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Project: Aqaba-Amman Water Desalination and Conveyance (AAWDC)

2025 Environmental and Social Impact Assessment

Appendix 6-1 Terrestrial Critical Habitat Assessment



Critical Habitat Assessment for the Aqaba-Amman pipeline Project, Jordan

Cover image: Steppe Eagle by Francesco Veronesi, licenced under CC BY-SA 2.0.

Authors: This report was compiled by TBC (Filipe Canário, Lucy Murrell, Marc Freestone, Ricardo Tomé, Vineet Katariya).

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THE BIODIVERSITY CONSULTANCY

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Acronym table

Acronym	Definition
AZE	Alliance for Zero Extinction (site)
BAP	Biodiversity Action Plan
CH	Critical Habitat
CHA	Critical Habitat Assessment
CR	Critically Endangered
EAAA	Ecologically Appropriate Area of Analysis
EN	Endangered
EOO	Extent of Occurrence
ESIA	Environmental and Social Impact Assessment
GBIF	Global Biodiversity Information Facility
GN	(IFC) Guidance Note
IBA	Important Bird and Biodiversity Area
IBAT	Integrated Biodiversity Assessment Tool
IFC PS6	International Finance Corporation, Performance Standard 6
IRA	Internationally Recognised Areas
IUCN	International Union for Conservation of Nature
KBA	Key Biodiversity Area
LC	Least Concern
LPA	Legally Protected Area
NH	Natural Habitat
NNL	No Net Loss
NT	Near Threatened
MH	Modified Habitat
PA	Protected Area
POWO	Plants Of the World Online
RR	Restricted Range
TBC	The Biodiversity Consultancy
VU	Vulnerable
WFO	World Flora Online

1 Introduction

1.1 Purpose and context

ECO Consult (the Client) has commissioned The Biodiversity Consultancy (TBC), in collaboration with Energies Group, to prepare a Critical Habitat Assessment (CHA) for the Aqaba Amman Water Desalination and Conveyance Project (AAWDC, the Project), in Jordan.

Potential Lenders involved in the financing of this Project may include: the International Finance Corporation (IFC), European Bank for Reconstruction and Development (EBRD), European Investment Bank (EIB), Agence Française de Développement (AFD), World Bank Group (WBG) and Green Climate Fund (GCF). While all Lender standards make reference to Critical Habitat, only three of these Lenders, IFC, EBRD and EIB, have detailed criteria and thresholds for Critical Habitat. This CHA has therefore been developed in alignment with the IFC Performance Standard 6 (IFC PS6) and Guidance Note 6, EBRD Performance Requirement 6 (EBRD ESR6) and EIB Standard 4 (EIB S4) criteria and thresholds[1].

The aim of this CHA is to identify potential Critical Habitat-qualifying species and ecosystems, based on IFC PS6, EBRD ESR6 and EIB S4 criteria and thresholds, which will require special attention and specific mitigation planning, and to determine whether the Project is in an area of Natural or Modified Habitat. EBRD ESR6 also defines Priority Biodiversity Features (PBFs), which have also been included in this CHA.

1.2 Description of the project

Jordan faces one of the world's most serious water shortages. The Project aims to generate 300 million cubic metres (MCM) of drinking water per year by taking water from the Gulf of Aqaba and treating it in a new desalination plant. The drinking water will then be transported to Amman via pipeline. The Project comprises three main components: marine works and desalination, conveyance and renewable energy facilities (see Figure 1):

- Marine works and desalination plant - Intake system (including some limited offshore works) composed of a pumping station, three parallel pipelines (4 for intake and 2 for outtake) to convey seawater to the desalination plant. Reverse osmosis seawater desalination plant sized to produce 300 million of cubic meters per year of desalinated water through four independent parallel production lines, located in the Aqaba area.
- Conveyance system - Composed of a 438 km long underground water pipeline of variable diameter (76" to 90"), three tanks and four pumping stations to convey water to the Aqaba turnout (located c. 10 km from the desalination plant) and to the existing reservoirs of Abu Alanda and Al Muntazah near Amman.

[1] Where criteria and/or thresholds differ, the most stringent and/or precautionary have been applied.

- Solar power plant - with production capacity equal to 281 MWp near the Wadi Rum, area next to the existing Quweira solar plant and about 55 km from the Desalination Plant site.

The OHTL will be developed by the National Electric Power Company (NEPCO) and is considered as an associated facility to the Project. The OHTL is a new 132 kV transmission line running between the solar power plant and the Desalination plant, with an approximate length of 65 km, to transport electricity to the Desalination plant. Electricity grid expansion works will be carried out by NEPCO1, JEPCO2 and EDCO3.

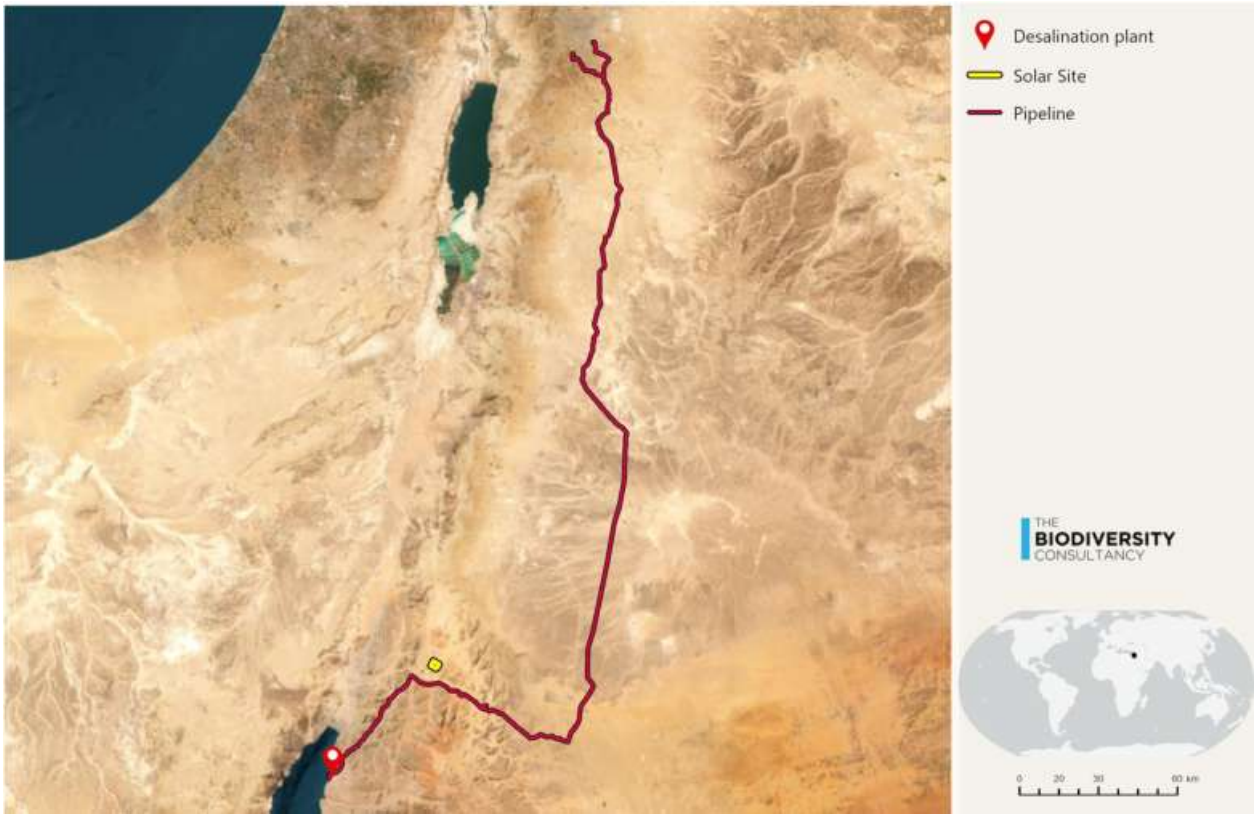


Figure 1. Location of Project infrastructure.

1.3 Ecological context

The Project will be situated within the Red Sea, Arabian Deserts and Salt Marshes Bioregion[2], which is part of the Greater Arabian Peninsula sub-realm. On a more precise scale, based on Taifour *et al.* (2022), the majority of the pipeline route falls within the Saharo- Sindian – Arabian biogeographical region; though the southern end falls within the Saharo- Sindian – Nubo-Sindian region, and the northern end falls within the Irano- Turanian region (Taifour *et al.* 2022).

[2] Red Sea, Arabian Deserts & Salt Marshes (PA26) | One Earth

Habitats in the Project's Area of Influence (AoI) include Natural Habitat (as defined by IFC PS6), comprising desert (bare/sparse vegetation) and some patches of grassland. There are also areas of Modified Habitats in the form of built-up areas (primarily roads, roadsides and settlements) and some patches of cropland.

Project components overlap the buffer zone for the Wadi Rum World Heritage Site, as well as two Internationally Recognized Areas (IRAs):

- Aqaba Coast and Mountains Key Biodiversity Area[3] (KBA) and Important Bird Area (IBA), which was designated due to a migratory population of 3000 Levant Sparrowhawks (*Accipiter brevipes*). This represents up to 30% of the global population estimate of 10,000 individuals.
- Hisma Basin – Rum KBA[4]. A total of 34 bird, reptile and plant species are listed on this KBA's webpage as KBA triggers. However, the assessment was undertaken in 2016 and therefore it is not confirmed if these meet the global KBA criteria.

1.4 IFC PS6, EBRD ESR6 and EIB S4

The objectives of IFC PS6, EBRD ESR6 and EIB S4 are to protect and conserve biodiversity, adopt the mitigation hierarchy, maintain benefits from ecosystem services, and promote the sustainable management of living natural resources through the adoption of practices that integrate conservation needs and development priorities.

1.4.1 Critical Habitat, Natural Habitat and Priority Biodiversity Features

IFC PS6 and EIB S4 require projects to classify the area within which they operate into the following categories: modified habitat, natural habitat and critical habitat based on the extent of human modification of the ecosystem and the presence of high biodiversity values (Table 1). Note that, although EIB S4 also allows areas to be assigned to the category "semi-natural habitat", this category is not recognised by IFC PS6.

Table 1. Summary of the PS6 scheme for classifying habitat.

		Human modification of the ecosystem	
		Not significant	Significant
High biodiversity values	Present	**Critical Habitat**	**Critical Habitat**
	Absent	**Natural Habitat**	**Modified Habitat**

Note: No universal thresholds exist for identifying natural habitat and modified habitat

[3] https://www.keybiodiversityareas.org/site/factsheet/8202

[4] https://www.keybiodiversityareas.org/site/factsheet/8201

As a rule of thumb, a project should favour developments in areas of modified habitat over natural habitat, and natural habitat over critical habitat. It must demonstrate the full application of the mitigation hierarchy framework to manage biodiversity impacts (avoid, minimise, restore, and when needed, offset) (CSBI & TBC 2015) in consultation with relevant stakeholders, and should achieve a no net loss of biodiversity in areas of natural habitat and a net gain in critical habitat.

The relevant lender standard/requirement guidance notes (EIB 2018, 2022; IFC 2019; EBRD 2023) provide further guidance through well-defined criteria and thresholds on how to identify critical habitat, as well as guidance on identifying natural and modified habitat (IFC 2019), which are summarised in 0. Note that, as Jordan is not an EU member state and is not a signatory nation of the Bern Convention, some EBRD ESR6 and EIB S4 criteria for Critical Habitat do not apply to this project, namely those relating to the EU Habitats Directive, the EU Birds Directive and the Bern Convention.

Criteria to consider when assessing the presence of critical habitat are:

1. **Globally and/or regionally threatened species** (IFC PS6 Criterion 1, EBRD ESR6 Criterion 2 and EIB S4 Criterion 2)
2. **Endemic and restricted range species** (IFC PS6 Criterion 2, EBRD ESR6 Criterion 2 and EIB S4 Criterion 3)
3. **Migratory and congregatory species** (IFC PS6 Criterion 3, EBRD ESR6 Criterion 2 and EIB S4 Criterion 4)
4. **Highly Threatened and/or Unique Ecosystems** (IFC PS6 Criterion 4, EBRD ESR6 Criterion 1 and EIB S4 Criterion 1)
5. **Key evolutionary processes** (IFC PS6 Criterion 5 and EIB S4 Criterion 6)
6. **Biodiversity of socio-economic value** (EIB S4 Criterion 5)

The determination of critical habitat for the first four criteria in the above list (corresponding to IFC PS6 Criteria 1-4, EBRD ESR6 Criteria 1 and 2, and EIB S4 Criteria 1-4) is based on quantitative thresholds, whereas the last two criteria above (IFC PS6 Criterion 5 and EIB S4 Criterion 5 and 6) are determined through a qualitative expert-based judgement (see Appendix 1). The identification of critical habitat should be done at a landscape-level to consider the dynamics of the ecosystem beyond the project footprint. IFC PS6, EBRD ESR6 and EIB S4 also make provision for Legally Protected Areas (LPAs) and Internationally Recognised Areas (IRAs), which should be duly identified and mapped (see PS6 paragraph 20).

IFC PS6 defines natural habitat as "*areas composed of viable assemblages of plant and/or animal species of largely native origin, and/or where human activity has not essentially modified an area's primary ecological functions and species composition*". It also notes that "Project sites will often be located among a mosaic of habitats with varying levels of anthropogenic and/or natural disturbance. Clients are responsible for delineating the project site as best as possible in terms of modified and natural habitat. This determination is made based on the level of human-induced disturbance (for example, presence of invasive species, level of pollution, extent of habitat fragmentation, viability of existing naturally occurring species assemblages, resemblance

of existing ecosystem functionality and structure to historical conditions, degree of other types of habitat degradation) and the biodiversity values of the site (for example, threatened species, ecosystems, and ecological processes necessary for maintaining nearby critical habitats). The level of anthropogenic impact should be determined with respect to the greater landscape/seascape in which the project is located."

IFC PS6, EBRD ESR6 and EIB S4 stipulate that critical, natural and modified habitats should be mapped within an Ecologically Appropriate Area of Analysis (EAAA) (PS6 GN26). The EAAA is identified at a landscape level, considering large-scale ecological processes where appropriate, which are often larger than the project impact area to ensures all risks are taken into consideration. The EAAA is designed to ensure that the biodiversity significance of the project landscape is appropriately evaluated; it is not a management unit and the choice of EAAA does not place any management obligations on the project.

In addition to critical habitat values, EBRD ESR6 also considers a suite of PBFs which are of lower concern, but still important for a project to consider. PBFs include: threatened ecosystems, threatened, range-restricted, migratory and congregatory species (see Appendix 1 for details) (EBRD 2023).

1.4.2 Implications of findings

Projects located within critical habitat need to pay special attention to the management of biodiversity impacts, especially on the biodiversity values that trigger critical habitat.

Where impacts do occur, lender standards require projects to fully execute the mitigation hierarchy. In critical habitat, this means that overall net gain of critical habitat-qualifying biodiversity is required. A high threshold of proof will be required to demonstrate that it is feasible to deliver these net gains.

Critical habitat determination is an assessment of the biodiversity importance of an area, based on the biodiversity values and not the potential impacts associated with a project. The presence of critical habitat does not necessarily imply an impact from the project. Table 2 shows the requirements of IFC PS6 paragraph 17 and 18, with respect to critical habitat[5]. EBRD and EIB have similar requirements.

The projects will also need to meet the IFC PS6 expectations for the management of impacts on modified and natural habitat. Table 3 shows the requirements of IFC PS6 paragraph 15 with respect to these.

[5] IFC is generally the most stringent of the lenders in regard to critical habitat.

Table 2. IFC PS6 paragraphs 17 & 18 on critical habitat.

PS6 reference	PS6 text
PS6 paragraph 17	'In areas of critical habitat, the client will not implement any project activities unless all of the following are demonstrated: • **No other viable alternatives** in the region exist for development of the project on modified or natural habitats that are not critical; • The project **does not lead to measurable adverse impacts** on those biodiversity values for which the critical habitat was designated, and on the ecological processes supporting those biodiversity values; • The project **does not lead to a net reduction** in the global and/or national/regional population of any Critically Endangered or Endangered species over a reasonable period of time; • A robust, appropriately designed, and **long-term biodiversity monitoring and evaluation program** is integrated into the client's management program'.
PS6 paragraph 18	'In such cases where a client is able to meet the requirements defined in paragraph 17, the project's mitigation strategy will be described in a **Biodiversity Action Plan (BAP)** and will be designed to achieve **net gains** of those biodiversity values for which the critical habitat was designated'.

Table 3. IFC PS6 paragraphs related to requirements for projects in natural habitat and modified habitat that holds significant biodiversity value.

PS6 reference	PS6 text
PS6 paragraph 12	'This Performance Standard applies to those areas of modified habitat that include **significant biodiversity value**, as determined by the risks and impacts identification process required in Performance Standard 1. The client should **minimize impacts** on such biodiversity and **implement mitigation measures** as appropriate.'
PS6 paragraph 15	'In areas of natural habitat, mitigation measures will be designed to achieve **no net loss** of biodiversity where feasible.'
PS6 footnote 9	'No net loss is defined as the point at which project-related impacts on biodiversity are balanced by measures taken to avoid and minimize the project's impacts, to undertake on-site restoration and finally to offset significant residual impacts, if any, on an appropriate geographic scale (e.g. local, landscape-level, national, regional).

It should be noted that, according to IFC PS6 and EBRD ESR6, areas not acceptable for financing (with the possible exception of projects specifically designed to contribute to the conservation of the area) include UNESCO World Heritage Sites and Alliance for Zero Extinction (AZE) Sites (IFC 2019; EBRD 2023). The EIB will also not invest in projects affecting certain protected areas, specifically UNESCO World Heritage Sites (EIB 2022).

Additionally, AFD applies the AFD Group exclusion list to their investments. Paragraph 17 of the exclusion criteria refers to biodiversity criteria potentially of relevance for this Project:

i. Any financing in the (a) sites of the Alliance for Zero Extinction (AZE), (b) natural and mixed sites on the UNESCO World Heritage List[6] and (c) legally protected areas (IUCN categories)[7]
ii. Any operation leading to an adverse and irreversible[8] residual impact on a critical habitat[9]

2 Determination of critical habitat

2.1 Review of available information

TBC consulted the Integrated Biodiversity Assessment Tool (IBAT)[10], a source of globally authoritative biodiversity datasets including the IUCN Red List of Threatened Species, the World Database on Protected Areas, and the World Database of Key Biodiversity Areas (including Important Bird and Biodiversity Areas). IBAT was used to identify the presence of threatened, restricted-range and migratory species, protected areas, Key Biodiversity Areas (including Important Bird and Biodiversity Areas), World Heritage Sites and Alliance for Zero Extinction sites. European Space Agency (ESA) data was used to classify natural and modified habitats within the Ecologically Appropriate Areas of Analysis.

In addition to IBAT, several internationally and nationally relevant datasets and assessments were consulted, including:

- The IUCN Red List of Threatened Species (IUCN Red List of Threatened Species)
- National Red data book of mammals in Jordan (Eid *et al.* 2020) (https://portals.iucn.org/library/sites/library/files/documents/RL-569.5-001-En.pdf)
- Jordan Plant Red List (Taifour & El-Oqlah 2014; Taifour 2017)
- The conservation status and distribution of the breeding birds of the Arabian peninsula (Symes *et al.* 2017)
- IUCN Red List of Ecosystems (IUCN Ecosystems)

[6] Unless the financing aims to conserve or restore these areas.

[7] Unless the financing aims to conserve or restore these areas or complies with the management and spatial planning plans for the latter, such as those formalised in plans with international standards relating to the activities being financed – categories I-VI in World Database on Protected Areas | IUCN.

[8] Irreversible impact: permanent conversion or degradation of biodiversity or of the ecological functions or characteristics that warranted the critical habitat designation.

[9] Unless the said project is of overriding general interest for the destination country, in which case a derogation can be presented to the Group's governance for a decision.

[10] Integrated Biodiversity Assessment Tool

- The Global Biodiversity Information Facility (GBIF) (https://www.gbif.org/)
- eBird (http://www.ebird.org)
- BirdLife data zone (http://datazone.birdlife.org/home)
- Movebank (Movebank)
- POWO – Plants of the world online, Royal Botanic Gardens, Kew (https://powo.science.kew.org)
- WFO – The World Flora Online (http://wfoplantlist.org)
- Jordan BirdWatch (JBW) (https://www.jordanbirdwatch.com/)

The following documents were developed for the Project and have also been consulted in the preparation of this assessment:

- Final Environmental and Social Impact Assessment Report (Tetra Tech 2022)
- Environmental and Social Impact Assessment Report (Updated January 2025) (Engicon 2025)
- Biodiversity rapid risk screening and ESIA review (TBC 2024)
- Interim Terrestrial Ecological Baseline Survey Report (NCPC *et al.* 2025a)
- Terrestrial Baseline Survey Report (NCPC *et al.* 2025b)
- Preliminary Terrestrial Critical Habitat Assessment (NCPC *et al.* 2025c)
- Avi-Fauna Survey (Draft) Report (NCPC *et al.* 2025d)
- Spring 2025 Bird Survey Report (NCPC *et al.* 2025e)
- Autumn 2025 Bird Survey Report (NCPC *et al.* 2025f)
- Minutes of meeting with RSCN - Royal Society for the Conservation of Nature (NCPC *et al.* 2025g)

The CHA was also informed by consultation with the Royal Society for the Conservation of Nature (RSCN) through a meeting between TBC and RSCN[11], and consultation with local expert Dr. Zuhair Amr – ecologist, fauna specialist and co-author of the National Red data book of mammals in Jordan (Eid et al. 2020)[12].

2.2 Ecologically Appropriate Area of Analysis (EAAA)

In line with IFC PS6 Guidance Note 6 (IFC 2019) and EBRD ESR6 Guidance Note (EBRD 2023), a CHA should be conducted for all the species with regular occurrence in the Project's area of

[11] The meeting took place in Amman on 12/10/2025. Participants were Nashat Hamidan, Tareq Qaneer (RSCN); Lana Zubi (ECO Consult); Ricardo Tomé (TBC).

[12] This was a virtual meeting on 29/10/2025. Participants were Zuhair Amr, Lana Zubi (ECO Consult), Filipe Canário and Lucy Murrell (TBC).

influence, or ecosystem, covered by Criteria 1-4, within an Ecological Appropriate Area of Analysis (EAAA).

As this is a large Project that will be developed in a wide area of relatively uniform arid habitats and there is scarcity of detailed information regarding the distribution and specific habitat features of importance for most species in the region, the first stage of the CHA followed a pragmatic, yet precautionary, approach, defining two EAAAs: a larger one for more mobile species (Avian EAAA) and a smaller one for species with less mobility (Terrestrial EAAA). The Terrestrial EAAA was defined using a 5 km buffer around the Project footprint, while the Avian EAAA was defined using a 10 km buffer around the same area (Figure 2). These buffers are expected to capture the direct and indirect impacts of the Project. The Hisma Basin – Rum KBA was also included in both EAAAs due to its importance for birds and terrestrial species, while the Abu Rukbah proposed Protected Area and the Aqaba Coast and Mountains KBA were also included in the Avian EAAA due to their importance for birds. The Project is not expected to impact freshwater waterbodies; therefore, an aquatic EAAA has not been defined, and freshwater species (e.g. freshwater fish) are not included in this CHA. If the revised ESIA or any future assessment identifies potential pathways of impact to freshwater waterbodies, this CHA may need to be revised.



Figure 2. Map of the Avian EAAA and Terrestrial EAAA in relation to Project infrastructure

This approach allowed to determine which species could potentially exceed the defined thresholds for critical habitat (see section 2.3).

Following this exercise, specific EAAAs were defined for the species that were considered potential critical habitat triggers. These EAAAs were based on landscape features, habitat availability, congregation areas and protected areas. The EAAAs are described in Table 4 and represented in Figures 4 to 9.

Table 4: Description of the Ecological Appropriate Area of Analysis (EAAA) used to determine the presence of Critical Habitat for taxa that were considered possible Critical Habitat triggering species.

Species	Scientific name	EAAA description and Rationale
Jordan Wormwood	*Artemisia jordanica*	The EAAA includes an area of arid habitat (bare rock, sand plain, chert plain, (Franceschini *et al.* 2019) which encompasses the known distribution area of this species in Jordan. This species has only been recorded in arid locations in Ma'an and Wadi Rum (Taifour & El-Oqlah 2014).
Egyptian Henbane	*Hyoscyamus muticus*	This species is only known in Jordan from a single population near Zarqa, far from the Project area. During baseline surveys the Egyptian Henbane was found in small wetland area created by a water leakage from an existing water pipeline that runs parallel to the Project. The proposed EAAA corresponds to a 500 m buffer around this pipeline.
Calligonum	*Calligonum comosum*	This is a rare species in Jordan, which nevertheless has a wide distribution in arid areas (Taifour & El-Oqlah 2014). The EAAA was defined to include areas of sand dunes and chert plains within the known area of distribution of the species (Franceschini *et al.* 2019).
Levant Sparrowhawk	*Accipiter brevipes*	The EAAA was defined as the Aqaba Coast and Mountains KBA. The Levant Sparrowhawk is only present in Jordan during migration. This species seldom stops during migration, but it triggers KBA and IBA criteria for the Aqaba Coast and Mountains KBA which is designated due to a migratory population of 3,000 Levant Sparrowhawks, that represents up to 30% of the lower global population estimate of 10,000 individuals.
Steppe Eagle	*Aquila nipalensis*	The EAAA was defined as the Abu Rukbah proposed Nature Reserve and a 5 km buffer around it. The Steppe Eagle occurs in Jordan during migration and occasionally also in winter. It migrates in a broad front and there is only one known area of congregation, which is the Abu Rukbah proposed nature reserve, and especially a dumping site for expired chicken carcasses that is located in its vicinity.
Sooty Falcon	*Falco concolor*	The EAAA corresponds to the Hisma Basin-Rum KBA, which is the stronghold of Jordan's breeding population of Sooty Falcon (it triggers IBA criteria in this KBA).

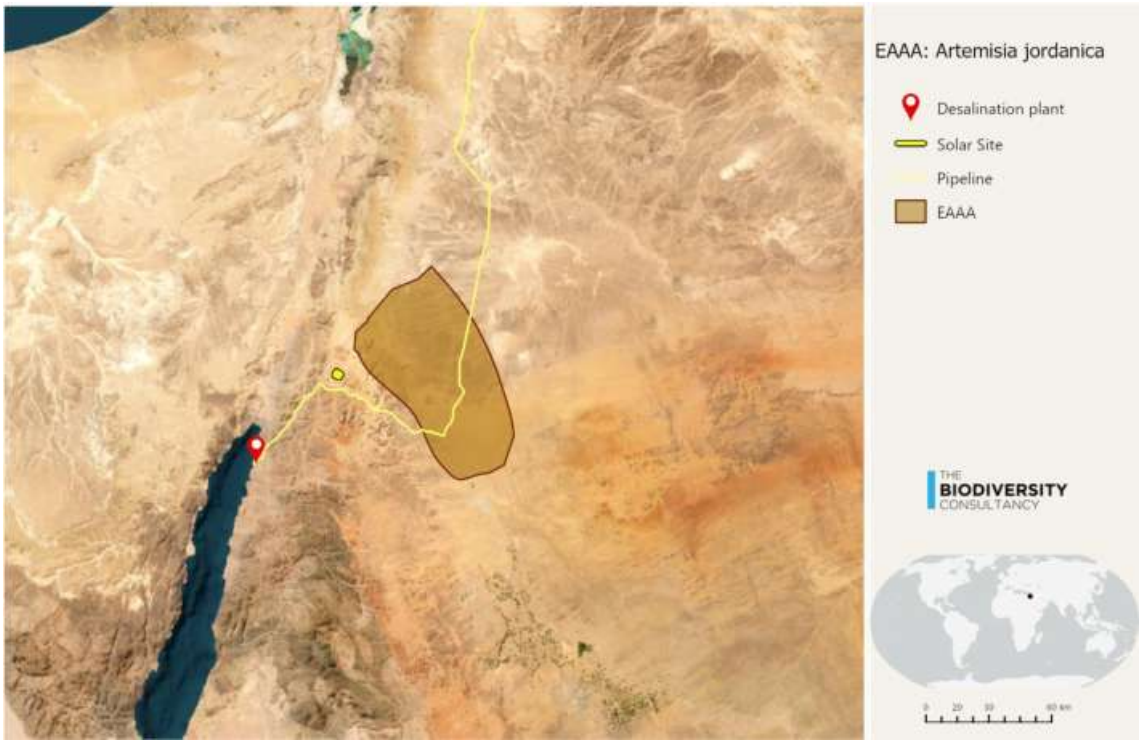


Figure 3: EAAA used to assess Critical Habitat for the Jordan Wormwood (Calligonum comosum).



Figure 4: EAAA used to assess Critical Habitat for the Egyptian Henbane (Hyoscyamus muticus)

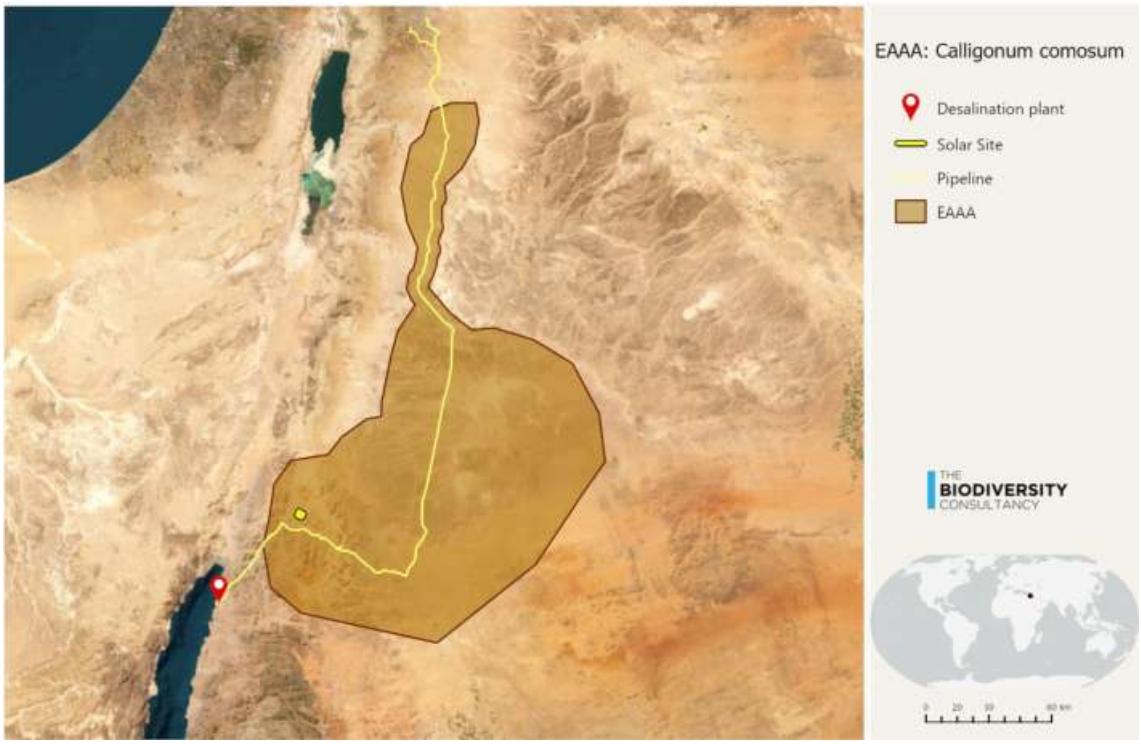


Figure 5: EAAA used to assess Critical Habitat for the Jordan Wormwood (Calligonum comosum).



Figure 6: EAAA used to assess Critical Habitat for the Levant Sparrowhawk (Accipiter brevipes).



Figure 7: EAAA used to assess Critical Habitat for the Steppe Eagle (Aquila nipalensis).

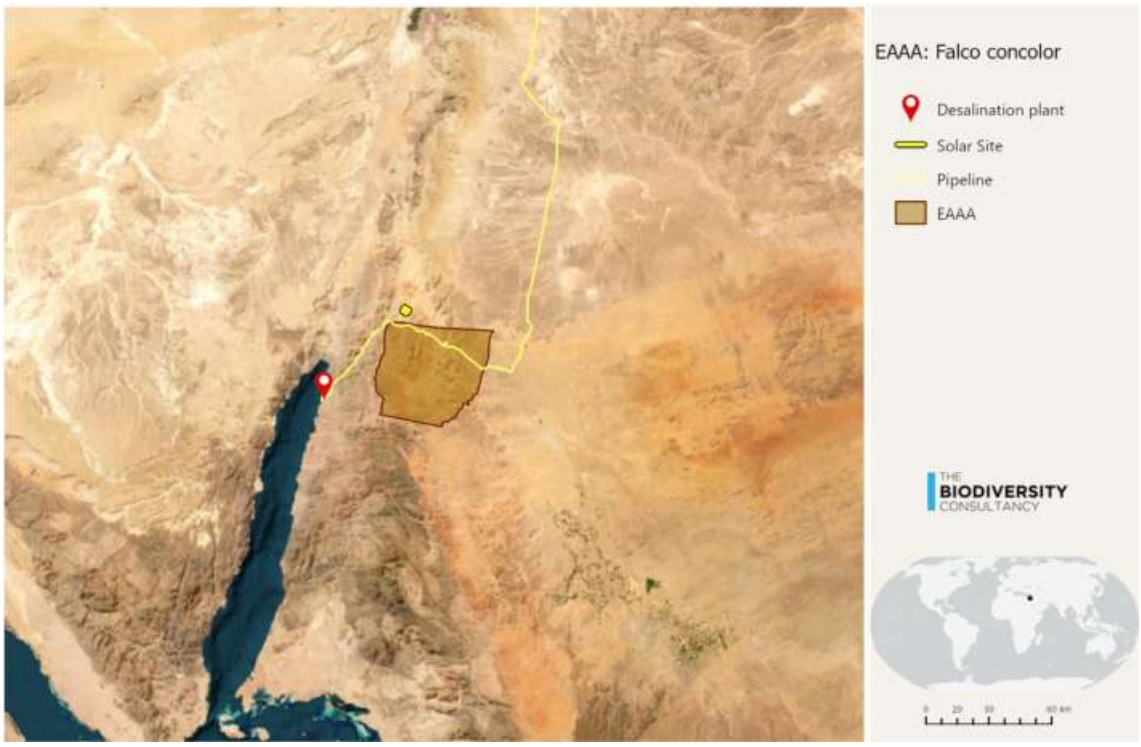


Figure 8: EAAA used to assess Critical Habitat for the Sooty Falcon (Falco concolor).

2.3 CH Determination

To support the identification of Critical Habitat- qualifying features, TBC conducted an IFC PS6/EBRD ESR6 aligned biodiversity screening, to identify a shortlist of species for more detailed assessment. These included:

- All globally or nationally Critically Endangered (CR), Endangered (EN) and Vulnerable (VU) species with overlap between the EAAAs and their global ranges and potential presence in the EAAAs
- All restricted range species
- Migratory and congregatory species, either i) with greater than 1% overlap between the EAAAs and their respective global ranges, or ii) recorded in the EAAAs in numbers that possibly exceed 1% of the global population
- Species triggering KBA and/or IBA criteria in the KBAs/IRAs overlapping, or in proximity to, the EAAAs.

The shortlist of species was then assessed against the applicable CH criteria and thresholds (Appendix 1) and informed by field survey data, secondary data and expert input on their status and distribution within the terrestrial and avian EAAAs. Where population data was not available, the overlap between the species range and the EAAA was used as a proxy for the population likely to be present.

Five categories of certainty were used based on the evidence that a species qualifies as triggering Critical Habitat:

- **Certain** – if data demonstrate exceedance (e.g. numbers based on field surveys);
- **Likely** – if the range overlap, or other evidence, suggests the EAAA is likely to exceed the threshold, and the species' presence has been confirmed in the Project area;
- **Possible** – if the range overlap is close to the threshold, or there is the potential for the EAAA to have a higher proportion of the population than average, and the species' presence has been confirmed in the Project area;
- **Non-conclusive** - If the outcome of the assessment would have otherwise been likely/possible CH, but the species presence has not been confirmed in the Project area; and,
- **Does not qualify** – if available evidence is that the threshold is not exceeded.

As mentioned in the previous section, the next step was to refine the EAAAs for species that could potentially trigger critical habitat (see section 2.2). These species were then reassessed against the CH criteria with relation to the refined EAAA.

2.4 Constraints and limitations

Potential constraints to the desktop-based analysis for this CHA include the usage of some global biodiversity datasets, which may not yet include species that could be present, but which have not yet been evaluated on the IUCN Red List.

Those species with national Red List assessments were possible to assess against Criterion 1.c (IFC 2019) but this criterion does not provide quantitative thresholds for assessment, requiring the use of expert judgement.

Additionally, the application of the quantitative critical habitat thresholds should be considered precautionary, due to lack of population data for some species. In some cases, lack of precise information on species distribution makes it challenging to determine whether a species is likely to meet the IFC PS6 GN6 thresholds for criteria 1-3 and equivalent criteria for EBRD ESR6 and EIB S4.

3 Results of the CHA

A total of 702 species were identified for critical habitat screening based on their potential presence in the relevant EAAAs as indicated in IUCN Red List distribution maps, other global datasets such as GBIF, eBird or BirdLife data zone, or from field survey data. See Appendix 2 for a subset of species screened. A total of 33 species were assessed in detail against IFC ESR6, EBRD ESR6 and EIB S4 criteria for CH (see Table 5 for results and Appendix 1 for criteria and thresholds).

Three qualify as critical habitat, corresponding to two plants (the Jordan Wormwood *Artemisia jordanica* and Egyptian Henbane *Hyoscyamus muticus*), and one bird (the Levant Sparrowhawk *Accipiter brevipes*).

Four species possibly qualify as critical habitat, corresponding to two plants (*Stipagrostis spp.* and *Calligonum comosum*) and two birds (Sooty Falcon *Falco concolor* and Steppe Eagle *Aquila nipalensis*) (Table 5).

