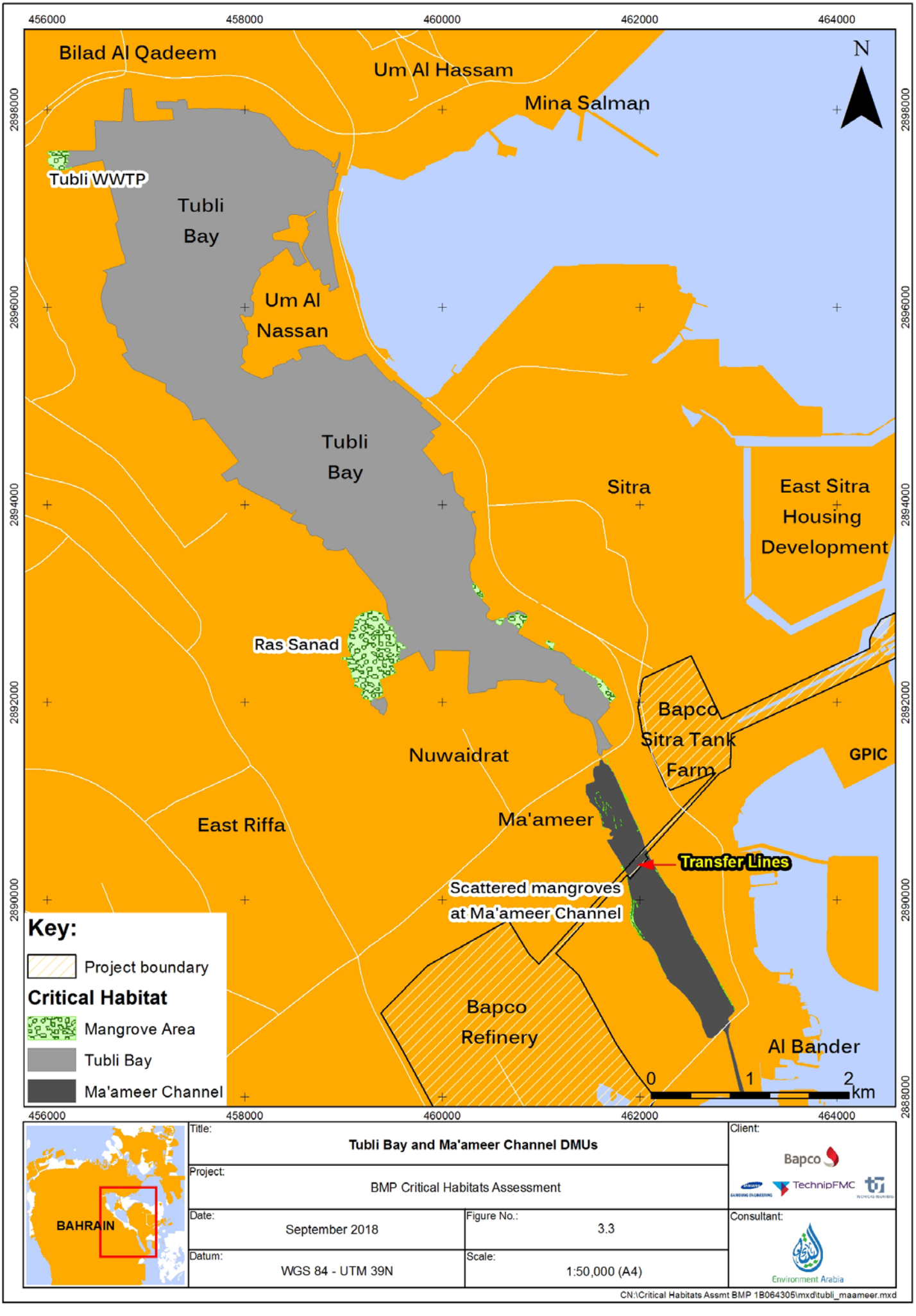
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4 METHODOLOGY OF CHD

The following presents the method of Critical Habitat Determination (CHD). Where necessary secondary data presented within EACS (2016) ESIA has been augmented following renewed secondary data collection and/or consultation with specialists with extensive national and regional experience.

4.1.1 Criterion 1

Species which have been identified within baseline surveys (EACS, 2016 ESIA), or have the potential to be present (following additional collection of secondary data and/or consultation[29]) within the DMUs have been screened to ascertain if they are classified as CR or EN on an international, regional or national stage.

In this regard reference is made to the IUCN Red List of Threatened Species and the Arab Regional Centre for World Heritage (2017) The First Regional Red List Assessment of Selected Species in the Kingdom of Bahrain (RRLA). **Table 4.1** lists those species which have either been recorded within or potentially may be present within one or more of the DMUs.

4.1.2 Criterion 2 – Endemic and/or Restricted-Range Species

As per IFC PS6 endemic and restricted range species are defined as:

- An endemic species is defined as one that has ≥ 95 percent of its global range inside the country or region of analysis.
- Restricted-range species is defined in the PS6 guidance notes as:
  - For terrestrial vertebrates, a restricted-range species is defined as those species which have an extent of occurrence of 50,000 km^2 or less.
  - For marine systems, restricted-range species are provisionally being considered those with an extent of occurrence of 100,000 km2 or less.
  - For plants, restricted-range species may be listed as part of national legislation. Plants are commonly referred to as “endemic”, and the definition provided in paragraph GN79 would apply.

According to the Bahrain First National Report to the Convention on Biological Diversity – 2006 there are no reported lists of endemic species[30]. Review of the IUCN Redlist database indicate only one species, the sole fish *Zebria captivus*, observed in 1983 and caught a by-catch from trawls. Further, none of the species identified in EACS (2016) ESIA are identified as endemic or restricted range. This criterion is therefore not considered further within this document.

[29] Consultation with specialists e.g. Dr. Saeed Mohammed Al Khuazi representative of BirdLife International and Howard King, national bird recorder.

[30] The 2011, 2015 and 2016 national reports do not make reference to endemic species.

Table 4.1 Determination of CE or EN Species as per Criterion 1

Species	Common Name	IUCN	RRLA	Comment and Source
Avifauna				
Egreta gularis	Western Reef Heron	LC	VU	Potentially present within Tubli Bay, Ma'ameer Channel and mud flats associated with the Coastal Zone DMU - SCE & ARCWH (2018). **Tubli Bay is considered critical habitat for *Charadrius alexandrinus* (Table 4.2), Ma'ameer channel** as default due to link with Tubli.
Phalacrocorax nigrogularis	Socotra Cormorant	VU	VU	
Charadrius alexandrinus	Kentish Plover	LC	NT	
Mangrove				
Avicennia marina	Grey Mangrove	LC	CR	Present within both Tubli Bay and Ma'ameer Channel – EACS (2016). **Both therefore considered as critical habitat due to national (RRLA) classification of CR**.
Reptiles				
Chelonia mydas	Green turtle	EN	EN	Not observed during EACS (2016) survey. Presence in Bahrain recorded (IUCN) and is possible within the Coastal Zone and *Fasht Al Adhm.* **The DMUs of the Coastal Zone and Fasht Al Adhm are not considered to host significant numbers (Geomatec, 2006) hence these DMUs are not considered as critical habitat for these species.**
Eretmochelys imbricata	Hawksbill turtle	CR	CR	
Caretta caretta	Logger head turtle	VU	-	Not observed during EACS (2016) survey. Presence in Bahrain recorded (IUCN) and is possible (individuals), although unlikely (Geomatec, 2006), within the Coastal Zone and Fasht Al Adhm only. **As such both DMUs are not considered critical habitat for this species.**
Marine mammals				
Dugong dugon	Sea Cow	VU	VU	Potentially present (individuals) within the Coastal Zone and Fasht Al Adhm DMUs – EACS (2016). Main areas of congregation fall outside the project marine DMUs. **As such both DMUs are not considered critical habitat for this species.**
Neophocaena phocaenoides	Finless Porpoise	VU	CR	Possible (individuals) but unlikely present in any significant numbers within Coastal Zone and Fasht Al Adhm. **As such both DMUs are not considered critical habitat for this specie**
Sousa plumbea	Indian Ocean	EN	-	Present within the Coastal Zone, Fasht Al Adhm and Deep water DMUs – EACS