3.1 Critical habitat- qualifying species

3.1.1 Endangered (EN) and Critically Endangered (CR) species

A total of three globally EN or CR species were assessed in detail against Criterion 1.a. of IFC PS6 and the equivalent criteria of EBRD ESR6 and EIB S4 (see Appendix 1). These include one reptile, the EN Jordanian Fringe-fingered Lizard (*Acanthodactylus ahmaddisii*), and two birds, the EN Steppe Eagle and the EN Egyptian Vulture (*Neophron percnopterus*). Of these, the Steppe Eagle was considered to possibly qualify as CH under this Criterion (see Table 5).

A total of six globally VU species were assessed in detail against Criterion 1.b. of IFC PS6 and the equivalent criteria of EBRD ESR6 and EIB S4 (see Appendix 1). These include two VU plants, the Black Iris (*Iris nigricans*) and *Limonium palmyrense*; one mammal, the VU Nubian Ibex (*Capra nubiana*); one reptile, the VU Egyptian Spiny–tailed Lizard (*Uromastyx aegyptia*); and two birds, the VU Syrian Serin and Sooty Falcon. However, none of these species were considered possibly or likely to qualify as CH under this Criterion (see Table 5).

A total of 16 nationally or regionally EN or CR species were assessed in detail against Criterion 1.c. of IFC PS6 and the equivalent criteria of EBRD ESR6 and EIB S4 (see Appendix 1). These include nine nationally EN or CR plants; two nationally EN mammals, the Nubian Ibex and Grey Wolf (*Canis lupus*); and five regionally EN birds, the Syrian Serin, Sooty Falcon, Steppe Eagle, Buff-rumped Wheater (*Oenanthe moesta*) and Griffon Vulture (*Gyps fulvus*). Of these, the Jordan Wormwood and Egyptian Henbane were considered to qualify as CH, and *Calligonum comosum* and Steppe Eagle were considered to possibly qualify as CH under this Criterion (see Table 5). Concerning *Stipagrostis* spp., it is still required to identify the specimens to the species level to be able to determine if they qualify as critical habitat or not.

3.1.2 Endemic and restricted-range species

A total of nine restricted-range species were assessed in detail against Criterion 2 of IFC PS6 and the equivalent criteria of EBRD ESR6 and EIB S4 (see Appendix 1). These include six plant species; one reptile species (the Jordanian Fringe-fingered Lizard); one insect species (*Lacon ammanensis*) and one bird species (the Syrian Serin. However, none of these species were considered possibly or likely to qualify as CH under this Criterion (see Table 5).

3.1.3 Migratory and congregatory species

A total of 14 migratory bird species, primarily migratory soaring birds, were assessed in detail against Criterion 3. Of these, the Levant Sparrowhawk qualifies as CH, while the Sooty Falcon and the Steppe Eagle were considered to possibly qualify as CH under this Criterion.

Table 5. Species assessed in detail against critical habitat criteria. For a longer list of species screened, refer to Table A1 of Appendix 2.

Scientific name	Common English name	Global RL status [1]	National / Regional RL status	Presence in EAAA [2]	Source for EAAA confirmation	Critical Habitat Criteria [3]	Conclusion [4]	Justification
Plants								
Artemisia jordanica	Jordan Wormwood	Not assessed	EN	Confirmed	ESIA (2022)	Assessed against C1.c of IFC PS6 and the equivalent criteria of EBRD ESR6 and EIB S4	**Certain CH (C1.c)**	Prior to surveys for the Project, this nationally EN shrub had only been recorded in two locations in Jordan, at Ma'an and Wadi Rum, on either side of the proposed pipeline alignment with the nearest record approximately 10 km from the proposed alignment. The species was recorded in Segment 5 during surveys for the 2022 ESIA (Tetra Tech 2022), although it was not recorded during surveys for the Interim Terrestrial Ecological Baseline. In Jordan the species is confined to extreme desert areas, where it grows in wadis with sandy ground, principally in the Wadi Rum area, and is unlikely to extend further northward (Z. Amr, personal communication, November 2025). If still extant, it is likely that the population recorded in 2022 constitutes an 'important concentration' of the species, given that Taifour & El-Oqlah (2014) reported that only two other populations are known in Jordan and no information is available on the number of individuals in either. Danin & Fragman-Sapir (2025) report six records from Jordan, although none have been recorded in the last 20 years. It therefore qualifies as CH under Criterion 1.c of IFC PS6 and the equivalent criteria of EBRD ESR6 and EIB S4.
Hyoscyamus muticus	Egyptian Henbane	Not assessed	CR	Confirmed	Interim Terrestrial Ecological Baseline (2025)	Assessed against C1.c of IFC PS6 and the equivalent criteria of	**Certain CH (C1.c)**	This nationally CR species is only known from a single population (near Zarqa) in Taifour (2017) and there are no records of the species in Jordan in GBIF (GBIF 2025). The species was observed in Segment 5 of the pipeline (NCPC *et al.* 2025a), in a mini-wetland area due to water leakage from the Disi Pipeline. This represents a micro-habitat

Scientific name	Common English name	Global RL status [1]	National / Regional RL status	Presence in EAAA [2]	Source for EAAA confirmation	Critical Habitat Criteria [3]	Conclusion [4]	Justification
						EBRD ESR6 and EIB S4		caused by anthropogenic activity, not typical of the habitats in the region (this micro-habitat will likely disappear if the pipeline is repaired or decommissioned). The occurrence of this species in the Project area is therefore not typical (NCPC *et al.* 2025a). Nevertheless, it is likely that the recorded population constitutes an 'important concentration' of the species, given that only one other population is known in Jordan (Taifour & El-Oqlah 2014). It therefore qualifies as CH under Criterion 1.c of IFC PS6 and the equivalent criteria of EBRD ESR6 and EIB S4.
Calligonum comosum	Calligonum	Not assessed	EN	Confirmed	Interim Terrestrial Ecological Baseline (2025)	Assessed against C1.c of IFC PS6 and the equivalent criteria of EBRD ESR6 and EIB S4	**Possible CH (C1c)**	This nationally EN species has a wide distribution in arid areas of Jordan, but the number of individuals is limited (reportedly due to sterility) and the number of locations are few (Taifour & El-Oqlah 2014). Seven populations in the country are recorded in Taifour & El-Oqlah 2014). The species was observed in Segment 5 of the pipeline (NCPC *et al.* 2025a, 2025c). With seven other populations in the country, it is possible that the species' occurrence in the Project area constitutes an 'important population' according to IFC PS6 and the equivalent criteria of EBRD ESR6 and EIB S4.
Stipagrostis spp.	-	-	-	Confirmed	Interim Terrestrial Ecological Baseline (2025)	Assessed against C1.c of IFC PS6 and the equivalent criteria of EBRD ESR6 and EIB S4	**Possible CH (C1.c)**	An unidentified *Stipagrostis* sp. was recorded in the Interim Terrestrial Ecological Baseline (NCPC *et al.* 2025a). There are 11 species of *Stipagrostis* in Jordan (Z. Amr, personal communication, November 2025), two of which are nationally CR (none are EN) (Taifour 2017): *Stipagrostis lanata* is only known from a single population near Shobak approximately 45 km west of the pipeline alignment (Taifour 2017).

Scientific name	Common English name	Global RL status [1]	National / Regional RL status	Presence in EAAA [2]	Source for EAAA confirmation	Critical Habitat Criteria [3]	Conclusion [4]	Justification
								Stipagrostis pungens is only known from a single population near Azraq approximately 70 km east of the pipeline alignment (Taifour 2017). If either of these species are recorded in the Project area, its presence would likely constitute an important concentration of either species according to IFC PS6 / EBRD ESR6 / EIB S4 and would qualify the EAAA as Critical Habitat.
Arum hygrophilum	Water Arum	NT	EN	Unconfirmed	-	Assessed against C1.c of IFC PS6 and the equivalent criteria of EBRD ESR6 and EIB S4	Unlikely CH	This nationally EN species occurs in the western Mediterranean region of Jordan (NCPC *et al.* 2025a). Several records occur south and west of Amman, but it has not been recorded in previous surveys for the Project, and the degraded habitat in this part of the Project area suggests it is unlikely to occur there. It prefers rocky areas with high rainfall (Z. Amr, personal communication, November 2025), habitat that is not present in the Project area.
Blepharis attenuata	-	Not assessed	LC	Confirmed	GBIF 2025	Assessed against C2.a of IFC PS6 and the equivalent criteria of EBRD ESR6 and EIB S4	Unlikely CH	This restricted range species occurs in western Jordan (Taifour & El-Oqlah 2014), with records observed in 2025 within the Project area near Aqaba (GBIF 2025). However, the proportion of global records within the Terrestrial EAAA is <10% suggesting it is unlikely that >10% of the species' global population occurs within the EAAA, and thus, unlikely that the species qualifies the EAAA as Critical Habitat under IFC PS6.
Cleome droserifolia	-	Not assessed	EN	Confirmed	Interim Terrestrial Ecological Baseline (2025)	Assessed against C1.c of IFC PS6 and the equivalent	Unlikely CH PBF	This nationally EN species is restricted in Jordan to the southern arid region, where it is known from seven records in Taifour & El-Oqlah (2014). The species was observed in Segments 1 and 2 of the pipeline in (NCPC *et al.* 2025a, 2025c). With seven other populations

Scientific name	Common English name	Global RL status [1]	National / Regional RL status	Presence in EAAA [2]	Source for EAAA confirmation	Critical Habitat Criteria [3]	Conclusion [4]	Justification
						criteria of EBRD ESR6 and EIB S4		in the country, it is probably unlikely that the species' occurrence in the Project area constitutes an 'important population' according to IFC PS6. The species' conservation status assessment in Taifour & El-Oqlah (2014) does not mention a decline in the number of populations, suggesting that all seven populations are likely to still be extant. This species qualifies as a Priority Biodiversity Feature under EBRD ESR6.
Iris atrofusca	Jal'ad Iris	NT	EN	Unconfirmed	-	Assessed against C1.c and C2.a of IFC PS6 and the equivalent criteria of EBRD ESR6 and EIB S4	Unlikely CH	This nationally EN and restricted range species is restricted to the northern Mediterranean highlands and their wadis (Taifour & El-Oqlah 2014) with a recent record from western Jordan west of Basira (GBIF 2025). It grows in the Irano-Turanian zone and to a lesser extent in the Mediterranean zone in loess, calcareous hills and batha, in Irbid, Ajloun, Madaba and Tal Al-Rumman (Taifour & El-Oqlah 2014). The species' range in its IUCN RedList assessment is mapped west of Amman (IUCN 2025a), but it has not been recorded in previous surveys for the Project, and the degraded habitat in this part of the Project area suggests it is unlikely to occur there.
Iris edomensis	Edom Iris	Not assessed	EN	Unconfirmed	-	Assessed against C1.c and C2.a of IFC PS6 and the equivalent criteria of EBRD ESR6 and EIB S4	Unlikely CH	This nationally EN and restricted range species has only been recorded on 10 occasions in GBIF (2025) and is noted as being recorded on four occasions in two locations in Jordan in Taifour & El-Oqlah 2014). It is endemic to Jordan, and grows in limestone and sandstone hills at Tafila, Petra and Dana (Taifour & El-Oqlah 2014). However, it is unlikely to occur in the Project area further west due to the different geology and climate compared to its known distribution.

Scientific name	Common English name	Global RL status [1]	National / Regional RL status	Presence in EAAA [2]	Source for EAAA confirmation	Critical Habitat Criteria [3]	Conclusion [4]	Justification
Iris nigricans	Black Iris	VU	EN	Unconfirmed	-	Assessed against C1.b, C1.c and C2.a of IFC PS6 and the equivalent criteria of EBRD ESR6 and EIB S4	Unlikely CH	This globally VU, nationally EN, restricted range species is endemic to Jordan where it occurs in the Moab highlands overlooking the Dead Sea (Taifour & El-Oqlah 2014), although several recent records occur in the southern outskirts of Amman (GBIF 2025) and the species' distribution in Taifour & El-Oqlah (2014) extends to the Project area south of Amman (Z. Amr, personal communication, November 2025). It grows in fallow fields and steppe habitats, in Karak, Madaba and south of Amman (Taifour & El-Oqlah 2014). The nearest GBIF records are approximately 4 km from the proposed pipeline alignment (GBIF 2025), although NCPC *et al.* (2025b) suggested (without supporting evidence) that these records may be cultivated specimens. The species was not recorded in the Project area during field surveys (Tetra Tech 2022; NCPC *et al.* 2025a) and is not known to occur in the Project area by local botanical experts consulted in NCPC *et al.* (2025a). In addition, the degraded condition of habitat in the northern part of the Project area suggests it is unlikely to occur in the Project area.
Leopoldia bicolor	Taccel Hyacinth	NT	LC	Unconfirmed	-	Assessed against C2.a of IFC PS6 and the equivalent criteria of EBRD ESR6 and EIB S4	Unlikely CH	This restricted range species has a coastal Mediterranean distribution (GBIF 2025), but with several records from western and southern Jordan (Taifour & El-Oqlah 2014), including immediately north of Wadi Rum (IUCN 2025a). The Terrestrial EAAA overlaps with 10.3% of the species' range, although it is not known to occur in the Project area by local botanical experts consulted in NCPC *et al.* (2025a).Also, according to the IUCN Red List, this species occurs in coastal areas, in sandy habitats such as stabilized sand-dunes, which are not present in the EAAA.

Scientific name	Common English name	Global RL status [1]	National / Regional RL status	Presence in EAAA [2]	Source for EAAA confirmation	Critical Habitat Criteria [3]	Conclusion [4]	Justification
Limonium palmyrense	-	VU	Not assessed	Unconfirmed	-	Assessed against C1.b of IFC PS6 and the equivalent criteria of EBRD ESR6 and EIB S4	Not CH	This globally VU species occurs in Jordan and Syria where it occurs in oases and salt marshes (IUCN 2025a). The Terrestrial EAAA overlaps 0.4% of the species' mapped range and the habitat in which it occurs is not present in the Terrestrial EAAA, indicating that the EAAA does not qualify as Critical Habitat for this species.
Verbascum petrae	-	Not assessed	Not assessed	Unconfirmed	-	Assessed against C2.a of IFC PS6 and the equivalent criteria of EBRD ESR6 and EIB S4	Unlikely CH	This restricted range species is endemic to western Jordan from Amman south to Wadi Musa (GBIF 2025). The proposed pipeline alignment near Amman occurs within 7 km of the nearest record, although it is probably unlikely to occur within the Project area, as the habitat in this part of the alignment is degraded and the species has not been recorded in field surveys to date.
Mammals								
Capra nubiana	Nubian Ibex	VU	EN	Confirmed	Interim Terrestrial Ecological Baseline (2025)	Assessed against C1.b and C1.c of IFC PS6 and the equivalent criteria of EBRD ESR6 and EIB S4	Unlikely CH PBF	The Nubian Ibex is globally VU and nationally EN in Jordan. The terrestrial EAAA overlaps with 0.21% of the species' "resident" range. The species is present in Jordan, Egypt, Israel, Oman, Saudi Arabia, Sudan, Yemen and Syria, and has an Extent of Occurrence (EOO) of 2,728,301 km^2. It occurs in rocky, desert mountains with steep slopes and hills, and associated plateaus, canyons and wadis. The global population is estimated at 4,500 mature individuals. Populations have declined in Jordan due to hunting pressure and competition with livestock. The species in Jordan is primarily distributed west of the Project, e.g. populations have become established in Wadi Mujib

Scientific name	Common English name	Global RL status [1]	National / Regional RL status	Presence in EAAA [2]	Source for EAAA confirmation	Critical Habitat Criteria [3]	Conclusion [4]	Justification
								(~200 individuals) and Dana (<250 individuals) Biosphere reserves. However, populations are also known to be present in Wadi Rum Protected Area (IUCN 2025a), where the population size was 60 individuals in October 2015 (Eid *et al.* 2020); this site is within the terrestrial EAAA. The species is a feature of the Hisma Basin-Rum KBA, Wadi Ibn Hammad - Haditha KBA, Wadi Mujib KBA and Dana KBA, which are all in proximity to the Project. According to the 2022 ESIA, the species is either actually or potentially present in the southern end of the pipeline route (Tetra Tech 2022). One individual was recorded during the terrestrial baseline survey in July 2025, in the southern end of the Project, southwest of Aqaba. There are two GBIF records in the terrestrial EAAA in the last two years. However, with few individuals recorded, there is no indication that the EAAA supports globally or regionally important concentrations of this VU mammal. It is therefore unlikely to qualify as CH under Criteria 1.b and 1.c of IFC PS6 or the equivalent criteria of EBRD ESR6 and EIB S4. This species qualifies as a Priority Biodiversity Feature under EBRD ESR6.
Canis lupus	Grey Wolf	LC	EN	Reported	GBIF	Assessed against C1.c of IFC PS6 and the equivalent criteria of EBRD ESR6 and EIB S4	Unlikely CH	The globally LC Grey Wolf is nationally EN in Jordan. The terrestrial EAAA overlaps with 0.01% of the species' range. This is the world's most widely distributed terrestrial mammal, living throughout most of the northern hemisphere, including the Arabian Peninsula. In Jordan, this species is recorded from Aqaba, Um Al Quttain, Wadi Araba, Abu Anseer, Ma'an, Reishah, Wadi Finan, Wadi Rum, Ajlun, Azraq, Marab Swaia'ad, Ash Shawbak, Fifa Protected Area, Humrat Ma'in Special Conservation Area, Jabal Masuda Protected Area, Qatar Protected Area, Wadi Al Mujib, and Yarmouk Protected Area

Scientific name	Common English name	Global RL status [1]	National / Regional RL status	Presence in EAAA [2]	Source for EAAA confirmation	Critical Habitat Criteria [3]	Conclusion [4]	Justification
								(Eid *et al.* 2020). Suitable habitat for the species includes desert, which is present in the terrestrial EAAA. The species has historically been present in the Wadi Rum Protected Area, within the EAAA. According to the 2022 ESIA, the species is either actually or potentially present in the southern half of the pipeline route (Tetra Tech 2022), and there are two GBIF records within the EAAA. However, the species in Jordan is distributed primarily to the west of the Project, and it was not recorded during the terrestrial baseline surveys in July 2025. Also, interviews with locals indicate that the wolf has not been seen for several decades from Wadi Rum. The species is not expected to be encountered along the pipeline route(Z. Amr, personal communication, November 2025). It is unlikely that the EAAA contains 'important concentrations' of this nationally EN species. It is therefore unlikely to qualify as CH under Criterion 1.c of IFC PS6, and the equivalent criteria of EBRD ESR6 and EIB S4.
Reptiles								
Acanthodactylus ahmaddisii	Jordanian Fringe-fingered Lizard	EN	-	Unconfirmed	NA	Assessed against C1.a and C2.a of IFC PS6 and the equivalent criteria of EBRD ESR6 and EIB S4	Unlikely CH	This globally EN lizard has an EOO of 4,790 km^2 and therefore a restricted-range species. The terrestrial EAAA overlaps with 14.92% of the species' range. Its range lies in the northern part of the pipeline route, just south of Amman. It was described based on a single specimen collected in the Dab'a region and is considered endemic to the area. Suitable habitat, in the form of semi-desert with small shrubs, is present in the EAAA, although the section of the Project area that overlaps with the species' range is primarily modified habitat or degraded natural desert habitat with very little vegetation. The population of this species has not been estimated,

Scientific name	Common English name	Global RL status [1]	National / Regional RL status	Presence in EAAA [2]	Source for EAAA confirmation	Critical Habitat Criteria [3]	Conclusion [4]	Justification
								but it thought to be relatively common within suitable habitat, with fluctuations in population size related to rainfall (IUCN 2025a). The IUCN assessment of this species is from 2006 and therefore required reassessment, particularly as there are no known records of the species since this assessment. It was not recorded during the terrestrial baseline surveys in July 2025 and there are no records of the species on GBIF. A recent, extensive reptile survey, conducted in the Daba'a rangeland Reserve to inform the upcoming national red list assessment of reptiles, did not record the species. Despite the EAAA overlapping 14.92% of the species' range, with no evidence of the species' presence within the EAAA, it is unlikely to be regularly occurring in the Project area of influence. This EN and restricted-range lizard is therefore unlikely to qualify as CH under either Criterion 1.a or 2.a of IFC PS6, or the equivalent criteria of EBRD ESR6 and EIB S4. If, however, the species is recorded in the terrestrial EAAA in future surveys, it should be reassessed for CH.
Uromastyx aegyptia	Egyptian Spiny–tailed Lizard	VU	-	Confirmed	Interim Terrestrial Ecological Baseline (2025)	Assessed against C1.b of IFC PS6 and the equivalent criteria of EBRD ESR6 and EIB S4	Unlikely CH PBF	This lizard is globally VU. It occurs throughout most of the Arabian Peninsula and northeastern Egypt and has an EOO of ~3,000,000 km^2. This species is widespread but declining in parts of Jordan. The species occurs in open, flat, gravelly, stony and rocky areas (IUCN 2025a), which are present in the terrestrial EAAA. The EAAA overlaps with 0.14% of the species' range. There are no GBIF records in the EAAA. However, the species is a feature of Hisma Basin-Rum KBA and Dana KBA which are both in close proximity to the Project. The species was recorded during the baseline surveys in July 2025, in Segment 6 which is in the lower-middle section of the pipeline, near Ma'an (number of individuals unknown). Suspected burrows of this species were also recorded in Segment 1 at the southern end of the

Scientific name	Common English name	Global RL status [1]	National / Regional RL status	Presence in EAAA [2]	Source for EAAA confirmation	Critical Habitat Criteria [3]	Conclusion [4]	Justification
								pipeline. From consultation with the Royal Society for the Conservation of Nature (RSCN) in Jordan, it is understood that there is a large population of *Uromastyx aegyptia* in the area located 30-40 km south of Ma'an, approximately in the area proposed for the Project's Regulating Tank 3, inside Segment 6 (NCPC *et al.* 2025g). Despite the apparently large population of the species within the terrestrial EAAA, due to the small range overlap (<1%) and the wide distribution of recent GBIF records across the Arabian Peninsula, it is unlikely that the EAAA contains globally important concentrations of this VU species, and the loss of individuals in the EAAA is very unlikely to lead to the species meeting the IUCN thresholds for EN or CR. It is therefore unlikely to qualify as CH under Criterion 1.b of IFC PS6, or the equivalent criteria of EBRD ESR6 and EIB S4. This species qualifies as a Priority Biodiversity Feature under EBRD ESR6.
Insects								
Lacon ammanensis		DD	-	Unconfirmed	NA	Assessed against C2.a of IFC PS6 and the equivalent criteria of EBRD ESR6 and EIB S4	Not CH	This DD beetle has an EOO of 2,505 km^2, so it is a restricted-range species. The terrestrial EAAA overlaps 3.44% of the species' range. The species is endemic to northwestern Jordan and its range lies at the northern end of the pipeline near Amman. Species of this genus are saproxylic, but there is no significant information about the ecology and habitats for this species. The species was not recorded during the baseline surveys in July 2025 and there are no records of the species on GBIF. It is very unlikely that the EAAA contains at least 10% of the population of this restricted-range beetle. It therefore

Scientific name	Common English name	Global RL status [1]	National / Regional RL status	Presence in EAAA [2]	Source for EAAA confirmation	Critical Habitat Criteria [3]	Conclusion [4]	Justification
								does not qualify as CH under Criterion 2.a of IFC PS6, or the equivalent criteria of EBRD ESR6 and EIB S4.
Birds								
Serinus syriacus	Syrian Serin	VU	EN	Reported	eBird	Assessed against C1.b, C1.c, C2.a and C3.a of IFC PS6 and the equivalent criteria of EBRD ESR6 and EIB S4	Unlikely CH (C3.a) PBF	This globally VU bird is regionally EN in the Arabian Peninsula and is migratory. It has an EOO of 24,100 km^2. Therefore, it is considered a restricted-range species. The species breeds in Lebanon, Syria, Israel and Jordan, and also winters in Egypt and Palestine. The minimum global population is estimated at 7,000 mature individuals (IUCN 2025a). The avian EAAA overlaps with 1.16% of the species' passage range and 0.16% of the breeding range, for a total of 1.32% range overlap. It breeds in rocky tracts of open or semi-arid Mediterranean woodland, and in non-breeding seasons it occurs at lower levels near acacias and thorn-scrub habitats across desert and semi-desert areas, as well as in vegetated wadis, which are present in the avian EAAA. The species triggers KBA and IBA criteria in Dana KBA/IBA, which lies ~10.5 km from the avian EAAA. According to RSCN, breeding of this species in Jordan is confined to the Dana Reserve region (within the Dana KBA), in a small area of just 10-15 km^2. Recent GBIF and eBird records also show the species in Jordan to be concentrated around this area (but this may reflect more intense activity by birdwatchers); there are just four records in the avian EAAA since 2024. In 2022, 880-980 mature individuals were remaining in Dana (IUCN 2025a), which represents up to 14% of the global population size. In the winter the species moves south, in broad front and in a rather erratic and unpredictable pattern, spreading over a larger region, including Wadi Rum (there are eBird records of landing Syrian Serin in Wadi Rum) and areas in northern

Scientific name	Common English name	Global RL status [1]	National / Regional RL status	Presence in EAAA [2]	Source for EAAA confirmation	Critical Habitat Criteria [3]	Conclusion [4]	Justification
								Saudi Arabia. It is therefore impossible to define an EAAA for this species as a migrant. It was not recorded during the spring or autumn 2025 bird surveys for the transmission line, though bird surveys have not yet been conducted for the rest (remaining ~90%) of the Project footprint. As the species in Jordan is concentrated >10 km from the avian EAAA, and considering the likely small territory size of the species, it is unlikely that the avian EAAA contains globally important concentrations of this VU species, and the loss of individuals in the EAAA is very unlikely to lead to the species meeting the IUCN thresholds for EN or CR. It is therefore unlikely to qualify as CH under Criterion 1.b of IFC PS6, or the equivalent criteria of EBRD ESR6 and EIB S4. There is also no indication that the EAAA contains important concentrations of this regionally EN species, so it is unlikely to qualify as CH under Criterion 1.c of IFC PS6, or the equivalent criteria of EBRD ESR6 and EIB S4. It is also unlikely that the EAAA holds at least 10% of the global population of this restricted-range species, so it is unlikely to qualify as CH under Criterion 2.a of IFC PS6, or the equivalent criteria of EBRD ESR6 and EIB S4.
Falco concolor	Sooty Falcon	VU	EN	Reported	eBird	Assessed against C1.b, C1.c and C3.a of IFC PS6 and the equivalent criteria of EBRD ESR6 and EIB S4	**Possible CH (C3.a)**	This migratory raptor is globally VU and regionally EN in the Arabian Peninsula. It has an EOO of 2,370,000 km^2, from the breeding areas in the Middle East (including Jordan) and North Africa, down to the wintering areas in Madagascar, Mauritius, Réunion, Mozambique and South Africa. The EAAA for this species corresponds to the Hisma Basin-Rum IBA/KBA, which overlaps with less than 0.15% of the breeding range of the species, and 0.03% of the passage range, totaling less than 0.2%. The minimum global population is estimated at 2,800 mature individuals. Suitable habitat for the species includes

Scientific name	Common English name	Global RL status [1]	National / Regional RL status	Presence in EAAA [2]	Source for EAAA confirmation	Critical Habitat Criteria [3]	Conclusion [4]	Justification
								desert (IUCN 2025a), which is within the EAAA. The species triggers IBA criteria in the Hisma Basin-Rum IBA/KBA, within the EAAA, where it is known to breed in the sandstone mountains. Six mature individuals were present here in 1999. The species is also a feature of other KBAs overlapping or in proximity to the EAAA, but only as a migrant: Aqaba coast and mountains KBA, Southern Arava valley and Elat mountains KBA, Wadi Gerafi KBA, Wadi Mujib KBA and Dana KBA. According to RSCN, the area to the east of Manshir (and 10-20 km to southwest of Regulating Tank 3 proposed site) is an important breeding area for the species. There are 23 eBird/GBIF records from the last five years within the EAAA. The species was not recorded during the spring or autumn 2025 bird surveys for the transmission line. Despite the apparent significant population in the EAAA, it is unlikely that the avian EAAA contains globally important concentrations of this VU species, and the loss of individuals in the EAAA is very unlikely to lead to the species meeting the IUCN thresholds for EN or CR. It is therefore unlikely to qualify as CH under Criterion 1.b of IFC PS6, or the equivalent criteria of EBRD ESR6 and EIB S4. It also appears unlikely that the EAAA contains important concentrations of this regionally EN species, so is unlikely to qualify under Criterion 1.c of IFC PS6 and the equivalent criteria of EBRD ESR6 and EIB S4. Considering the importance of the breeding area within the Hisma Basin-Rum IBA/KBA, it is possible that the EAAA contains at least 1% of the global population (at least 28 mature individuals) of this migratory species at any point. It therefore possibly qualifies as CH under Criterion 3.a of IFC PS6 and the equivalent criteria of EBRD ESR6 and EIB S4. But for

Scientific name	Common English name	Global RL status [1]	National / Regional RL status	Presence in EAAA [2]	Source for EAAA confirmation	Critical Habitat Criteria [3]	Conclusion [4]	Justification
								confirmation, directed census need to be conducted in order to quantify the number of individuals present in the EAAA.
Accipiter brevipes	Levant Sparrowhawk	LC	-	Reported	eBird	Assessed against C3.a of IFC PS6 and the equivalent criteria of EBRD ESR6 and EIB S4	**Certain CH (C3.a)**	This globally LC raptor is migratory. It breeds in eastern and southern Europe and western Asia, and winters in Africa. It has a large EOO of 3,620,000 km^2. The avian EAAA overlaps with just 0.03% of the passage range of the species. However, it appears that the species passes in much higher concentrations due to the position of the EAAA in the flyway of the species. In fact, almost the entire global population of this species is expected to pass through Israel and/or western Jordan during migration. The Levant Sparrowhawk triggers KBA and IBA criteria for the Aqaba coast and mountains KBA/IBA, which lies within the EAAA, and is designated due to a migratory population of 3,000 Levant Sparrowhawks. This represents up to 30% of the lower global population estimate of 10,000 individuals. The species is also a feature of the Southern Arava valley and Elat mountains KBA/IBA (16,280-49,836 individuals in 1988) and Wadi Mujib KBA/IBA (8,000 individuals in 1992). These IBAs, which lie to the west of the Project, are migration bottleneck sites for the species. eBird shows a high-count of 350 individuals in the Aqaba Coast and Mountains IBA in September 2022 (3.5% of the lower global population estimate), with evidence of birds landing/resting in the IBA in trees and by water. Movebank also shows multiple tracks passing through the southern end of the Project area. However, according to RSCN, the species has not been recorded in large number in recent years, and the main migratory routes in the region seem to have shifted eastwards (main migratory route now seems to cross Azraq), possibly due to the impacts of increased disturbance in Aqaba region that prevent the species to

Scientific name	Common English name	Global RL status [1]	National / Regional RL status	Presence in EAAA [2]	Source for EAAA confirmation	Critical Habitat Criteria [3]	Conclusion [4]	Justification
								find suitable roosting areas. The Levant Sparrowhawk was not recorded during the spring or autumn 2025 bird surveys for the transmission line. Nevertheless, this species is known to migrate in very large flocks, often comprising a significant proportion of the population, so if a survey does not cover the full duration of the migratory period, there is a high likelihood that no, or very few, individuals will be recorded. There is also evidence that at least some birds migrate at night (Stark & Liechti 1993; Spaar *et al.* 1998). Due to the high likelihood of a significant percentage of the global population of this migratory raptor being within the EAAA during migration, and with evidence of birds landing in the EAAA, the species qualifies as CH under Criterion 3.a of IFC PS6 and the equivalent criteria of EBRD ESR6 and EIB S4.
Aquila nipalensis	Steppe Eagle	EN	EN	Confirmed	Spring 2025 bird surveys (NCPC *et al.* 2025d) Autumn 2025 bird surveys (NCPC *et al.* 2025f)	Assessed against C1.a, C1.c and C3.a of IFC PS6 and the equivalent criteria of EBRD ESR6 and EIB S4	**Possible CH (C1.a, 1c, 3a)**	This migratory raptor is globally and regionally EN. It's breeding range spans from western Russia across Central Asia to eastern China. It winters in Africa, parts of the middle east and southern Asia. It has a very large EOO of 12,600,000 km^2. The avian EAAA lies on the flyway for this species, and overlaps with 0.03% of the species' passage range. The species has a lower global population estimate of 50,000 mature individuals. There are at least 60 eBird/GBIF records since 2024 within the avian EAAA, many of which are in the Project area (although the majority of birds recorded seem to pass at high altitude). A total of 84 individuals were recorded flying over during the autumn 2025 bird surveys for the transmission line, and six were recorded flying over in the spring surveys (NCPC *et al.* 2025d). According to RSCN, the Abu Rukbah proposed Nature Reserve, which overlaps with the Project, is very important for Steppe Eagles during Spring and Autumn migration, concentrating

Scientific name	Common English name	Global RL status [1]	National / Regional RL status	Presence in EAAA [2]	Source for EAAA confirmation	Critical Habitat Criteria [3]	Conclusion [4]	Justification
								up to 1,000 individuals, which represents up to 2% of the global population. Also, according to RSCN, near the boundary of the Abu Rukbah proposed Nature Reserve is a dumping site for expired chicken carcasses and remains that attracts a large number of Steppe Eagles that roost in the area. This area is especially important during migration periods, although some individuals also overwinter. Therefore, the Abu Rukbah proposed Nature Reserve, as the only known congregation area within Jordan, was considered as the EAAA for this species. As up to 2% of the global population could be inside the EAAA during migrations and with evidence of landing, it is possible that the EAAA contains at least 0.5% of the global population of this EN species, and at least 1% of the population of this migratory species during spring/autumn migration. With a very important site with up to 1,000 individuals in the EAAA, it is also possible that the EAAA contains "important concentrations" of this regionally EN species. It therefore possibly qualifies as CH under Criterion 1.a, 1.c and 3.a of IFC PS6 and the equivalent criteria of EBRD ESR6 and EIB S4. Directed census within the EAAA are needed to assess the number of individuals present, in order to verify if critical habitat is triggered.
Neophron percnopterus	Egyptian Vulture	EN	VU	Confirmed	Spring 2025 bird surveys (NCPC *et al.* 2025d) Autumn 2025 bird surveys (NCPC *et al.* 2025f)	Assessed against C1.a and C3.a of IFC PS6 and the equivalent criteria of	Unlikely CH PBF	This migratory raptor is globally EN. It has an extremely large EOO of 50,100,000 km^2 and its range spans much of Europe, Asia and Africa. The avian EAAA lies on the flyway of this species and overlaps with 0.04% of the species' passage range. This route is, however, one of a number of routes the species takes during migration to/from Africa (one of at least three main routes). Movebank shows two out of 16 Egyptian Vulture tracks crossing the EAAA during migration. The global population is estimated at a minimum of 12,400 mature

Scientific name	Common English name	Global RL status [1]	National / Regional RL status	Presence in EAAA [2]	Source for EAAA confirmation	Critical Habitat Criteria [3]	Conclusion [4]	Justification
						EBRD ESR6 and EIB S4		individuals. This species is a feature of Hisma Basin-Rum KBA (and Wadi Rum), Southern Arava valley and Elat mountains KBA, Wadi Mujib KBA and Dana KBA. There are four GBIF/eBird records in the avian EAAA since 2024. One individual was recorded during the spring 2025 bird surveys for the transmission line (NCPC *et al.* 2025d), and one was recorded during the autumn 2025 surveys, both flying at high altitude, indicating migratory movements (NCPC *et al.* 2025f). According to RSCN, very few individuals were detected during migration across the Project's area of influence. Despite the wider region being an important flyway for the species, there is no indication that this EN species passes through the EAAA, and lands, in concentrations of at least 0.5% of the global population. It is therefore unlikely to qualify as CH under Criterion 1.a. or 3.a of IFC PS6 and the equivalent criteria of EBRD ESR6 and EIB S4. This species qualifies as a Priority Biodiversity Feature under EBRD ESR6.
Oenanthe moesta	Buff-rumped Wheatear	LC	EN	Confirmed	Spring 2025 bird surveys (NCPC *et al.* 2025d)	Assessed against C1.c of IFC PS6 and the equivalent criteria of EBRD ESR6 and EIB S4	Unlikely CH PBF	This globally LC bird is regionally EN in the Arabian Peninsula. It has a range spanning north Africa and parts of the Middle East and has a range of 4,590,000 km^2. It is not a migrant. The avian EAAA overlaps with 0.58% of the species' range. According to the regional Red List assessment there are a few breeding pairs in Jordan (Symes *et al.* 2017). Suitable habitat for the species includes desert which is in the EAAA. The species triggers IBA criteria in the Hisma Basin-Rum IBA/KBA (no population estimate available), which is inside the EAAA and overlaps with the Project area. According to RSCN, the area of the wadi ~10 km north of the Project's Regulating Tank 3 proposed site is important for this species. A recently published distribution

Scientific name	Common English name	Global RL status [1]	National / Regional RL status	Presence in EAAA [2]	Source for EAAA confirmation	Critical Habitat Criteria [3]	Conclusion [4]	Justification
								map of the species in Jordan also shows several occurrences along segment 7 of the pipeline route and north of Hisma Basin-Rum IBA/KBA (Khoury *et al.* 2025). One individual was recorded during the Spring 2025 bird surveys for the transmission line (NCPC *et al.* 2025d). Despite an important site being ~10 km from the Project (at the edge of the avian EAAA), because the species is not migratory and likely has a small territory size of ~0.2 km^2 (Khoury *et al.* 2020), it is unlikely that the EAAA contains important concentrations of this regionally EN species. It is therefore unlikely to qualify as CH under Criterion 1.c of IFC PS6 and the equivalent criteria of EBRD ESR6 and EIB S4. This species qualifies as a Priority Biodiversity Feature under EBRD ESR6.
Buteo rufinus	Long-legged Buzzard	LC	LC	Confirmed	Spring 2025 bird surveys (NCPC *et al.* 2025d). Autumn 2025 bird surveys (NCPC *et al.* 2025f)	Assessed against C3.a of IFC PS6 and the equivalent criteria of EBRD ESR6 and EIB S4	Not CH	This globally LC raptor is migratory. It has a range spanning parts of Europe, Asia and Africa, and has a large EOO of 32,300,000 km^2. The species is resident in Jordan and the avian EAAA overlaps 0.05% of the species' resident range. The wider area is also used as a flyway between Eurasia and Africa. The global population is estimated at a minimum of 100,000 mature individuals, and there are an estimated 2,000 mature individuals in Jordan. Suitable habitat for the species includes rocky areas, which are present the EAAA. The species is known to be present in the Wadi Rum Protected Area and Hisma Basin-Rum KBA/IBA, which are within the EAAA. eBird and GBIF records indicate that the species is quite common in these areas, as well as in the Project area itself. Three individuals were recorded during the spring 2025 bird surveys for the transmission line (NCPC *et al.* 2025d), and 11 individuals were recorded during the autumn

Scientific name	Common English name	Global RL status [1]	National / Regional RL status	Presence in EAAA [2]	Source for EAAA confirmation	Critical Habitat Criteria [3]	Conclusion [4]	Justification
								surveys (NCPC *et al.* 2025f). However, it is very unlikely that the EAAA contains at least 1% of the global population of this migratory species at any point. Therefore, it does not qualify as CH under Criterion 3.a of IFC PS6 and the equivalent criteria of EBRD ESR6 and EIB S4.
Circaetus gallicus	Short-toed Snake-eagle	LC	VU	Confirmed	Autumn 2025 bird surveys (NCPC *et al.* 2025f)	Assessed against C3.a of IFC PS6 and the equivalent criteria of EBRD ESR6 and EIB S4	Not CH	This globally LC migratory raptor has a range spanning parts of Europe, Asia and Africa, and has a large EOO of 48,800,000 km^2. The global population is estimated at a minimum of 50,000 mature individuals. The species breeds in Jordan and also passes through the country during migration to/from Africa. There are an estimated 30 pairs (i.e. 60 mature individuals) breeding in Jordan (Symes *et al.* 2017). The avian EAAA overlaps with 0.03% of the species' breeding range, and 0.01% of its passage range (though Movebank tracks show the vast majority of tagged individuals passing through Israel instead of Jordan/the EAAA). The species historically breeds in the Hisma Basin-Rum KBA/IBA and Wadi Rum Protected Area, though no population estimates are available. eBird and GBIF records indicate that the species occurs regularly in the EAAA and Project area. However, there have been no recent nests observed in Wadi Rum, and it is unlikely that the breeding distribution continues to overlap with the Project area (Z. Amr, personal communication, November 2025). Four individuals were recorded flying over at a height of >50 m during the bird surveys for the transmission line in autumn 2025 (NCPC *et al.* 2025f). It is very unlikely that the EAAA contains at least 1% of the global population (i.e. 500 mature individuals) of this migratory species at any point. It is therefore

Scientific name	Common English name	Global RL status [1]	National / Regional RL status	Presence in EAAA [2]	Source for EAAA confirmation	Critical Habitat Criteria [3]	Conclusion [4]	Justification
								does not qualify as CH under Criterion 3.a of IFC PS6 and the equivalent criteria of EBRD ESR6 and EIB S4.
Gyps fulvus	Griffon Vulture	LC	EN	Reported	eBird	Assessed against C1.c and C3.a of IFC PS6 and the equivalent criteria of EBRD ESR6 and EIB S4	Unlikely CH PBF	Thig globally LC raptor is regionally EN in the Arabian Peninsula and is migratory. It has a large range spanning parts of Europe, Asia and Africa, and has a large EOO of 20,400,000 km^2. The global population is estimated at a minimum of 80,000 mature individuals. The avian EAAA overlaps with 0.03% of the species' non-breeding range and 0.02% of the species' resident range. It is known to breed on mountains in Jordan. The species is a feature of Wadi Araba IBA/KBA, Wadi Mujib IBA/KBA, Dana IBA/KBA. It is considered rare in the Wadi Rum area (NCPC *et al.* 2025d). There are some recent eBird records of the species in the EAAA and Project area, and Movebank shows numerous tracks of the species within the EAAA and Project area. The species was not recorded during the bird surveys for the transmission line in spring and autumn 2025. It is considered unlikely that the species occurs frequently in the Project region, as it primarily nests on top of the mountains (Z. Amr, personal communication, November 2025). Based on this, and the distribution of publicly-available records of the species, it appears unlikely that the EAAA contains important concentrations of this regionally EN species. It is also unlikely that the EAAA contains at least 1% of the global population (i.e. 800 mature individuals) of this migratory species at any point. It is therefore unlikely to qualify as CH under Criterion 1.c. or 3.a of IFC PS6 and the equivalent criteria of EBRD ESR6 and EIB S4. This species qualifies as a Priority Biodiversity Feature under EBRD ESR6.

Scientific name	Common English name	Global RL status [1]	National / Regional RL status	Presence in EAAA [2]	Source for EAAA confirmation	Critical Habitat Criteria [3]	Conclusion [4]	Justification
Ciconia nigra	Black Stork	LC	-	Confirmed	Autumn 2025 bird surveys (NCPC *et al.* 2025f)	Assessed against C3.a of IFC PS6 and the equivalent criteria of EBRD ESR6 and EIB S4	Unlikely CH	This globally LC bird is migratory. It has a very large range spanning parts of Europe, Asia and Africa, and has a large EOO of 25,100,000 km^2. The global population is estimated at a minimum of 21,400 mature individuals. Jordan is on the species' flyway between Eurasia and Africa. It is known to frequent water bodies in the Jordan Valley to feed on fish (Z. Amr, personal communication, November 2025). The avian EAAA overlaps with 0.03% of the species' passage range. The species is known to be present in the Wadi Rum Protected Area (NCPC *et al.* 2025d). The species triggers IBA criteria in the Southern Arava valley and Elat mountains IBA/KBA, west of the EAAA, where there were 3,771 individuals estimated in 1991. This represents up to 17.6% of the current global population, although this estimate is very outdated. There are some recent eBird records of the species in the EAAA and Project area. Movebank shows a few tracks of the species within the EAAA and Project area, but the vast majority of tracks pass west of the EAAA over Israel. Its (landing) presence in the EAAA is uncertain due to the lack of permanent water bodies (Z. Amr, personal communication, November 2025). Five individuals were recorded during the bird surveys for the transmission line in autumn 2025, flying <50 m high (NCPC *et al.* 2025f). It is unlikely that the EAAA contains at least 1% of the global population (i.e. 214 mature individuals) of this migratory species at any point. It is therefore unlikely to qualify as CH under Criterion 3.a of IFC PS6 and the equivalent criteria of EBRD ESR6 and EIB S4.
Ciconia ciconia	White Stork	LC	NT	Reported	eBird	Assessed against C3.a of IFC PS6 and	Not CH	This globally LC bird is migratory. It has a very large range spanning Europe, Africa and parts of Asia, and has a large EOO of 52,700,000 km^2. The global population is estimated at a minimum of 526,000

Scientific name	Common English name	Global RL status [1]	National / Regional RL status	Presence in EAAA [2]	Source for EAAA confirmation	Critical Habitat Criteria [3]	Conclusion [4]	Justification
						the equivalent criteria of EBRD ESR6 and EIB S4		mature individuals. Jordan is on the species' flyway between Eurasia and Africa. The avian EAAA overlaps with 0.03% of the species' passage range. The species is described as an uncommon autumn migrant in the Wadi Rum Protected Area (NCPC *et al.* 2025d). The species triggers IBA criteria in the Southern Arava valley and Elat mountains IBA/KBA, west of the EAAA, where there were 11,000 individuals in 1991. This represents up to 2% of the current global population, although this estimate is very outdated. There are many recent eBird records of the species in the EAAA and Project area. Movebank shows many tracks of the species passing through the EAAA and Project area, but the vast majority of tracks pass west of the EAAA over Israel. The species was not recorded during the bird surveys for the transmission line in spring and autumn 2025. It is very unlikely that the EAAA contains at least 1% of the global population (i.e. 5,260 mature individuals) of this migratory species at any point. Therefore, it does not qualify as CH under Criterion 3.a of IFC PS6 and the equivalent criteria of EBRD ESR6 and EIB S4.
Buteo buteo (vulpinus)	Common / Steppe Buzzard	LC	LC	Confirmed	Spring 2025 bird surveys (NCPC *et al.* 2025d)	Assessed against C3.a of IFC PS6 and the equivalent criteria of EBRD ESR6 and EIB S4	Unlikely CH	This globally LC bird is migratory. It has a very large range spanning Eurasia and parts of Africa, and has a large EOO of 33,500,000 km^2. The global population is estimated at a minimum of 2,000,000 mature individuals. The species didn't appear on the IBAT screening as the IUCN mapped range does not overlap with the avian EAAA, however this area is known to be located on the species' flyway between Eurasia and Africa and there are many eBird and GBIF records of the species along the western side of Jordan in the region of the Project. There were 396 individuals recorded during the 2025 spring bird surveys for the transmission line (NCPC *et al.* 2025d), and 80 recorded during the autumn surveys (NCPC *et al.* 2025f).

Scientific name	Common English name	Global RL status [1]	National / Regional RL status	Presence in EAAA [2]	Source for EAAA confirmation	Critical Habitat Criteria [3]	Conclusion [4]	Justification
								However, >99% were recorded flying at a height of over 20 m, and there was no evidence of landing. There are no areas in, or in proximity to, the EAAA that are considered particularly important stop-over sites for this species (e.g. IBAs). Despite the relatively high counts recorded during surveys, with the very high global population of 2,000,000 mature individuals and with no indication of large numbers landing in the EAAA, it is unlikely that this migratory species is present, and lands, in the EAAA in concentrations of at least 1% of the global population (i.e. >20,000 individuals) at any point. It is therefore unlikely to qualify as CH under Criterion 3.a of IFC PS6 and the equivalent criteria of EBRD ESR6 and EIB S4.
Pernis apivorus	European Honey-buzzard	LC	-	Confirmed	Spring 2025 bird surveys (NCPC *et al.* 2025d)	Assessed against C3.a of IFC PS6 and the equivalent criteria of EBRD ESR6 and EIB S4	Unlikely CH	This globally LC bird is migratory. It has a very large range spanning Eurasia and Africa, and has a large EOO of 18,200,000 km^2. The global population is estimated at a minimum of 290,000 mature individuals. Jordan is on the species' flyway between Eurasia and Africa, on one of at least three routes that the species takes. The avian EAAA overlaps with 0.03% of the species' passage range. It triggered IBA criteria in the Southern Arava valley and Elat mountains IBA/KBA to the west of the avian EAAA, based on population estimates from 1977-1988. Movebank tracks show the species to pass west of the EAAA and no tracks pass through the EAAA. A total of 170 individuals were recorded during surveys for the transmission line in spring 2025, with <99% flying over 20 m high and no evidence of landing (NCPC *et al.* 2025d). This represents ~0.06% of the global population. It is unlikely that this migratory species is present, and lands, in the EAAA in concentrations of at least 1% of the global population (i.e. >2,900 individuals) at any

Scientific name	Common English name	Global RL status [1]	National / Regional RL status	Presence in EAAA [2]	Source for EAAA confirmation	Critical Habitat Criteria [3]	Conclusion [4]	Justification
								point. It is therefore unlikely to qualify as CH under Criterion 3.a of IFC PS6 and the equivalent criteria of EBRD ESR6 and EIB S4.
Milvus migrans	Black Kite	LC	-	Confirmed	Spring 2025 bird surveys (NCPC *et al.* 2025d) Autumn 2025 bird surveys (NCPC *et al.* 2025f)	Assessed against C3.a of IFC PS6 and the equivalent criteria of EBRD ESR6 and EIB S4	Not CH	This globally LC bird is migratory. It has an extremely large range spanning Europe, Africa, and much of Asia and Australasia, with an extremely large EOO of 115,653,659 km^2. The global population is estimated at a minimum of 4,000,000 mature individuals. Jordan is on the species' flyway between Eurasia and Africa, on one of at least three routes that the species takes. The avian EAAA overlaps with 0.01% of the species' passage range. There are no areas in, or in proximity to, the EAAA that are considered particularly important stop-over sites for this species (e.g. IBAs). Movebank tracks show the species to pass west of the EAAA and no tracks pass through the EAAA. A total of 55 individuals were recorded in spring (NCPC *et al.* 2025d), and 26 individuals recorded in autumn (NCPC *et al.* 2025f) during the 2025 bird surveys for the transmission line. All individuals were flying >20 m high and there was no evidence of landing. It is extremely unlikely that this migratory species is present, and lands, in the EAAA in concentrations of at least 1% of the global population (i.e. >40,000 individuals) at any point. Therefore, it does not qualify as CH under Criterion 3.a of IFC PS6 and the equivalent criteria of EBRD ESR6 and EIB S4.
Hieraaetus pennatus	Booted Eagle	LC	-	Confirmed	Spring 2025 bird surveys (NCPC *et al.* 2025d)	Assessed against C3.a of IFC PS6 and the equivalent criteria of	Unlikely CH	This globally LC bird is migratory. It has a very large range spanning Europe, Africa, and much of Asia and Australasia, with a very large EOO of 62,000,000 km^2. The global population is estimated at a minimum of 150,000 mature individuals. Jordan is on the species' flyway between Eurasia and Africa, on one of three routes that the species takes. The avian EAAA overlaps with 0.04% of the species'

Scientific name	Common English name	Global RL status [1]	National / Regional RL status	Presence in EAAA [2]	Source for EAAA confirmation	Critical Habitat Criteria [3]	Conclusion [4]	Justification
						EBRD ESR6 and EIB S4		passage range. There are no areas in, or in proximity to, the EAAA that are considered particularly important stop-over sites for this species (e.g. IBAs). A total of 36 individuals were recorded during bird surveys for the transmission line in spring 2025 (and 5 in autumn 2025). All individuals were recorded flying at over 50 m high and there was no evidence of landing. The spring data represents ~0.02% of the global population. It is unlikely that this migratory species is present, and lands, in the EAAA in concentrations of at least 1% of the global population (i.e. >1,500 individuals) at any point. It is therefore unlikely to qualify as CH under Criterion 3.a of IFC PS6 and the equivalent criteria of EBRD ESR6 and EIB S4.

Notes:

[1] **Red List (RL) status**: **CR** = Critically Endangered; **EN** = Endangered; **VU** = Vulnerable; **NT** = Near Threatened; **LC** = Least Concern; **DD** = Data Deficient; **NE** = Not Evaluated

[2] **Presence in EAAA**: **Confirmed** = presence confirmed through recent field surveys in the relevant EAAA; **Reported** = presence reported on publicly-available biodiversity databases (e.g., GBIF, eBird); **Unconfirmed**= presence unconfirmed but considered possible given the overlap between study area and species range and/or suitability of habitats; **Unlikely** = presence considered unlikely given the lack of suitable habitats or other evidence.

[3] A description of the IFC PS6, EBRD ESR6 and EIB S4 criteria is provided in Appendix 1.

[4] **Critical Habitat Result**: **Confirmed CH** = if data demonstrate exceedance of at least one threshold (e.g. numbers confirmed by field verification); **Likely CH** = if the range overlap, or other evidence (e.g. from publicly-available data or expert consultation), suggests the EAAA is likely to exceed at least one threshold, but where there is no direct field verification; **Possible CH** = if the range overlap is close to at least one threshold, or potential for the EAAA to have a higher proportion of the population than average (e.g. based on publicly-available data or expert consultation); **Unlikely CH** = if available evidence is that thresholds are unlikely to be exceeded; **Not CH** = if available evidence is that thresholds would not be exceeded.

3.2 Priority Biodiversity Features (PBFs)

A total of 14 species have been identified as PBFs for this Project, in alignment with EBRD ESR6 criteria (see Appendix 1), including nine bird species, two reptile species, one plant species and one mammal species (Table 6).

Table 6. Species identified as Priority Biodiversity Features (PBFs) for the Project

Scientific name	Common name	Global RL status	Nat/reg RL status	PBF Criteria
Plants				
Cleome droserifolia	-	-	EN	EAAA for regularly occurring nationally or regionally listed EN or CR species
Mammals				
Capra nubiana	Nubian Ibex	VU	EN	EAAA supports VU species EAAA for regularly occurring nationally or regionally listed EN or CR species
Reptiles				
Testudo graeca	Spur-thighed / Common Tortoise	VU	-	EAAA supports VU species
Uromastyx aegyptia	Egyptian Spiny-tailed Lizard	VU	-	EAAA supports VU species
Birds				
Aquila heliaca	Eastern Imperial Eagle	VU	-	EAAA supports VU species
Aquila verreauxii	Verreaux's Eagle	LC	EN	EAAA for regularly occurring nationally or regionally listed EN or CR species
Clanga clanga	Greater Spotted Eagle	VU	-	EAAA supports VU species
Falco peregrinus	Peregrine Falcon	LC	EN	EAAA for regularly occurring nationally or regionally listed EN or CR species
Gyps fulvus	Griffon Vulture	LC	EN	EAAA for regularly occurring nationally or regionally listed EN or CR species
Neophron percnopterus	Egyptian Vulture	EN	-	EAAA supports < 0.5 per cent of global population OR < 5 reproductive units of a CR or EN species.
Oenanthe moesta	Buff-rumped Wheatear	LC	EN	EAAA for regularly occurring nationally or regionally listed EN or CR species
Pluvialis squatarola	Grey Plover	VU	-	EAAA supports VU species
Serinus syriacus	Syrian Serin	VU	EN	EAAA supports VU species
Streptopelia turtur	European Turtle Dove	VU	-	EAAA supports VU species

3.3 Highly Threatened or Unique Ecosystems

Critical habitat Criterion 4 of IFC PS6, Criterion 1 of EBRD ESR6 and Criterion 1 of EIB S4 relate to highly threatened and unique ecosystems. Jordan does not have a national Red List of threatened ecosystems, and the IUCN Red List of Ecosystems[13] does not include any ecosystems which are located in Jordan. Therefore, critical habitat criteria 4.a of IFC PS6, 1.b of EBRD ESR6 and 1.b of EIB S4, relating to IUCN CR/EN ecosystems in the EAAAs, will not be triggered. Additionally, no habitats within the EAAAs are considered to be the equivalent of any habitats in Annex 1 of the Habitats Directive (European Union 1992), so Criterion 1.a of EIB S4 will not be triggered. However, Criterion 4.b of IFC PS6, 1.c of EBRD ESR6 and 1.c of EIB S4, regarding *"ecosystems outside the EU and not yet assessed by IUCN, but determined to be of high priority for conservation on the basis of regional or national level systematic conservation planning or informed specialist input"*, could possibly be triggered by the presence of Wadi Rum Protected Area (WRPA) within the EAAAs.

Wadi Rum was designated as a protected area in 1997 by Jordan's Council of Ministers and was then inscribed in 2011 as a mixed (cultural and natural) World Heritage Site (WHS) under various criteria including criterion vii: Exceptional desert landscape and geological features. The site is internationally recognised for its representative desert geomorphology and diverse assemblage of sandstone landforms. The area contains extensive mountain and valley systems, natural arches, narrow gorges, cliffs, landslides, and cavernous weathering formations. WRPA provides a protected setting that demonstrates a rare combination of landform development driven by drainage incision, salt and biological weathering, and gravitational collapse of steep sandstone slopes, resulting in one of the most extensive examples of honeycomb and cavernous weathering systems known globally (IUCN 2025b; UNESCO World Heritage Centre 2025). However, there are no significant biodiversity values that would lead to consider it to be a unique ecosystem of high priority for conservation. Therefore, it does not qualify under Criterion 4.b of IFC PS6, 1.c of EBRD ESR6 and 1.c of EIB S4.

3.4 Key Evolutionary Processes

Indicators for the potential presence of key evolutionary process include certain features of a landscape, including high spatial heterogeneity, environmental gradients, connectivity between habitats and sites of demonstrated importance for climate change adaptation. No quantitative thresholds exist for this criterion, so there is a reliance on expert opinion and qualitative value judgement. Review of existing information did not identify any structural attributes of the landscape within the EAAAs that are likely to be associated with key evolutionary processes. Despite the Wadi Rum Protected Area containing *"landscapes with high spatial heterogeneity"* (IFC 2019), it is unlikely that key evolutionary processes occur here. The small number of unique

[13] IUCN Ecosystems

and endemic species occurring within the EAAAs also suggests that they are unlikely qualify as CH under this criterion.

3.5 Biodiversity of socio-economic value (EIB criterion)

EIB S4 contains a critical habitat criterion (Criterion 5) that is additional to IFC PS6 and EBRD ESR6 on biodiversity of socio-economic value, which states that *"areas of semi-natural and natural habitat used by indigenous peoples and local communities to obtain essential or priority benefits will be considered critical from an ecosystem service perspective."* There is no evidence that the EAAAs contain areas of high ecosystem service reliance that would trigger EIB S4 Criterion 5, with increasing emphasis on tourism and infrastructure development in the EAAAs. In the larger areas of primarily natural habitat, such as the Hisma Basin - Rum KBA (and Wadi Rum PA), local communities have historically practiced pastoralism, small-scale agriculture, and tourism. While traditional knowledge and land use persist, there is no evidence of ongoing dependence on ecosystem services for essential resources at a scale that would trigger this criterion. Tourism and conservation projects appear to have shifted livelihoods away from direct ecosystem reliance in the region (Strachan 2012; UNDP 2025). Therefore, no areas are likely to qualify as critical habitat under Criterion 5 of EIB S4.

3.6 Natural and modified habitat

The Terrestrial EAAA is located within a landscape composed of predominantly natural habitat in the south and mid parts of the alignment and predominantly modified habitat in the north closer to Amman (Figure 9, Appendix 3). Natural habitat is predominantly desert, which is mapped by the European Space Agency (ESA) as "Bare / sparse vegetation". Small areas of naturally vegetated land are also Natural Habitat ("Grassland" class in the ESA data). Natural habitats cover approximately 94% of the Terrestrial EAAA based on ESA data (Table 7). Modified habitat is mostly towns, roads and other development ("Built-up" class in the ESA data) and cropland, which cover approximately 6% of the Terrestrial EAAA (Table 7). It is important to note that the Terrestrial EAAA is substantially larger than the Project area and contains a higher proportion of natural habitat than what occurs in the Project area, which generally follows roads and settlements where the majority of modified habitat is concentrated. Taifour *et al.* (2022) mapped native vegetation across Jordan, although high resolution data behind these maps is not publicly available. According to the mapping of Taifour *et al.* (2022), the Terrestrial EAAA extends across Gravel, Runoff and Sandy Gravel (*Vachellia* and *Artemisia*), Hamada, Granite and Sandstone Shrubland, Sand Dune, *Acacia* Woodland, and Steppe vegetation types.

The Interim Terrestrial Ecological Baseline Survey (NCPC *et al.* 2025a) mapped natural and modified habitats along the length of the proposed pipeline easement. This mapping appears to be broadly accurate based on a brief desktop review against satellite imagery from Google Earth, although it could probably benefit from being refined by mapping at a smaller scale. The Interim Terrestrial Ecological Baseline Survey mapping is presented in Appendix 3, and has been modified to include the solar farm, which is likely natural habitat. It should be noted that there is rapid development along the pipeline easement, particularly along the highway, so areas

currently mapped as natural habitat along the pipeline easement are rapidly reducing over time, which should be considered when the Residual Impact Assessment (RIA) is conducted[14].

"Natural Habitat" as mapped by NCPC *et al.* (2025a) included "Natural" and "Semi-natural" classes, which are interpreted as corresponding to largely intact (i.e. high quality) and disturbed (i.e. low to moderate quality) natural habitats respectively, according to IFC PS6 / EBRD ESR6 / EIB S4 (Table 8). These natural habitat classes covered 58% of the Project area. It is possible that some areas mapped by NCPC *et al.* (2025a) as "Semi-natural" may contain small areas of modified habitat, depending on the resolution at which the habitat is mapped. "Modified Habitat" as mapped by NCPC *et al.* (2025a) included "Urban" and "Agricultural" classes, which covered 42% of the Project area are interpreted as corresponding to modified habitats, according to IFC PS6 / EBRD ESR6 / EIB S4 (Table 8). It is possible that some areas mapped by NCPC *et al.* (2025a) as "Mixed Agricultural Modified Habitat" may contain small areas of degraded natural habitat, depending on how long ago any agricultural fields were abandoned and the vegetation composition present.

Table 7: Translation of habitat classes from NCPC et al. (2025a; grey columns) to IFC PS6 / EBRD ESR6 / EIB S4 habitat classification (blue column)

Main habitat class	Secondary	Tertiary	Description	Corresponding IFC PS6 / EBRD ESR6 / EIB S4 categorisation
Modified Habitat	Urban	Residential	Mainly residential area	Modified habitat
		Commercial / Industrial	Mainly commercial/industrial	Modified habitat
		Mixed	Mixed residential with commercial / industrial	Modified habitat
	Agricultural	Active	Agricultural fields/orchards actively cultivated.	Modified habitat
		Mixed	Agricultural fields both active and fallow / abandoned.	Modified habitat, possibly some areas of low-quality natural habitat
Natural Habitat	Natural		No observable changes to naturally occurring habitat	High quality natural habitat
	Semi-natural		Limited change to habitat considered to be >75% natural	Medium-Low quality Natural habitat, possibly some areas of modified habitat

[14] More detailed information may be required to quantify the extent of natural habitat during the RIA.

Table 8: Land cover for the Terrestrial EAAA based on ESA data.

Land cover type	Description	Area within terrestrial EAAA (km² / %)
Natural Habitat:		
Tree cover	This class corresponds to natural areas with a predominance of tree or shrub elements which form a more or less continuous canopy with a height greater than 5 m.	15 km² / 0.3%
Shrubland	Corresponds to areas with a predominance of shrub elements which form a more or less continuous canopy with a height less than 5 m.	6 km² / 0.1%
Grassland	Corresponds to areas dominated by grass cover, excluding areas of cropland.	99 km² / 1.7%
Bare or sparse vegetation	Corresponds to areas with no or little vegetation.	5,218 km² / 91.7%
Permanent water bodies	Corresponds to the permanent, intermittent and seasonal bodies of water that comprise lakes, lagoons, and natural or artificial ponds of fresh water (non-saline), reservoirs and bodies of moving water, like rivers.	2 km² / 0.0%
	Total Natural Habitat	**5,339 km² / 93.8%**
Modified Habitat:		
Cropland	Cropland	207 km² / 3.6%
Built-up	Areas predominantly of urban centers and those peripheral areas that are being incorporated into urban areas through a gradual process of urbanization or change of land use towards residential, commercial, industrial, services and recreation.	147 km² / 2.6%
	Total Modified Habitat	**354 km² / 6.2%**

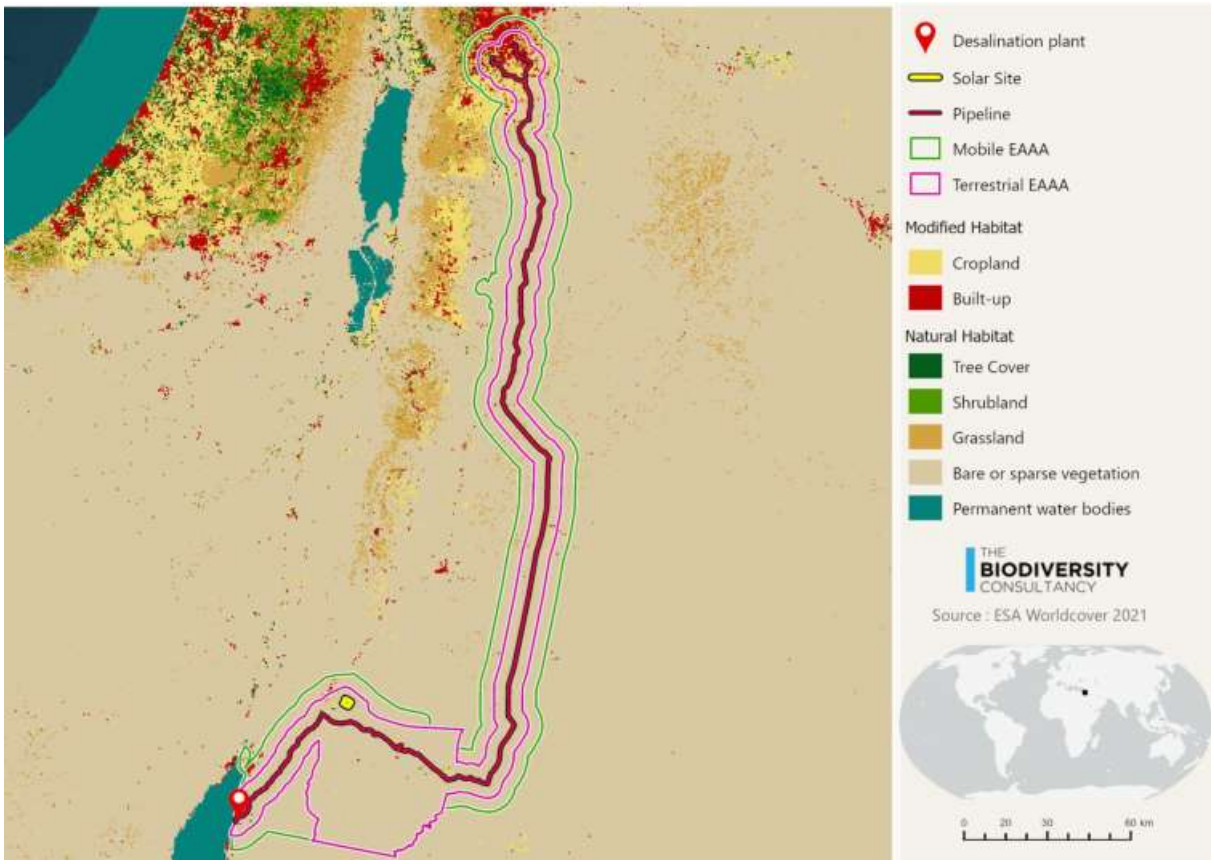


Figure 9. Map of land cover, including natural and modified habitats, across the EAAAs.

4 Legally Protected Areas and Internationally Recognised Areas

The Project overlaps with two Key Biodiversity Areas (KBAs) and Important Bird and Biodiversity Areas (IBAs), the Hisma Basin – Rum KBA/IBA and the Aqaba coast and mountains KBA/IBA:

- The **Hisma Basin – Rum Key Biodiversity Area (KBA) and Important Bird and Biodiversity Area (IBA)** will be crossed by the proposed pipeline in the southern end of the route, with the pipeline route running southeast through the northern part of this site (Figure 10). This KBA, which has an area of 2,099 km^2, comprises an isolated tract of large sandstone and granite mountains, ranging up to 1,754 m (Jabal Rum, the highest point in Jordan), separated from each other by flat, sandy 'corridor'-wadis, and surrounded by a desert of siltflats and mobile dunes. The predominant desert vegetation is a scanty shrub-steppe bushes. The site is known to support an unusually varied assemblage of desert and mountain birds. There are 22 bird species that triggered IBA criteria for the site in 2000, including the VU Sooty Falcon (*Falco concolor*), the EN Egyptian Vulture (*Neophron percnopterus*), the Red-rumped Wheatear (*Oenanthe moesta*). Other species in the KBA

include the VU Egyptian Spiny–tailed Lizard (*Uromastyx aegyptia*), the VU Nubian Ibex (*Capra nubiana*), and several plant species (BirdLife International 2025a; Key Biodiversity Areas Partnership 2025a). Approximately 35% of this KBA is covered by the Wadi Rum Protected Area (see below).

- The **Aqaba Coast and Mountains KBA and IBA** will be crossed by the southern end of the pipeline as well as the OHTL (Figure 10), and has an area of 382.5 km^2. This site includes Jordan's only coastline. Most habitats in the area have been substantially altered, particularly around Aqaba, though some natural scrub vegetation survives near the Israeli border along with some undisturbed desert to the south of the area. This site represents a migratory bottleneck site for birds and also holds a breeding bird community representative of the Rift Valley. The enormous spring passage of raptors across the border at Eilat occasionally passes over Aqaba (with maximum daily counts of B*uteo buteo* (105, April) and *Accipiter brevipes* (75, September)), but spring passage at Aqaba exceeds 50,000 raptors per season nevertheless. The Levant Sparrowhawk (*Accipiter brevipes*) triggered KBA and IBA criteria in this site, with 3,000 individuals recorded in 2000. Another six bird species triggered IBA criteria in 2000, including the VU Sooty Falcon (BirdLife International 2025b; Key Biodiversity Areas Partnership 2025b).

Additionally, the Project overlaps the buffer zone of the Wadi Rum PA and World Heritage Site (WHS):

- The **Wadi Rum PA and WHS**[15] buffer zone (500 m) is overlapped by the southern end of the pipeline (Figure 10). The site, inscribed in 2011 as a mixed natural and cultural site, has an area of 741.8 km^2. It qualifies as a WHS under Criterion (iii), (v) and (vii). Wadi Rum encompasses a diverse desert landscape featuring sandstone mountains, gorges, arches, cliffs, landslides, and cavernous weathering forms. These landforms result from fluvial incision, salt and biological weathering and erosion, forming globally significant honeycomb weathering networks. The site contains over 25,000 petroglyphs and 20,000 inscriptions, evidencing 12,000 years of human occupation and early symbolic and linguistic development. The site lies within the Sudanian Biogeographical Region. The high mountains in the site (over 1,700 m above sea level) enable some unusual elements of the Mediterranean Bioregion to persist here, e.g. Juniper trees and Mediterranean reptiles. The site is known to support 183 flora species (including at least two endemics), 26 mammals, 34 reptiles and 119 birds, including a number of globally threatened species. The level of bird species diversity is considered exceptional for a habitat within the Sudanian Biogeographical Region of Jordan. Notable fauna include the Arabian Oryx (*Oryx leucoryx*), currently being

[15] It should be flagged that UNESCO has formally requested improved habitat management within Wadi Rum over the next three years, citing excessive expansion of tourism infrastructure; failure to meet these expectations may result in the site's removal from the World Heritage List. Any proposed habitat modifications within the Wadi Rum WHS are subject to a rigorous UNESCO review process, which includes impact assessments and, according to RSCN, carries a high likelihood of rejection due to the site's current management concerns.

reintroduced after becoming nationally extinct, and the Nubian Ibex (*Capra nubiana*), threatened with becoming nationally extinct (IUCN 2025b; UNESCO World Heritage Centre 2025).

The Project also overlaps with one proposed Protected Area (PA), the Abu Rukbah Proposed Nature Reserve, which will no longer be considered for designation. From consultation with RSCN it is understood that, since 2020, there have been some very significant habitat modifications, including sewage run-offs into natural water courses and proliferation of OHTLs, resulting in the area no longer fulfilling the criteria for classification as a Protected Area. Consultation with RSCN has confirmed that the site will be removed from the list of proposed Protected Areas in Jordan and is not of relevance for this Project.

The EAAAs overlap with two other IRAs and four other (terrestrial) PAs:

- Madaba – Hisban KBA/IBA
- Southern Arava valley and Elat mountains KBA/IBA
- Aqaba Mountains Proposed Nature Reserve
- Aqaba Bird Observatory Special Conservation Area
- Qatar Nature Reserve

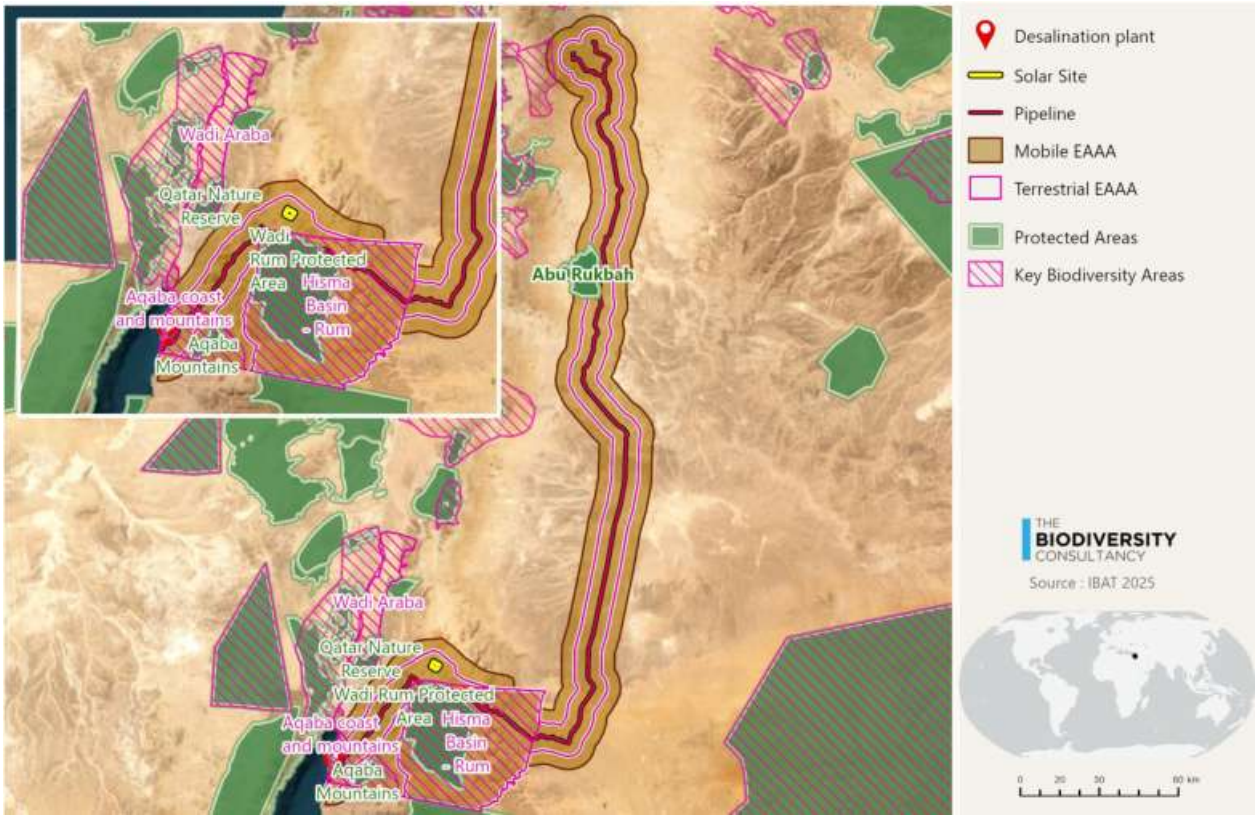


Figure 10. Map of Protected Areas and Internationally Recognised Areas in the context of the EAAAs.