Species	Common Name	IUCN	RRLA	Comment and Source
	Humpback Dolphin			(2016). The species is observed across widespread areas nationally. ***Fasht Al Adhm*** **and the Coastal Zone is likely to represent an important habitat for this species therefore considered as critical habitat.**
Seagrass				
Halophila stipulacea	Seagrass	LC	EN	*H. uninervis* and *H. ovalis* observed during EACS (2016) survey but all species widespread through Fasht Al Adhm and most likely sporadically in low coverage throughout Coastal Zone DMU - Michael Arora pers obs. **Both areas are not considered as critical habitat for these species.** Main distribution located towards the south east of the country and north of, and including, the Hawar islands (Geomatec, 2006).
Halophila ovalis		LC	EN	
Halodule uninervis		LC	EN	
Fish				
Epinephelus coioides	Orange spotted grouper	NT	NT	Not observed during EACS (2016) survey. Presence in Coastal Zone and Fasht Al Adhm recorded - Michael Arora per obs. **Fasht Al Adhm is not considered as critical habitat for this specie.**
Hemipristis elongata	Fossil Shark	VU	-	Not observed during EACS (2016) survey. Presence in Bahrain recorded (IUCN) and is possible within the Coastal Zone and Fasht Al Adhm. **As such both DMUs are considered critical habitat for *Pristis zijsron* as both fall within its known habitat and its CR classification.**
Pristis zijsron	Sawfish	CR	CR	
Rhina ancylostoma	Guitar fish	VU	-	
Stegostoma fasciatum	Leopard shark	VU	-	
Cephalopholis hemistiktos	Half spotted hind	NT	-	Not observed during EACS (2016) survey. Presence in Coastal Zone and Fasht Al Adhm recorded - Michael Arora per obs. **DMUs not considered as critical habitat for this species.**
Corals				
Porites harrisoni		NT	-	Not observed during EACS (2016) survey. Presence in Bahrain recorded (IUCN) and is possible within the Coastal Zone and Fasht Al Adhm albeit in very low coverage. **Given the rarity, nationally, and the physical attributes of Fasht Al Adhm to support such species, it is assigned as a critical habitat for coral species.**
Porites lobata		NT	-	
Platygyra lamellina		NT	-	
Pavona cactus		VU	CR	
Acropora clathrata		LC	-	

Key: LC - Least Concern, NT - Near Threatened, VU – Vulnerable, EN - Endangered, CR - Critically Endangered

4.1.3 Criterion 3 – Migratory and Congregatory Species

Tubli Bay conforms to Tier 2 under IBA A4i, the site is known or thought to hold congregations of ≥1% of the global population of one or more species on a regular or predictable basis. Similarly under the Middle East category (B1i) the site is known or thought to hold ≥ 1% of a flyway or other distinct population of a waterbird species. In particular the classification is triggered by those species identified in **Table 4.2**.

Table 4.2 Species Triggering IBA A4i, B1i (Birdlife International (2018))

Species	Season	Year(s) of estimate	Population estimate	IBA Criteria Triggered
Charadrius alexandrinus	passage	1991	1,500 individuals	A4i, B1i
Charadrius alexandrinus	winter	1988-1992	330-731 individuals	B1i
Pluvialis squatarola	passage	1991	500 individuals	B1i
Charadrius mongolus	passage	1991	2,000 individuals	A4i, B1i
Charadrius mongolus	winter	1988-1992	233-824 individuals	B1i
Calidris falcinellus	passage	1991	800 individuals	A4i, B1i
Calidris alpina	winter	1988-1992	616-1,586 individuals	B1i
Larus genei	passage	1991	3,000 individuals	A4i, B1i

Following consultation with two regional avifaunal experts (Dr. Saeed Al Khuzai and Howard King in September 2018) it is determined that, legally, Ma'ameer channel is an extension of Tubli Bay and that the habitat it provides, although not recognised as an IBA or Ramsar site, can be considered critical habitat for those species which trigger both IBA and Ramsar status in Tubli Bay. As such Ma'ameer channel should be considered a Critical Habitat for avifauna.

4.1.4 Criterion 4 – Highly Threatened and/or Unique Ecosystems

Certainly both Tubli Bay and Ma'ameer Channel can be considered unique nationally primarily due to the presence of mangroves and which are not naturally occurring elsewhere in the country[31]. The habitat they provide to both avifauna and juvenile fish is key. The importance of both is recognised via appropriate legislation and protective status (both internationally and nationally – **Section 2**). As such both meet the requirements of criterion 4 as critical habitat due to the 'CR' classification under RRLA.

Fasht Al Adhm is the largest reef system in Bahrain representing a diverse mixed habitat comprising sea grass, corals, macroalgae and sand beds. Decades of reclamation have targeted other shallow reefs (Fashts) due to the economics associated with reclaiming shallow waters (i.e. less fill material required and close proximity to the mainland). Hence the importance of those Fashts remaining have increased and certainly the recognition of Fasht Al Adhm as being the 'best fishing ground' nationally (Geomatec, 2006) ensures its level of importance nationally. As such it can be considered that Fasht Al Adhm meets the requirements of criterion 4 as critical habitat.

[31] Small stands of mangroves have been planted in the Nationally protected Arad Bay Nature Reserve.

4.1.5 Criterion 5 – Key Evolutionary Processes

The project area does not represent conditions that exhibit special or unique features which could influence evolutionary processes. The seabed topography is typical within the Arabian Gulf (i.e. shallow and intertidal reefs/fashts interspersed with relatively deeper waters). Levels of endemism within the marine environment of the Arabian Gulf is low; there are few or no endemic corals in the Gulf (Sheppard *et al*. 2010) and only 16 known species of fish (Coles and Tarr, 1990).

The marine habitats do not represent particular ectones, corridors or oases that are exceptionally important to evolutionary processes and hence are not consider as critical habitat under criterion 5.

4.2 Summary and Conclusions

Table 4.3 summarises the findings of the Critical Habitat Determination (CHD). It should be noted that as per GN57 of IFC PS6 Guidance Notes, both Tubli Bay and Ma'ameer Channel are, by default, considered critical habitats due to their national protective status and, in the case of Tubli Bay, its classification as an IBA (A4i, B1i). Fasht Al Adhm and the Coastal Zone, although not afforded any national protection, meets many of the requirements for critical habitat and as such is indicated as such in **Table 4.3**.

Critical Habitat provides a description of areas with the highest biodiversity conservation requirements and takes into account both global and national priorities and builds on the conservation principles of 'vulnerability' (threat) and 'irreplaceability' (rarity/restricted distribution). It is understood that not all Critical Habitats are equal. The IFC distinguish two main grades:

Tier 1 Critical Habitat highest importance in which development is very difficult to implement and offsets are generally not possible except in exceptional circumstances.