5 Conclusion and recommendations

This assessment finds that:

- The Project is likely to be located in a landscape that includes areas of critical habitat.

Three species are likely to qualify as critical habitat:

  - two plants (the Jordan Wormwood *Artemisia jordanica* and Egyptian Henbane *Hyoscyamus muticus*), which only occur in small patches of habitat, with specific requirements (i.e., small wetlands resulting from pipeline leakage for *H. muticus*, and extreme desert areas for *A. jordanica*). Further studies are needed to determine the exact area that is considered critical habitat for these species.
  - one bird - the Levant Sparrowhawk *Accipiter brevipes,* for which the Aqaba Coast and Mountains KBA likely qualifies as critical habitat.

Four species possibly qualify as critical habitat:

  - two plants (*Stipagrostis spp.* and *Calligonum comosum*) and two birds (Sooty Falcon *Falco concolor* and Steppe Eagle *Aquila nipalensis*) (Table 5).
    Regarding *Stipagrostis spp.* further investigations are needed to determine which species is/are present and if they, in fact, trigger critical habitat.
    C. comosum is known from only seven populations in Jordan. The importance of this species' populations within the EAAA needs to be assessed to determine if it triggers the critical habitat threshold.

- The Project overlaps with two Key Biodiversity Areas (KBAs) and Important Bird and Biodiversity Areas (IBAs), the Hisma Basin – Rum KBA/IBA and the Aqaba Coast and Mountains KBA/IBA.
- The Project also overlaps the buffer zone of the Wadi Rum PA and World Heritage Site (WHS). According to RSCN, any proposed habitat modifications within the Wadi Rum WHS are subject to a rigorous UNESCO review process, which includes impact assessments.
- The terrestrial EAAA is composed primarily of natural habitat (~94%), with some areas of modified habitat (~6%).

We recommend that targeted flora surveys are conducted for the four plant species that qualify or possibly qualify as critical habitat, i.e. Jordan Wormwood *Artemisia jordanica*, Egyptian Henbane H*yoscyamus muticus*, *Stipagrostis spp.* and *Calligonum comosum*, to understand their abundance and distribution in the Project area to inform mitigation. These surveys should also confirm whether the *Stipagrostis* species present is one of the two nationally CR species (*S. lanata* or *S. pungens*), and if the Egyptian Henbane present represents a viable population. We also recommend that targeted bird surveys are conducted as well as expert consultation, for the bird species that possibly qualify as critical habitat, i.e. Sooty Falcon *Falco concolor* and Steppe Eagle *Aquila nipalensis*, to understand their abundance and spatial use of the Project area to inform mitigation.

Additionally, a pre-construction walk-over assessment should be conducted 2-3 months prior to construction, by suitably trained and qualified biodiversity specialists with local experience. This should focus on identifying any potential CH- qualifying species or PBFs as per this CHA.

As the Project is located in an area composed primarily of natural habitat that likely qualifies as critical habitat, the development of a Biodiversity Action Plan (BAP) is necessary to ensure that Net Gain and No Net Loss are achieved for the relevant biodiversity values, in line with IFC PS6, EBRD ESR6 and EIB S5.

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Appendix 1 Critical habitat criteria and thresholds

Table A1. Lenders' criteria and thresholds for critical habitat used for this Critical Habitat Assessment (CHA), according to IFC PS6[16], EBRD ESR6[17] and EIB Standard 4[18]. This table has been adapted from the Preliminary Terrestrial CHA (NCPC et al. *2025c). Note that, as Jordan is not an EU member state and is not a signatory nation of the Bern Convention, some criteria for critical habitat do not apply to this project (i.e. those relating to the EU Habitats Directive, the EU Birds Directive and the Bern Convention) and are therefore not shown in this table.*

	IFC PS6	EBRD ESR6	EIB Standard 4
Globally and regionally threatened species			
Criteria	**Criterion 1:** Species threatened with global extinction and listed as CR and EN on the IUCN Red List of Threatened Species Species that are listed nationally/regionally as CR or EN in countries that adhere to IUCN guidance shall be determined on a project-by-project basis	**Criterion 2:** Threatened species (b) IUCN Red List EN or CR species (c) IUCN Red List VU species (d) Nationally or regionally (for example, Europe) listed EN or CR species	**Criterion 2:** A habitat of priority and/or significant importance to critically endangered, endangered or vulnerable species, as defined by the IUCN Red List of threatened species and in relevant national legislation.
Critical Habitat Thresholds	(a) Areas that support globally important concentrations of an IUCN Red-listed EN or CR species (≥ 0.5% of the global population AND ≥ 5 reproductive units of a CR or EN species) (b) Areas that support globally important concentrations of an IUCN Red-listed Vulnerable (VU) species, the loss of which would result in the	(b) EAAA supports ≥ 0.5 per cent of the global population AND ≥ 5 reproductive units of a CR or EN species (c) EAAA supports globally significant population of VU species necessary to prevent a change of IUCN Red List status to EN or CR, and satisfies threshold (b) (d) EAAA for important concentrations of a nationally or regionally listed EN or CR species	a) A population of an IUCN Red-listed endangered or critically endangered species that is ≥ 0.5% of the global population and/or ≥ 5 established reproductive units of an endangered or critically endangered species b) Significant concentration of an IUCN Red-listed vulnerable species or of multiple IUCN Red-listed vulnerable species, especially where the loss of the area would result in the change of the IUCN Red List status to endangered or critically endangered

[16] (IFC 2019)

[17] (EBRD 2023)

[18] (EIB 2018, 2022)

	IFC PS6	EBRD ESR6	EIB Standard 4
	change of the IUCN Red List status to EN or CR and meet the thresholds in (a) (c) As appropriate, areas containing important concentrations of a nationally or regionally listed EN or CR species		c) Nationally or regionally-important concentration of a species listed as endangered or critically endangered on a regional/national IUCN Red List, or equivalent on national/regional listing.
Priority Feature Threshold	-	(b) EAAA supports < 0.5 per cent of global population OR < 5 reproductive units of a CR or EN species. (c) EAAA supports VU species (d) EAAA for regularly occurring nationally or regionally listed EN or CR species	
Endemic and restricted range species			
Criteria	**Criterion 2:** For terrestrial vertebrates and plants, restricted-range species are defined as those species that have an Extent of occurrence (EOO) less than 50,000 square kilometers (km^2). For marine systems, restricted-range species are provisionally being considered those with an EOO of less than 100,000 km^2. For coastal, riverine, and other aquatic species in habitats that do not exceed 200 km width at any point (for example, rivers), restricted range is defined as having a global range of less than or equal to 500 km linear geographic span (i.e., the distance between occupied locations furthest apart).	**Criterion 2:** Range-restricted species	**Criterion 3:** A habitat of priority and/or significant importance to a population, range or distribution of endemic or restricted-range species, or highly distinctive assemblages of species For terrestrial vertebrates and plants, restricted-range species are defined as those species that have an Extent of occurrence (EOO) less than 50,000 square kilometers (km^2). For marine systems, restricted-range species are provisionally being considered those with an EOO of less than 100,000 km^2. For coastal, riverine, and other aquatic species in habitats that do not exceed 200 km width at any point (for example, rivers), restricted range is defined as having a global range of less than or equal to 500 km linear geographic span (i.e., the distance between occupied locations furthest apart).
Critical Habitat Thresholds	Areas that regularly hold ≥10% of the global population size AND ≥10 reproductive units (the	(a) EAAA regularly holds ≥ 10 per cent of global population AND ≥ 10 reproductive units of the species	a) They regularly hold ≥10% of the global population size and support ≥10 reproductive

	IFC PS6	EBRD ESR6	EIB Standard 4
	minimum number and combination of mature individuals necessary to trigger a successful reproductive event) of a species.		units of an endemic or restricted-range species b) They are considered by relevant specialists to support unique or rare assemblages of species that occur there habitually, predictably or repeatably. The constituent species may not meet other critical habitat thresholds mentioned here in their own right, but may present assemblages that are considered important to maintain high biodiversity in the area
Priority Feature Threshold	-	(a) EAAA for regularly occurring range restricted species	
Migratory and congregatory species			
Criteria	**Criterion 3:** Migratory species are defined as any species of which a significant proportion of its members cyclically and predictably move from one geographical area to another Congregatory species are defined as species whose individuals gather in large groups on a cyclical or otherwise regular and/or predictable basis.	**Criterion 2:** Migratory and congregatory species	**Criterion 4:** A habitat required for the survival of migratory species and/or congregatory species
Critical Habitat Thresholds	(a) Areas known to sustain, on a cyclical or otherwise regular basis, ≥ 1 percent of the global population of a migratory or congregatory species at any point of the species' lifecycle (b) Areas that predictably support ≥10 percent of the global population of a species during periods of environmental stress	(a) EAAA sustains, on a cyclical or otherwise regular basis, ≥ 1 per cent of the global population at any point of the species' lifecycle (b) EAAA predictably supports ≥ 10 per cent of global population during periods of environmental stress	a) They sustain ≥ 1%of the global population of a migratory or congregatory species at any point of the species' lifecycle on a cyclical or otherwise regular basis b) They are needed to support migratory or congregatory species during periods of environmental stress
Priority Feature Threshold	-	(a) EAAA identified, as per recognised national or international process, as important for migratory birds (especially wetlands)	
Highly Threatened or Unique Ecosystems			
Criteria	**Criterion 4:**	**Criterion 1:** (b) IUCN Red List EN or CR ecosystems	**Criterion 1:** A highly threatened and/or unique ecosystem;

	IFC PS6	EBRD ESR6	EIB Standard 4
	The IUCN is developing a Red List of Ecosystems, this should be used where formal IUCN assessments have been performed. Where formal IUCN assessments have not been performed, make assessments using systematic methods at the national/regional level.		
Critical Habitat Thresholds	a) Areas representing ≥5% of the global extent of an ecosystem type meeting the criteria for IUCN status of CR or EN. b) Other areas not yet assessed by IUCN but determined to be of high priority for conservation by regional or national systematic conservation planning.	(b) EAAA ≥ 5 per cent of global extent of an ecosystem type with IUCN status of CR or EN (c) EAAA is ecosystem determined to be of high priority for conservation by national systematic conservation planning	a) Priority Habitats (listed in Annex I of the Habitats Directive) and habitats considered to be their equivalent in countries outside the EU b) ≥5% of the global extent of an ecosystem type meeting the criteria for IUCN's Red List of Ecosystems with a status of critically endangered or endangered c) Examples of ecosystems outside the EU and not yet assessed by IUCN, but determined to be of high priority for conservation on the basis of regional or national level systematic conservation planning or informed specialist input
Priority Feature Threshold	-	(b) EAAA < 5 per cent of the global extent of an ecosystem type with IUCN status of CR or EN	
Key Evolutionary Processes			
Criteria	**Criterion 5:** The structural attributes of a region can influence the evolutionary processes that give rise to regional configurations of species and ecological properties. For illustrative purposes, some potential examples of spatial features associated with evolutionary processes are as follows: • Landscapes with high spatial *heterogeneity.* • *Environmental gradients*, also known as *ecotones.* • *Edaphic interfaces* are specific juxtapositions of soil types (for example, serpentine outcrops, limestone, and gypsum deposits).		**Criterion 6:** A habitat of key scientific value and/or associated with key evolutionary processes. This may include, but is not limited to, exceptional representations of: a) Landscapes with high spatial *heterogeneity* b) *Environmental gradients*, also known as *ecotones* c) *Edaphic interfaces* that juxtapose soil types (e.g. serpentine outcrops, limestone and gypsum deposits) d) *Connectivity* between habitats (e.g. biological corridors) e) Sites of demonstrated importance to *climate change adaptation* for either species or ecosystems

	IFC PS6	EBRD ESR6	EIB Standard 4
	• *Connectivity* between habitats (for example, biological corridors). • Sites of demonstrated importance to *climate change adaptation* for either species or ecosystems are also included within this criterion.		
Critical Habitat Thresholds	The significance of structural attributes in a landscape that may influence evolutionary processes will be determined on a case-by-case basis, and the determination of critical habitat will be heavily reliant on scientific knowledge.	Expert Judgement required, no fixed thresholds	Expert Judgement required, no fixed thresholds
Priority Feature Threshold		Expert Judgement required, no fixed thresholds	
Biodiversity of socio-economic value			
Criteria	-	-	**Criterion 5:** Biodiversity and/or an ecosystem of significant social, economic or cultural importance to local communities and indigenous groups;
Critical Habitat Thresholds	-	-	Areas of semi-natural and natural habitat used by indigenous peoples and local communities to obtain essential or priority benefits will be considered critical from an ecosystem service perspective. Criteria for identifying priority ecosystem services should be developed for each project

Internationally recognized areas

IFC PS6 Guidance Note (GN) 54 (IFC 2019) also states that certain internationally recognized areas of high biodiversity value may be recognized as critical habitat and should be given special attention during assessments. Examples include the following:

- Areas that meet the criteria of the IUCN's Protected Areas Categories Ia, Ib and II (Dudley 2008);
- Key Biodiversity Areas (KBAs), which encompass Important Bird and Biodiversity Areas (IBAs)

Appendix 2 Species screened as part of the CHA

Table A1. List of species initially considered for critical habitat screening within the relevant EAAA boundary derived from the IUCN Red List of Threatened Species spatial data accessed via IBAT, and supplemented with species recorded during Project surveys. Least Concern and Near Threatened species (that are not nationally or regionally EN/CR) are not shown although were assessed for C2. Species without evidence of migration on the IUCN Red List are not shown. For the short list of species screened in detail in relation to critical habitat, refer to Table 5.

Scientific Name	Common Name	Class	IUCN Red List Category	Reg/Nat Red List Category	Migratory
Accipiter brevipes	Levant Sparrowhawk	AVES	LC	-	Full Migrant
Accipiter nisus	Eurasian Sparrowhawk	AVES	LC	-	Full Migrant
Acrocephalus melanopogon	Moustached Warbler	AVES	LC	NT	Full Migrant
Acrocephalus palustris	Marsh Warbler	AVES	LC	-	Full Migrant
Acrocephalus scirpaceus	Common Reed-warbler	AVES	LC	LC	Full Migrant
Acrocephalus stentoreus	Clamorous Reed-warbler	AVES	LC	LC	Full Migrant
Actitis hypoleucos	Common Sandpiper	AVES	LC	-	Full Migrant
Alauda arvensis	Eurasian Skylark	AVES	LC	-	Full Migrant
Alcedo atthis	Common Kingfisher	AVES	LC	NT	Full Migrant
Anas crecca	Common Teal	AVES	LC	-	Full Migrant
Anthropoides virgo	Demoiselle Crane	AVES	LC	-	Full Migrant
Anthus campestris	Tawny Pipit	AVES	LC	LC	Full Migrant
Anthus cervinus	Red-throated Pipit	AVES	LC	-	Full Migrant
Anthus pratensis	Meadow Pipit	AVES	LC	-	Full Migrant
Anthus spinoletta	Water Pipit	AVES	LC	-	Full Migrant
Anthus trivialis	Tree Pipit	AVES	LC	-	Full Migrant
Apus affinis	Little Swift	AVES	LC	LC	Full Migrant
Apus pallidus	Pallid Swift	AVES	LC	LC	Full Migrant
Aquila chrysaetos	Golden Eagle	AVES	LC	EN	Full Migrant
Aquila heliaca	Eastern Imperial Eagle	AVES	VU	-	Full Migrant
Aquila nipalensis	Steppe Eagle	AVES	EN	EN	Full Migrant
Aquila verreauxii	Verreaux's Eagle	AVES	LC	EN	Not a Migrant
Ardea alba	Great White Egret	AVES	LC	-	Full Migrant
Ardea cinerea	Grey Heron	AVES	LC	NT	Full Migrant
Ardea purpurea	Purple Heron	AVES	LC	NT	Full Migrant
Ardeola ralloides	Squacco Heron	AVES	LC	LC	Full Migrant
Arenaria interpres	Ruddy Turnstone	AVES	NT	-	Full Migrant
Aythya nyroca	Ferruginous Duck	AVES	NT	NT	Full Migrant
Bubulcus ibis	Cattle Egret	AVES	LC	LC	Full Migrant
Burhinus oedicnemus	Eurasian Thick-knee	AVES	LC	LC	Full Migrant
Buteo buteo vulpinus	Steppe Buzzard	AVES	LC	LC	Full Migrant
Buteo rufinus	Long-legged Buzzard	AVES	LC	LC	Full Migrant

Calandrella brachydactyla	Greater Short-toed Lark	AVES	LC	LC	Full Migrant
Calidris alba	Sanderling	AVES	LC	LC	Full Migrant
Calidris alpina	Dunlin	AVES	NT	-	Full Migrant
Calidris canutus	Red Knot	AVES	NT	-	Full Migrant
Calidris falcinellus	Broad-billed Sandpiper	AVES	VU	-	Full Migrant
Calidris ferruginea	Curlew Sandpiper	AVES	VU	-	Full Migrant
Calidris pugnax	Ruff	AVES	LC	-	Full Migrant
Caprimulgus aegyptius	Egyptian Nightjar	AVES	LC	LC	Full Migrant
Carduelis carduelis	European Goldfinch	AVES	LC	EN	Full Migrant
Carpospiza brachydactyla	Pale Sparrow	AVES	LC	-	Full Migrant
Cecropis daurica	Red-rumped Swallow	AVES	LC	LC	Full Migrant
Cercotrichas galactotes	Rufous-tailed Scrub-robin	AVES	LC	-	Full Migrant
Cettia cetti	Cetti's Warbler	AVES	LC	LC	Full Migrant
Charadrius alexandrinus	Kentish Plover	AVES	LC	LC	Full Migrant
Charadrius asiaticus	Caspian Plover	AVES	LC	-	Full Migrant
Charadrius dubius	Little Ringed Plover	AVES	LC	LC	Full Migrant
Charadrius hiaticula	Common Ringed Plover	AVES	LC	-	Full Migrant
Charadrius leschenaultii	Greater Sandplover	AVES	LC	NT	Full Migrant
Chlamydotis macqueenii	Asian Houbara	AVES	VU	-	Full Migrant
Chloris chloris	European Greenfinch	AVES	LC	-	Full Migrant
Ciconia ciconia	White Stork	AVES	LC	NT	Full Migrant
Ciconia nigra	Black Stork	AVES	LC	-	Full Migrant
Circaetus gallicus	Short-toed Snake-eagle	AVES	LC	VU	Full Migrant
Circus aeruginosus	Western Marsh-harrier	AVES	LC	NT	Full Migrant
Circus cyaneus	Hen Harrier	AVES	LC	-	Full Migrant
Circus macrourus	Pallid Harrier	AVES	NT	-	Full Migrant
Circus pygargus	Montagu's Harrier	AVES	LC	-	Full Migrant
Clamator glandarius	Great Spotted Cuckoo	AVES	LC	NT	Full Migrant
Clanga clanga	Greater Spotted Eagle	AVES	VU	-	Full Migrant
Clanga pomarina	Lesser Spotted Eagle	AVES	LC	-	Full Migrant
Coccothraustes coccothraustes	Hawfinch	AVES	LC	-	Full Migrant
Columba oenas	Stock Dove	AVES	LC	-	Full Migrant
Coracias garrulus	European Roller	AVES	LC	NT	Full Migrant
Corvus corone	Carrion Crow	AVES	LC	LC	Full Migrant
Corvus monedula	Eurasian Jackdaw	AVES	LC	LC	Full Migrant
Coturnix coturnix	Common Quail	AVES	LC	LC	Full Migrant
Cuculus canorus	Common Cuckoo	AVES	LC	NT	Full Migrant
Curruca cantillans	Subalpine Warbler	AVES	LC	-	Full Migrant
Curruca communis	Common Whitethroat	AVES	LC	-	Full Migrant
Curruca conspicillata	Spectacled Warbler	AVES	LC	-	Full Migrant
Curruca curruca	Lesser Whitethroat	AVES	LC	LC	Full Migrant
Curruca melanocephala	Sardinian Warbler	AVES	LC	LC	Full Migrant
Curruca mystacea	Menetries's Warbler	AVES	LC	-	Full Migrant

Curruca nana	Asian Desert Warbler	AVES	LC	-	Full Migrant
Curruca ruppeli	Rüppell's Warbler	AVES	LC	-	Full Migrant
Cursorius cursor	Cream-coloured Courser	AVES	LC	LC	Full Migrant
Egretta garzetta	Little Egret	AVES	LC	LC	Full Migrant
Elanus caeruleus	Black-winged Kite	AVES	LC	VU	Full Migrant
Emberiza caesia	Cretzschmar's Bunting	AVES	LC	LC	Full Migrant
Emberiza calandra	Corn Bunting	AVES	LC	LC	Full Migrant
Emberiza cia	Rock Bunting	AVES	LC	LC	Full Migrant
Emberiza cineracea	Cinereous Bunting	AVES	NT	LC	Full Migrant
Emberiza citrinella	Yellowhammer	AVES	LC	-	Full Migrant
Emberiza melanocephala	Black-headed Bunting	AVES	LC	LC	Full Migrant
Eremalauda eremodites	Arabian Lark	AVES	LC	-	Nomadic
Erithacus rubecula	European Robin	AVES	LC	-	Full Migrant
Eudromias morinellus	Eurasian Dotterel	AVES	LC	-	Full Migrant
Falco biarmicus	Lanner Falcon	AVES	LC	CR	Not a Migrant
Falco cherrug	Saker Falcon	AVES	EN	CR	Full Migrant
Falco columbarius	Merlin	AVES	LC	-	Full Migrant
Falco concolor	Sooty Falcon	AVES	VU	EN	Full Migrant
Falco naumanni	Lesser Kestrel	AVES	LC	NT	Full Migrant
Falco peregrinus	Peregrine Falcon	AVES	LC	EN	Full Migrant
Falco subbuteo	Eurasian Hobby	AVES	LC	-	Full Migrant
Falco tinnunculus	Common Kestrel	AVES	LC	LC	Full Migrant
Falco vespertinus	Red-footed Falcon	AVES	VU	-	Full Migrant
Ficedula albicollis	Collared Flycatcher	AVES	LC	-	Full Migrant
Ficedula parva	Red-breasted Flycatcher	AVES	LC	-	Full Migrant
Francolinus francolinus	Black Francolin	AVES	LC	EN	Not a Migrant
Fringilla coelebs	Common Chaffinch	AVES	LC	LC	Full Migrant
Fringilla montifringilla	Brambling	AVES	LC	-	Full Migrant
Fulica atra	Eurasian Coot	AVES	LC	LC	Full Migrant
Galerida cristata	Crested Lark	AVES	LC	LC	Full Migrant
Gallinago gallinago	Common Snipe	AVES	LC	-	Full Migrant
Glareola nordmanni	Black-winged Pratincole	AVES	NT	-	Full Migrant
Glareola pratincola	Collared Pratincole	AVES	LC	LC	Full Migrant
Gyps fulvus	Griffon Vulture	AVES	LC	EN	Full Migrant
Haematopus ostralegus	Eurasian Oystercatcher	AVES	NT	-	Full Migrant
Haliaeetus albicilla	White-tailed Sea-eagle	AVES	LC	-	Full Migrant
Hieraaetus pennatus	Booted Eagle	AVES	LC	-	Full Migrant
Himantopus himantopus	Black-winged Stilt	AVES	LC	LC	Full Migrant
Hippolais languida	Upcher's Warbler	AVES	LC	LC	Full Migrant
Hippolais olivetorum	Olive-tree Warbler	AVES	LC	LC	Full Migrant
Hirundo rustica	Barn Swallow	AVES	LC	-	Full Migrant
Iduna pallida	Eastern Olivaceous Warbler	AVES	LC	-	Full Migrant
Ixobrychus minutus	Common Little Bittern	AVES	LC	LC	Full Migrant

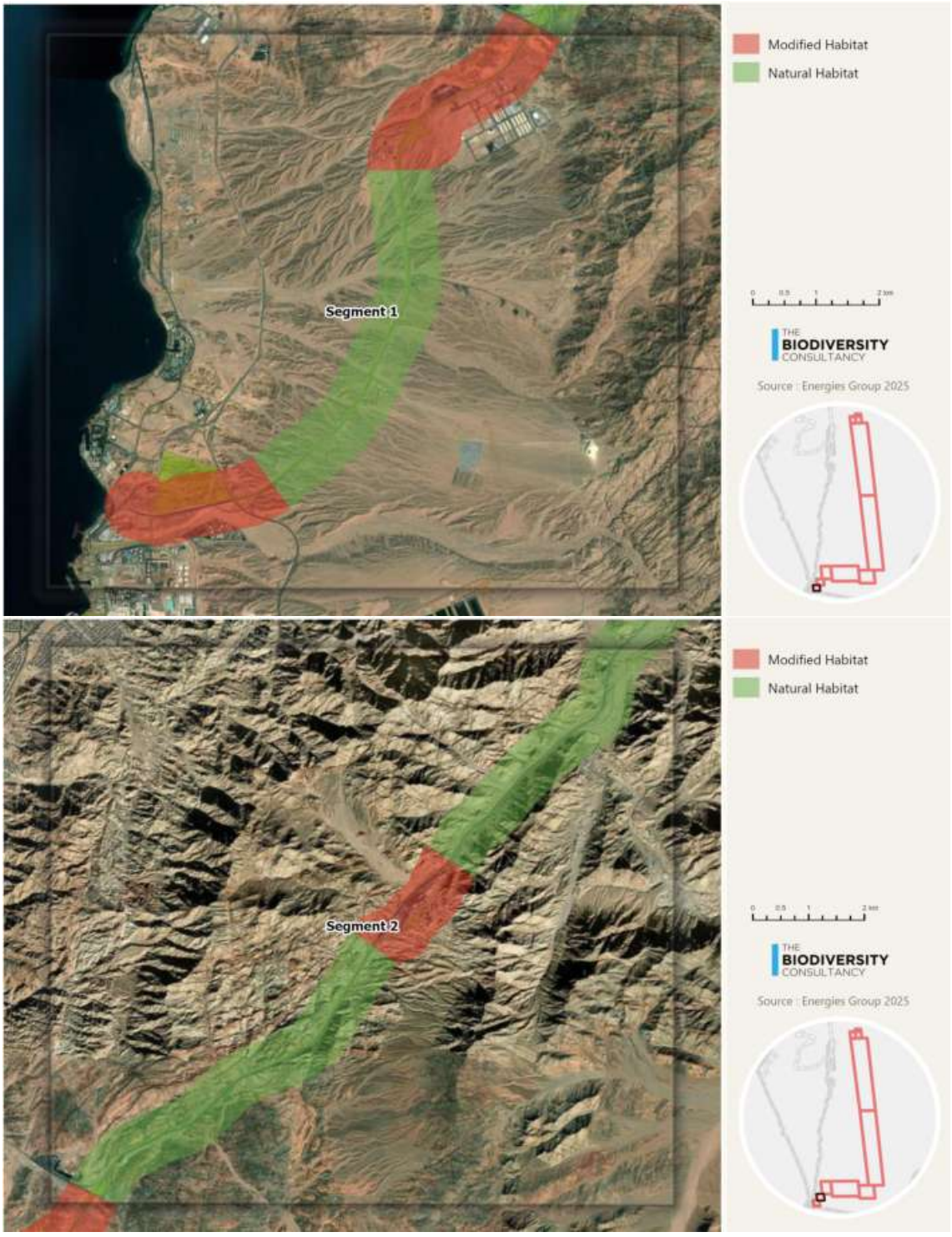
Ketupa zeylonensis	Brown Fish-owl	AVES	LC	CR	Not a Migrant
Lanius excubitor	Great Grey Shrike	AVES	LC	-	Full Migrant
Lanius isabellinus	Isabelline Shrike	AVES	LC	-	Full Migrant
Lanius nubicus	Masked Shrike	AVES	LC	-	Full Migrant
Lanius phoenicuroides	Red-tailed Shrike	AVES	LC	-	Full Migrant
Lanius senator	Woodchat Shrike	AVES	NT	-	Full Migrant
Larus armenicus	Armenian Gull	AVES	LC	-	Full Migrant
Larus cachinnans	Caspian Gull	AVES	LC	-	Full Migrant
Larus canus	Mew Gull	AVES	LC	-	Full Migrant
Larus fuscus	Lesser Black-backed Gull	AVES	LC	-	Full Migrant
Larus genei	Slender-billed Gull	AVES	LC	LC	Full Migrant
Larus ichthyaetus	Pallas's Gull	AVES	LC	-	Full Migrant
Larus michahellis	Yellow-legged Gull	AVES	LC	-	Full Migrant
Larus ridibundus	Black-headed Gull	AVES	LC	-	Full Migrant
Limosa limosa	Black-tailed Godwit	AVES	NT	-	Full Migrant
Linaria cannabina	Common Linnet	AVES	LC	-	Full Migrant
Locustella fluviatilis	River Warbler	AVES	LC	-	Full Migrant
Lullula arborea	Woodlark	AVES	LC	LC	Full Migrant
Luscinia svecica	Bluethroat	AVES	LC	-	Full Migrant
Marmaronetta angustirostris	Marbled Duck	AVES	NT	NT	Full Migrant
Melanocorypha calandra	Calandra Lark	AVES	LC	LC	Full Migrant
Merops apiaster	European Bee-eater	AVES	LC	-	Full Migrant
Merops persicus	Blue-cheeked Bee-eater	AVES	LC	LC	Full Migrant
Milvus migrans	Black Kite	AVES	LC	-	Full Migrant
Monticola solitarius	Blue Rock-thrush	AVES	LC	LC	Full Migrant
Motacilla alba	White Wagtail	AVES	LC	-	Full Migrant
Motacilla cinerea	Grey Wagtail	AVES	LC	NT	Full Migrant
Motacilla flava	Western Yellow Wagtail	AVES	LC	-	Full Migrant
Muscicapa striata	Spotted Flycatcher	AVES	LC	LC	Full Migrant
Neophron percnopterus	Egyptian Vulture	AVES	EN	VU	Full Migrant
Numenius arquata	Eurasian Curlew	AVES	NT	-	Full Migrant
Oena capensis	Namaqua Dove	AVES	LC	LC	Full Migrant
Oenanthe cypriaca	Cyprus Wheatear	AVES	LC	-	Full Migrant
Oenanthe deserti	Desert Wheatear	AVES	LC	LC	Full Migrant
Oenanthe finschii	Finsch's Wheatear	AVES	LC	LC	Full Migrant
Oenanthe hispanica	Black-eared Wheatear	AVES	LC	LC	Full Migrant
Oenanthe isabellina	Isabelline Wheatear	AVES	LC	LC	Full Migrant
Oenanthe lugens	Mourning Wheatear	AVES	LC	LC	Full Migrant
Oenanthe moesta	Buff-rumped Wheatear	AVES	LC	EN	Not a Migrant
Oenanthe oenanthe	Northern Wheatear	AVES	LC	LC	Full Migrant
Oenanthe xanthoprymna	Kurdish Wheatear	AVES	LC	LC	Full Migrant
Otus brucei	Pallid Scops-owl	AVES	LC	LC	Full Migrant
Otus scops	Eurasian Scops-owl	AVES	LC	LC	Full Migrant

Oxyura leucocephala	White-headed Duck	AVES	EN	EN	Full Migrant
Pandion haliaetus	Osprey	AVES	LC	LC	Full Migrant
Passer hispaniolensis	Spanish Sparrow	AVES	LC	LC	Full Migrant
Passer moabiticus	Dead Sea Sparrow	AVES	LC	LC	Full Migrant
Pelecanus onocrotalus	Great White Pelican	AVES	LC	-	Full Migrant
Pernis apivorus	European Honey-buzzard	AVES	LC	-	Full Migrant
Phoenicopterus roseus	Greater Flamingo	AVES	LC	LC	Full Migrant
Phoenicurus ochruros	Black Redstart	AVES	LC	NT	Full Migrant
Phoenicurus phoenicurus	Common Redstart	AVES	LC	NT	Full Migrant
Phylloscopus collybita	Common Chiffchaff	AVES	LC	-	Full Migrant
Phylloscopus trochilus	Willow Warbler	AVES	LC	-	Full Migrant
Pluvialis squatarola	Grey Plover	AVES	VU	-	Full Migrant
Prunella modularis	Dunnock	AVES	LC	-	Full Migrant
Pterocles alchata	Pin-tailed Sandgrouse	AVES	LC	LC	Full Migrant
Pterocles orientalis	Black-bellied Sandgrouse	AVES	LC	EN	Full Migrant
Pterocles senegallus	Spotted Sandgrouse	AVES	LC	LC	Full Migrant
Ptyonoprogne obsoleta	Pale Rock Martin	AVES	LC	LC	Full Migrant
Ptyonoprogne rupestris	Eurasian Crag Martin	AVES	LC	LC	Full Migrant
Ramphocoris clotbey	Thick-billed Lark	AVES	LC	-	Nomadic
Recurvirostra avosetta	Pied Avocet	AVES	LC	NT	Full Migrant
Remiz pendulinus	Eurasian Penduline-tit	AVES	LC	DD	Full Migrant
Saxicola rubetra	Whinchat	AVES	LC	-	Full Migrant
Saxicola torquatus	Common Stonechat	AVES	LC	LC	Full Migrant
Serinus serinus	European Serin	AVES	LC	LC	Full Migrant
Serinus syriacus	Syrian Serin	AVES	VU	EN	Full Migrant
Spatula querquedula	Garganey	AVES	LC	-	Full Migrant
Spilopelia senegalensis	Laughing Dove	AVES	LC	LC	Full Migrant
Spinus spinus	Eurasian Siskin	AVES	LC	-	Full Migrant
Streptopelia turtur	European Turtle-dove	AVES	VU	LC	Full Migrant
Sturnus vulgaris	Common Starling	AVES	LC	LC	Full Migrant
Sylvia atricapilla	Eurasian Blackcap	AVES	LC	LC	Full Migrant
Sylvia borin	Garden Warbler	AVES	LC	-	Full Migrant
Tachymarptis melba	Alpine Swift	AVES	LC	LC	Full Migrant
Tetrax tetrax	Little Bustard	AVES	NT	-	Full Migrant
Thalasseus sandvicensis	Sandwich Tern	AVES	LC	-	Full Migrant
Tringa erythropus	Spotted Redshank	AVES	LC	-	Full Migrant
Tringa nebularia	Common Greenshank	AVES	LC	-	Full Migrant
Tringa ochropus	Green Sandpiper	AVES	LC	-	Full Migrant
Tringa totanus	Common Redshank	AVES	LC	-	Full Migrant
Troglodytes troglodytes	Northern Wren	AVES	LC	LC	Full Migrant
Turdus iliacus	Redwing	AVES	NT	-	Full Migrant
Turdus merula	Eurasian Blackbird	AVES	LC	LC	Full Migrant
Turdus philomelos	Song Thrush	AVES	LC	-	Full Migrant

Turdus pilaris	Fieldfare	AVES	LC	-	Full Migrant
Turdus viscivorus	Mistle Thrush	AVES	LC	LC	Full Migrant
Upupa epops	Common Hoopoe	AVES	LC	LC	Full Migrant
Vanellus gregarius	Sociable Lapwing	AVES	CR	-	Full Migrant
Vanellus leucurus	White-tailed Lapwing	AVES	LC	LC	Full Migrant
Vanellus spinosus	Spur-winged Lapwing	AVES	LC	LC	Full Migrant
Zapornia pusilla	Baillon's Crake	AVES	LC	-	Full Migrant
Anax ephippiger	Vagrant Emperor	INSECTA	LC	-	Full Migrant
Anax imperator	Blue Emperor	INSECTA	LC	-	Nomadic
Brachythemis impartita	Northern Banded Groundling	INSECTA	LC	-	Nomadic
Diplacodes lefebvrii	Black Percher	INSECTA	LC	-	Nomadic
Flabellotilloidea palaestina		INSECTA	DD	-	
Ischnura senegalensis	Tropical Bluetail	INSECTA	LC	-	Nomadic
Lacon ammanensis		INSECTA	DD	-	
Nimbus harpagonis		INSECTA	DD	-	
Pantala flavescens	Wandering Glider	INSECTA	LC	-	Full Migrant
Procraerus levantinus		INSECTA	DD	-	
Pseudophilotes jordanicus	Jordan Blue	INSECTA	DD	-	
Trithemis annulata	Violet Dropwing	INSECTA	LC	-	Nomadic
Trithemis arteriosa	Red-veined Dropwing	INSECTA	LC	-	Nomadic
Vanessa atalanta	Red Admiral	INSECTA	LC	-	Full Migrant
Vanessa cardui	Painted Lady	INSECTA	LC	-	Full Migrant
Zygonyx torridus	Ringed Cascader	INSECTA	LC	-	Nomadic
Arum hygrophilum	Water Arum	LILIOPSIDA	NT	EN	
Gagea procera	Gagée géante	LILIOPSIDA	DD	-	
Iris atrofusca	Jal'ad Iris	LILIOPSIDA	NT	EN	
Iris edomensis	Edom Iris	LILIOPSIDA	-	EN	
Iris nigricans	Black Iris	LILIOPSIDA	VU	EN	
Stipagrostis spp.	-	LILIOPSIDA	-	CR (2 spp.)	
Triticum urartu		LILIOPSIDA	DD	-	
Artemisia jordanica	Jordan Wormwood	MAGNOLIOPSIDA	-	EN	
Calligonum comosum	Calligonum	MAGNOLIOPSIDA	-	EN	
Cleome droserifolia	-	MAGNOLIOPSIDA	-	EN	
Hyoscyamus muticus	Egyptian Henbane	MAGNOLIOPSIDA	-	CR	
Limonium palmyrense		MAGNOLIOPSIDA	VU	-	
Canis lupus	Grey Wolf	MAMMALIA	LC	EN	
Capra nubiana	Nubian Ibex	MAMMALIA	VU	EN	Not a Migrant
Caracal caracal	Caracal	MAMMALIA	LC	CR	Not a Migrant
Felis chaus	Jungle Cat	MAMMALIA	LC	CR	Not a Migrant
Felis margarita	Sand Cat	MAMMALIA	LC	CR	Not a Migrant
Gazella arabica	Arabian Gazelle	MAMMALIA	VU	-	
Gazella dorcas	Dorcas Gazelle	MAMMALIA	VU	CR	
Gazella marica	Arabian Sand Gazelle	MAMMALIA	VU	CR	Nomadic

Hyaena hyaena	Striped Hyaena	MAMMALIA	NT	EN	Not a Migrant
Hypsugo ariel		MAMMALIA	DD	-	
Lepus capensis	Cape Hare	MAMMALIA	LC	EN	
Procavia capensis	Rock Hyrax	MAMMALIA	LC	EN	
Rhinolophus euryale	Mediterranean Horseshoe Bat	MAMMALIA	NT	EN	
Rhinolophus ferrumequinum	Greater Horseshoe Bat	MAMMALIA	LC	EN	
Rhinopoma microphyllum	Greater Mouse-tailed Bat	MAMMALIA	LC	EN	Full Migrant
Taphozous perforatus	Egyptian Tomb Bat	MAMMALIA	LC	EN	
Vormela peregusna	Marbled Polecat	MAMMALIA	VU	-	Not a Migrant
Vulpes cana	Blanford's Fox	MAMMALIA	LC	EN	
Acanthodactylus ahmaddisii		REPTILIA	EN	-	
Ophiomorus latastii		REPTILIA	DD	-	
Uromastyx aegyptia	Egyptian Spiny-tailed Lizard	REPTILIA	VU	-	

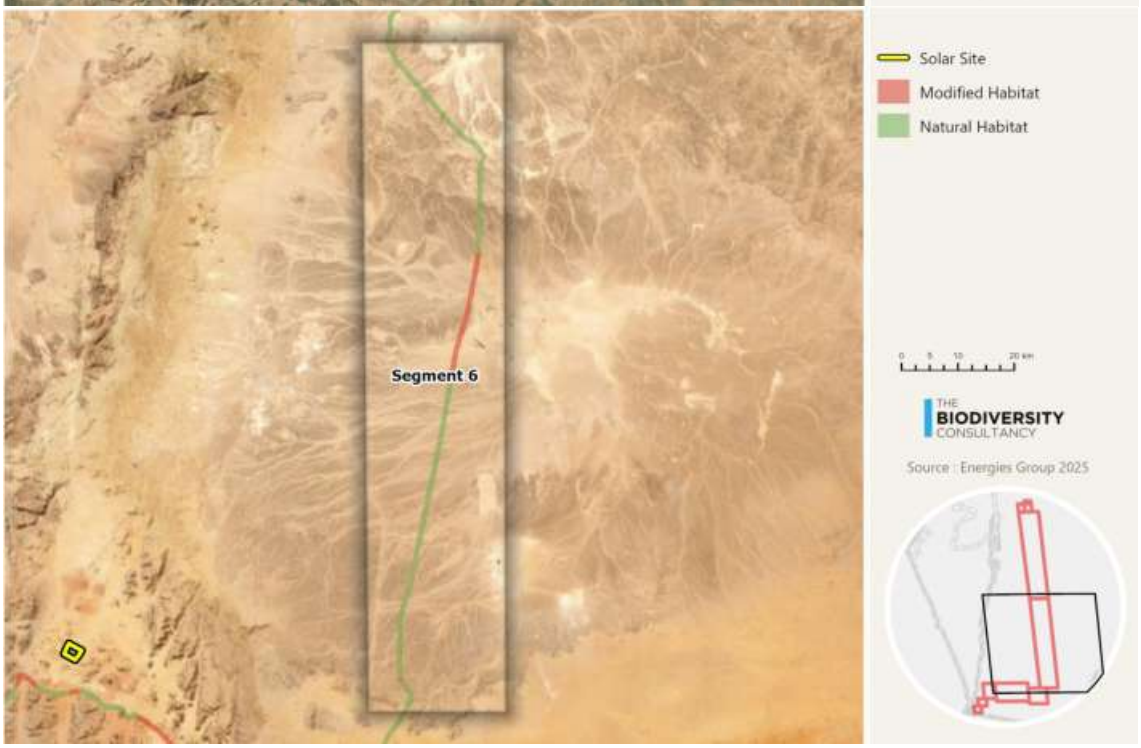
Appendix 3 Habitat maps




Segment 3
Modified Habitat
Natural Habitat
THE
BIODIVERSITY
CONSULTANCY
Source : Energies Group 2025


Segment 4
Solar Site
Modified Habitat
Natural Habitat
THE
BIODIVERSITY
CONSULTANCY
Source : Energies Group 2025


Segment 5
Modified Habitat
Natural Habitat
0 1 3 5 km
THE
BIODIVERSITY
CONSULTANCY
Source : Energies Group 2025


Segment 6
Solar Site
Modified Habitat
Natural Habitat
0 5 10 20 km
THE
BIODIVERSITY
CONSULTANCY
Source : Energies Group 2025


Segment 7
Modified Habitat
Natural Habitat
0 5 10 20 km
THE BIODIVERSITY CONSULTANCY
Source : Energies Group 2025
Segment 8
Modified Habitat
Natural Habitat
0 0.8 2 3 km
THE BIODIVERSITY CONSULTANCY
Source : Energies Group 2025


Segment 9
Modified Habitat
Natural Habitat
THE
BIODIVERSITY
CONSULTANCY
Source : Energies Group 2025

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2025 Environmental and Social Impact Assessment

Appendix 6-2 Marine Critical Habitat Assessment

Aqaba Amman Water Conveyance and Desalination (AAWDC) Project
Draft Marine Critical Habitat Assessment (CHA)

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Executive Summary

This Marine Critical Habitat Assessment (CHA) has been prepared for the marine components of the Aqaba Amman Water Desalination and Conveyance (AAWDC) Project, to identify biodiversity values which qualify as Critical Habitat (CH) or Priority Biodiversity Features (PBFs). The following lender policies were considered:

- International Finance Corporation (IFC) Performance Standards (PSs) (2012, 2019) and supporting Guidance Notes (GNs)
- European Bank for Reconstruction and Development (EBRD) Environmental and Social Policy (2024) and associated Environmental and Social Requirements (ESRs) and supporting GNs
- European Investment Bank (EIB) Environmental and Social Standards (2022) and supporting GNs
- U.S. International Development Finance Corporation (DFC) Environmental and Social Policy and Procedures (2024)
- Agence française de développement (AFD) Group Exclusion List (2022)
- World Bank Group (WBG) Environmental and Social Framework (2017)
- Green Climate Fund (GCF) Revised Environmental and Social Policy (2021)

Of the seven Lender policies listed above, EIB, EBRD and IFC provide explicit criteria for the assessment of CH while EBRD also defines PBF. These policies are provided in full detail in Appendix 2. It is understood that the Project will adhere to the most stringent. Within this CHA, "Critical Habitat" is defined using the IFC, as well as EBRD and EIB definitions. The IFC definition is taken to concur with the World Bank definition.

This CHA is based upon data available from national and regional datasets, accessible literature, consultation with national specialists and field surveys, including those completed for the 2022 ESIA, and the Project information. A systematic process was used to screen and evaluate 213 preliminary biodiversity values. Of these, 92 were scoped in and 121 were scoped out prior to consultation with the MEG. Following MEG input, 19 values remained scoped in.

The outcome of the Marine CHA confirms:

- Four species and two habitats / ecosystems trigger CH status (as per IFC/EBRD/EIB definitions)
- Thirteen species are identified as PBFs (as per EBRD definition)
- The direct Project footprint does not overlap with any legally protected or internationally recognised areas. However, it does overlap with a candidate designated site for two shark species
- The majority of the Ecologically Appropriate Areas of Analysis (EAAAs) are Natural Habitat with localised and discrete areas of Modified Habitat, associated with areas of coastal development

The outcome of the Seabirds CHA confirms:

- No biodiversity seabird values trigger CH status
- Two biodiversity species are identified as PBF

The findings of this CHA will be used by the Project to inform the approach to protecting and conserving biodiversity values, using a precautionary approach and through application of the Biodiversity Mitigation Hierarchy. The Hierarchy will be applied throughout the design and implementation of the Project,

evaluation of Project alternatives and preparation of the Environmental and Social Impact Assessment (ESIA) to demonstrate Net Gain (NG) and No Net Loss (NNL), respectively, for biodiversity values that trigger Critical Habitat (CH), and Priority Diversity Features (PBF) status. A Biodiversity Management Plan (BMP), and potentially, should a need for biodiversity offsetting be identified, a Biodiversity Action Plan (BAP), will be developed.

Abbreviations and Acronyms

AAWDC	Aqaba-Amman Water Desalination and Conveyance
AFD	French Development Agency (Agence française de développement)
AMP	Aqaba Marine Park
AMR	Aqaba Marine Reserve
AMRMP	Aqaba Marine Reserve Management Plan
AoI	Area of Influence
AoO	Area of Occupancy
ASEZA	Aqaba Special Economic Zone Authority
BAP	Biodiversity Action Plan
BBOP	Business and Biodiversity Offsets Programme
BMP	Biodiversity Management Plan
CBD	Convention on Biological Diversity
CHA	Critical Habitat Assessment
CH	Critical Habitat
CITES	Convention on International Trade in Endangered Species of Wild Flora and Fauna
CMS	Conservation of Migratory Species
CR	Critically Endangered
CSBI	Cross-Sector Biodiversity Initiative
DFC	Development Finance Corporation
DWC	Deep Water Corals
EAAA	Ecologically Appropriate Area of Analysis
EBRD	European Bank for Reconstruction and Development
EHS	Environmental, Health, and Safety
EN	Endangered

EoO	Extent of Occurrence
ES	Ecosystem Services
ES	Environmental Standard
ESHS	Environmental, Social Health and Safety
ESIA	Environmental and Social Impact Assessment
ESP	Environmental and Social Policy
ESRs	Environmental and Social Requirements
EIB	European Investment Bank
EU	European Union
GCF	Green Climate Fund
GCRMN	Global Coral Reef Monitoring Network
GEF	Global Environment Facility
GNs	Guidance Notes
GoA	Gulf of Aqaba
IBAT	Integrated Biodiversity Assessment
ICRI	International Coral Reef Initiative
IFC	International Finance Corporation
IGO	Intergovernmental Organisation
IMMA	Important Marine Mammal Area
IMTA	Important Marine Turtle Area
IOSEA	Indian Ocean and South East Asia
ISRA	Important Shark and Ray Areas
IUCN	International Union for Conservation of Nature
JNPA	Jordan National Protected Areas Network
KBAs	Key Bird and Biodiversity Areas

km	Kilometre
kV	Kilovolt
MCM	Million cubic metres
MEG	Marine Expert Group
MHWM	Mean High Water Mark
MoU	Memorandum of Understanding
MPA	Marine Protected Area
MSS	Marine Survey Station
NBSAP	National Biodiversity Strategy and Action Plan

1 Introduction

1.1 Purpose and Scope of the Marine Critical Habitat Assessment (CHA)

This Marine Critical Habitat Assessment (CHA) has been prepared by Energies Group, with the support of ECO Consult, One Ocean and a team of national scientific experts for the marine components of the Aqaba Amman Water Desalination and Conveyance (AAWDC) Project, hereinafter referred to as 'the Project'. A separate Seabirds CHA, prepared by The Biodiversity Consultancy (TBC) is provided in Appendix 6. The outcomes of the seabirds CHA process are included in Sections 5.2 and 6.2.

The aim of this CHA is to identify biodiversity values which qualify as Critical Habitat (CH) or Priority Biodiversity Features (PBFs), as defined in the respective Lender Performance Standards (PSs) and Performance Requirements (PRs), in relation to the Project.

This document, combined with the Marine Technical Report, also supports the identification of data gaps and requirements for additional biodiversity surveys or studies for relevant marine biodiversity values (i.e., species, habitats, ecosystems).

CHA is an inherently iterative process, as the potential for additional biodiversity values to be assessed exists throughout the Environmental and Social Impact Assessment (ESIA) process into the construction and operation phases. This CHA enables the Project to be aware of key marine biodiversity values at the early design and ESIA phases, enabling timely identification of appropriate biodiversity protection, including avoidance, mitigation, management and, if required and agreed with Lenders, biodiversity offsets. This CHA has been prepared prior to the collection of the Project-specific marine biodiversity surveys. It should be noted that, given the high levels of endemism in the Red Sea region and the relative lack of historic survey effort, there is potential for previously unrecorded species, and /or additional data on known species, to be identified as the Project and associated survey effort progresses.

The Project's approach to environmental sustainability, including biodiversity values, is based on alignment with the following Environmental and Social Standards:

- National Environmental, Social, Health and Safety (ESHS) laws and regulations, including national obligations under international law that apply to the Project
- International Finance Corporation (IFC) Performance Standards (PSs) (2012) and supporting Guidance Notes (GNs)
- European Bank for Reconstruction and Development (EBRD) Environmental and Social Policy (2024) and associated Environmental and Social Requirements (ESRs) and supporting GNs
- European Investment Bank (EIB) Environmental and Social Standards (2022) and supporting GNs
- U.S. International Development Finance Corporation (DFC) Environmental and Social Policy and Procedures (2024)
- Agence française de développement (AFD) Group Exclusion List (2022)
- World Bank Group (WBG) Environmental and Social Framework (2017)
- Green Climate Fund (GCF) Revised Environmental and Social Policy (2021)
- European Union (EU) substantive environmental standards (as required by the EBRD)

- The Regional Organisation for the Conservation of the Environment of the Red Sea and Gulf of Aden (PERSGA) ('Jeddah Convention') Protocols Concerning the Conservation of Biological Diversity and the Establishment of Network of Protected Areas in the Red Sea and Gulf of Aden (PERSGA, 2004) and PERSGA Standard Survey Methods for Key Habitats and Key Species in the Red Sea and Gulf of Aden (2019)
- The Cross-Sector Biodiversity Initiative (CSBI) guide for implementing the Mitigation Hierarchy (2015)
- Good Practices for the Collection of Biodiversity Baseline Data prepared for the Multilateral Financing Institutions Biodiversity Working Group and Cross-Sector Biodiversity Initiative (CSBI). (Gullison *et al*,. 2015)
- Addis Ababa Principles and Guidelines for the Sustainable Use of Biodiversity (CBD Guidelines) Montreal: Secretariat of the Convention on Biological Diversity (2004)

Of the seven Lender policies listed above, EIB, EBRD and IFC provide explicit criteria for the assessment of Critical Habitat (provided in full detail in Appendix 2), and it is understood that the Project will adhere to the most stringent.

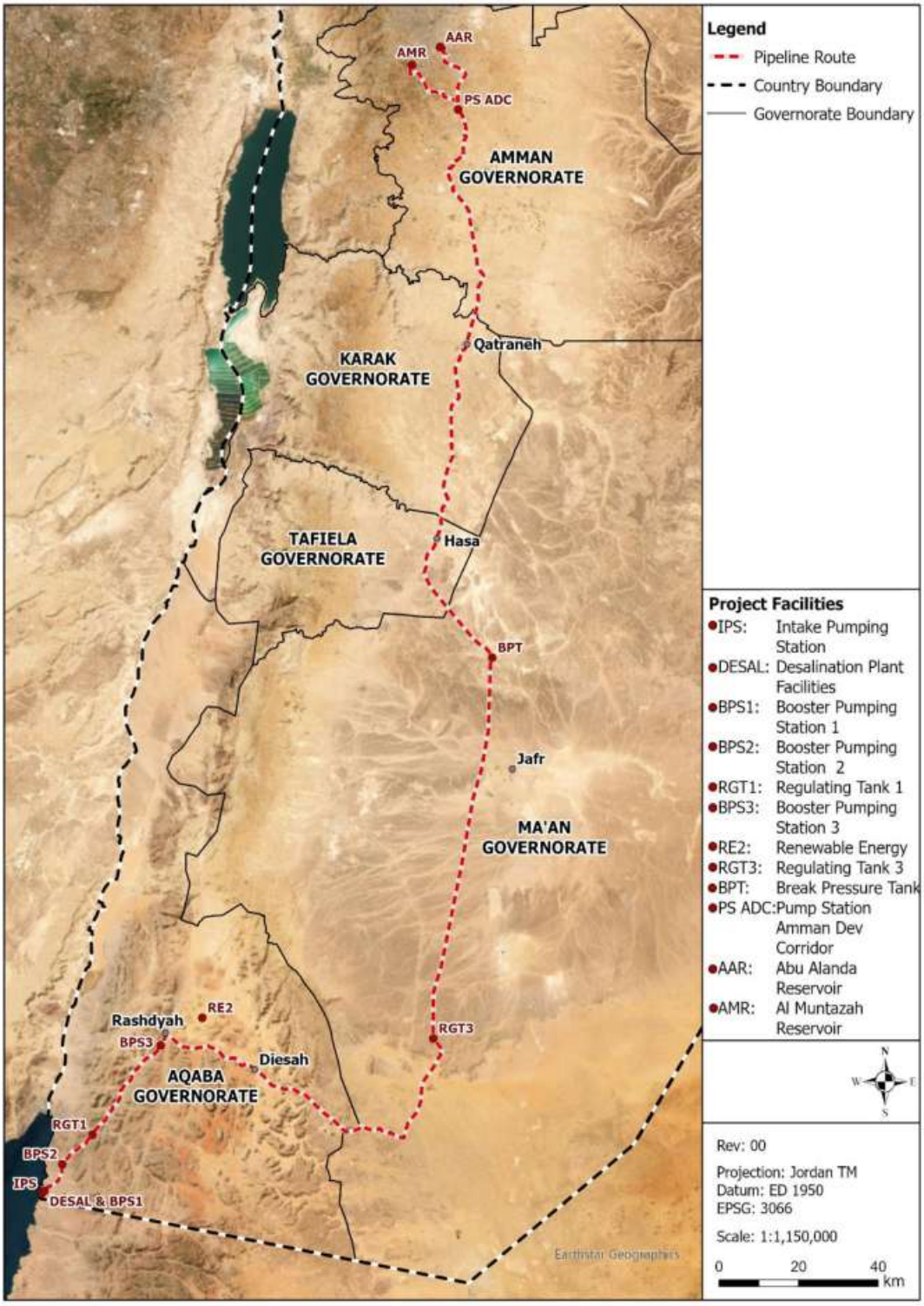
1.2 Project Description

Jordan faces one of the world's most serious water shortages. The aim of the Project is to generate 300 million cubic metres (MCM) of drinking water per year by taking water from the Gulf of Aqaba and treating it in a new desalination plant. The drinking water will then be transported to Aqaba and Amman via pipeline. The Project will be the largest water generation scheme to be implemented in the history of Jordan, and it is fundamental for Jordan's water security.

The Project comprises (refer to Figure 1-1):

- Seawater Reverse Osmosis (SWRO) Desalination Plant connected to Intake and Outfall Facilities comprising marine intake and outfall infrastructure, pumping and transfer facilities
- Conveyance system comprising a buried pipeline (approximately 438km long); four pumping stations; and two regulating tank facilities and one break pressure tank
- Renewable Energy (RE) facility comprising solar photovoltaic (PV) power plant and supporting electrical substation

Figure 1-1: Project Overview



2 Performance Standards and Guidance Notes

There are seven Lenders involved in the financing of the Project. Their respective Environmental and Social Standards (PSs) and associated Guidance Notes (GNs) are summarised below and detailed in Appendix 2. While all Lender standards make reference to Critical Habitat, only three of these Lenders (IFC, EBRD and EIB) have detailed criteria and thresholds for Critical Habitat and these are therefore the focal frameworks applied within this CHA. EBRD also defines PBF. Where criteria and/or thresholds differ, the most stringent and/or precautionary shall be applied. All relevant Lender criteria are detailed within the CHA Determination (Section 5).

2.1 The World Bank

The World Bank Environmental and Social Framework (2017) sets out the commitment to sustainable development, through a Bank Policy and a set of Environmental and Social Standards. Of direct relevance to this CHA is Environmental Standard 6: Biodiversity Conservation and Sustainable Management of Living Natural Resources that define Critical Habitat as:

Paragraph 23. "Critical habitat is defined as areas with high biodiversity importance or value, including:

a) habitat of significant importance to Critically Endangered or Endangered species, as listed in the IUCN Red List of threatened species or equivalent national approaches

b) habitat of significant importance to endemic or restricted-range species

c) habitat supporting globally or nationally significant concentrations of migratory or congregatory species

d) highly threatened or unique ecosystems

e) ecological functions or characteristics that are needed to maintain the viability of the biodiversity values described above in (a) to (d)"

2.2 International Finance Corporation (IFC)

The International Finance Corporation's (IFC) Performance Standards are part of the IFC's Sustainability Framework. IFC's Performance Standard 6: Biodiversity Conservation and Sustainable Management of Living Natural Resources (2012) is supported by the IFC's Guidance Note 6: Biodiversity Conservation and Sustainable Management of Living Natural Resources (2019). The IFC define Critical Habitat as:

Paragraph 16. *"Critical habitats are areas with high biodiversity value, including*

(i) habitat of significant importance to Critically Endangered and/or Endangered[1] *species*

(ii) habitat of significant importance to endemic and/or restricted-range species

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

(iii) habitat supporting globally significant concentrations of migratory species and/or congregatory species

(iv) highly threatened and/or unique ecosystems; and/or

(v) areas associated with key evolutionary processes"

2.3 European Bank for Reconstruction and Development (EBRD)

The European Bank for Reconstruction and Development (EBRD) Environmental and Social Policy (2024) and its supporting Guidance Note 6 Biodiversity conservation and sustainable management of living natural resources (2025) includes a comprehensive set of specific Environmental and Social Requirements (ESRs) including ESR 6 that defines Critical Habitat as:

Paragraph 14. *"The most sensitive biodiversity features are defined as critical habitat, comprising one of the following: (i) highly threatened or unique ecosystems; (ii) habitats of significant importance to endangered*[2] *or critically endangered species; (iii) habitats of significant importance to endemic or geographically restricted species; (iv) habitats supporting globally significant migratory or congregatory species; or (v) areas associated with key evolutionary processes."*

Priority Biodiversity Features are defined as:

"Priority biodiversity features are a sub-set of biodiversity, which are irreplaceable or vulnerable, but at a lower priority level than critical habitats."

2.4 European Investment Bank (EIB)

The European Investment Bank's (EIB) Environmental and Social Standards (2022) includes 11 environmental and social standards, including Standard 4: Biodiversity and Ecosystems that is supported by Guidance Note for Standard 3 on Biodiversity and Ecosystems (2018). Critical Habitat is defined as:

Paragraph 16 *"Critical habitat is the most sensitive of the high-value biodiversity features and is defined as comprising one of the following:*
a. A highly threatened and/or unique ecosystem
b. A habitat of priority and/or significant importance to critically endangered, endangered or vulnerable species, as defined by the IUCN Red List of threatened species[3] *and in relevant national legislation*
c. A habitat of priority and/or significant importance to a population, range or distribution of endemic or restricted-range species, or highly distinctive assemblages of species
d. A habitat required for the survival of migratory species and/or congregatory species
e. Biodiversity and/or an ecosystem of significant social, economic or cultural importance to local communities and indigenous groups
f. A habitat of key scientific value and/or associated with key evolutionary processes"

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

2.5 U.S. International Development Finance Corporation (DFC) Environmental Policy & Procedures

DFC adopts the IFC's Performance Standards on Social and Environmental Sustainability and the World Bank Group's Environmental, Health, and Safety (EHS) Guidelines, including any subsequent revisions to those standards (and any underlying standard or guideline e.g., PS6 and GN6 and definitions therein) as a Standard for assessment, review, and management of environmental and social risks and impacts.

2.6 Agence Française de Développement (AFD) Group Exclusion List

The objective of the exclusion list is to clearly indicate the activities that the Group will not finance due to ethical, regulatory, environmental or social criteria, and arising from the application of normative requirements as well as its strategic choices. The present exclusion list is a result of cross-cutting work by the Group and is applied by its member entities: AFD and its subsidiaries PROPARCO and Expertise France (together referred to as "AFD Group" or the "Group"). Such activities are deemed not to align with AFD Group's commitments to sustainable development. Of relevance to this CHA is:

Paragraph 17. *"Biodiversity:*
17. Biodiversity: (i) Any financing in the (a) sites of the Alliance for Zero Extinction (AZE)[4][5]*, (b) natural and mixed sites on the Unesco World Heritage List 20 and (c) legally protected areas (IUCN categories) List 21 and,*
(ii) Any operation leading to an adverse and irreversible[6] *residual*[7] *impact on a critical habitat*[8],[9]*."*

Within this CHA, "Critical Habitat" is defined using the IFC, as well as EBRD and EIB definitions; the IFC definition is taken to concur with the World Bank definition.

2.7 Green Climate Fund (GCF) Environmental Policy and Social Policy Procedures

GCF's overarching Environmental and Social Policy prescribes how GCF integrates environmental and social considerations into its decision-making and operations to effectively manage environmental and social risks and impacts and improve outcomes. Of relevance to this CHA is:

Guiding Principle (s) "**Biodiversity.** *All GCF-financed activities will be designed and implemented in a manner that will protect and conserve biodiversity and critical habitats, ensure environmental flows of*

4 Unless the area of influence of the funded activities and their associated facilities does not encroach on zones that effectively meet the criteria for being designated as an
AZE site – https://zeroextinction.org/site-identification/aze-site-criteria/

5 Unless the area of influence of the funded activities and their associated facilities does not encroach on zones that effectively meet the criteria for being designated as an
AZE site – https://zeroextinction.org/site-identification/aze-site-criteria/
6 Irreversible impact: permanent conversion or degradation of biodiversity or of the ecological functions or characteristics that warranted the critical habitat designation.
7 Residual impact: a project's measurable impact on a biodiversity value, after implementation of avoidance and mitigation measures, but before implementation of restoration and compensation measures.
8 Critical habitat: within the meaning of the World Bank's Environmental and Social Standard 6 – 2018 or IFC-GN PS6 2019.
9 Unless the said project is of overriding general interest for the destination country, in which case a derogation can be presented to the Group's governance for a decision.

water, maintain the benefits of ecosystem services, and promote the sustainable use and management of living natural resources."

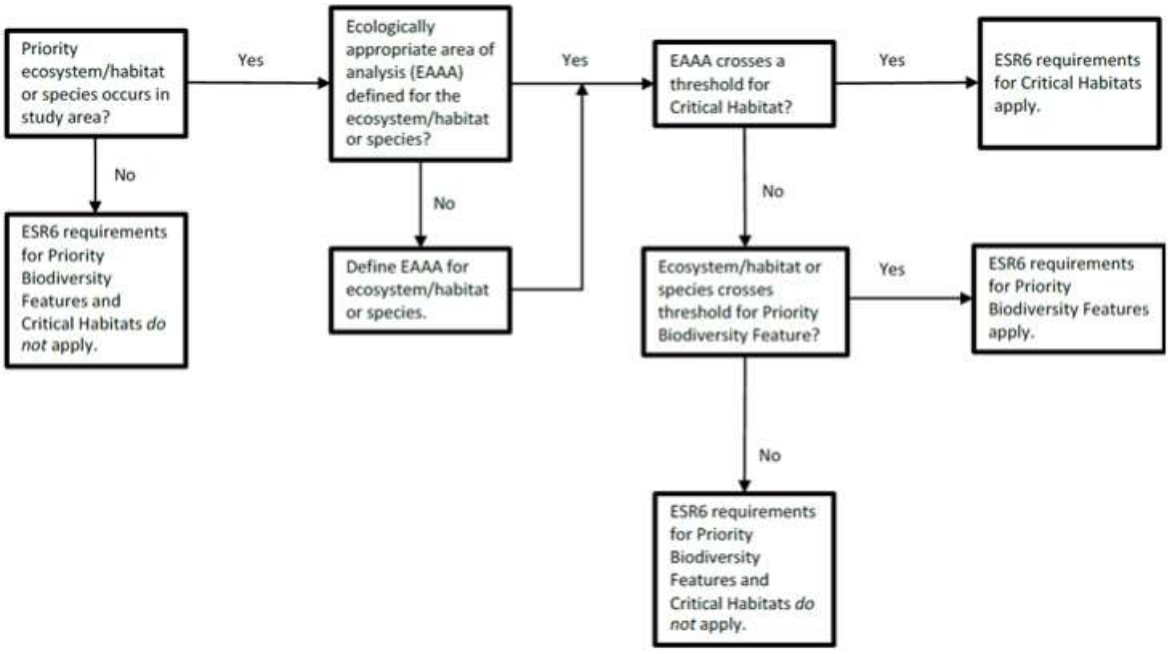
2.8 Key EBRD, IFC & EIB Principles & Requirements

The key aspects of the EBRD, IFC & EIB Principles & Requirements are:

- To protect and conserve biodiversity using a precautionary approach through application of EBRD ESR6, IFC PR6, EIB Standard 4 and respective supporting Guidance Notes (GNs)
- Adopt the biodiversity mitigation hierarchy in the design and implementation of projects with the aim of achieving No Net Loss (NNL)/Net Gain (NG) of biodiversity and maintaining benefits from Ecosystem Services (ES)

EBRD, IFC and EIB have specific PS requirements and associated thresholds for the assessment of Critical Habitat (CH), Natural Habitat (NH), and for EBRD, Priority Biodiversity Features (PBFs). These have been applied herein and are summarised below in Figure 2-1 , which is extracted from EBRD GN ESR6 (2023).

Figure 2-1: Logical Flow of Critical Habitat Assessment (EBRD, 2025 (Draft))



2.8.1 Relevance of EU Legislation to this CHA

2.8.1.1 EBRD's Commitments

The EBRD does not require clients to refer to the Habitats Directive and/or Birds Directive outside of the EU or candidate countries. In all other countries the EBRD is committed to ensuring that projects comply with the appropriate EU principles, practices and standards, subject to local conditions (EBRD, 2024).

2.8.1.2 EIB's General Requirements

Paragraph 7 states that all projects located in the rest of the world shall comply with the applicable national legislation and with the core principles and essential procedural elements laid down by the EU legislation that the EIB considers relevant to the assessment and management of environmental, climate and/or social impacts and risks, particularly those contained in the EIA Directive, which are set out in the paragraphs 14 – 31 and annexes of the EIB Standard (EIB, 2022).

For these reasons, where relevant, criteria and thresholds relating to the EU Habitats Directive (92/43/EEC) have been applied in this CHA.

2.9 Objectives of the CHA Process

To determine if any biodiversity values considered within respective Ecologically Appropriate Areas of Analysis (EAAAs) qualify as Critical Habitat (CH), Natural Habitat (NH), Modified Habitat (MH) or Priority Biodiversity Features (PBFs), as defined by IFC, EBRD or EIB (refer to Section 4.1 for further definition of EAAAs). It is noted that there are some differences in terms, terminology and definitions between Lenders; these are captured in Appendix 2.

Critical Habitats are high biodiversity values (i.e., species, habitats or ecosystems), that meet one or more of the following five criteria. These are defined slightly differently by different Lenders (see Appendix 2 as mentioned above), but the common focus is upon:

- Critically Endangered (CR), Endangered (EN) species and/or Vulnerable (VU) species
- Endemic and/or restricted-range species
- Migratory and/or congregatory species
- Highly threatened and/or unique ecosystems
- Key evolutionary processes and/or key scientific value

Note: Each of these five criteria is equally weighted. Definitions and, where applicable, qualitative thresholds to inform the assessment of biodiversity values against these are provided in IFC (PS6), EBRD (ESR6) and EIB (Standard 4) and respective supporting GNs.

PBFs are subsets of biodiversity values that are irreplaceable or vulnerable, but at a lower priority level than CH.

Ecologically Appropriate Areas of Analysis (EAAAs) should:

- Consider the distribution and connectivity of biodiversity values in the context of the seascape and the ecological processes and functions that support them
- Biodiversity values with a patchy distribution across a seascape may require an EAAA that encompasses multiple disjunct areas
- For some wide-ranging species, the EAAA may be informed by areas of aggregation, recruitment or other specific habitat features of importance
- Where multiple biodiversity values have overlapping ecological requirements and distributions, common or aggregated EAAAs may be appropriate

Figure 2-2 below is extracted from EBRD GN ESR6 (2025), within which the quantitative thresholds are aligned with both the IFC's and EIB's standards. There are differences in other aspects of each Lender's

PSs/ESRs/PRs, which are also taken into consideration in this CHA, as shown in Appendix 2. These thresholds are derived from thresholds published in the International Union for Conservation of Nature's (IUCN) 'A Global Standard for the Identification of Key Bird and Biodiversity Areas (KBAs)' as well as Red List Categories and Criteria.

Figure 2-2: Criteria and thresholds for Identifying Critical Habitat and PBFs (EBRD, 2025)

Criterion	Priority Biodiversity Feature	Critical Habitat
Priority ecosystems		
Threatened ecosystems/habitats (a) Habitats listed in Annex 1 of EU Habitats Directive (EU members only) or Resolution 4 of Bern Convention (signatory nations only) (b) IUCN Red List EN or CR ecosystems (c) Ecosystem/habitats listed in national systematic conservation planning	(ESR6 para. 12-i) (a) Habitat type listed in Annex 1 of EU Habitats Directive or Resolution 4 of Bern Convention (b) Ecosystem type with IUCN status of EN or CR	(ESR6 para. 14-i) (a) Habitat type listed in Annex 1 of EU Habitats Directive marked as "priority habitat type" (b) EAAA* ≥5% of global extent of an ecosystem type with IUCN status of CR or EN (c) EAAA for ecosystem/habitat determined to be of high priority for conservation by national systematic conservation planning
Priority species and their habitats		
Threatened species (a) Species and their habitats listed in EU Habitats Directive and Birds Directive (EU members only) or Bern Convention (signatory nations only) (b) IUCN global Red List VU, EN or CR species (c) IUCN national or regional (e.g., Europe) Red List EN or CR species (or analogous national listing)	(ESR6 para. 12-ii) (a) Species in the area of impact listed in Annex II of Habitats Directive, Annex I of Birds Directive, or Resolution 6 of Bern Convention (b) Species in the area of impact with IUCN global Red List status of VU, EN or CR (c) Species in the area of impact with national or regional status of EN or CR	(ESR6 para. 14-ii) (a) EAAA supports species listed in Annex II of Habitats Directive marked as "priority species" (b) EAAA supports ≥ 0.5% of the global population AND ≥ 5 reproductive units of a CR or EN species, or EAAA supports globally significant population of VU species necessary to prevent a change of IUCN Red List status to EN or CR (c) EAAA for important concentrations of species with national or regional status of EN or CR
Range-restricted species (a) All range-restricted species**	(ESR6 para. 12-ii) (a) All range-restricted species in the area of impact	(ESR6 para. 14-iii) (a) EAAA regularly holds ≥ 10% of global population AND ≥ 10 reproductive units of the species***
Migratory and congregatory species (a) All migratory species (b) All congregatory species	(ESR6 para. 12-ii) (a) All migratory species in the area of impact	(ESR6 para. 14-iv) (a) EAAA sustains, on a cyclical or otherwise regular basis, ≥ 1 percent of the global population at any point of the species' lifecycle (b) EAAA predictably supports ≥10 percent of global population during periods of environmental stress****

*EAAA = *ecologically appropriate area of analysis*
**See footnote 6
***The IUCN Key Biodiversity Areas standard cites the following definition for reproductive unit: "the minimum number and combination of mature individuals necessary to trigger a successful reproductive event at a site. Examples of five reproductive units include five pairs, five reproducing females in one harem, and five reproductive individuals of a plant species."
****The IUCN Key Biodiversity Areas Guidance defines environmental stress as "natural events like floods, droughts, storms, wildfires, earthquakes as well as high or low temperature caused by global change; it can also describe the lack of food due to the bottom-up effect of environmental stress or massive die-off of prey in ecosystem due to infectious disease. Environmental stress refers to extreme environmental conditions, whether natural or anthropogenic."

2.10 The Marine Expert Group

While the above numerical thresholds have been defined for some of the IFC/EBRD/EIB CH and PBF criteria (i.e. CR/EN species; endemic/restricted-range species; migratory/congregatory species; threatened and unique ecosystems) they are not prescriptive. It is preferable to apply these thresholds to EAAAs insofar as is possible; however, the data deficiencies for marine biodiversity within the GoA, which is not abnormal, creates challenges transferring CHA to marine contexts (see Section 4.2.1). Emphasis is placed on the need for expert input and professional judgement.

The following is an extract from IFC GN6 (2019):

*"IFC: GN56…**these thresholds are indicative and serve as a guideline for decision-making only**. There is no universally accepted or automatic formula for making determinations on critical habitat. The involvement of external experts and project-specific assessments is of utmost importance, especially when data are limited (as will often be the case)".*

The need for specialist input in relation to these indicative thresholds is also emphasised in other Lender guidance. The following, for example, is extracted from EIB GN3 (2018):

"..They [the indicative thresholds] should be applied with appropriate specialist input, which may require engagement of local and international specialists, interaction with conservation NGOs and local community representatives and engagement with government organisations or others responsible for systematic conservation planning…"

Lender standards therefore require projects to engage and consult with relevant, qualified specialists during the desk-based and field data collection stages of the CHA process. This is particularly important in instances where Critically Endangered and/or Endangered species are present, as is the case in this instance. Energies Group and ECO-Consult identified five Jordanian marine specialists, to collectively form the Marine Expert Group (MEG), with the purpose of providing inputs, sharing data and resources and ongoing consultation throughout the CHA process. IUCN Species Survival Commission specialist group members and other university academics were also consulted where relevant.