Tier 2 Critical Habitat of high importance in which development may be possible and offsets may be possible under some circumstances. As per the information provided in **Table 4.3**, all identified CH are considered to be Tier 2.

Table 4.3 Critical Habitat Summary

Criterion	Feature	Rationale	Critical Habitat
Criterion 1: Critically Endangered (CR) and/or Endangered (EN) species	*Avicennia marina*	Both Tubli Bay and Ma'ameer Channel support nationally important (RRLA classification of CE) concentrations of this species.	Yes – Tier 2
	Sousa plumbea	Fasht Al Adhm and the Coastal Zone provides an important habitat and source of food to this EN species.	Yes – Tier 2
	Pristis zijsron	Fasht Al Adhm and the Coastal Zone provide an important habitat and source of food to this CR species.	Yes – Tier 2
	Porites harrisoni	Fasht Al Adhm represents the physical attributes to support such coral species. Similar habitats (shallow reef with hard substrate) are considered rare nationally and hence although only *P. cactus* has been assigned a CR classification, the corals indicated are afforded a similar national class following local and expert opinion.	Yes – Tier 2
	Porites lobata		
	Platygyra lamellina		
	Pavona cactus		
	Acropora clathrata		
Criterion 3: Migratory and/or congregatory species	Avifauna - *Charadrius alexandrinus*, *Pluvialis squatarola*, *Charadrius mongolus*, *Calidris falcinellus*, *Calidris alpina*	Tubli Bay conforms to Tier 2 under IBA A4i, the site is known or thought to hold congregations of ≥1% of the global population of one or more species on a regular or predictable basis. Similarly under the Middle East category (B1i) the site is known or thought to hold ≥ 1% of a flyway or other distinct population of a waterbird species. Given the physical link to Tubli and the movement of birds, Ma'ameer channel can also be considered a critical habitat for avifauna.	Yes – Tier 2
Criterion 4: Highly threatened and/or unique ecosystems	*Avicennia marina*	Tubli Bay and Ma'ameer Channel support the only presence of *Avicennia marina* within the Kingdom of Bahrain. Further the protective status of both confirms its uniqueness nationally but also its threatened status.	Yes – Tier 2
	Mixed habitats of Fasht Al Adhm (sea grass, corals and algae)	Fasht Al Adhm is second to none nationally both in size and diversity of habitats.	Yes – Tier 2

5 BASELINE DATA – ADDITIONAL 2018 SURVEYS

5.1 Introduction

In response to the determination of the Ma'ameer channel as a CH and the potential for this habitat to be adversely impacted as a result of the proposed pipeline crossing, a walk over survey was conducted on the 13th August 2018 to assess mangrove coverage within the affected area. The following sections present the findings.

5.2 BMP 2018 walkover survey

5.2.1 Extent of study area

The aim of the walkover survey was to provide a more accurate determination of the coverage of the grey mangrove *Avicennia marina* within the potential work zone for the at the Ma'ameer pipeline crossing. The potential work zone for the purpose of this investigation has been defined as an area:

1. Extending +200 m south of the existing pipeline crossing ,on each side of the channel - this is where the main work area will be located;
2. +100 m north of the existing pipeline crossing, on both sides of the channel, which is included as a conservative approach as this area may be considered for use during construction.

This resulted in four discrete survey sections and as highlighted in **Figure 5.1**.

5.2.2 Methodology

The survey methods used were based on the Standard Survey Methods and the Mangrove Monitoring Program developed by PERSGA, as described in PERSGA (2004)[32].

Data collection involved the entire estimation of mangrove coverage along each of the four sections both as identifiable parcels (groups of trees) or individual trees. A tape measure was used to estimate the area of each parcel or individual tree in meters (i.e. length by width) or in the case of larger parcels the percentage coverage within the defined parcel. In each case the average height of the individual tree or parcel of trees was also recorded. The results are presented in **Table 5.1** and graphically represented in **Figure 5.1**.

General observations were also recorded such as the presence of dead or felled trees, mature trees with dropped limbs, trees with top dying uppermost outermost sun branches, presence of seedlings and leaves with spotty chlorosis and necrosis and / or curling leaves and presence of Pneumatophores[33]

[32] Some modifications were made to the methodology to suit the local conditions.
[33] Aerial roots specialized for gaseous exchange.

5.2.3 Findings

Section 1 comprised five small parcels of adult trees, some of which only contained a single adult tree. Section 3 and 4 on the West side of the bank had a larger density of mature trees, with the greatest coverage within Section 4.

Section 2 appeared to consist of two uniform rows of saplings spaced approximately 1 m apart along the length of the 100 m section. The uniform nature of the presence of saplings gave the indication that they had been planted (see circled areas in **Figure 5.3**). The general condition of these saplings was poor, with very few green leaves present and the majority of the plants had curled and brown leaves. There were no mature trees in Section 2.

Average heights for adult trees at all locations were above 1 m (where they occurred), and over 2 m at some locations with the exception of Section 2 which comprised small saplings. Although there is no parametric data available for *A. marina* species in Bahrain, Moore *et al.* (2015) recorded canopy heights, in the UAE, of up to 3 m, while PERSGA (2004) documented *A. marina* in the Red Sea reaching up to 6 m in height.

Based on observations and the survey data, the mangroves within the study area appear to be relatively healthy with the exception of Section 2 (see **Figure 5.3**). Although leaves with spotty chlorosis and necrosis were present throughout the site they were not a dominating feature in most instances and there were no dead or felled trees.

Pneumatophores also appear to be in good condition and present throughout Sections 1, 3 and 4. Although dead tips and bending was recorded throughout the survey location they were only present in very low proportions.

Table 5.1 Results of walkover survey in potential work zone at pipeline crossing within Ma'ameer channel

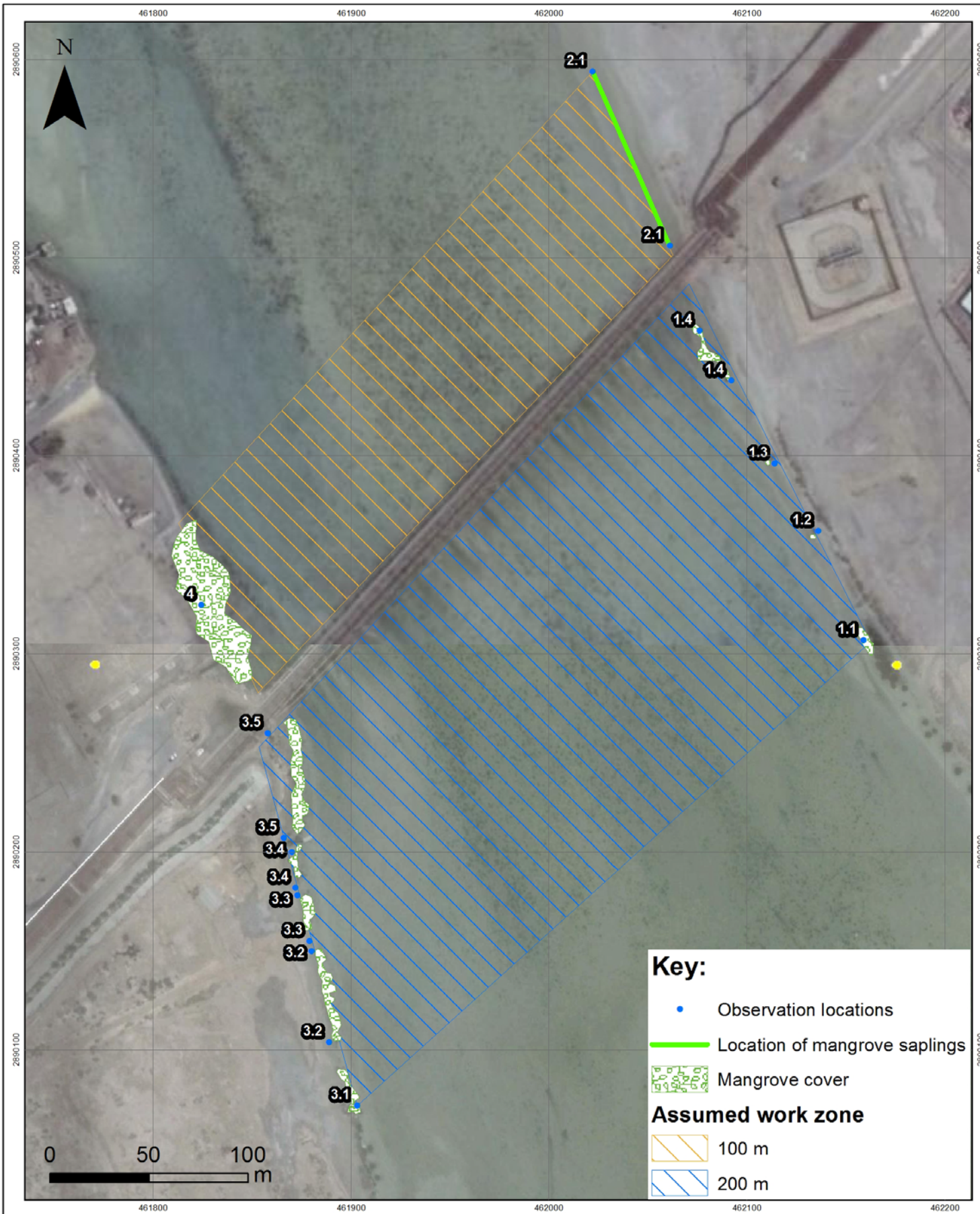
Section	Coordinates, UTM WGS 84		Number of mature trees	Number of saplings	Estimated coverage (total m^2)	Average height of mature tree
	Northing	Easting				
1.1	2890307	0462159	5	10	15.7	1.0
1.2	2890362	0462136	1	-	3.0	1.4
1.3	2890396	0462114	1	-	2.55	1.5
1.4	2890452	2890452	7	>40	57.55	1.5
	2890463	0462076				
Estimated total area of coverage Section 1 - 78.8 m^2						
2.1	2890594	0462022	0	~80 - 100	<1.0	0.20
	2890506	0462061				
Estimated total area of coverage Section 2 - <1.0 m^2 [34]						
3.1	2890072	0461903	7	6	41.75	1.1
	2890088	0461896				
3.2	2890104	0461889	26	20	150.0	1.5
	2890150	0461880				
3.3	2890155	0461879	20	15	64.8	1.5

[34] It is estimated that all saplings could fit into an area of less than 1 m^2.

Section	Coordinates, UTM WGS 84		Number of mature trees	Number of saplings	Estimated coverage (total m^2)	Average height of mature tree
	Northing	Easting				
	2890178	0461873				
3.4	2890182	0461872	16	20	63.0	1.75
	2890200	0461870				
3.5	2890207	0461866	>50	>50	235.1	1.75
	2890260	0461858				
Estimated total area of coverage Section 3 - 554.65 m^2						
4.1	2890364	0461818	>80	>50	841.5	2.0
	2890287	0461849				
Estimated total area of coverage Section 4 - 841.5 m^2						
Estimated total area of coverage (all Sections)					**1,475.95 m^2**	

Figure 5.2 provides a photomontage of the general site conditions on site at Sections 1, 3 and 4.

It should be noted that there were large amounts of waste and litter throughout all of the 3 sections surveyed, as highlighted in **Figure 5.4**. The waste consisted of scrap wood, metal, plastic, tyres, construction waste etc.



Title: **Mangrove Coverage**		Client: Bapco, TechnipFMC
Project: BMP Critical Habitat Assessment		
Date: August 2018	Figure No.: 5.1	Consultant: Environment Arabia
Datum: WGS 84 - UTM 39N	Scale: 1:2500 (A4)	

CN:\Critical Habitats Assmt BMP 1B064305\mxd\mangrovesurvey1.mxd

Figure 5.2 **Photomontage of *Avicennia marina* in Section 1 (top image) and Section 3 (middle image) and Section 4 (bottom image)**

Figure 5.3 Photomontage of *Avicennia marina* saplings within Section 2

Figure 5.4 Significant amounts of waste and rubbish intertwined in the mangrove stands and surrounding areas

6 ASSESSMENT METHODOLOGY

6.1 Introduction

Impact significance is 'calculated' as a product of sensitivity criteria (**Section 6.2**), and the magnitude of an impact (**Section 6.3**). To calculate the level of significance, the formula presented below has been utilized.

Impact Significance = Magnitude of Impact x sensitivity of Receptor

Table 6.1 provides classifications of the resulting impact. A definition of each is presented in **Table 6.3**.

Table 6.1 Calculation of Impact Significance

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

6.2 Sensitivity criteria

Sensitivity of marine habitats and/or species of note takes into account its rarity (e.g. IUCN Red List status, occurrence on a national scale), diversity, size, naturalness, vulnerability, representativeness and recoverability. Sensitivity criteria are devised to be consistent over extended periods; however, where natural habitats continue to be rapidly lost due to anthropogenic activities (e.g. reclamation), the value of these habitats and associated biota as sensitive receptors increases with time.

Table 6.2 presents the sensitivity criteria developed for marine ecological receptors.

Table 6.2 Marine Ecological Interests – Sensitivity Criteria

Scale	Sensitivity
High	The marine or coastal habitat(s) and/or one or more species (the 'receptor') within the potentially impacted area are of national and/or international importance, and may constitute, in part or whole, a national or internationally designated conservation/protected site and/or conservation priority species which is/are considered to be sparsely represented nationally and beyond. The habitat(s) may be an extremely good example of its type such as an intertidal flat, coastal lagoon, seagrass meadow or coral reef. The habitat(s) is likely to constitute a key primary producer and/or support highly diverse or unique assemblages of associated biota, including mammals (Dugong) and turtles and/or avifauna. The potential for the receptor to recover following physical disturbance is low (i.e. long term). **Meets the criteria for Critical Habitat under IFC Performance Standard 6**
Medium	The marine or coastal habitat(s) and/or one or more species are of importance within a national context. The habitat(s) supports moderately diverse

Scale	Sensitivity
	assemblages of epibiota, infauna and/or fishes. Examples of such marine habitats may include rock with sand veneer, patchy seagrass and macroalgal beds, and are representative of a largely undisturbed marine environment. The potential for the receptor to recover following physical disturbance is moderate (i.e. medium term).
Low	The marine or coastal habitat(s) and its associated species (the 'receptor') within the potentially impacted area are of lower importance as conservation features and/or primary producers, both locally and nationally, and may have been subjected to previous anthropogenic disturbance or be well represented as a national resource, for example, deep-water mud habitats. The habitat(s) may possess low biodiversity. The potential for the receptor to recover following physical disturbance is likely over the short term.
Negligible	The marine or coastal habitat(s) and associated biota, are of negligible national importance as a conservation feature, primary producer or exploitable resource as result of having been severely impacted by present and/or past anthropogenic activities. Examples of such degraded habitats may be within dredged areas in the marine environment or industrialised coastal fringes.