Within marine contexts, this is particularly important as interpretation of the results of the CHA process often requires professional expert judgement and consultation with species and regional specialists. This is due to a number of factors, such as the inherent data deficiencies and scales of connectivity within marine environments, as well as the challenges of transferring qualitative thresholds designed for terrestrial biodiversity into marine contexts. Having an external panel of experts (the MEG, other university academics and IUCN specialist group members) to review the CHA process ensures it is robust, and precautionary where necessary, which is essential for the management of risk and impacts to biodiversity values.

Table 2-1: The MEG and other Subject Matter Experts

Specialist Name	Specialism	Organisation
Dr. Maroof Khalaf	Fish and Fisheries	Jordan University - Amman and Aqaba Branch
Dr. Mohammad Al-Zibdah	Marine Turtle specialist	Jordan University - Amman and Aqaba Branch
Dr. Fuad Horani	Coral and Benthic Ecology	Jordan University - Amman and Aqaba Branch

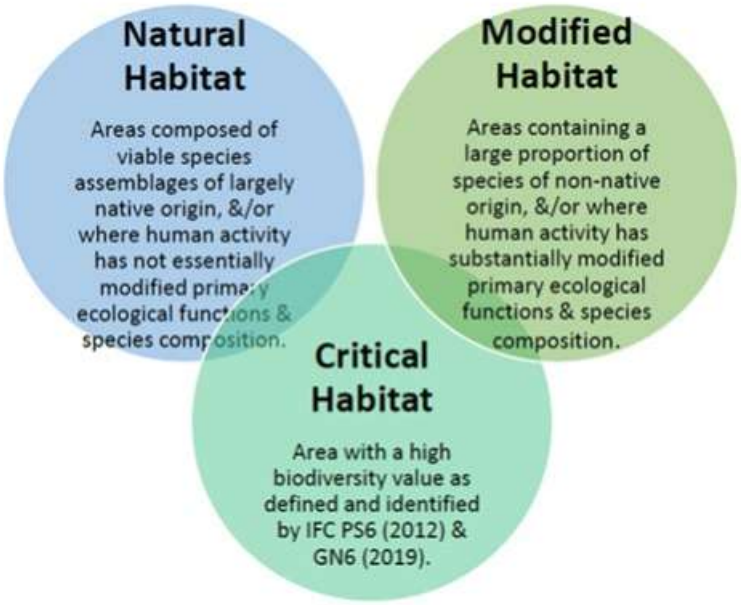
Specialist Name	Specialism	Organisation
Dr. Tareq Najjar	Seagrass and Plankton	Jordan University - Amman and Aqaba Branch
Dr. Riyad Manasrah	Hydrodynamics/Marine processes	Jordan University - Amman and Aqaba Branch
Mr. Robert Baldwin	Marine Mammals and Sea Turtles	One Ocean (member of IUCN SSC CSG and MTSG)
Dr. Friedhelm Krupp	Fish	Senckenberg Society for Nature Research (Curator of Ichthyology - retired)

2.11 Habitat Categories

Three types of habitat are commonly defined by lenders; Natural, Modified or Critical Habitats. These are defined slightly differently by different Lender policies (Appendix 2) and Figure 2-3 below is based upon IFC definitions. Projects are often located within a mosaic of habitat types within which Natural and Modified Habitats can exist on a continuum e.g., from pristine Natural Habitats to intensively managed/altered Modified Habitats.

Within the EAAAs for this Project, the majority of the habitat is deemed to be Natural Habitat, but there are also discrete areas of Modified Habitat, particularly in association with coastal development (e.g., Port of Aqaba). Projects are required to meet different requirements before any activities can be permitted in Critical and/or Natural Habitats. If these requirements are defensibly met and activities proceed further, Lender requirements stipulate specific outcome-focused measurable requirements for biodiversity conservation.

Figure 2-3: IFC Definitions of Habitat Types



3 National, Regional and International Treaties and Conventions

This CHA also supports the implementation of applicable treaties and conventions in Jordan, including the following:

- The Convention on Biological Diversity, 1992
- The Convention on the Conservation of Migratory Species (CMS) of Wild Animals, 1979 (Bonn Convention)
- Memorandum of Understanding (MoU) on the Conservation and management of Marine turtles and their habitats of the Indian Ocean and South East Asia (IOSEA) (signatory)
- Memorandum of Understanding (MoU) on the Conservation of Migratory Sharks 2010 (signatory)
- The Convention on International Trade in Endangered Species of Wild Flora and Fauna (CITES), 1975
- The Convention on Wetlands of International Importance especially as Waterfowl Habitat, 1971 (Ramsar Convention)
- The Convention Concerning the Protection of World Cultural and Natural Heritage, 1972 (UNESCO World Heritage Convention)
- The Regional Convention for the Conservation of the Red Sea and Gulf of Aden Environment ('Jeddah Convention'): subsequent protocols developed include the Protocol Concerning the Conservation of Biological Diversity and the Establishment of Network of Protected Areas in the Red Sea and Gulf of Aden (PERSGA, 2004)
- Convention on the Conservation of Wildlife and their Natural Habitats in the Countries of The Gulf Cooperation Council: aimed at conserving ecosystems and wildlife. Includes annexes listing floral and faunal species to be protected and animal species threatened with extinction
- International Convention on Oil Pollution Preparedness, Response and Co-operation, 1990 (OPRC Convention)

Jordan is currently (as of September 2025) reviewing the Final Draft of the new National Biodiversity Strategy and Action Plan, the focus of which is conserving natural resources, protecting ecosystems and ensuring sustainable use of biodiversity in accordance with national sustainable development goals.

4 CHA Approach and Methodology

4.1 The Critical Habitat Assessment (CHA) Process

CHA is an iterative process, as detailed in IFC GN6 (2019), GN60 - GN83, and summarised below. The approximate location of a project and its maximum Area of Influence (AoI) for each biodiversity value (i.e., species, habitats and ecosystems) should be considered, as well as consideration of the spatial extent for assessment, known as the Ecologically Appropriate Area of Analysis (EAAAs) (GN59, 2019), of those biodiversity values during the CHA process.

EAAAs should extend beyond the AoI for each biodiversity value. The project type, its impacts and its mitigation strategy are irrelevant in carrying out the CHA process itself (GN60, 2019). Rather, the CHA determines whether the area (EAAA) contains any important biodiversity values that may qualify for CH or PBF status, irrespective of the Project or any other influences. EAAAs also consider any protected and designated sites within ecologically relevant distances, extending to ecologically relevant temporal and spatial scales for the biodiversity values known or deemed likely to be present via the CHA screening process (see Methodology, Section 4.2, below).

EAAAs encompass the complete distribution of biodiversity values and the ecological patterns, processes, and functions required to maintain them throughout this distribution. For wide-ranging species, such as marine megafauna (marine mammals, turtles, elasmobranchs), EAAAs are extensive as they incorporate habitat features, ecological connectivity and ecosystem processes that maintain the viability of these biodiversity values. The focus is on ecologically relevant scales at which to consider the interlinked and overlapping biodiversity values of interest, based on their abundance, distribution and life history traits at different stages of their lifecycle.

Due to the concurrent production of a Terrestrial CHA for the Project it was decided to capture all ornithological receptors within that scope (although results for seabirds are provided in Sections 5.2 and 6.2 as well as 0 of this document for completeness of this marine CHA).

Where practicable within this CHA, the EAAAs have been identified for groups of biodiversity values with the same known habitat preferences (e.g., depth ranges, benthic habitat types, etc.) and life history characteristics (e.g., spatially discrete functional habitats used at different life stages or close habitat association). These commonalities are relevant both for the CHA and during the preparation of the concurrent ESIA for the identification of avoidance and mitigation approaches, as they will influence the potential impacts of the Project on these values. Furthermore, the degree of confidence regarding the certainty of the presence of a biodiversity value within an EAAA (i.e., “recorded/confirmed”, “likely” or “possible” as captured in Appendices I & II) has also been taken into account. An advantage of grouping similar values is that if one species in a group is “recorded” but the others are only considered “likely” to be present they are captured within the umbrella of the overarching EAAA, in a precautionary manner.

CHA broadly follows a three-step process:

Step 1: Stakeholder Consultation/Initial Literature Review

Aim: To obtain an understanding of biodiversity values, and their relevance to CHA, within the seascape from the perspective of relevant stakeholders.

Process: Field consultation exercises and desktop research.

Step 2: Field Data Collection and Verification of Available Information

Aim: To collect and review available field data and verify available detailed information necessary for the CHA.

Process: Engage qualified specialists to collect field data as necessary both within and outside of the EAAAs (see GN59 of IFC GN6, 2019.)

Step 3: Critical Habitat Determination

Aim: Determine whether the project is situated in Critical Habitat and/or Natural Habitat.

Process: Analysis and interpretation of the desktop and field data collected.

As mentioned above, CH determination is undertaken completely independently of the project type, impacts or its mitigation strategy. The determination of CH is based on the presence of high biodiversity values regardless of the project.

The Project has undertaken and implemented these three steps as outlined in Table 4-1 below.

Table 4-1: Overview of CHA Approach

Task	Summary
Identification of local stakeholders to support CHA	Participation of local experts, the Marine Expert Group (MEG), to support the identification, collection and review of applicable data On-going consultation with the MEG
Stakeholder Consultation/Initial Literature Review	Targeted, topic specific CHA related questionnaires and on-going consultation with the MEG Verification of available information
Field Data Collection and Verification of Available Information	Field survey planning and execution supported by the MEG Data from / identified by local experts will be collated and reviewed, data gaps will be noted (see Notes) Outputs from marine survey will be collated and incorporated into the CHA (see Notes)
CHA Determination	Screening of biodiversity values against IFC, EBRD and EIB criteria via an Excel Database Review of screening by the MEG and other relevant specialists CHA Reporting of screened in biodiversity values Review of draft CHA determination by specialism by the MEG and other relevant specialists
Notes: Refer to Section 4.4 in relation to status of 2025 Marine Baseline Survey. Results from the survey are planned to be incorporated into subsequent CHA updates.	

4.2 Methodology

4.2.1 Screening

Screening commenced with a preliminary review of the project design and location(s) to provide relevant spatial context. Relatively broad ecological units (i.e. seascapes within the GoA) were initially screened to determine the likelihood of them supporting biodiversity values that may qualify as CH or PBFs.

To identify the candidate species, habitats and ecosystems (i.e. biodiversity values) to be assessed against the IFC, EBRD and EIB criteria (i.e., included in the CHA process) an "Initial CHA Screening Long List" was produced with inputs from the MEG comprising initially 213 biodiversity values. This process combined information collated and screened from a range of secondary data sources for the marine biodiversity of the GoA including site listings for protected, designated and recognised sites, in particular Jordanian waters.

For screening of species, initial lists of biodiversity values were compiled for the Arabian Peninsula (e.g., for fishes; DiBattista et al. 2016, and for marine mammals; Baldwin, 2003 and Baldwin 2024). For each biodiversity value, screening then involved developing rationale for either including ('screened in') or excluding ('screened out') the feature from further analysis. To achieve this, species considered as Critically Endangered (CR), Endangered (EN) or Vulnerable (VU) according to the IUCN Red List were then added to the screening list to assess Criterion 1. These were extracted from the IUCN database using the search parameters: geographical scope = global; Red List = CR, EN, VU; and marine region = Indian Ocean, and added to the screening list if their distributions included the Red Sea, and specifically the Jordan Gulf of Aqaba.

The screening long list was also initially filtered so as to include only species endemic to the Red Sea region, focused on those species known or thought to occur in the Jordan Gulf of Aqaba. This, combined with knowledge of species behaviour, provided an appreciation of biodiversity values relevant to Criterion 2.

Next, species appearing on the Convention on the Conservation of Migratory Species of Wild Animals (CMS) database under Appendix 1 were added to the screening list, along with species listed as forming spawning aggregations in the Science and Conservation of Fish Aggregations (SCRFA) database. This provides an indication of applicability of Criterion 3.

For Criteria 4 and 5, estimates of coverage by habitats (using existing habitat maps) noted to be important in national/international management planning documents and regional literature reviews were conducted. Key components of screening against criteria 4 and 5 also included searches of the IUCN Red List of Ecosystems.

This entire process was supported by targeted literature review of scientific papers, published reports (e.g., the AMR Management Plan), Protected Planet and the Integrated Biodiversity Assessment (IBAT) and the previous ESIA for the Project which includes Marine Baseline Survey data. Other factors considered included biodiversity values recorded/confirmed (by a Project specific survey, or other surveys/observations), or likely presence of species and habitats within both the GoA and Jordanian waters.

Dialogue with the MEG commenced with a collective, then individual Teams calls, follow on communications were then undertaken primarily via email. The objective was to obtain access to available data, scientific papers and reports and to understand the nature and cause of data gaps identified.

One of the first tasks appointed to the MEG was a review of the "Initial CHA Screening Long List" (Appendix 1) individually, as relevant by specialism. Biodiversity values were then further added or removed from the list based upon the MEG's responses. To supplement this review and consultation process, the MEG were also asked to complete a "CHA Questionnaire" comprising overarching and specialism specific questions. The responses were used to inform the refinement of the "CHA Screening Long List" and to identify data gaps.

The information and communications related to this consultation process with the MEG are captured in the Marine Technical Report which includes an appended summary Gap Analysis capturing these findings

and identifying further needs for surveys and/or research, and potential focal areas for biodiversity offsetting.

The MEG were also involved in the design and implementation of the marine biodiversity surveys to ensure, insofar as is possible for CHA biodiversity baseline data collection, that the marine surveys are proportional to, and appropriate for, the marine biodiversity features present. The spatial and temporal limitations of the marine surveys (e.g., surveys were limited to a single season only) undertaken to inform the baseline are noted.

The initial long list (213 biodiversity values) was compiled using Microsoft Excel, and was refined by MEG, literature review, database searches, reference to information held by relevant organisations (as listed above) and expert opinion. The next step of the screening process involved identification CR, EN and VU species, congregatory species and/or migratory species, with those not qualifying for any one of these criteria being screened out. This led to a final short list of 19 screened-in biodiversity values (Attachment 1) that were then subject to the next phases of the assessment, namely definition of EAAA (according the methods in Section 4.3 below), followed by the CH determination process itself (Section 5).

4.2.2 Limitations and Constraints

There are inherent constraints and limitations to marine baseline survey data collection due to the significant costs involved with marine surveys. For this reason, they must be well designed and appropriately focused on key biodiversity values. It is common for a project's schedule and budget to preclude data collection across all seasons and over consecutive years.

Due to the life history traits of highly mobile and widely distributed marine species (i.e. marine mammals, turtles, elasmobranchs) it is not feasible to undertake robust, long-term baseline surveys for species known, or likely, to be present. Available primary and secondary data sources for these species within Jordanian waters, the GoA and wider Red Sea region have been reviewed and synthesised, and notable data gaps recorded.

All of the data and information collected from and via the MEG was used to supplement the existing sources to characterise the marine biodiversity baseline for the CHA, to define the EAAAs for different biodiversity values and undertake the CHA process. The Marine Technical Report and the Gap Analysis provide further information on the limitations and constraints for different biodiversity values.

There are notable limitations to the application of the CHA process to marine contexts, including significant data deficiencies for many species, many species being wide-ranging, highly mobile and/or have poorly researched or understood populations. For many marine species it is not possible to estimate population size and density, as they are either not known, not published nor feasible to calculate at a global, national or relevant unit of analysis level. This means it is often challenging, or not possible, to define the global extent of occurrence[10] (EoO), area of occupancy[11] (AoO) or population size, and determination of CH must therefore use proxies for such information where possible and/or expert opinion.

10 EOO is defined as the area contained within the shortest continuous imaginary boundary which can be drawn to encompass all the known, inferred or projected sites of present occurrence of a species, excluding cases of vagrancy (IUCN 2001).
11 AOO is defined as the area within a species extent of occurrence which is occupied by that species, excluding cases of vagrancy. This measure reflects the fact that a species will not usually occur throughout the full area of its EOO, which may contain unsuitable or unoccupied habitats (IUCN 2001).

CHA focuses solely on biodiversity values identified as a priority (i.e. CH, PBFs). The need for additional and/or repetition/extension of the baseline survey scope has been considered during completion of the CHA (as captured in the Gap Analysis).

4.3 Definition of Ecologically Appropriate Areas of Analysis

The EAAA defines the geographic scope of the CHA for each screened-in biodiversity value. Where practicable, EAAAs have been identified for groups of biodiversity values with the same habitat preferences and life history characteristics. For wide-ranging species, such as marine megafauna, and for habitats that show spatially-extensive ecological connectivity, such as coral reefs, EAAAs are relatively extensive. Derived CH extent for all biodiversity values is nevertheless defined to be equivalent in scale to areas mapped for practical site-based conservation management activities (GN59). This is because biophysical connectivity is inherent in marine systems meaning direct and diffuse linkages exist between biodiversity features along dynamic, three dimensional, temporal and spatial boundaries. For these reasons it is often challenging to delineate marine environments for the purposes of CH demarcation.

EAAAs may or may not have an actual management boundary (e.g., a legally protected marine park) or could instead be defined by some other functional ecologically definable boundary (e.g., specific habitat association, water depth). They should account for protected and designated sites, capture ecologically relevant temporal and spatial scales and extend beyond the largest ESIA Areas of Influence (AoIs). The ESIA AoIs shall be reviewed following the outputs of the modelling (i.e. Desalination Plant discharges, thermal, sediment plume, underwater noise, and accidental events e.g., marine fuel spills) undertaken to inform the ESIA and the associated impact assessments. Given the high connectivity of marine biodiversity features, and the semi-enclosed and largely self-contained character of the GoA, it is appropriate to consider this CHA at a GoA wide level.

4.3.1 Definition of EAAAs for screened-in biodiversity values

The following EAAAs have been identified for this CHA and are grouped according to their physiology, biology and ecology. As described in GN59, EAAAs must take into taking “into account the distribution of species or ecosystems (within and sometimes extending beyond the project’s area of influence) and the ecological patterns, processes, features, and functions that are necessary for maintaining them”. Necessarily, these can be large, although they be refined where appropriate data are available, for example as described in Section 4.3.1.1.

4.3.1.1 EAAAs for marine megafauna (marine mammals, turtles and elasmobranchs)

In order to be relevant ecologically (i.e. incorporating movements of species within and between functional habitats, migratory paths, ecological patterns and variation, as well as protected areas) an area encompassing the entire GoA is defined as the EAAA for turtles, marine mammals and elasmobranchs. For the Indian Ocean humpback dolphin the EAAA is limited to waters <25m depth within this area as this is a coastal obligate species. A number of species of turtles, marine mammals and elasmobranchs are included in the Aqaba Marine Reserve Management Plan (AMRMP) and this site is therefore included within the EAAA for these species. The Aqaba Marine Reserve has recently been proposed as a World Heritage Site and is listed as such on the UNESCO World Heritage Convention website (https://whc.unesco.org/en/tentativelists/6630/). In addition, both the candidate and formal Important Shark and Ray Areas (ISRAs) and the candidate Important Marine and Mammal Area (IMMA) (currently an identified ‘Area of Interest’) at the mouth of the GoA are encompassed, for elasmobranchs and marine mammals respectively.

It is worth noting however, that if more information were to become available, such large areas could potentially be refined. For example, it may be possible for the EAAA for marine mammals foraging in the Gulf of Aqaba, to be limited to areas defined by more local ecological drivers for foraging using indicators such as habitat type, bathymetry, slope, distance from shore, chlorophyll a concentrations, temperature and prey availability. Breeding areas, resting areas and habitual, regular movement corridors are arguably the three other most important ecological features to consider. The most likely habitual movement corridors could be approximated based on more refined depth, slope and bathymetric features, using knowledge of movement by the species based on, for example, tracking studies. Breeding areas (where applicable - i.e. for resident species) are more difficult to predict due to lack of data, and for offshore pelagic species of marine mammals, breeding occurs in the context of the animals' behavioural ecology (i.e. specific, defined locations for breeding generally do not occur). For turtles, breeding in the GoA has not been documented and indeed appears to be unlikely based on recent study (Rees et al, 2025). Maps presenting defined EAAA boundaries for marine megafauna are provided in Appendix 4.

4.3.1.2 EAAAs for coral and seagrass ecosystems

For photosynthetic species (corals and seagrass) the EAAA is defined as a combination of the extent of the photosynthetic zone (<150m, less for seagrass ~70m), the availability of appropriate substrate for settlement/growth and oceanographic conditions (e.g., currents, wave action) that enable such growth. The EAAA also includes relevant protected, designated and recognised sites. It is assumed that there is limited ecological connectivity with coral ecosystems outside of the GoA because predominant currents flow from north to south within this semi-enclosed waterbody although ecological connection to coral communities to the south could be important. Regardless, some connectivity may be present through ecological linkages. Similarly, there are highly likely to be ecological linkages between coral reef habitats and other benthic habitats within the GoA, such as seagrass beds, especially those created by nektonic fish species that use, and move between, more than one type of habitat. As more data becomes available, for example data on mesophotic environments that have not yet been studied in the GoA, it may be possible to refine the extent of EAAAs. Maps presenting defined EAAA boundaries for coral and seagrass ecosystems are provided in Appendix 4.

4.3.1.3 EAAAs for reef fishes and reef invertebrates

For benthic habitat-associated, rather than pelagic (open water), teleosts and invertebrates (i.e. those associated with shallow benthic habitats) the EAAA is defined as the extent of waters <150m deep (i.e. within the photic zone) throughout the GoA containing the mosaic of coastal benthic habitats (e.g., coral reef, seagrass, rocky reefs, sandy seabed) including relevant protected, designated and recognised sites. For photosynthetic clams, the EAAA is reduced to a very restricted depth range (0-<5m) within the entire GoA, including relevant protected, designated and recognised sites, due to habitat preference. Maps presenting defined EAAA boundaries for reef fish and invertebrates are provided in Appendix 4.

4.4 Marine Biodiversity Baseline

The following baseline characterisation is not intended to be a comprehensive baseline assessment. This section draws upon a range of sources, including scientific papers and reports shared by the MEG and/or identified through literature review, datasets from the Aqaba Special Economic Zone Authority (AZESA), and publicly available secondary data sources and databases (e.g., IUCN Red List).

Biodiversity baselines characterise existing conditions and trends of biodiversity values within an area prior to any project works commencing. This information gathering phase is fundamental to identifying the potential impacts and risks of a project to biodiversity values. It is also particularly pertinent in the

context of the rapidly shifting baselines of so many biodiversity features (e.g., due to climate change). This is of importance in such climate change sensitive locations as the GoA, where many biodiversity values already exist at the upper margins of tolerance.

The Red Sea region (including the GoA) is characterised by high spatial heterogeneity, which is a driving force in speciation as species are naturally selected based on their ability to adapt and diversify. Transitional environmental gradients, ecotones, are associated with speciation and high species and genetic diversity. For these reasons, there are high levels of unique biodiversity and endemism across the Red Sea and GoA region.

The GoA has warm water temperatures (for a high latitude basin) and is generally unaltered by freshwater runoff from the otherwise arid adjacent coastal lands. The high marine biodiversity value of the Red Sea region, including the GoA, reflects its positioning at the crossroads of three major zoogeographical realms - its pivotal location between Africa and Eurasia - and isolation due to global climatic changes since the last ice age. These characteristics have shaped distinct, evolutionarily unique, and often endemic, marine species and habitats.

The 2005 Protocol Concerning the Conservation of Biological Diversity, and the establishment of protected areas by PERSGA in December 2005, was the beginning of a coordinated approach to conservation across the Red Sea region[12]. This work was conducted under the Habitat and Biodiversity Conservation Component of the Strategic Action Programme (SAP) for the Red Sea and Gulf of Aden, a Global Environment Facility (GEF) project implemented by the United Nations Development Programme (UNDP), the United Nations Environment Programme (UNEP) and the World Bank.

PERSGA is the Regional Organisation for the Conservation of the Environment of the Red Sea and Gulf of Aden. It is an intergovernmental organisation (IGO) comprising seven member states: Jordan, Saudi Arabia, Egypt, Djibouti, Somalia, Sudan and Yemen. PERSGA has Regional Action Plans and Regional Programmes for many of the biodiversity values considered within this CHA.

The GoA is located at the most north-eastern point of the Red Sea basin. It is a unique waterbody with a maximum depth of 1,830m. It reaches 200km in length and 25km at its widest point. It is semi-isolated at its westernmost extent by the 252m deep Sill of Tiran. The GoA is highly oligotrophic (nutrient-deficient with high water clarity) due in part to low precipitation rates and an absence of major riverine inputs. These factors, coupled with its geographic position and climate, result in very high surface light penetration depths (Khalaf, 2005). Depth and light are two key biophysical limiting factors within marine environments. They are used to distinguish marine zones as they determine the ecological processes that can occur and, in turn, the abundance and distribution of species within them. The GoA is also characterised by both high temperatures (20.5°C – 27.3°C) and hyper-salinity (40.3-41.6 psu).

The GoA encompasses a variety of complex and diverse marine and coastal habitats with high biological diversity, including endemic species. It generally has a low tidal range, consequently the intertidal zone is relatively limited (Al-Zibdah, 2007). The Jordanian coastline extends south for about 27km from the most northeastern tip of the GoA. The northern coast is characterised by sandy flats, which extend south for about 5km beyond which fringing coral reefs start, extending south to the border with Saudi Arabia (Khalaf, 2004) and beyond.

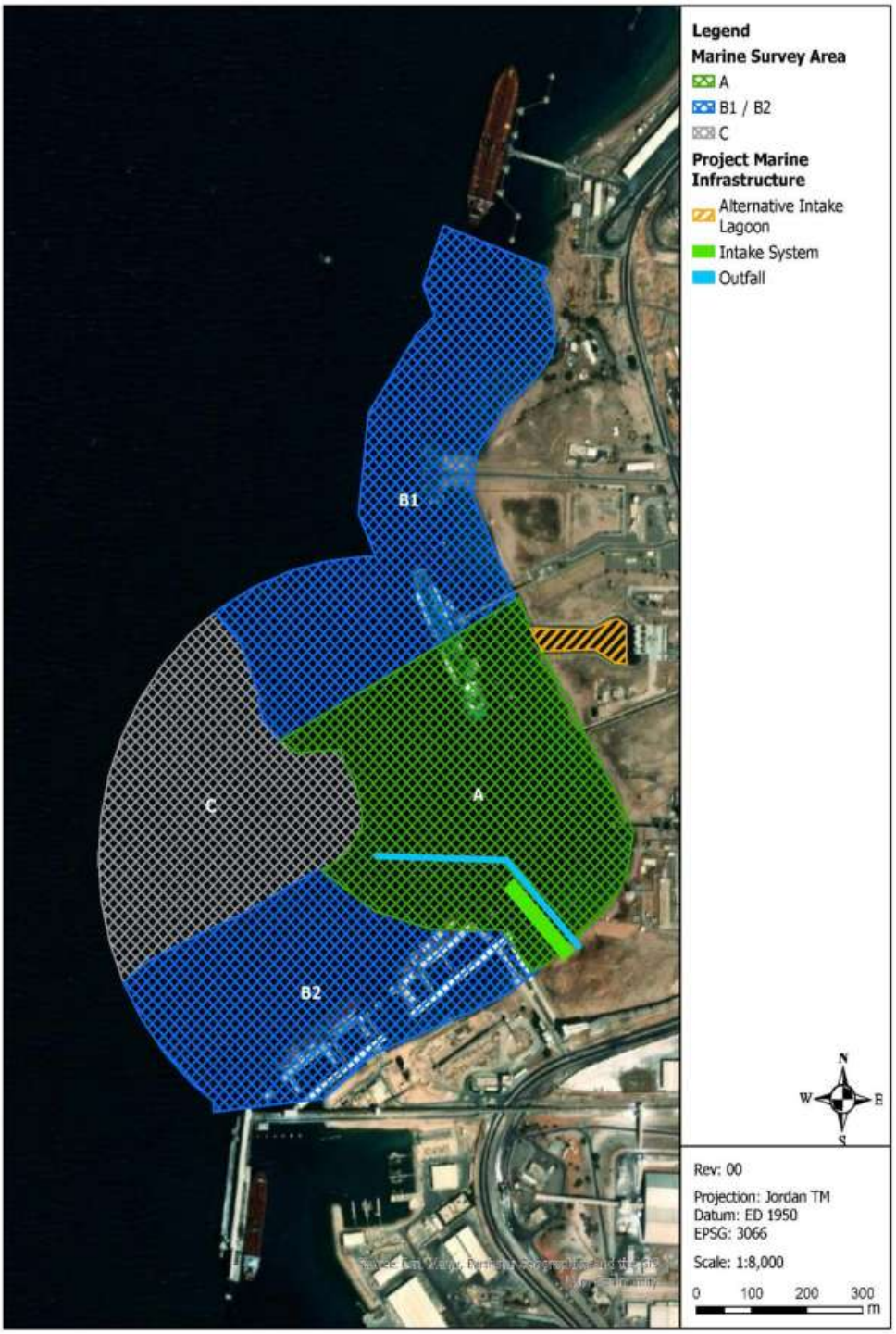
Aqaba Marine Reserve (AMR) is the only Marine Protected Area (MPA) in Jordanian waters and forms part of the Jordan Protected Areas Network. The habitats it was selected to protect include extensive coral reef complexes and seagrass beds as well as fishes, invertebrates, marine mammals and turtles of

12 https://persga.org/programmemes/marine-biodiversity/

high conservation value (UNDP, 2023). Section 4.4.8 discusses protected and designated sites in more detail.

The Project designed, and is currently undertaking, a site-specific Marine Baseline Survey in consultation with the MEG and relevant international specialists to inform the ESIA and CHA. The extent of the survey area is shown in Figure 4-1.

Figure 4-1: Extent of 2025 Marine Baseline Survey



The key objectives of the Survey are:

1. Rapidly identify and map predominant benthic habitat types across the survey areas using structured point sampling stratified by zone and depth band
2. Quantify benthic community composition and condition along standardised diver transects focused in Zone A (development area) with a reference/control effort in Zone B1. There are unlikely to be extensive coral reef habitats present within other areas (B2 and C) due to either water depth or the presence of existing infrastructure
3. Generate georeferenced spatial maps and a structured representative dataset of the data collected (seabed habitats, sediment and water quality, and any incidental megafauna sightings data) with full metadata to support requirements for habitat mapping, ESIA and CHA

The Marine Baseline Survey commenced on 21st September 2025. Once the survey results are available, they will be incorporated into later iterations of this CHA.

4.4.1 Previous Marine Baseline Survey

Marine Baseline Survey work was undertaken to support the production of the previous ESIA for the Project in 2022. The dive survey was undertaken from the coast to <35m depths using a combination of underwater video and application of the Standard Reef Check methodology. A total of 36 survey belts, 5m in width were surveyed. A Remotely Operated Video (ROV) survey was also undertaken with still and video recording.

This survey work confirmed the presence of the following biodiversity values of relevance to this CHA:

- Seagrass beds
- Reef – note in the 2022 report, this term refers to both healthy coral reef and reef structures which can include rubble of damaged corals, dead corals, coral rock
- Critically Endangered hawksbill turtle (*Eretmochelys imbricata*) (sighted under the phosphate loading berth)
- Endangered humphead wrasse (*Cheilinus undulatus*)
- Endangered giant clam (*Tridacna squamosina*)

The long-term on-going monitoring by the Marine Survey Station (MSS) adds some supplementary contextualisation:

- Southern sites of the Jordanian coast have more coral cover compared with the northern sites
- The deep (15m) transects contain higher percent cover of healthy corals than shallow transects (8m). Both hard and soft corals are recorded
- Fish larval abundance varies seasonally, reaching maxima during July and minima during winter (November-February)
- In addition to corals, many other benthic species (e.g., sponges, clams, sea anemones and algae) occur along the Jordanian coast of the GoA

4.4.2 Plankton

An overview of the planktonic communities is provided herein for ecological context. Consideration of the planktonic phases of corals and fishes (larvae/planulae and ichthyoplankton respectively) will be captured in the ESIA.

The concurrent presence of cosmopolitan (widely distributed globally) species and regional species indicates a high level of connectivity with neighbouring water bodies, while also reflecting the GoA's distinctive role as a biodiversity hotspot at the northern edge of the tropical marine biome (Al-Najjar, 2025).

Phytoplankton in Jordan's Gulf of Aqaba is characterised by low biomass and is heavily influenced by seasonal changes, with picophytoplankton dominating in the summer and larger diatoms and dinoflagellates emerging following winter nutrient influxes via deep mixing. The ecosystem is oligotrophic, with nutrient limitation being a key factor driving phytoplankton growth and community composition, particularly phosphate limitation in summer (Al-Najjar, 2025).

The complexity of primary production, nutrient cycling and ecosystem services in the GoA is evidenced by the taxonomic and ecological diversity of phytoplankton present. The coexistence of benthic and pelagic microalgae suggests strong bentho-pelagic coupling (processes that connect the benthic zone and pelagic zone through the exchange of energy, mass or nutrients) critical for nutrient regeneration, organic matter flux, and food web stability. High representation of dinoflagellate genera, alongside diatoms and other classes, infers potential for rapid blooms and food web restructuring in response to episodic nutrient inputs or environmental perturbations. Shifts in dominant phytoplankton groups often serve as early indicators of anthropogenic stressors (e.g., pollution, or climate-induced stratification changes) and reflect ecosystem health (Al-Najjar et al., 2008).

Zooplankton are important grazers in the pelagic zone aiding in the vertical export of carbon out of the mixed layer as particulate, skeletal, and faecal material. Within the zooplankton community, organisms of different sizes may play different roles in biogeochemical cycling and so influence processes associated with the biological-mediated drawdown of atmospheric CO_2, and its transformation into particles and sedimentation in the ocean (Al-Najjar et al., 2008).

There are two types of coral spawning: broadcast spawning, where eggs and sperm are released into the water column for external fertilisation, and brooding, where fertilisation occurs internally and larvae are released once fully developed.

The release of coral eggs, sperm and larvae as plankton is an important event that can impact the viability of coral habitats. In the GoA, broadcast spawning occurs around the June full moon with this event often triggered by a rapid 1–1.5°C rise in water temperature. While spawning is generally synchronised within species, events are asynchronous with depth, occurring earlier in shallow waters than in deeper waters (Bouwmeester & Berumen, 2015; Liberman et al., 2022). A number of hard and soft corals have a brooder reproductive strategy whereby larvae are released and often tend to settle close to parent colonies (Rachmilovitz et al., 2024; Kochman & Fine, 2025). These types of corals are important primary colonisers of degraded/impacted sites and are important for natural reef restoration and maintenance.

4.4.3 Benthic Ecology

The coral species present in the GoA are considered of particular importance due to their high thermal resilience, enabling them to tolerate sea temperature changes that cause bleaching elsewhere in the world (Hoegh-Guldberg et al., 2022; Kochman-Gino & Fine, 2023).

This region also contains rich mesophotic coral diversity, however mesophotic corals are not considered further herein as in the GoA they inhabit >150m depths and have yet to be systematically studied. Deep Water Coral (DWC) communities in the region are also excluded from this CHA due to their depth ranges and difficulty of study.

In the GoA, shallow water corals represent the upper limit (both geographic and bio-geochemical) of coral distribution globally. A discontinuous belt of reefs fringe 13km of the 27km Jordanian shoreline and vary considerably in physical size; in some places only reaching 3-4m in width. In general, the coastline is fringed by a discontinuous series of coral reefs characterised by two morphological units: Coral reef flats and the outer reef slopes, which jointly include i) scattered coral heads, ii) fragmented reef flat elements, iii) continuous reef flats representing a narrow fringing reef and iv) well-structured reef where a back reef channel develops.

The area has around 160 species of hard coral and 120 species of soft coral (Bouchon *et al*., 1981; Al Tawaha *et al*., 2019; UNESCO, 2023). Hard corals produce a rigid external skeleton made of calcium carbonate ($CACO_3$) and are the primary reef building corals. Soft corals do not form reefs but are found within reef ecosystems along with many other reef-associated benthic invertebrates. Jordanian coral reefs are generally in good condition (Al-Horani, 2006; UNESCO, 2023), with up to 90% coral cover in some localised areas. At the proposed location of inlet and outfall structures, hard coral cover between 20% to 30% has been recorded along with 25% to 40% soft corals (Al-Horani et al., 2006). It is important to note that the recent marine survey data collected at the site shows much higher coverage in places reaching 70%, suggesting recovery, perhaps following previous construction periods. Reefs in the area were found to support a diversity of other benthic fauna, including clams, sea anemones, sponges and ascidians. Hard corals are of critical importance as they construct the foundation ecosystem underpinning all other shallow habitat types. Soft corals are often the first colonisers of anthropogenically impacted areas.

The bathymetry of the southern coast of Jordan slopes steeply at the reef edge/slope to average depths of around 800m (Ribot, 2021) and include habitats with physical and chemical conditions suited to deep water corals (Chimienti *et al*., 2025). Coral frameworks are likely to include species within the families Caryophylliidae and Dendrophylliidae (Chimienti *et al*., 2025; Nolan *et al*., 2024).

Three species of giant clam occur within the northern Red Sea and GoA. These reef dwelling bivalves, like corals, have photosymbiotic algae which enable them to grow more rapidly. They have other similarities to corals, such as becoming stressed at elevated temperatures and requiring oligotrophic water due to their sensitivity to eutrophication-associated turbidity (Killam et al., 2021).