6.3 Magnitude criteria

Quantifying the magnitude of an impact is defined via a number of sub-criteria. Typically these may be informed following specialist modelling studies (e.g. sediment dispersion modelling studies), expert opinion, review of contractor's methodologies, and reference to published data (e.g. sediment 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 temporary (T-less than one year), short-term (ST-one to five years), medium term (MT-five to ten 10 years), long-term (LT-over ten years), or permanent (P).
- **Likelihood:** 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 (Li), and definite (De)).
- **Direct** (D): impacts that result from direct interaction between a project activity and the receiving environment (e.g. destruction of habitat beneath development footprint).
- **Indirect** (I): impacts that result from other activities as a consequence of the project (e.g. smothering of species at a nearby location as a result of deposition of suspended sediment generated by construction activity).

6.4 Impact significance

Table 6.3 presents the impact scale of significance and as employed to define the level of impact upon ecological receptors.

Table 6.3 Scale of Impact Significance

Impact significance	Impact Description
Negligible	Very short term and of limited spatial extent typically limited to the immediate area adjacent to the source of impact. The loss is negligible and unlikely to register on a national scale.
Minor Adverse	Short term, temporary impacts where natural recovery is very likely over a very short time period (e.g. less than 1 year), or where the receptor has low level physiological responses to identified stressors (e.g. behavioural responses, etc.). The loss is small compared to national resources.
Moderate Adverse	Medium to long term (3-5 years) or spatial extent of the stressor (e.g. extent of plume) with regards its level of impact (e.g. lethality or physical damage). This may result in the displacement of species on a temporary basis.The loss represents a significant proportion of the national resource
Major Adverse	Long term (i.e. five years) or permanent loss of the receptor. Rrecoverability is unlikely even in the event of cessation of stressor. The loss represents a major proportion of the regional resource.

6.5 Mitigation

Mitigation for identified impacts can be addressed via implementation of best practice as presented within **Section 7**. Where critical habitat is identified, under PS6 (paragraph 17) it is stated that the client will not implement any project activities.

Key requirements (to address legally protected areas and CH) are stated in paragraphs 13 – 20 of PS6 and are summarised in **Table 6.4**.

Table 6.4 Key mitigatory requirements under PS6

Paragraph	Requirement
14	– Seek alternative locations if possible. – Consult with stakeholders. – Apply habitat mitigation according to mitigation hierarchy.
15	– Apply mitigation to achieve no net loss. – Identify and protect “set asides”. – Implement measures to minimise habitat fragmentation. – Restore habitats during and/or after operations. – Implement biodiversity offsets.
17	– Client will not implement any project activities unless the following implemented: o No other viable alternatives within the region exist for development of the project on modified or natural habitats that are not critical. o The project does not lead to measurable adverse impacts on those biodiversity values for which the critical habitat was designated, an on the ecological processes supporting those biodiversity values. o The project does not lead to a net reduction in the global and/or national/regional population of any CE or EN species over a

Paragraph	Requirement
	reasonable period of time o A robust, appropriately designed, and long term biodiversity monitoring programme and evaluation program is integrated into the client's management program[35].
18	– Where the client can meet the requirement of paragraph 17, the mitigation strategy will be described in a Biodiversity Action Plan (BAP) and which will be designed to achieve net gains of those biodiversity values for which the critical habitat was designated.
19	– Where biodiversity offsets are proposed as part of a mitigation strategy, the client must demonstrate through an assessment that the project's significant residual impacts on biodiversity will be adequately mitigated to meet paragraph 17.
20	Where the project is in a legally protected area, the client will meet the requirements of paragraphs 13-19 in addition to: – Demonstrate that the development is legally permitted. – Conform to government recognised management plans for the area. – Conduct consultation with appropriate stakeholders. – Implement additional programs to promote and enhance conservation aims of the area.

[35] Bapco has, for the past 3 decades engaged the services of Stockholm University to conduct regular marine monitoring surveys to assess the state of the marine ecology within and around the area of influence of the Bapco Outfall. The continuation of such surveys would likely comply with this requirement, however may need to be updated with increased frequency or modifications as a result of the BMP. This requirement will be presented in the future Biodiversity Action Plan (BAP).

7 IMPACT ASSESSMENT OF CRITICAL HABITATS

7.1 Introduction

The following sections provide an assessment of potential impacts arising from construction and operational related activities on the identified Critical Habitats. Detailed construction methodologies have not been provided at this stage; however, they are likely to include generic operations (e.g. excavation, temporary reclamation, piling etc) from which impacts are well documented.

Impact significance is based on the sensitivity criteria and magnitude of impact as defined in **Section 6**.

7.2 Construction related impacts

Table 7.1 identifies the project DMUs and, based on the project description and findings of EACS (2016) BMP ESIA, those which will not be affected by construction related activities. Those that are identified as being at risk are subsequently discussed in the following sections.

Table 7.1 Rapid construction impact risk assessment

DMU	Interaction with project construction activities	
	Direct	Indirect
Tubli Bay	None	Unlikely
Ma'ameer channel	Yes	Yes
Coastal Zone	None	None
Fasht Al Adhm	None	None

As construction works will not take place within the Fasht Al Adhm and Coastal Zone DMUs, these areas are not considered in **Section 7.2**. The following sections address the DMUs of Tubli Bay and Ma'ameer channel only; the former is included due to its physical link to the Ma'ameer channel only. Impacts are discussed per DMU with only those activities deemed to have an impact.

7.2.1 Tubli bay

There are no construction activities required within Tubli Bay; the closest works (construction of the pipe bridge) are identified in Ma'ameer channel (**Section 5** and **Figure 5.1**) which is located some 1.1 km to the south of the southernmost tip of Tubli Bay. The two bodies of water are partially separated by a road crossing where culverts are in the order of 20 m width. Given restrictions at the southern end of the channel (a culvert of appx 2-3 m), it is thought that the channel only supports a dominant southern directional water flow[36].

Consequently there is **no impact** on the CH of Tubli Bay either directly (e.g. physical destruction of habitats) or indirectly (e.g. degradation of marine water quality by marine sediment loading).

[36] This will be confirmed via specialist studies as part of the Ma'ameer Channel ESIA.

The assessment of a large spill of fuel/oil at the work site, and which could theoretically travel up the channel to Tubli Bay, has not been made as such spills are most unlikely and suitable mitigation presented in **Section 8**.

7.2.2 Ma'ameer Channel

As part of the BMP, the existing pipeline bridge crossing Ma'ameer channel will need to be replaced with new designs allowing for additional pipe capacity and increased height over the water body so as to minimise the effect of corrosive seawater on both concrete and steel structures.

For the purpose of this CHA, the study area is defined as an area extending +200 m south of the existing pipeline crossing on either side of the channel, this is where the main work area will be located; and +100 m north of the existing pipeline crossing (**Figure 5.1**). As a worst-case scenario it is assumed that all mangroves that fall within this area will be lost as a consequence of:

- The bridge footprint itself.
- Proposed temporary reclamation work which will require a platform to be temporarily reclaimed to facilitate, amongst others, piling activities.
- Indirect impacts associated with degradation of water quality due to marine sediment loading and spills of fuels/oils.

7.2.2.1 Direct loss of mangroves due to pipe bridge

Section 5 highlights the outcome of a survey undertaken in August 2018 within the defined work zone in which it can be assumed (as a worse case) that the physical destruction of the critical habitat qualifying biodiversity feature (i.e. mangroves) would be 100% (i.e. 1,475.95 m^2).

The national coverage of mangroves is estimated at approximately 30 hectares (ha) / 30,0000 m^2 [37], hence, the loss represents approximately 0.5% of the national inventory. The coverage within the Ma'ameer Channel DMU has been estimated[38] as approximately 36,194 m^2. Hence, the loss of critical habitat qualifying biodiversity features as a percentage of the Ma'ameer Channel DMU has been calculated as approximately 4%.

The sensitivity of the receptor is considered high based on the criteria highlighted in **Table 6.2**. The geographical extent of the impact is low given the insignificant coverage of the mangroves within the affected area although the impact, for those affected plants, is considered permanent. Subsequently a magnitude of low is assigned which, following the method shown in **Section 5**, results in a **moderate adverse impact**. The features of the impact are further summarised in **Table 7.2**.

[37] Rapid assessment of coverage by EACS (using Google Earth, 2016) as stated in the BMP ESIA.
[38] Rapid assessment of coverage by EACS (using Google Earth, 2018) during this assessment.

7.2.2.2 Sediment loading and suspension on mangroves

Construction activities in the Ma'ameer Channel DMU have the potential to result in sediment loading of marine waters. This may result in temporary adverse impacts on those species which utilise specific feeding modes, particularly suspension/filter-feeding organisms, but also impairment of photosynthesis within macroalgal species and impeding respiratory functions of fish. In the case of Ma'ameer channel, such receptors are limited to infaunal species which are ubiquitous throughout and accustomed to high turbidity associated with the ambient channel conditions.

The CH trigger species, *Avicennia marina*, naturally stabilize sediments which can result in the formation of new mudflats, Okello *et al* (2014)[39], however large releases of sediments can result in adverse impacts. Moderate sedimentation is said to be beneficial to mangroves as a source of nutrients (NOAA 2014).

The proposed construction works will be temporary in nature and sediment suspension arising from reclamation and piling works will be controlled via suitable mitigation as dictated by national guidance EIA-8 including the use of low silt sediments for reclamation and use of silt curtains.

The magnitude of impact is considered negligible given the temporary nature of the works, the likely volumes of sediments released (controlled due to design mitigation) is considered negligible and as such the physical extent of any impact is not anticipate to extend beyond the area identified in **Section 5.2**. Subsequently a **Minor adverse impact** is assigned. The features of the impact have been summarised in **Table 72**.

7.2.2.3 Impact of loss of feeding grounds on avifauna

Although birds are not known to nest at Ma'ameer, the channel does provide an important food source. Estimated at 100 hectares (ha) the shallow waters and mudflats are rich in invertebrates. The proposed pipe crossing will result in a negligible permanent loss of habitat due to the presence of piled structures; additionally the temporary reclamation will lead to a loss of feeding area approximately of 1.5 ha (equivalent to 1.5% of the channel). The proposed reclamation will be removed following completion of construction works and it is thought that the natural marine habitat will be recolonised by invertebrate communities with a short period of time. As such the loss of feeding area for birds is considered negligible and hence a **minor adverse impact** is assigned.

7.2.2.4 Impact of noise on fish

Given the shallow waters (less than 1 m) and restricted access of Ma'ameer channel, megafauna (i.e. turtles, dugong and dolphins) cannot enter the channel hence noise impacts are not applicable to these receptors. Fish however are known to breed in the waters and juveniles are regularly observed within the mangrove root systems and surrounding waters.

[39] Okello JA, Robert EMR, Beeckman H, Kairo JG, Dahdouh-Guebas F, Koedam N. Effects of experimental sedimentation on the phenological dynamics and leaf traits of replanted mangroves at Gazi bay, Kenya. *Ecology and Evolution*. 2014;4(16):3187-3200. doi:10.1002/ece3.1154.

Construction operations will result in the propagation of marine noise particularly associated with the temporary reclamation and piling works. The shallow nature of the waters will to some extent promote the attenuation of sound waves either via nature of the sandy seabed and/or water surface.

Underwater noise generated from impulsive pile driving could potentially cause physical injury or mortality to fish, especially those with a swim bladder (e.g. snapper, rabbitfish, perch, grouper). Impulsive noise could potentially result in swim bladder tissue damage, including rupture of the swim bladder that will lead to death, if a fish is in the vicinity of where impulsive pile driving occurs. This of course is dependent upon a number of factors including locations, energy from piling and type of fish.

Fish may potentially experience auditory tissue damage (i.e., damage to the sensory hair cells of the ear) or temporary hearing loss where exposed to high levels of sound for short durations or lower levels of sound for longer period of time. The extent of tissue damage varies depending on a number of factors, including pressure level, frequency, duration, repetition rate of the sound, size and development stage of the fish (i.e. juvenile, adult, etc.).

It has been found that fish are able to recover from varying levels of substantial auditory tissue damage within a period of less than 18 hours after exposure (Popper *et al*., 2006). However, severe damage could lead to permanent loss of hearing. Indirect effects of hearing damage or loss in fish may relate to the fish's reduced fitness, which may increase its vulnerability for predation and result in the reduction or elimination of its ability to locate prey, communicate, and sense the physical environment (Popper *et al*., 2006).

Given that Ma'ameer channel is designated a CH (due to presence of mangroves, avifauna and its legally protective status as a biodiverse area), the receptor sensitivity is considered high. The features of the marine noise impact are temporary in nature and limited geographical extent. As such a negligible magnitude classification is made resulting in a **minor adverse impact**. The features of the impact have been summarised in **Table 7.2.**

7.2.2.5 Impact of spillages of fuels on mangroves and avifauna

Marine construction works will require the use of heavy plant (cranes, generators, excavators etc.) all of which will require refueling. As such there will likely be a requirement for diesel to be stored on site and close to the banks of Ma'ameer channel. Although best practice will require such fuel stores to be placed at least 20 m from the water's edge and within bunded areas, the potential for a spill event exists either directly from storage areas, from plant at works sites, or during refueling.

Marine organisms are known to be highly sensitive to diesel spills. Diesel is considered to be one of the most acutely toxic oil types (NOAA 1999). The chemical components light oils such as diesel have a higher biological availability and damage through toxicity is more likely than for heavy fuel oil (HFO) (ITOPF, undated). Fish kills following small diesel spills have only been reported for small spills in confined, shallow water (NOAA, 2006).

Effects of oil on mangroves are documented (NOAA, 2014) and summarised below:

- Mangroves are highly susceptible to oil exposure; oiling may kill them within a few weeks to several months.
- Lighter oils are more acutely toxic to mangroves than are heavier oils. Increased weathering generally lowers oil toxicity.
- Oil-impacted mangroves may suffer yellowed leaves, defoliation, and tree death.
- More subtle responses include branching of pneumatophores, germination failure, decreased canopy cover, increased rate of mutation, and increased sensitivity to other stresses.
- The amount of oil reaching the mangroves and the length of time spilled oil remains near the mangroves are key variables in determining the severity of effect.
- Mangrove-associated invertebrates and plants recover more quickly from oiling than do the mangroves themselves, because of the longer time for mangroves to reach maturity.
- Under severe oiling conditions, mangrove impacts may continue for years to decades, resulting in permanent habitat loss.