Three species of seagrass are present: *Halophila stipulacea*, *Halodule uninervis* and *Halophila ovalis.* These occur in soft sediment habitats to depths of up to 70m (Al-Rousan *et al*., 2011; Hulings & Kirkman, 1982). Seagrass habitats are of fundamental ecological importance as primary producers and for ecosystem service provision, including carbon sequestering. These habitats also act as nursery grounds and refugia for fish larvae and juveniles, they support an abundance of invertebrate species both within the meadows (e.g., gastropods) and sediments (e.g., bivalves) (Al-Zibdah, 2007), and they are a food source for herbivorous grazers, such as fishes and green turtles.

Data is limited for intertidal and subtidal sediment-based communities, areas of soft sediment habitats most likely support a relatively low diversity and abundance of infaunal and epifaunal species (e.g., polychaetes, urchins, starfish, clams, sea cucumbers and sponges), many of which are found throughout the contiguous mosaic of coastal habitats.

4.4.4 Fish Ecology

The size and mobility of fish species vary greatly. Some, such as tunas and mackerels are pelagic whilst others, such as soles are demersal (bottom dwelling). Some species, such as reef dwellers, may be more limited in their range and movements due to strong habitat associations, site fidelity, life history phase or physiological limitations. Fish play a range of functional ecological roles; they link trophic food webs by consuming plankton, and in turn are key dietary components of higher trophic groups (e.g., marine mammals). Larger predatory fish also act as apex predators feeding on other fish, marine mammals and turtles. Fish also play key roles in maintaining the physical integrity and health of ecosystems.

Fish diversity is remarkably high in the GoA. Ecological analysis of Jordanian marine fishes indicates that the majority of fish species (82.8%) inhabit benthic habitat while the rest are pelagic. Among benthic habitats, 51.1% of the fish species inhabit areas dominated by coral and boulders, 11.7% inhabits sandy bottoms, 11.1% are deep benches, 8.3% live in seagrass meadows, and 0.6% are bathydemersal (inhabit depths >200m) (Khalaf, 2005).

4.4.5 Elasmobranchs

The term elasmobranch collectively refers to sharks, rays and skates. Unlike most fish species which have a bony skeleton (referred to as teleosts), elasmobranchs have a skeleton made of cartilage. Within the Red Sea region most elasmobranch populations remain poorly studied and the spatial-temporal distribution of almost all elasmobranch species in the Red Sea remains largely undescribed. There is a strong spatial bias in research to date, with most studies conducted over a limited spatial area in proximity to research institutions and/or known hotspots for high profile species, such as whale sharks (*Rhincodon typus*) (Garzon *et al*., 2022).

There are a number of Important Shark and Ray Areas (ISRAs) within the Red Sea region. ISRAs are defined as a “discrete, three-dimensional portion of habitat, important for one or more species of shark, ray, or chimaera species, that has the potential to be delineated and managed for conservation” based on robust scientific criteria[13].

A candidate ISRA has been identified in Jordanian waters called the Northern Jordan Area of Interest. It expands from the southern Aqaba beach to Al-Ghandour Beach with a depth range of 0-450m. It has been identified for aggregations of shortfin mako (*Isurus oxyrinchus*) and potential undefined aggregations of tiger shark (*Galeocerdo cuvier*).

There is an ISRA in Israel at Eilat North Beach for coach whipray (*Himantura uarnak*), and reproductive areas for spotted eagle ray (*Aetobatus ocellatus*) and undefined aggregations of cowtail ray (*Pastinachus sephen*). The Strait of Tiran is also identified as an ISRA Area of Interest for elasmobranchs due to citizen science reports of whale sharks and oceanic manta rays (*Mobula birostris*). These are shown in Figures 5.1 and 5.2 in Section 5.

A recent multi-method characterisation of elasmobranch communities in the north-eastern Red Sea and GoA was undertaken to address the data gaps for these species, particularly in relation to occurrence and distribution. The focal area of, and driver for, the study was the NEOM project in Saudi Arabia. Four species of rays and nine species of sharks previously unrecorded were listed, and a range extension for the pink whipray (*Himantura fai*) and the round ribbontail ray (*Taeniurops meyeni*) into the GoA was also recorded (Garzon *et al*., 2022).

13 https://sharkrayareas.org/isra/faq

4.4.6 Marine Mammals

Of the 16 cetacean species known, or likely, to be present in the Red Sea and GoA only nine are considered to occur regularly, the remainder likely to be sporadic sightings of Indian Ocean 'vagrants'. The regularly occurring species include: Bryde's whale (*Balaenoptera edeni*), false killer whale (*Pseudorca crassidens*), Risso's dolphin (*Grampus griseus*), Indian Ocean humpback dolphin (*Sousa plumbea*), Indo-Pacific bottlenose dolphin (*Tursiops aduncus*), Common bottlenose dolphin (*Tursiops truncatus*), Indo-Pacific common dolphin (*Delphinus delphis tropicalis*), pantropical spotted dolphin (*Stenella attenuata*) and spinner dolphin (*Stenella longirostris*) (Notarbartolo *et al*., 2017).

There are currently three Important Marine Mammal Areas (IMMAs) in the Red Sea region. These are defined as "discrete portions of habitat, important to marine mammal species, that have the potential to be delineated and managed for conservation". They are identified to assist governments, IGO's and NGO's with identifying and prioritising conservation actions. At present, there are no IMMAs within the main body of the GoA, however the Strait of Tiran has been identified as an Area of Interest for the potential future designation of an IMMA[14], not least because of the recorded presence of the Indian Ocean humpback dolphin and dugong (*Dugong dugon*) around the Strait of Tiran (see Section 5.1.8 and Figure 2-2).

4.4.7 Turtles

Within Jordan's territorial waters, strandings and sightings of both the Critically Endangered (CR) hawksbill turtle and Endangered (EN) green turtle (*Chelonia mydas*) are often recorded. While turtles traverse open water, foraging is strongly associated with coastal habitats, especially those containing coral reefs and seagrass meadows (Al-Zibdah, 2007). These habitats may also be used as refugia during migration and as developmental habitats for juveniles. There is currently no turtle nesting recorded within Jordanian waters (Rees & Al-Zibdah, 2025). At present there is no mapping of Important Marine Turtle Areas (IMTAs) in the GoA.

4.4.8 Designated and Protected Sites - Jordan

In 2020, His Majesty King Abdulla II declared the existing Aqaba Marine Reserve (AMR) as a new MPA. The AMR was then included within the Jordan National Protected Areas Network (JNPA) becoming the first Marine Reserve in Jordan.

The AMR is characterised by distinctive and unique biodiversity, including a high degree of endemism. It is located in the North-Western Indo-Pacific biogeographic region, which contains the Wadi Rum World Heritage Site (WHS) (a landlocked area in the proximity of the Project). The AMR is currently listed as an IUCN Category VI protected area, within which sustainable use of natural resources is permitted. It is intended, following future management intervention, for the IUCN conservation category of the site to be upgraded as Jordan has a very limited marine area containing numerous conflicting activities (e.g., shipping, fishing, industrial development, tourism, conservation) (UNDP, 2023).

The AMR was added to the IUCN Green List in 2024[15]. With strict environmental monitoring, community outreach, marine research, and conservation programs, the reserve plays a vital role in preserving the region's ecological integrity (UNDP, 2023).

14 https://www.marinemammalhabitat.org/imma-eatlas/
15 https://iucngreenlist.org/sites/aqaba-marine-reserve/

The AMR covers an area of 2.8km^2 encompassing 3% of Jordan's territorial waters and 26% of its coastline. Approximately 1km^2 comprises coral reefs running the length of the reserve out to <300m, whilst the terrestrial boundary lies 50m from the Mean High Water Mark (MHWM). The reserve has buffer zones which cover a 1.5km^2 area (collectively) along the landward and seaward extents.

Key objectives of the Aqaba Marine Reserve Management Plan (AMRMP) 2022 – 2026 include maintaining and improving healthy, resilient, biodiverse reefs and seagrass habitats as both are recognised for their conservation and commercial importance (UNDP, 2023). The location and extent of the AMR is shown in Figure 5-1.

Many of the priority BD values that are associated with the AMR are also species and habitats that are subject to assessment in this CHA. It is established that the AMR holds 25% of the entire coral reef ecosystem in the Jordan GoA, which provides important context for the relative value of this area compared to the relatively small area of coral reef present in the Project site. A similar conclusion could be drawn for seagrass habitat. However, it is has also been noted by the marine survey team, that the two locations are dissimilar in many ways, not least because the substrate/sediment along the coast changes from being dominated by coarser sands to the south to increasingly finer sediment to the north, with consequences for coral diversity and growth.

4.4.9 Other Protected and Designated Sites - GoA

Other Protected and Designated Sites in the GoA include the extensive Ra's Suwayhil/Ra's al-Qasbah Marine Protected Area covering an area of 3,705km^2, whilst Ras Abu Galum National Park covers an area of 400km^2 on the Egyptian coast of the GoA, north of Dahab. The park is designated for a variety of terrestrial habitats and species, including birds, as well as some coastal and marine features, such as coral reefs and mangroves. Eilat Coral Reserve covers an area of 1.2km^2 and is located at the northern end of the GoA on the coast of Israel. This reserve is primarily designated for the protection of coral reef and associated species. The location of these protected and designated sites are shown in Figure 5-1.

5 CHA Determination

5.1 The Critical Habitat Assessment (CHA) Process

This CHA determination section is structured differently from the Biodiversity Baseline as the focus is on the highest priority biodiversity values, based on factors such as IUCN Red Listing, rather than overarching characterization and contextualization. It presents the results of the CHA determination process, providing a list of biodiversity values that qualify for CH and PBF status, with supporting rationale.

213 biodiversity values were 'screened-in' to the CHA (Appendix 1) and taken forward for further assessment and determination in accordance with the CHA process. Note that Appendices I, II and III support the narrative for the screening process, capturing key information for assessing marine biodiversity values known, or likely, to be present in the GoA. Biodiversity values are identified by scientific and common names (as applicable), global and regional conservation status (IUCN Red List categories), and systematically assessed against criteria from the EBRD, IFC and EIB frameworks for identifying threatened, endemic, and/or range-restricted species and/or migratory and/or congregatory species. Additional columns note habitat preferences (including depth ranges), life history characteristics, population data, known sensitivities and threats. Other factors presented include whether a species is listed in protected or designated sites, ecosystem/habitat uniqueness and/or threat level. Where relevant, specialist inputs from the MEG are noted and other data sources are referenced.

A summary of the determinations for CH and PBF is provided in Table 5-1 below and detailed in the Sections below.

Table 5-1: Summary of Critical Habitat (CH) and Priority Biodiversity Features (PBF) Determination

Biodiversity Value	CH Status	PBF Status
Turtles	0	2
Marine mammals (cetaceans)	0	3
Elasmobranchs (sharks and rays)	0	8
Teleosts (Bony fish)	3	0
Giant clam	1	0
Coral habitat	1 (all coral reef habitat)	0
Seagrass habitat	1 (all seagrass habitat)	0
TOTAL	6	13

5.1.1 Turtles

One species of turtle recorded in the Jordanian GoA, the hawksbill, is Critically Endangered. The other, the green turtle, was declassified from Endangered to Least Concern globally in 2024, but remains Vulnerable to extinction at the regional level (IUCN Northwest Indian Ocean RMU). Both species are listed on Annex IV of the EU Habitats Directive and are also CMS Appendix 1 listed, reflecting their migratory life history characteristics. In 2004, PERSGA produced a Regional Action Plan for the Conservation of Marine Turtles and their Habitats in the Red Sea and the Gulf of Aden, as the region supports globally important foraging and nesting habitats for these threatened, protected and migratory species.

The PERSGA protocol for protection for marine turtles and PERSGA's standardised methods for monitoring and research, including stock monitoring and tagging, are implemented nationally by member states. The Aqaba Special Economic Zone Authority (ASEZA) and the MSS are currently developing training programmes for rangers for marine environment protection measures (Al-Zibdah, 2025).

5.1.1.1 CHA determination

With reference to CHA criteria, both **the hawksbill turtle and the green turtle are considered to qualify for PBF status**, but neither species trigger CH status, based on the following rationale:

- PBF status rationale
    - **EBRD, (ESR6 para. 12-iii).** The hawksbill turtle occurs in the area and is an IUCN Red List *CR species*. It is also a *migratory species* and, given that it does not nest in Jordan, foraging individuals must originate from rookeries elsewhere in the GoA and northern Red Sea. The green turtle is also a migratory species and regional satellite tracking studies (Mann *et al*., 2024) provide valuable insight into the movement and connectivity of green turtle populations in the Red Sea region. Demonstrating the GoA's role within broader migratory turtle networks across the region, with its shallow coastal belt of fringing reef systems and seagrass providing stopover and feeding areas for migrating turtles. The potential importance of transitional habitats (e.g., sandy/mixed substrate zones) within the GoA for post-nesting and/or foraging turtles has not been studied to date. The observed movement patterns nevertheless highlight regional connectivity and indicate that turtles utilising Jordanian waters may originate from, or travel to, distant nesting or feeding areas within the Red Sea basin (Mann *et al*., 2024). This clearly demonstrates the need for coordinated, transboundary conservation strategies, as led regionally by PERSGA
- Non-CH status rationale
    - There is insufficient data to quantify the population status of foraging hawksbill turtles in the EAAA, and important concentrations cannot be discounted. However, nesting does not occur in Jordan (Rees at al., 2025) and is rare in the Gulf of Aqaba (occurring only very occasionally on the coast of Sinai and even more rarely close to the Straits of Tiran in the southern Gulf of Aqaba in Saudi Arabia). Given the high site fidelity of hawksbill turtles, their propensity to migrate relatively short distances in the region (e.g., Pilcher et al., 2014) and the relative abundance of foraging habitats close to nesting sites (making it energetically less costly to remain nearby), it is considered unlikely that the population occurs in important concentrations at the development site, or more widely in the GoA. Populations of hawksbill turtle in the EAAA are unlikely to exceed *0.5%* of the global population (with reference to IFC Criterion 1). Globally, nesting females estimates vary between 20,000-26,000 (Spotila, 2004) meaning that total numbers of individuals globally (taking into account females and males of all age classes) is orders of magnitude higher. Even if considering population estimates regionally, based on the rationale that hawksbill turtles in the Red Sea exhibit genetic distinctiveness (N. Wildermann, pers.comm.), the relatively low population abundance expected in the GoA is considered unlikely to justify CH status recognition (IFC Criterion 1). Based on similar rationale, the hawksbill turtle does not exceed the thresholds for as CH status as a congregatory or migratory species, and is not range-restricted in the Red Sea region (IFC Criteria, 2 and 3)
    - With reference to EIB Criterion 2c, 2d and 3b, nationally or regionally-important *concentrations* of hawksbills are considered unlikely to occur for the reasons described above. Rather they are likely to occur in relatively low numbers in the EAAA and there is

insufficient data to understand whether they occur in *assemblages* that are *habitually, predictably or repeatably* recorded

- Although *environmental gradients, also known as ecotones,* occur in the GoA, these are associated with effects that are manifested over a much larger area, namely the Red Sea as a region, and it is at this scale that *the process of speciation and high species and genetic diversity* occurs**.** Justification of CH status under IFC Criterion 5/EIB Criterion 6b, at the scale of the EAAA is therefore not considered appropriate

Further context that has supported this assessment and to be considered in the Project Biodiversity Management Plan and monitoring program includes the following:

- Recent regional research (N. Wildermann, pers.comm.) provides strong evidence that northern Red Sea hawksbill turtle populations exhibit strong genetic distinctiveness and high site fidelity, which supports the potential existence of sub-populations
- Given the semi-enclosed nature of the Red Sea and evidence of restricted gene flow, there is a reasonable likelihood that hawksbill turtles in the GoA are part of a distinct, isolated population, separate from the Indian Ocean. This distinction may not only be reflected in their genetic structure but also potentially in unique behavioural, phenological, reproductive and ecological traits, shaped by the extreme environmental characteristics of the Red Sea
- CHA for hawksbill turtles, as a CR species, should be repeated if/when more information on population parameters, behavioural ecology and genetics becomes available in the GoA. Further targeted research, including genetic sampling and tagging studies, is required to substantiate population structure and conservation significance of both species in Jordanian waters (Al-Zibdeh, 2025)

5.1.1.2 Delineation of hawksbill and green turtle PBF habitat

Both turtle species are primarily associated with shallow coastal habitats such as seagrass beds, fringing reefs, reef flats and rocky habitats. These habitats are used during foraging, and potentially as refugia during migration / developmental habitats for juveniles. Within Jordanian waters, both species predominantly occur within <50 depth waters, primarily in habitats <25m depths in association with coral reefs and seagrass beds (Al-Zibdah, 2025). These depth contours and two key habitat types could serve as proxies to map PBF habitat for these species. Maps presenting defined PBF boundaries based on these depth contours for turtles are provided Appendix 5.

5.1.2 Marine Mammals

Three marine mammal species, the Endangered Indian Ocean humpback dolphin (*Sousa plumbea*), Indo-Pacific bottlenose dolphin (*Tursiops aduncus*) and Pantropical spotted dolphin (*Stenella attenuata*) have been screened into this CHA due to confirmed recorded sightings in the Jordanian GoA. The latter two of these three species are also listed in the UNESCO 2023 AMR site description. Two additional species (Risso's dolphins, *Grampus griseus* and spinner dolphin, *Stenella longirostris*) are known to occur widely in the GoA, but their precise distribution is not known and they have not been recorded in Jordan. Two further species, the humpback whale (*Megaptera novaeangliae)*, and false killer whale (*Pseudorca crassidens*) have been rarely recorded in the northern GoA but are not considered to occur regularly (Notarbartolo et al., 2017). These additional species are therefore not included in this CHA.

Both the Indo-Pacific bottlenose and Pantropical spotted dolphin are CMS Appendix 1 listed due to their migratory traits. Of the three, the Indian Ocean humpback dolphin is the only IUCN threatened species (EN).

5.1.2.1 CHA determination

With reference to CHA criteria, **all three dolphin species are considered to qualify for PBF status**, but none trigger CH status, based on the following rationale:

- PBF status rationale
    - **EBRD (ESR6 para. 12-iii) (a)** "*All migratory species within the area of impact*". The extent, seasonality and reasons for migratory movement is unknown for any of these marine mammal species
- Non-CH status rationale
    - Neither the Indo-Pacific bottlenose dolphin nor the pantropical spotted dolphin are listed as CR, EN or VU (they are classified as NT and LC respectively). In addition, it is highly likely that neither species occurs in numbers large enough to meet population threshold criteria that trigger CH status. They are also not considered to be range restricted species. Neither of these two species therefore trigger any of the CH criteria (IFC, EBRD or EIB)
    - Indian Ocean humpback dolphins have one of the most specific habitat requirements of any marine megafauna. It is only found in the western and north-western Indian Ocean, including the Red Sea, which makes it geographically highly restricted at a global scale. However, this statement alone vastly overestimates its actual range, because the species is not distributed uniformly across this entire region, but instead is restricted to an extremely narrow zone along the coastline, typically within 2km from shore, in depth ranges of 3–25m (Braulik et al., 2017). This makes the species particularly vulnerable to threats resulting from human activities, particularly bycatch in fishing gear, habitat modification or loss due to coastal and island development, the impact of chemical pollutants, disturbance and injuries from boat traffic and the effects of underwater noise (Kiani and Van Waerebeek, 2015; Plön et al., 2015; Braulik et al., 2017). This species has a relatively low reproductive rate, and it typically occurs in small, localised populations, or in some cases small populations spread along large distances of the coast. Even moderate levels of anthropogenic mortality are thus likely to result in population declines (Braulik et al., 2017). There are no formal global population estimates but is considered to be as low as tens of thousands (Braulik et al., 2017). The species is listed as globally Endangered by the IUCN Red List and populations are thought to be declining (Braulik et al., 2017). The species has been recorded on video within Jordanian waters and via photo in northern GoA in Israeli waters, and into the northern Red Sea and the Suez Canal. Breeding grounds have been confirmed within an archipelago (in proximity to Sindalah Island, Saudi Arabia) in the north-eastern Red Sea, where a pod of ~ 20 individuals is thought to be resident (Unpublished data). However, he habitat in this area is characterised by deep embayments, islands, sand bars, channels and shallows and is very distinct from the mostly linear shoreline, shelving steeply into deeper waters, along the coast of Jordan
    - Information on the genetic population structure for this species in the Red Sea is lacking, therefore, the level of any differentiation between animals from the Red Sea and those from elsewhere across the species range is currently unknown. The same is true for potential genetic population structure within the Red Sea. Given the relatively closed nature of the Red Sea, it is reasonable to assume that the Red Sea animals may be somewhat differentiated

from those from the wider Indian Ocean, and that further genetic structuring may occur within the Red Sea (Baldwin et al., 2004; Mendez et al., 2011)

- However, even though the species is Endangered, endemic to the western Indian Ocean and highly restricted in its range, within the Red Sea and especially within the GoA, population abundance is likely to be insufficient to trigger thresholds for CH status (with reference to IFC Criteria 1, 2 and 3). It is considered likely that only relatively few individuals are present in the Jordanian GoA at any one time with activity may be limited to foraging
- With reference to EIB Criterion 2c, 2d and 3b, nationally or regionally-important *concentrations* of Indian Ocean humpback dolphins are considered unlikely to occur for the reasons described above. Rather they are likely to occur in relatively low numbers in the EAAA and there is insufficient data to understand whether they occur in *assemblages* that are *habitually, predictably or repeatably* recorded

Further context that has supported this assessment and to be considered in the Project Biodiversity Management Plan and monitoring program includes the following:

- The Red Sea is widely acknowledged to be relatively data deficient for marine mammals, with most species currently described as understudied, particularly in relation to much needed genetic research (Notarbartolo *et al*., 2017). Globally, cetaceans are acknowledged to be extremely valuable for evolutionary research into the formation of new subspecies (genomic divergence of populations evolving separately) and/or ecotypes (inshore and offshore populations) of species or subspecies. Several cetacean species exhibit ecotypic differentiation, including bottlenose dolphins (genus Tursiops) (Pratt *et al*., 2023). This is of particular significance in the Red Sea region which is known to drive speciation, genetic diversity and endemism. This is a notable knowledge gap for all cetacean species at a regional, not just national or project scale. There is therefore significant potential for genetic isolation of the populations present. However, it is not possible to substantiate this potential for genetically distinct sub-populations to be present, due lack of much needed genetic research

5.1.2.2 Delineation of PBF habitat for marine mammals

The <25m depth contour can be used to delimit PBF habitat for the Indian Ocean humpback dolphin, whilst slightly greater depth (<200) can be used for the (largely coastal) Indo-Pacific bottlenose dolphin. Water depths >200m could be used to demarcate PBF habitat for the pantropical spotted dolphin. Maps presenting defined PBF boundaries based on these depth contours for marine mammals are provided in Appendix 5.

5.1.3 Elasmobranchs

Following the desk-based review and consultation with the MEG, eight species of elasmobranchs have been screened-in for consideration in this CHA: the Critically Endangered spinetail devil ray (*Mobula mobular*), Endangered spotted eagle ray, coach whipray, oceanic manta ray, panther torpedo (*Torpedo panthera*), shortfin mako, the Vulnerable pink whipray and the Near Threatened tiger shark.

Of these species the coach whipray, spinetail devil ray, whale shark, panther torpedo are confirmed as being present in Jordanian waters by the MEG (see Appendix 1). Both the shortfin mako and tiger shark are listed as the candidate qualifying species for an independently identified Area of Interest for ISRAs and therefore are considered to be confirmed within Jordanian waters by relevant species specialists. The oceanic manta is listed in the UNSECO site description for the AMR, and the spotted eagle ray is

currently unconfirmed within Jordanian waters but is recorded elsewhere in the GoA (Garzon *et al.,* 2022).

5.1.3.1 CHA determination

With reference to CHA criteria, **all eight of the elasmobranch species are considered to qualify for PBF status**, but none trigger CH status, based on the following rationale:

- PBF status rationale
  - **EBRD (ESR6 para. 12-ii)(b)** "Species in the area of impact with IUCN global red list status of VU, EN or CR"
- Of these eight (which excludes the tiger shark), two are additionally determined to be PBFs based on the following EBRD Criteria due to being CMS Appendix 1 listed species; these are the oceanic manta ray and the spinetail devil ray
  - **EBRD (ESR6 paragraph 12-iii) (a)** "All migratory species within the area of impact"
- Non-CH status rationale
  - None of the elasmobranch species have been determined to trigger CH status, mostly due to the notable data deficiencies for all species and limited national elasmobranch research to date. It is also considered highly likely that the proportion of habitat contained within the EAAA for elasmobranchs is much less than 1% threshold (criterion IFC Criterion 1c and EBRD ESR6 para. 14-iv); indeed it is estimated to be less than 0.1% in all cases. This also makes it highly unlikely that any species reaches the population abundance criteria thresholds (with reference to IFC Criterion 1, 2 and 3)

Further context that has supported this assessment and to be considered in the Project Biodiversity Management Plan and monitoring program includes the following:

- Should the Northern Jordan Area of Interest become a designated ISRA then this will have to be reassessed as potential CH. With the exception of tiger sharks, these are all threatened species and therefore priority species for conservation. All have either been recently recorded in the GoA, identified in relation to the establishment of future conservation potential (ISRAs), and/or the MEG have confirmed their presence. Although it is preferable to apply Lender thresholds to the EAAAs for species, it is necessary to acknowledge the data deficiencies for elasmobranchs within the GoA and wider region
- To account for this, emphasis is placed on the role and inputs of the MEG and the importance of embracing the precautionary principle especially within marine contexts. "*The involvement of external experts and project-specific assessments is of utmost importance, especially when data are limited (as will often be the case*)" (IFC: GN:56, 2019)

5.1.3.2 Delineation of PBF Habitat

With the exception of the aforementioned ISRAs and Areas of Interest, the general scarcity of these species and low encounter rates due to their habitat preferences means elasmobranchs are often challenging to map, particularly those with pelagic and deep-water preferences. These PBF species are a mixture of demersal species predominantly found in coastal habitats and on the continental shelf to depths of ~70m (which can be demarked using depth contours), and pelagic species with far greater depth ranges. Mapping for these species incorporates the ISRAs and ISRA Areas of Interest listed. Maps

presenting defined PBF boundaries based on these depth contours for elasmobranchs are provided in Appendix 5.

5.1.4 Teleosts (Bony Fish)

Most of the fish included in the CHA Screening phase were not taken forward to the full assessment due to factors such as; data deficiency (e.g., only being recorded from one locality), no CH or PBF criteria being met, and consultation with the MEG.

Ultimately, as advised by the MEG and following detailed review, only three species were taken forward to the CHA determination stage: The Endangered humphead wrasse (*Cheilinus undulatus*), sky emperor (*Lethrinus mahsena*) and Red Sea coral grouper (*Plectropomus marisrubri*) which is currently assessed as Vulnerable but has been previously documented (Choat et al. 2018) as a declining population with a trend estimated globally to be at least 30 % over the past two generation lengths, and is currently considered more likely to be EN due to intense fisheries pressures throughout its range (Friedhelm Krupp, Pers. Comms., 2025). The humphead wrasse is specifically named in the AMRMP, but no management provisions are specified.

There is insufficient regional and/or potential sub-population data to apply IFC C1a threshold, however all species are deemed likely to qualify under C1c given their high site fidelity, close habitat associations and known low abundance (i.e., rarity) throughout their ranges.

- CHA determination
    - With reference to CHA criteria, **all three teleost species are considered to qualify for CH status**, based on the following rationale
- CH status rationale
    - **IFC Criterion C1a and EBRD (ESR6 para. 14-ii)(b).** Both the humphead wrasse and the sky emperor are listed as Endangered (EN) species. They are highly sought after in local fisheries and there remains a high likelihood that populations include ≥5 reproductive units within the EAAA, and ≥0.5% of regional genetically unique populations. The latter assumption is based on a range-wide phylogeographic study of these species that found genetic differentiation at the peripheries of the species' ranges, including the western Indian Ocean (Ma et al. 2019) and highlights the likelihood that, for the extreme edges of geographic ranges, such as the GoA, unique genetic diversity is harboured. Note also that regional population estimates are unavailable for these species and so habitat, and more specifically, area of occurrence, is used as a proxy for abundance, with the broad assumption that densities are, by and large, similar throughout their ranges
    - **IFC Criterion C3a and EBRD (ESR6 para. 14-iv)(b).** The Red Sea coral grouper is a regional (Red Sea) endemic that forms large seasonal spawning aggregations, and is likely to be a relatively common occurrence in bays, lagoons and on seaward reef slopes in the EAAA, that likely support ≥1 % of the global population. As global population estimates are unavailable, habitat, and more specifically, area of occurrence, are used here as a proxy for abundance, with the broad assumption that densities are, by and large, similar throughout the Red Sea coral grouper's range

Further context that has supported this assessment and to be considered in the Project Biodiversity Management Plan and monitoring program includes the following:

- As mentioned above, CH status is dependent on genetic status and further work should be conducted to determine genetic differentiation/isolation of these species in the norther Red Sea/GoA region. Population abundance estimates should also be undertaken

5.1.4.1 Delineation of Critical Habitat

The humphead wrasse is rare throughout its range, displaying high site fidelity within well-developed coral reefs it is recorded to 100m depths. The sky emperor is also a coral reef associated species that also inhabits seagrass and sandy habitats to depths of 100m.

The Red Sea coral grouper is also rare regionally, it favours coral reefs in bays, lagoons and seaward reef slopes including the shallow coastal strip of habitats in the GoA. It predominantly occurs between 25 – 140m. Mapping of coral reef, seagrass and respective depth contours is therefore proposed as a starting point for the demarcation of Critical Habitat for these three species. Maps presenting defined CH boundaries based on these depths for teleosts are provided in Appendix 5.

5.1.5 Clams

Two species of clam (*Tridacna* sp.) were considered at the CHA screening stage but only one met the criteria to be taken forward to the CHA determination stage. The Endangered giant clam (*Tridacna squamosina*) is a regional endemic reported only from Jordan, Egypt, Israel, Saudi Arabia and Yemen, and has an extremely limited Area of Occupancy (AoO) of approximately 124km², only occurring between 0-5m depths, predominantly <2m depths. The species is notably rare throughout its range and to date fewer than 250 individuals have been directly observed according to the scientific literature. The Estimated Extent of Occurrence (EoO) for this species is 286,942km².

The total AoO is well established, as is the rarity of the species within its range. In other giant clam species, the lowest observed population densities are 0.2–0.3 individuals per hectare (Neo *et al*. 2017); for the AoO of *T. squamosina* this would indicate a total living population of 2,480–3,720 individuals (Neo & Li, 2024).

- CHA determination
    - With reference to CHA criteria, **this species is considered to qualify for CH status**, based on the following rationale
- CH status rationale
    - **IFC Criterion C1a and EBRD (ESR6 para. 14-ii)(b).** Assuming that the EAAA for this Endangered (EN) species is the coastal strip between 0-5m depth along the entire GoA shoreline, then based on the precautionary number of mature individuals globally (2,480 according to the IUCN Red List, Neo et al. 2017), the IFC 0.5% threshold for abundance (Criterion 1a) could feasibly be triggered, as this would equate to 12 individuals in the GoA. Indeed, Richter et al. (2008) found 13 individuals during extensive surveys along the Jordanian Red Sea coastline alone. Assuming this figure remains current, CH status is therefore determined, especially as the relatively limited linear extent of the Jordian coastline further indicates that more than 5 reproductive units of this species may be present

Further context that has supported this assessment and should be considered in the Project Biodiversity Management Plan and monitoring program to verify:

- The current population status in the EAAA, and especially in Jordanian waters

5.1.5.1 Delineation of Critical Habitat

The mapping of CH for the giant clam uses the 0-5m depth contour to demarcate probable CH.

The presence of this species in Jordanian waters is confirmed by primary and secondary data. Further surveys could help to refine CH determination and distribution. A map presenting a defined CH boundary based on this depth contour for the giant clam is provided in Appendix 5.

5.1.6 Coral Reefs

The Red Sea, including the GoA, is characterised by high levels of endemism reflecting active evolutionary processes. Corals are recorded more or less continuously along the length of the Red Sea and GoA shores, indicating strong ecological connectivity within these contiguous coastal areas. The high evolutionary significance of these coral reefs, particularly relating to genetic potential for resilience to climate change, emphasises the need for further ecological and genetic research. Coral reefs within the GoA are encompassed by the Red Sea biogeographic zone, a designated Worldwide Fund for Nature (WWF) “Global 200 Eco-Region” reflecting the unique marine biodiversity, high endemism and unique ecological processes present (UNDP, 2023).

Regional surveys were undertaken by PERSGA in 2010 to inform Regional Action Plans (RAPs) for a number of biodiversity values, including coral reefs. The PERSGA RAP for the Conservation of Coral Reefs in the Red Sea and Gulf of Aden (PERSGA, 2003) details priority actions for conservation. The RAP is implemented at national levels by PERSGA members, including Jordan (e.g., installation of mooring buoys to reduce anchor damage to Aqaba reefs). The PERSGA Standard Survey Methods (SSM) for Key Habitats and Key Species in the Red Sea and Gulf of Aden integrates research and monitoring of member countries into global initiatives such as the International Coral Reef Initiative (ICRI), the Global Coral Reef Monitoring Network (GCRMN).

The Aqaba Marine National Park was one of the initial ‘demonstration’ MPAs identified in the region by PERSGA, the priority objective being the development of 'flagship' demonstration sites as examples of effective coral reef management practices in the region.

Jordan is currently finalising its updated National Biodiversity Strategy and Action Plan (NBSAP), therefore reference is made to the preceding version (2015 – 2020). Coral reefs are specifically mentioned in the NBSAP and are recognised as being fundamental in the synergistic framework of associated marine ecosystems.

The IUCN is currently developing a Red List of Ecosystems. However, no formal IUCN assessment has been undertaken for coral reefs within the Gulf of Aqaba, or within Jordanian waters.

- CHA determination
    - With reference to CHA criteria, **coral reefs are considered to qualify for CH status**, based on the following rationale
- CH status rationale
    - **IFC Criterion C4b, EBRD (ESR6 para. 14-i)(c) and EIB Criterion 1c.** Coral reefs have been "determined to be of high priority for conservation at a regional or national systematic conservation planning level" in Jordan according to MEG members, and are identified as such in Jordan's NBSAP, and therefore rigger CH under IFC Criterion 4b and EBRD (ESR6 para. 14-i)(c). As mentioned above, the IUCN is currently developing a Red List of Ecosystems, but no assessments have been undertaken in the region to date. GN79 states that where formal

IUCN assessments have not been performed, "assessments using systematic methods at the national/regional level, carried out by governmental bodies, recognised academic institutions and/or other relevant qualified organizations (including internationally recognised NGOs)" may be used

- **IFC Criterion C5 and EIB Criterion 6e.** Analysis of the environments of the geologically oldest occurrences of marine genera make clear that shallow, tropical environments and carbonate substrates are linked to the highest rates of species origination (Kiessling et al. 2010) and that coral reefs are pre-eminent within this category. As the most biodiverse shallow water, tropical marine environments, coral reefs are not only extraordinarily diverse but are also highly significant in exporting diversity to other regions and acting as drivers of regional and global biodiversity: Raitsos et al. (2017) demonstrate that each Red Sea province acts as both a source and a sink for coral larvae from and to adjacent provinces, whilst Jablonski (2005) and Jablonski et al. (2006) highlight role of reefs in diversity export, including even to extratropical regions. Finally, resilience to thermal stress associated with climate change makes coral reefs in the GoA sites of demonstrated importance to climate change adaptation (Fine et al. 2013; Osman et al. 2018). This is further aided by the close proximity of deeper waters to the narrow coral reef zone along the coast. Such deeper water areas may act as mesophotic refuges, allowing the shallow reefs of these zones to display increased resilience as a consequence of the larval supply from mesophotic reefs in close vicinity (Slattery et al, 2011; Holstein et al. 2016; Feldman et al. 2018)

Further context that has supported this assessment and to be considered in the Project Biodiversity Management Plan and monitoring program includes the following:

- It is considered likely that several species of coral (see Appendix 1) confirmed as being present within Jordanian waters by the MEG may also have potential to trigger CH status at an individual species level, based on their IUCN global status, endemism, restricted range and potential for evolutionary /scientific value. However, this is not discussed further at this stage pending the provision of data at appropriate resolution from the 2025 Marine Baseline Survey

5.1.6.1 Delineation of Critical Habitat

Benthic habitat, including coral reefs, has been mapped for the Project area. For all other areas in the Jordanian GoA, the photic zone to a depth of 70m has been used to demarcate coral reef habitat. This is an over-estimation of distribution and requires refining, as mentioned in the caveats above. A map presenting a defined CH boundary based on depth contours for coral reef habitat is provided 0.

5.1.7 Seagrass

Three species of seagrass have been confirmed by the MEG as being present within Jordanian waters *Halophila stipulacea*, *Halodule uninervis* and *Halophila ovalis;* all are listed by IUCN as Least Concern. The PERSGA SAP for the Red Sea and Gulf of Aden lists destruction of seagrass beds as one of the major threats to the coastal and marine resources of the region and proposes that member countries develop conservation and management programmes for seagrass beds. Seagrass beds are included in the 2019 PERSGA Standard Survey Methods (SSMs) manual for Key Habitats and Key Species in the Red Sea and Gulf of Aden.

Jordan's NBSAP (2015 – 2020) notes the value of seagrass beds in relation to biomass and also their importance for maintaining water quality. Seagrasses are a key functional habitat within shallow, sheltered waters throughout the region. They are highly productive and provide a range of ecosystem

services, including stabilisation and containment of sediments and sequestration of carbon (Unsworth et al., 2019), particularly when compared to the terrestrial vegetation present in the GoA. These habitats are a refugia for juvenile fish and shellfish of conservation and commercial importance and provide functional habitat (e.g., foraging) for green turtles. Seagrass beds and coral reefs have strong ecological connectivity with many species migrating diurnally between the two, again highlighting the need for seascape wide approaches to conservation management (PERSGA, 1998).

The IUCN is currently developing a Red List of Ecosystems. However, no formal IUCN assessment has been undertaken for seagrass within the GoA, or within Jordanian waters.