In the event of a spill, volumes are likely to be small (i.e. less than 200 L) and at most equivalent to a one drum. In a worst-case scenario marine plant may become immersed resulting in a release of its diesel store - an estimate of 600 L is made. Given the volatile nature of diesel evaporate rates will be high hence the duration of impact is considered negligible. An impact of **minor adverse** on mangroves is made in the unlikely event of a spill; a similar classification is made for fish life given the narrow nature of the channel, the rapid nature that a spill could spread and the presence of an estimated 34,718 m^2 of mangroves located downstream (equivalent to 11.5% of the national resource). Appropriate mitigation is made within **Section 8**. The features of the impact have been summarised in **Table 7.2.**

In the event of a small spill of diesel as indicated above, it is likely that avifaunal interests will be impacted directly via the physical contact with the spill itself. The toxicity of diesel to avifauna is high although its rapid evaporation will mitigate this. The potential for beaching of a spill may contaminate food sources which may indirectly impact upon birdlife. Given the likelihood of a spill occurring is low and that the volumes associated with such a spill are small, the magnitude of the impact is considered negligible and as such, a **minor adverse impact** is assigned.

Table 7.2 Construction Impact Summary Table

Description of Impact	Location	Receptor sensitivity	Features of impact				Type of impact (D,I,S[a])	Impact significance
			Magnitude	Extent	Duration	Likelihood		
Construction works	Tubli bay	High	-	-	-	-	-	No impact
Direct oss of mangroves due to pipe bridge	Ma'ameer channel	High	Low	Limited	Permanent	Likely	Direct	Moderate adverse
Sediment loading/suspension on mangroves		High	Negligible	Limited	Temporary	Likely	Indirect	Minor adverse
Loss of feeding grounds on avifauna		High	Negligible	Limited	Temporary	Likely	Direct	Minor adverse
Noise on fish		High	Negligible	Limited	Temporary	Likely	Direct	Minor adverse
Spillage of fuels/oils on mangroves		High	Negligible	Limited	Temporary	Unlikely	Direct & Indirect	Minor adverse
Spillages of fuels/oils on avifauna		High	Negligible	Limited	Temporary	Unlikely	Direct & Indirect	Minor adverse
Release of diesel on fish		High	Negligible	Limited	Temporary	Unlikely	Direct & Indirect	Minor adverse

"-" – No values assigned / does not occur

7.3 Operation

Table 7.3 presents the potential impacts associated with the routine operation of the BMP on the receiving environment at the DMUs classified as CH.

Table 7.3 Identification of potential impacts during routine BMP

DMU	Routine operation
Tubli bay	No source of impact.
Ma'ameer channel	
Coastal Zone	Release of thermal effluent.
Fasht Al Adhm	

7.3.1 Tubli bay

As stated in **Section 7.2** and **Section 7.2.1** Tubli bay is identified as being within the project area due to the direct physical link with the Ma'ameer channel. However due to physical restrictions (i.e. bridges and culverts) and the presumed one way flow (or dominant southern flow) of waters within the Ma'ameer channel, **No Impacts** are identified on any receptor within Tubli bay as a result of the normal operational regime of the BMP.

7.3.2 Ma'ameer DMU

Routine operations post BMP will have **No Impact** on CH within the Ma'ameer channel. The pipeline crossing is a static structure with no release of effluents to the channel.

7.3.3 Coastal Zone

The key feature of effluents discharged to sea from the BMP is thermal pollution. EACS (2016) BMP ESIA has indicated that the total volume of effluents will decrease from the existing Bapco Refinery, and as such the footprint of thermal plume affected biological areas will reduce as a result of the BMP.

The existing refinery has been in operation for over 6 decades and as such impacts upon ecological receptors (i.e. marine habitats) have already taken place.

7.3.3.1 Impact on Longcomb Saw Fish - *Pristis zijsron*

As there is a potential for the Longcomb Saw Fish to exist (during some unknown stage of its life) within the affected section of the Coastal Zone DMU, the habitat has conservatively been classified as CH. The likelihood of the trigger specie being present is considered extremely low/unknown as there is no national specific data.

Should the fish be present, it would likely avoid those sea areas where unsuitable conditions (i.e. high temperatures) arise and which have been present for several decades. It should be noted that the EACS (2016) BMP ESIA carried out thermal plume dispersion modelling which showed that the majority of thermally affected areas were limited to within ~1,000 m of the discharge point and in shallow waters (< 2.0 m), unlikely to support such a species.

Given that the BMP will result in a smaller thermal plume footprint than that existing, no additional adverse impact upon *Pristis zijsron* habitat is likely, however as future plumes associated with the BMP will prevent natural rehabilitation of currently affected marine habitats a **minor adverse impact** has conservatively been assigned. The features of the impact have been summarised in **Table 7.4**.

7.3.3.2 Impact on Indo-Pacific Dolphin – *Sousa plumbea*

As stated in **Section 7.3.3.1** the BMP will result in a smaller thermal plume footprint than existing; furthermore, damage to marine habitat has already occurred and hence the loss of food resource for *Sousa plumbea* can be considered as an existing situation.

Sousa plumbea are regularly sighted in the coastal zone[40] indicating that existing food sources are available. The imposition of BMP will better the current situation however as stated in **Section 7.3.3.1** the continuation of thermal plumes will prevent natural rehabilitation of marine habitat and as such a **minor adverse impact** is conservatively assigned.

7.3.4 Fasht Al Adhm

7.3.4.1 Impact on corals due to thermal plume

Plume dispersion modelling carried out as part of EACS (2016) BMP ESIA showed that thermal plumes travel in a north and south trajectory parallel to the existing coastline. The modelling shows that at the point of interaction with Fasht al Adhm, delta T (difference between ambient baseline temperature and that from the outfall) is in the order of 0.1 °C. As such the magnitude of any impact upon corals is considered **negligible** although of long term duration.

As indicated in **Section 7.3.3**, the impacts upon sensitive ecological habitat and its components will have already take place during the preceeding 6 decades of Bapco refinery operations. As such a **negligible impact** is assigned. The features of the impact have been summarised in **Table 7.4.**

The reader is advised that a standalone thermal plume assessment is currently being carried out and will specifically focus on potential thermal impacts upon Fasht Al Adhm in particular corals and seagrass. Sensitivity criteria for these receptors will be presented based on thermal tolerance as absolute values and duration.

[40] Sarah Ben Arfa (pers comms, 2018).

Table 7.4 Operational Impact Summary Table

Description of Impact	Location	Receptor sensitivity	Features of impact				Type of impact (D,I,S[a])	Impact significance
			Magnitude	Extent	Duration	Likelihood		
Routine operation	Tubli bay	High	-	-	-	-	-	No impact
	Ma'ammer channel	High	-	-	-	-	-	No impact
Thermal pollution on Long comb Sawfish *Pristis zijsron*	Coastal Zone	High	Negligible	Limited	Permanent / long term	Definite	Direct	Minor adverse
	Fasht Al Adhm	High	Negligible	Limited	Permanent / long term	Definite	Direct	Minor adverse
Thermal pollution on Indo-Pacific Dolphin – *Sousa plumbea*	Coastal Zone	High	Negligible	Limited	Permanent / long term	Definite	Direct	Minor adverse
	Fasht Al Adhm	High	Negligible	Limited	Permanent / long term	Definite	Direct	Minor adverse
Thermal pollution on corals	Fasht Al Adhm	High	None	-	-	Unlikely	Direct	Negligible
Thermal pollution on marine habitat	Fasht Al Adhm	High	None	-	-	Unlikely	Direct	Negligible

"-" – No values assigned / does not occur

8 MITIGATION, RESIDUAL IMPACT AND MONITORING

8.1 Introduction

Following best practice, mitigation is to be applied to all identified impacts. EACS (2016) BMP ESIA presented much of these however in line with PS6 requirements (**Section 6.5** and **Table 6.4**), this section reintroduces these and, where necessary, presents suitable compensatory measures such that a net gain in biodiversity is achieved for those critical habitats where losses are identified.

The project will adhere to all the requirements of paragraph 20 (P20) of PS6 as it has been identified that the project is within a legally protected area. The requirement of paragraph 20 of PS6 states that the client must meet the requirements of paragraphs 13 through to 19. With reference to P14 of PS6, it has been demonstrated that there are no viable alternatives for the project to cross a modified habitat (rather than CH). In accordance with P17 of PS6, the Biodiversity Action Plan (BAP) shall include a robust, appropriately designed long term biodiversity monitoring and evaluation program.

In addition, additional programs, as appropriate, to promote and enhance the conservation aims and effective management of the area (as per P20 of PS6) shall be presented in the BAP following consultation with the SCE if required.

Section 8.2 and **Section 8.3** presents pertinent mitigation based on best practice and as presented in the EACS (2016) BMP ESIA. **Table 8.1** presents an impact summary table and which indicates the residual impact upon successful implementation of mitigation and/or biological offset.

8.2 Construction

8.2.1 Tubli Bay DMU

There will be no construction works conducted at this location hence there is no requirement for mitigation or monitoring.

8.2.2 Ma'ameer Channel DMU

As per the requirements of PS6, if any project activity is located in legally protected areas then the client has to demonstrate that the proposed development in such area is legally permitted. EACS is conducting an Environmental Impact Statement (EIS) for Ma'ameer Channel pipeline bridge work to obtain approval from the SCE. This EIS will outline the requirement for mitigation and monitoring; importantly it will link with a BAP (yet to be prepared) which will outline the measures required to ensure positive net gains for the mangrove resources.

8.2.2.1 Loss of mangroves

As highlighted in **Section 4**, the IFC PS6 distinguishes two Tiers (1 and 2). The CH potentially impacted by the BMP project fall under the category of Tier 2 and as such, development may be possible and offsets may be possible under some circumstances.

The required conservation outcome under PS6 is 'no-net-loss of biodiversity value achieved using the "like-for-like" or better principle of biodiversity offsets' (Stefan, C.I *et*

al 2013). It is noted that when a project occurs in critical habitat (CH) supporting exceptional biodiversity value, a **net gain in biodiversity value is required**.

A key principle of these requirements is that the project design and implementation will avoid impacts on critical habitat qualifying biodiversity features or, in cases where this may not be possible, follow the mitigation hierarchy of minimization, restoration and offsetting.

It will therefore be necessary to produce a Biodiversity Action Plan (BAP). A biodiversity action plan (BAP) is an internationally recognized program addressing threatened species and habitats and is designed to protect and restore biological systems. The original impetus for these plans derives from the 1992 Convention on Biological Diversity (CBD). The BAP should include a realistic and feasible plan to ensure that mangroves within the work zone are relocated. All efforts to achieve relocation will have to have a long term and comprehensive monitoring plan to ensure the success of the programme.

The calculation of losses and gains should ideally be completed in alignment with international guidelines such as the Business and Biodiversity Offset Programme (BBOP) guidelines[41]. It is recommended that this forms part of the BAP along with a detailed monitoring programme to assess construction related impacts upon CH triggering receptors within Ma'ameer channel.

8.2.2.2 Suspended solids

Construction works will result in possible release of sediments as a result of reclamation and rotary pile drilling. Pertinent mitigation is as follows:

- Ensure all materials used for reclamation is as per SCE (2010) EIA guidance. In summary this requires the material to be clean sand and free of plastics, wood and harmful substances. Reference is also made to DELFT (2008) Land Reclamation Manual. Ministry of Works which states that fill material should not exceed 10% fines by volume.
- Ensure that all reclamation is carried out with a fully enclosed bunded area. Materials used for the bund should be sufficient to prevent erosion and of non polluting substances. As per SCE (2010) EIA-8, these may include geotubes, rock, sheet piles etc.
- Ensure that an appropriate Total Suspended Solids (TSS) monitoring protocol is established (this has been detailed in the BMP ESIA Construction Environmental and Social Monitoring Plan (CESMP)).
- Fully contain the work zone, with silt curtains (i.e. north and south of the works area) as appropriate during activities.

8.2.2.3 Loss of feeding areas for avifauna

The implementation of the BAP will provide additional habitat which in turn will provide additional feeding grounds for avian interests within the Ma'ameer channel[42].

[41] Business and Biodiversity Offsets Programme (BBOP). 2012. Standard on Biodiversity Offsets. BBOP, Washington, D.C.

[42] Understood with consultation with the SCE that it is their intent to implement additional planting programmes within the Ma'ameer channel and hence this would be in line with the requirements and complimentary to the BAP.

8.2.2.4 Marine noise on fish

Given the lack of megafauna within the Ma'ameer channel and the logistics associated with such shallow waters (i.e. < 1 m) mitigation is both limited and not warranted. No mitigation is forwarded.

8.2.2.5 Release of fuels/oils

The mitigation forwarded address protection of the habitat and the receptors it supports (i.e. mangroves, fish and avifauna).

- All fuels should be stored at least 20 m from the water's edge and upon an impermeable base and bunded area capable of holding up to 110% of the stored volume. Spill kits should be made available across the site.
- Consider installing oil booms north and south of the works.
- Fuel stores should only be kept to a minimum onsite. All large plant should be refueled at an appropriate location offsite.
- Do not wash tools/plant/equipment in the waters of the channel.
- Ensure all equipment is well maintained and free from oil/fuel leaks, which could enter marine waters.
- Ensure plant operators have in place the necessary spill response plans and equipment and that staff are trained in its use.

8.2.3 Coastal Zone

There will be no construction works conducted at this location hence there is no requirement for mitigation or monitoring.

8.2.3.1 Fasht Al Adhm

There will be no construction works conducted at this location hence there is no requirement for mitigation or monitoring.

8.3 Operation

There are a number of monitoring requirements which need to be addressed via standardised monitoring protocols (these need to be commissioned). This should be commissioned by Bapco to address:

1. Water quality of both the effluent and receiving waters.
2. Marine ecology of affected areas and notably the DMUs of the Coastal Zone and Fasht al Adhm. Note reference is made to the Bapco Marine Survey[35] which in our opinion needs to be updated and revised regarding its scope and frequency.

Issues relating to thermal plumes shall, in due course, be further assessed in a separate standalone document. The thermal plume survey and assessment report will be produced to confirm the impacts of the BMP on Fasht Al Adhm. The findings of this report (i.e. CHA) are conditional until the thermal survey and assessment study is completed.

Table 8.1 Summary of residual impacts - construction

Description of Impact	Location	Impact significance	Residual impact
Construction works	Tubli bay	No impact	-
Loss of mangroves	Ma'ameer channel	Moderate adverse	Negligible
Sediment loading/suspension on mangroves		Minor adverse	Negligible
Loss of feeding areas on avifauna		Minor adverse	Negligible
Marine noise on fish		Minor adverse	Minor adverse
Release of diesel on mangroves		Minor adverse	Negligible
Release of diesel on avifauna		Minor adverse	Negligible
Release of diesel on fish		Minor adverse	Negligible

Table 8.2 Summary of residual impacts - operation

Description of Impact	Location	Impact	Residual impact
Routine operation	Tubli bay	No impact	-
	Ma'ameer channel	No impact	-
Thermal pollution on ecological resources	Coastal Zone	Minor adverse	To be determined following the TIA
	Fasht Al Adhm	Minor adverse	To be determined following the TIA

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