- CHA determination
    - With reference to CHA criteria, **seagrass ecosystems are considered to qualify for CH status**, based on the following rationale
- CH status rationale
    - **IFC Criterion C4b, EBRD (ESR6 para. 14-i)(c) and EIB Criterion 1c.** As in the case of coral reefs, seagrass habitat triggers CH, having been "determined to be of high priority for conservation at a regional or national systematic conservation planning level" through inclusion in Jordan's NBSAP. Although data limited, it is considered likely that seagrass habitats may also qualify for CH status based on assessment against Criteria C & D of the IUCN Red List for Threatened Ecosystems, with multiple high severity abiotic and biotic stressors forecast over next 50 years (Waycott et al. 2009; Unsworth et al. 2019)

5.1.7.1 Delineation of Critical Habitat

Benthic habitat, including seagrass beds, has been mapped for the Project area. For all other areas in the Jordanian GoA, the photic zone to a depth of 70m has been used to demarcate seagrass habitat. This is an over-estimation of distribution and requires refining, as mentioned in the caveats above. A map presenting a defined CH boundary based on depth contours for seagrass habitat is provided 0.

5.1.8 Protected, Designated and Recognised Sites

The Project is not located within any legally protected areas, defined as *"A clearly defined geographical space, recognised, dedicated and managed, through legal or other effective means, to achieve the long-term conservation of nature with associated ecosystem services and cultural values"*[16] or in any internationally recognised areas (i.e., UNESCO Natural World Heritage Sites, UNESCO Man and the Biosphere Reserves, KBAs or Ramsar sites or AEZs or WHSs) as defined in IFC GN6 (2019).

The closest distance between the Project infrastructure (based on the current design and alternatives under consideration) and the boundary of the AMR is approximately 2.5km. The closest boundary of the Northern Jordan Area of Interest is approximately 9.4km from the Project infrastructure and the ISRA boundary in Israel at Eilat North Beach is approximately 17.8km.

The desk-based CHA screening process used a combination of different online mapping resources to identify and demarcate all relevant legally protected areas (e.g., MPAs, UNESCO Natural World Heritage Sites, IBAs etc) as well as internationally and nationally recognised designated sites (e.g., ISRAs). Noting that both legally protected, and internationally designated or recognised sites (the latter often having no legal protection) all have the potential to contain or support CH and/or PBF biodiversity values, all sites were taken into consideration in this CHA.

16 https://portals.iucn.org/library/sites/library/files/documents/pag-021.pdf

All protected and designated sites within an ecologically relevant distance for their qualifying features (refer to Figure 5-1 and Figure 5-2) were taken into consideration when defining the EAAAs for different biodiversity values. In addition to which, the qualifying and/or candidate biodiversity values for which the sites have been identified have been considered at a species level within the "CHA Screening Long List" and MEG consultation processes. IUCN management categories Ia (Strict nature reserve), Ib (Wilderness area) and II (National park) are considered 'likely' to contain IFC Critical Habitat, while categories III-VI are considered to 'potentially' contain Critical Habitat (Martin *et al*., 2015).

At present the AMR is an IUCN Category VI this is defined as *"Protected areas with sustainable use of natural resources: Areas which conserve ecosystems, together with associated cultural values and traditional natural resource management systems. Generally large, mainly in a natural condition, with a proportion under sustainable natural resource management and where low-level non-industrial natural resource use compatible with nature conservation is seen as one of the main aims"*.

While the spatial extents of these sites have been incorporated into the EAAAs and many of the qualifying features of these sites are deemed to be CH (e.g., coral reef, seagrass beds) or PBFs (e.g., elasmobranchs) the sites themselves are not deemed to be. This is largely due to the AMR currently being IUCN Category VI and the Northern Jordan ISRA being an Area of Interest (candidate site) at this time, neither are therefore determined to achieve CH status in their own right. Appendix 3 presents a list of CHA-relevant species that occur in Protected Sites in Jordan.

Figure 5-1: Protected, Designated and Recognised Sites Within Northern Gulf of Aqaba

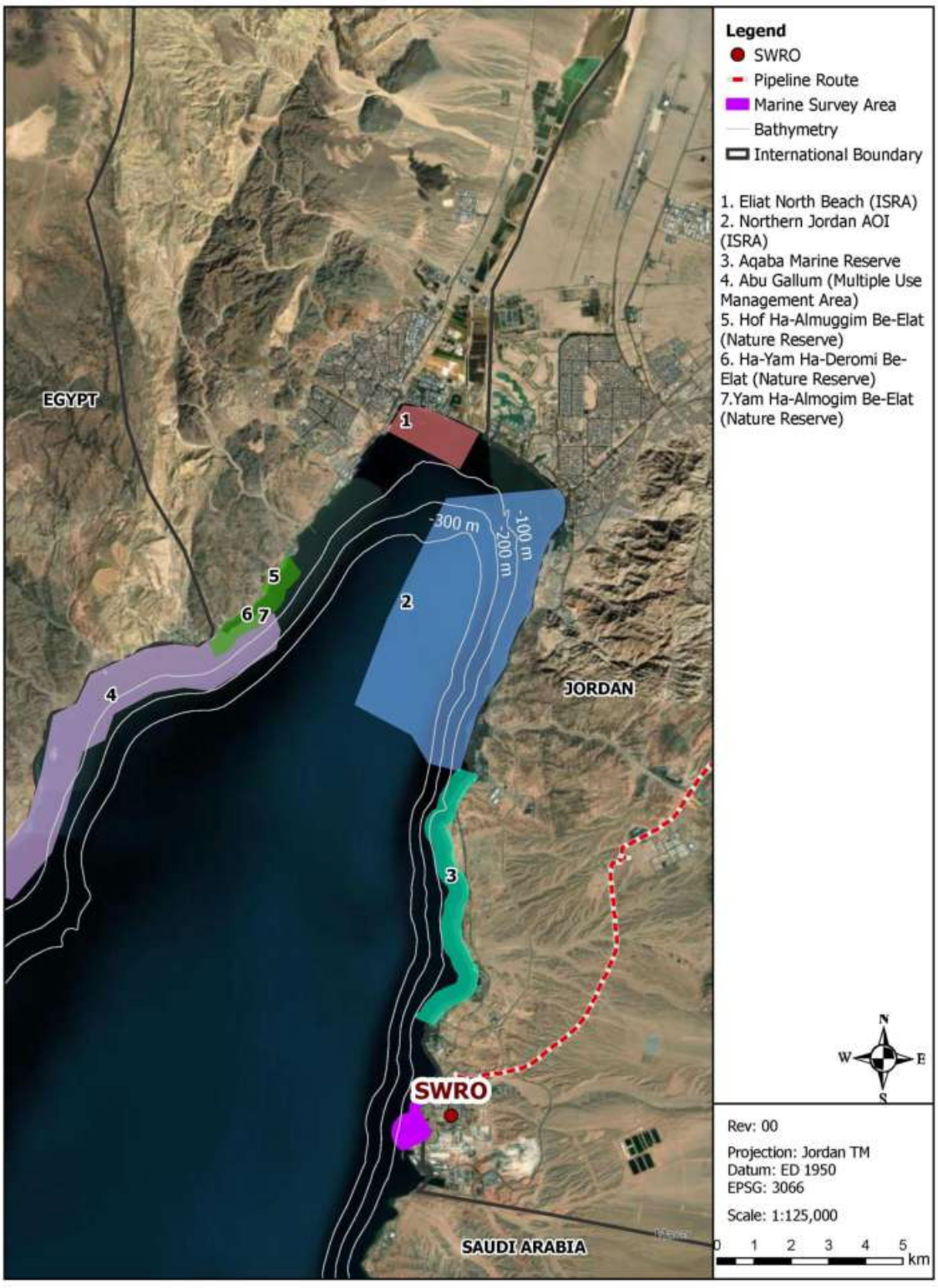
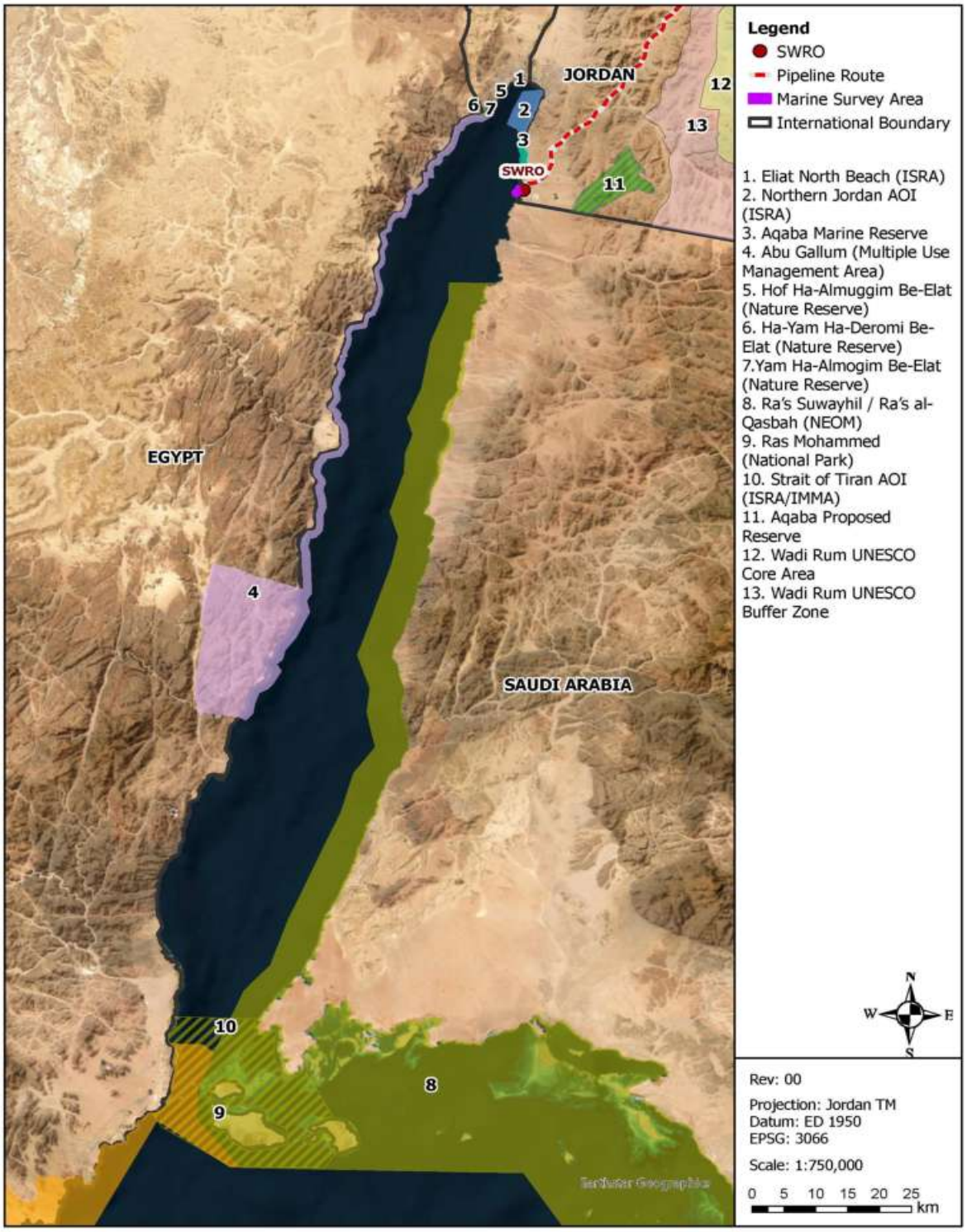


Figure 5-2: Protected, Designated and Recognised Sites Within Gulf of Aqaba



5.2 The Critical Habitat Assessment (CHA) Process Seabirds

To support the identification of Critical Habitat- qualifying seabirds, an IFC PS6/EBRD PR6 aligned biodiversity screening was conducted, to identify a shortlist of species for more detailed assessment. These included:

- Any globally or nationally Critically Endangered (CR), Endangered (EN) and Vulnerable (VU) species with overlap between the EAAA and their global ranges
- Any restricted range species
- Migratory and congregatory species, either i) with greater than 1% overlap between the EAAA and their respective global ranges, or ii) recorded in the EAAA in numbers that indicate potential for the threshold to be exceeded

The shortlist of species was then assessed against the applicable CH criteria and threshold and informed by records within the EAAA, primarily from publicly available databases due to the lack of seabird survey data for the Project. For the full list of species considered, refer to 0.

5.2.1 Critical Habitat Qualifying Species

Three globally Vulnerable (VU) seabird species were assessed against Criterion 1.b of IFC PS6 (and the equivalent criteria of EBRD PR6 and EIB S4), and 22 migratory and/or congregatory seabird species were assessed against and C3.a of IFC PS6 (and the equivalent criteria of EBRD PR6 and EIB S4). However, no species were considered possibly or likely to qualify as critical habitat (Table 5-2).

Table 5-2: Seabird Species Assessed Against Critical Habitat Criteria

Scientific name	Common English name	Global RL status[1]	Regional RL status	Presence in EAAA[2]	CH criteria and conclusion[3]	Justification
Calidris falcinellus	Broad-billed Sandpiper	VU	-	Unlikely	**Not CH** Assessed against C1.b and C3.a of IFC PS6 (and equivalent criteria of EBRD PR6 and EIB S4)	This species is globally VU and is migratory and congregatory. It has a lower global population estimate of 96,000 mature individuals and a large Extent of Occurrence (EOO) of 6,100,000 km2. There are two subspecies; *C. f. falcinellus* and *C. f. sibirica*. Jordan lies on the flyway of *C. f. falcinellus*. This subspecies breeds in Scandinavia and northwest Russia, and winters across east Africa and Arabia to western India and Sri Lanka. the EAAA overlaps with <0.001% of the passage range of the species. On migration this species shows a preference for muddy and boggy areas on the shores of ponds and lakes, but it is also found on shallow freshwater, brackish and saline lagoons, swamps, and flooded fields and meadows (BirdLife International 2025). Suitable stop-over habitat is not present within the EAAA. There are no records of this species in the EAAA, with the nearest from the salt ponds and lagoons west of Aqaba. This species does not qualify as CH under Criterion 1.b or 3.a of IFC PS6 or the equivalent criteria of EBRD PR6 and EIB S4.
Calidris ferruginea	Curlew Sandpiper	VU	-	Reported (eBird)	**Not CH** Assessed against C1.b and C3.a of IFC PS6 (and equivalent criteria of EBRD PR6 and EIB S4)	This species is globally VU and is migratory and congregatory. It has a lower global population estimate of 420,000 mature individuals and an EOO of 3,000,000 km2. The species breeds across Arctic Siberia and winters from sub-Saharan Africa through the Middle East and south and southeast Asia to Australasia. The EAAA overlaps <0.001% of the species' non-breeding (wintering) range. In the winter the species primarily occurs on coastal brackish lagoons, tidal mud/sand-flats, estuaries, saltmarshes, exposed coral, rocky shores and tidewrack on sandy beaches (BirdLife International 2025). Exposed coral and rocky shores are likely to be present within the EAAA. However, there is only one record on eBird/GBIF within the EAAA, from 2014. This species

Scientific name	Common English name	Global RL status[1]	Regional RL status	Presence in EAAA[2]	CH criteria and conclusion[3]	Justification
						does not qualify as CH under Criterion 1.b or 3.a of IFC PS6 or the equivalent criteria of EBRD PR6 and EIB S4.
Pluvialis squatarola	Grey Plover	VU	-	Reported (eBird)	**Not CH** Assessed against C1.b and C3.a of IFC PS6 (and equivalent criteria of EBRD PR6 and EIB S4)	This species is globally VU and is migratory and congregatory. It has a lower global population estimate of 1,000,000 mature individuals and a large EOO of 19,000,000 km2. This species breeds in Arctic Russia, Alaska and Canada, and winters extremely widely on coastlines of North and South America, Europe, Africa, Asia and Australasia. The EAAA overlaps <0.001% of the species' non-breeding (wintering) range. In the non-breeding season the species frequents intertidal mudflats, saltmarshes, sandflats and beaches of oceanic coastlines, bays and estuaries (BirdLife International 2025). These beaches are present within the EAAA. There are just three eBird/GBIF records within the EAAA from the last 10 years. This species does not qualify as CH under Criterion 1.b or 3.a of IFC PS6 or the equivalent criteria of EBRD PR6 and EIB S4.
Larus leucophthalmus	White-eyed Gull	LC	LC	Reported (Aqaba Marine Reserve Management Plan; and eBird)	**Unlikely CH** Assessed against C3.a of IFC PS6 (and equivalent criteria of EBRD PR6 and EIB S4)	This LC species is congregatory. It has a lower global population estimate of 35,800 mature individuals and a relatively small EOO for a seabird of 403,000 km2. The species breeds colonially on inshore islands/islets in the Gulf of Aden and the Red Sea, in Egypt (mainly on islands at the mouth of the Gulf of Suez), Sudan, Eritrea, Djibouti, Saudi Arabia, Yemen and Somalia. Wintering birds disperse throughout the breeding range. It generally breeds in colonies of >25 pairs, though occasionally larger colonies of hundreds of individuals can be observed. During the non-breeding season, it is usually found in small groups but can form flocks of hundreds or thousands to forage. It breeds on bare rock and sand flats on inshore islands, and outside the breeding season it often occurs further out to the sea. It roosts on rocks, coral reefs, piers and fishing vessels (BirdLife

Scientific name	Common English name	Global RL status[1]	Regional RL status	Presence in EAAA[2]	CH criteria and conclusion[3]	Justification
						International 2025). The EAAA overlaps 0.01% of the non-breeding (wintering) range of the species. According to the Management Plan of the Aqaba Marine Reserve (within the EAAA), the species is "a resident in the region". The highest counts of the species in the EAAA (from eBird) come from the Aqaba - Yamaniya Beach, where 50 individuals were recorded on one occasion in December 2022, and 30 individuals were recorded on one occasion in December 2024. This represents up to 0.14% of the global population. It is unlikely that the EAAA contains at least 1% of the global population of this congregatory species at any point. This species is therefore unlikely to qualify as CH under Criterion 3.a of IFC PS6 or the equivalent criteria of EBRD PR6 and EIB S4.
Sula leucogaster	Brown Booby	LC	LC	Reported (eBird)	**Not CH** Assessed against C3.a of IFC PS6 (and equivalent criteria of EBRD PR6 and EIB S4)	This LC species is congregatory. The global population is unknown but is estimated to number >200,000 individuals. It has a huge EOO of 223,000,000 km². It can be found throughout the pantropical oceans with few exceptions. Breeding sites include the Caribbean, the Atlantic coasts of Brazil and Africa, the Red Sea, northern Australia and many oceanic islands in the Pacific. This species is strictly marine, generally feeding on inshore waters. Individuals form colonies, though usually smaller than those of other *Sula* species (BirdLife International 2025). The EAAA overlaps <0.001% of the species' resident range. There are a total of six individuals recorded in the EAAA from 2024 on eBird. There is no indication of congregation of this species being present in the EAAA. It is very unlikely that the EAAA contains at least 1% of the global population of this congregatory species at any point. This species therefore does not qualify as CH under Criterion 3.a of IFC PS6 or the equivalent criteria of EBRD PR6 and EIB S4.

Scientific name	Common English name	Global RL status[1]	Regional RL status	Presence in EAAA[2]	CH criteria and conclusion[3]	Justification
Calidris alpina	Dunlin	NT	-	Reported (eBird)	**Not CH** Assessed against C3.a of IFC PS6 (and equivalent criteria of EBRD PR6 and EIB S4)	This NT species is migratory and congregatory. It has a lower global population estimate of 3,000,000 mature individuals and a large EOO of 30,000,000 km2. The species breeds in northern Alaska and Canada, Greenland, Iceland, the Faroe Islands and northern Europe, east throughout much of Siberia. Birds move south for the winter, mainly to coastlines in North and Central America, Western Europe, north and west Africa, the Arabian Peninsula, South Asia and East Asia. The EAAA overlaps with <0.001% of the species' passage range. In the non-breeding season this species prefers estuarine mudflats, but also occurs in a wide variety of freshwater and brackish wetlands including lagoons, muddy freshwater shores, tidal rivers, salt-works and sandy coasts (BirdLife International 2025). Although sandy coasts are present in the EAAA, it's preferred non-breeding habitat, estuarine mudflats, is not present in the EAAA. There are four eBird records within the EAAA, three from 2019 and one from 2024. It is very unlikely that the EAAA contains at least 1% of the global population of this migratory and congregatory species at any point. This species therefore does not qualify as CH under Criterion 3.a of IFC PS6 or the equivalent criteria of EBRD PR6 and EIB S4.
Charadrius leschenaultii	Greater Sandplover	LC	NT	Reported (eBird)	**Not CH** Assessed against C3.a of IFC PS6 (and equivalent criteria of EBRD PR6 and EIB S4)	This LC species is migratory and congregatory. It has a lower global population estimate of 100,000 mature individuals and an EOO of 9,590,000 km2. The species breeds in parts of Asia, and winters on the northern and eastern coastlines of Africa, parts of the Middle East, along the coastlines of South and Southeast Asia, and Australasia. The EAAA overlaps <0.001% of the non-breeding (wintering) range of the species. During the non-breeding season, the species prefers littoral habitats with mixed sand and mud substrata, but can also be found on sheltered sandy, shelly or muddy beaches, intertidal mudflats, sandbanks, lagoons, saltmarshes, estuaries, coral reefs and coastal

Scientific name	Common English name	Global RL status[1]	Regional RL status	Presence in EAAA[2]	CH criteria and conclusion[3]	Justification
						dunes. Although sandy/shelly beaches and coral reefs are present in the EAAA, the species' preferred non-breeding habitat is not present. The species is gregarious, feeding in flocks of 2-50, and can congregate in groups of up to 1,000 when roosting (BirdLife International 2025). eBird records from within the EAAA show between one and six individuals recorded on any occasion, with a total of 32 individuals recorded in the EAAA in 2019 (representing up to 0.03% of the global pop). It is very unlikely that the EAAA contains at least 1% of the global population of this migratory and congregatory species at any point. This species therefore does not qualify as CH under Criterion 3.a of IFC PS6 or the equivalent criteria of EBRD PR6 and EIB S4.
Actitis hypoleucos	Common Sandpiper	LC	-	Reported (eBird)	**Not CH** Assessed against C3.a of IFC PS6 (and equivalent criteria of EBRD PR6 and EIB S4)	This LC species is migratory and congregatory. It has a lower global population estimate of 3,230,000 mature individuals and a huge EOO of 47,200,000 km2, breeding from western Europe to eastern Russia and wintering in Africa, the Arabian Peninsula, across Asia and Australasia. The EAAA overlaps <0.001% of the species' non-breeding (wintering) range. In its winter range this species inhabits a wide variety of habitats including sandy and shingle shorelines (present in the EAAA). It usually remains solitary in its winter range (BirdLife International 2025). The highest count in the EAAA is four individuals in 2018 (eBird). Due to its very large distribution and no evidence of concentrations in the EAAA, it is very unlikely that the EAAA contains at least 1% of the global population of this migratory and congregatory species at any point. This species therefore does not qualify as CH under Criterion 3.a of IFC PS6 or the equivalent criteria of EBRD PR6 and EIB S4.

Scientific name	Common English name	Global RL status[1]	Regional RL status	Presence in EAAA[2]	CH criteria and conclusion[3]	Justification
Larus armenicus	Armenian Gull	LC	-	Reported (eBird)	**Not CH** Assessed against C3.a of IFC PS6 (and equivalent criteria of EBRD PR6 and EIB S4)	This LC species is migratory and congregatory. It has a lower global population estimate of 45,000 mature individuals and an EOO of 798,000 km2. It breeds from the Caucasus through Armenia to western Turkey and north-west Iran, wintering south to the eastern Mediterranean, northern Red Sea and Persian Gulf. The EAAA overlaps <0.001% of the species' non-breeding (wintering) range. In its winter range this species inhabits a variety of habitats including sandy and shingle shorelines (BirdLife International 2025). The highest counts of the species in the EAAA (from eBird) come from the Aqaba - Yamaniya Beach, where 30 individuals were recorded on one occasion in March 2019. This represents up to 0.07% of the global population. It is very unlikely that the EAAA contains at least 1% of the global population of this migratory and congregatory species at any point. This species therefore does not qualify as CH under Criterion 3.a of IFC PS6 or the equivalent criteria of EBRD PR6 and EIB S4.
Larus cachinnans	Caspian Gull	LC	LC	Reported (eBird)	**Not CH** Assessed against C3.a of IFC PS6 (and equivalent criteria of EBRD PR6 and EIB S4)	This LC species is migratory and congregatory. The global population size is unknown, but this species has an EOO of 5,820,000 km2. It is found in eastern Europe, the Middle East, north-west Africa and central Asia. Wintering grounds include the coast of south-west Asia, the north-east coast of Africa, and around the Arabian Peninsula up to north-west India. The EAAA overlaps <0.001% of the species' non-breeding (wintering) range. In the non-breeding season the species is more common along the coast, e.g. at harbours and ports, and in other marine habitats (BirdLife International 2025), which are present in the EAAA. The highest counts of the species in the EAAA (from eBird) come from the Aqaba - Yamaniya Beach, where 21 individuals were recorded on one occasion in December 2024. However, due to its wide distribution it is very unlikely that the EAAA contains at least 1% of the global population of this migratory and congregatory

Scientific name	Common English name	Global RL status[1]	Regional RL status	Presence in EAAA[2]	CH criteria and conclusion[3]	Justification
						species at any point. This species therefore does not qualify as CH under Criterion 3.a of IFC PS6 or the equivalent criteria of EBRD PR6 and EIB S4.
Larus fuscus	Lesser Black-backed Gull	LC	-	Reported (eBird)	**Not CH** Assessed against C3.a of IFC PS6 (and equivalent criteria of EBRD PR6 and EIB S4)	This LC species is migratory and congregatory. The global population size is unknown. It has a huge EOO of 19,400,000 km2, breeding across northern Europe and wintering extremely widely in Europe, the east coast of North America, Africa, the Arabian Peninsula and parts of Asia. The EAAA overlaps <0.001% of the species' passage and non-breeding (wintering) range. Outside the breeding season, the species is gregarious and mainly inhabits inshore and offshore seas, lagoons, estuaries, harbours, and tropical shores (BirdLife International 2025). The highest number recorded in the EAAA (eBird) is 80 from spring 2019. Due to the species' extremely wide distribution, it is very unlikely that the EAAA contains at least 1% of the global population of this migratory and congregatory species at any point. This species therefore does not qualify as CH under Criterion 3.a of IFC PS6 or the equivalent criteria of EBRD PR6 and EIB S4.
Larus genei	Slender-billed Gull	LC	LC	Reported (eBird)	**Not CH** Assessed against C3.a of IFC PS6 (and equivalent criteria of EBRD PR6 and EIB S4)	This LC species is migratory and congregatory. It has a lower global population estimate of 180,000 mature individuals and an EOO of 22,600,000 km². The species breeds at scattered sites from West and North Africa across southern Europe, the Black Sea, Asia Minor, and the Middle East to Central Asia. It winters around the Mediterranean, Black and Caspian Seas, the Arabian Peninsula, and south to the Horn of Africa. The EAAA overlaps <0.001% of the species' passage and non-breeding (wintering) range. The species is almost entirely coastal outside of the breeding season (BirdLife International 2025). The highest counts of the species in the EAAA come from the Aqaba - Yamaniya Beach, where 115 individuals were recorded on one

Scientific name	Common English name	Global RL status[1]	Regional RL status	Presence in EAAA[2]	CH criteria and conclusion[3]	Justification
						occasion in May 2022 (representing 0.06% of the lower global population estimate). It is very unlikely that the EAAA contains at least 1% of the global population of this migratory and congregatory species at any point. This species therefore does not qualify as CH under Criterion 3.a of IFC PS6 or the equivalent criteria of EBRD PR6 and EIB S4.
Pandion haliaetus	Osprey	LC	LC	Reported (eBird)	**Not CH** Assessed against C3.a of IFC PS6 (and equivalent criteria of EBRD PR6 and EIB S4)	This LC species is migratory and congregatory. It has a lower global population estimate of 100,000 mature individuals but a huge EOO of 298,000,000 km2 spanning six continents. The species' breeding range covers North America, Europe and Asia, and it is resident in some of these regions, as well as in Australasia. It winters in southern North America, South America, Africa, Asia and southern Australia. The EAAA overlaps <0.001% of the species' passage range. Suitable habitat includes rocky reefs, and gravel and sandy subtidal areas (BirdLife International 2025), which are present in the EAAA. There are several eBird records in the EAAA from recent years, though only recorded as individuals and there is no indication of concentrations occurring in the EAAA. Due to the species' extremely wide distribution, it is very unlikely that the EAAA contains at least 1% of the global population of this migratory and congregatory species at any point. This species therefore does not qualify as CH under Criterion 3.a of IFC PS6 or the equivalent criteria of EBRD PR6 and EIB S4.
Phoenicopterus roseus	Greater Flamingo	LC	LC	Reported (eBird)	**Not CH** Assessed against C3.a of IFC PS6 (and equivalent	This LC species is migratory and congregatory. It has a lower global population estimate of 550,000 individuals, and an EOO of 61,400,000 km2. It is resident in parts of Africa, southern Europe and western Asia, breeds in Kazakhstan, and winters in parts of the Middle East, including on the east coast on the Red Sea, as well as West and South Asia. The EAAA overlaps <0.001% of the species' non-breeding

Scientific name	Common English name	Global RL status[1]	Regional RL status	Presence in EAAA[2]	CH criteria and conclusion[3]	Justification
					criteria of EBRD PR6 and EIB S4)	(wintering) range. The species is gregarious and commonly occurs in flocks of 100 or more outside of the breeding season. It inhabits shallow eutrophic waterbodies such as saline or alkaline lagoons and lakes, saltpans sewage treatment pans, and coastal waters (BirdLife International 2025). The highest counts of the species in the EAAA come from the Aqaba - Yamaniya Beach, where 60 individuals were recorded on one occasion in September 2019 (representing 0.01% of the lower global population estimate). There is no indication that the EAAA constitutes an important site for this species, and it is very unlikely that the EAAA contains at least 1% of the global population of this migratory and congregatory species at any point. This species therefore does not qualify as CH under Criterion 3.a of IFC PS6 or the equivalent criteria of EBRD PR6 and EIB S4.
Thalasseus sandvicensis	Sandwich Tern	LC	-	Reported (eBird)	**Not CH** Assessed against C3.a of IFC PS6 (and equivalent criteria of EBRD PR6 and EIB S4)	This LC species is migratory and congregatory. It has a lower global population estimate of 325,000 mature individuals and a huge EOO of 98,800,000 km2. The species occurs in Europe, Africa, western Asia, and the Americas. It breeds seasonally on the coasts of Europe east to the Caspian Sea, wintering from the Caspian, Black and Mediterranean Seas to the coasts of Africa, and from the Red Sea to India and Sri Lanka. It also breeds and winters in the Americas. The EAAA overlaps <0.001% of the species' non-breeding (wintering) range. The species is gregarious throughout the year. Outside of the breeding season it frequents sandy or rocky beaches, mudflats with mangroves, estuaries, harbours and bays (BirdLife International 2025), some of which are present in the EAAA. There are many eBird records within the EAAA from recent years, with up to 10 individuals recorded at any one time (e.g. in Nov 2022). However, due to the extremely wide distribution of this species, it is very unlikely that the EAAA contains at least 1% of the global population of this migratory and congregatory

Scientific name	Common English name	Global RL status[1]	Regional RL status	Presence in EAAA[2]	CH criteria and conclusion[3]	Justification
						species at any point. This species therefore does not qualify as CH under Criterion 3.a of IFC PS6 or the equivalent criteria of EBRD PR6 and EIB S4.
Himantopus himantopus	Black-winged Stilt	LC	LC	Reported (eBird)	**Not CH** Assessed against C3.a of IFC PS6 (and equivalent criteria of EBRD PR6 and EIB S4)	This LC species is migratory and congregatory. It has a lower global population estimate of 486,000 mature individuals and an extremely large EOO of 335,000,000 km2. The species breeds across Europe and Asia, and parts of North America, and winters in Africa, Asia, Australasia and the Americas. The EAAA overlaps <0.001% of the species' resident and passage ranges. It's preferred habitat is freshwater or brackish wetlands and marshes but it can also occur in more saline coastal habitats (BirdLife International 2025). There is one recent eBird record of the species in the EAAA; 20 individuals recorded in Aqaba -Tala Bay in March 2018. Due to the extremely wide distribution of this species, it is extremely unlikely that the EAAA contains at least 1% of the global population of this migratory and congregatory species at any point. This species therefore does not qualify as CH under Criterion 3.a of IFC PS6 or the equivalent criteria of EBRD PR6 and EIB S4.
Egretta gularis	Western Reef-egret	LC	LC	Reported (Aqaba Marine Reserve Management Plan; and eBird)	**Not CH** Assessed against C3.a of IFC PS6 (and equivalent criteria of EBRD PR6 and EIB S4)	This LC species is congregatory. It has a lower global population estimate of 36,000 mature individuals and an EOO of 52,900,000 km2. It's range covers the west and east coasts of Africa (including Madagascar) and the coastlines of the Arabian Peninsula and western/southern Asia. here is little known about the movements of this species, although it apparently disperses widely (BirdLife International 2025). The EAAA does not overlap with the official range of the species, though it is near the resident and non-breeding ranges of the species. According to the management plan for the Aqaba Marine Reserve the species was known to breed previously in the area

Scientific name	Common English name	Global RL status[1]	Regional RL status	Presence in EAAA[2]	CH criteria and conclusion[3]	Justification
						(ASEZA et al. 2021). The species shows a preference for rocky or sandy shores and reefs, which are present in the EAAA. There are a total of four individuals recorded in the EAAA in the last 10 years. There is no sign that the species continues to breed in the EAAA. It is extremely unlikely that the EAAA contains at least 1% of the global population of this congregatory species at any point. This species is therefore does not qualify as CH under Criterion 3.a of IFC PS6 or the equivalent criteria of EBRD PR6 and EIB S4.
Sterna repressa	White-cheeked Tern	LC	LC	Reported (Aqaba Coast and Mountains KBA; and eBird)	**Not CH** Assessed against C3.a of IFC PS6 (and equivalent criteria of EBRD PR6 and EIB S4)	This LC species is migratory and congregatory. It has a global population estimate of 400,000 mature individuals and an EOO of 8,740,000 km2. The species is resident on the east coast of Africa, breeds on the coastlines of the Arabian Peninsula and western Asia, and winters in western and southern Asia. The EAAA does not overlap the official range of the species, but it is near the breeding range and is known to be present in the Aqaba Coast and Mountains KBA/IBA, which the EAAA overlaps ~1/2 of the coastline of. It nests on rock, sand, gravel or coral islands, bare and exposed sandflats (BirdLife International 2025), some of which are within the EAAA. There are many eBird records of this species in the EAAA. The highest count comes from the Aqaba - Yamaniya Beach, where 83 individuals were recorded on one occasion in August 2020, as a passing flock. Nevertheless, it is very unlikely that the EAAA contains at least 1% of the global population of this migratory and congregatory species at any point. This species therefore does not qualify as CH under Criterion 3.a of IFC PS6 or the equivalent criteria of EBRD PR6 and EIB S4.
Stercorarius parasiticus	Arctic/Parasitic Skua	LC		Reported (Aqaba	**Not CH**	This LC species is migratory and congregatory. It has a lower global population estimate of 400,000 mature individuals, and an enormous

Scientific name	Common English name	Global RL status[1]	Regional RL status	Presence in EAAA[2]	CH criteria and conclusion[3]	Justification
				Coast and Mountains KBA; and eBird)	Assessed against C3.a of IFC PS6 (and equivalent criteria of EBRD PR6 and EIB S4)	EOO of 148,000,000 km2. This species breeds on the northernmost coasts of Eurasia and North America, and winters on the southern tips of South America, Africa, and on the coasts of Australia and New Zealand (BirdLife International 2025). The EAAA does not overlap the official range of the species, but it has been recorded in the Aqaba Coast and Mountains KBA/IBA (75 in June, represents ~0.02% of global population) (Key Biodiversity Areas Partnership 2025). One individual was recorded within EAAA in July 2022 (eBird). Due to the extremely wide distribution of this species, it is extremely unlikely that the EAAA contains at least 1% of the global population of this migratory and congregatory species at any point. This species therefore does not qualify as CH under Criterion 3.a of IFC PS6 or the equivalent criteria of EBRD PR6 and EIB S4.
Calidris minuta	Little Stint	LC		Reported (eBird)	**Not CH** Assessed against C3.a of IFC PS6 (and equivalent criteria of EBRD PR6 and EIB S4)	This LC species is migratory and congregatory. It has a large population of at least 1,000,000 mature individuals and an EOO of 4,750,000 km2. It breeds in northern Europe and winters in Africa, the Arabian Peninsula and parts of Asia. In its winter range the species mainly inhabits coastal areas (BirdLife International 2025). The EAAA does not overlap the official range of the species but it is near the non-breeding (wintering) range and there are many records of the species in the EAAA. The highest count comes from the Aqaba - Yamaniya Beach, where 120 individuals were recorded on one occasion in December 2022. However, considering the extremely large global population and very large range, it is extremely unlikely that the EAAA contains at least 1% of the global population of this migratory and congregatory species at any point. This species therefore does not qualify as CH under Criterion 3.a of IFC PS6 or the equivalent criteria of EBRD PR6 and EIB S4.

Scientific name	Common English name	Global RL status[1]	Regional RL status	Presence in EAAA[2]	CH criteria and conclusion[3]	Justification
Onychoprion anaethetus	Bridled Tern	LC	LC	Reported (Aqaba Coast and Mountains KBA; and eBird)	**Not CH** Assessed against C3.a of IFC PS6 (and equivalent criteria of EBRD PR6 and EIB S4)	This LC species is migratory and congregatory. It has a global population estimate of 400,000 mature individuals and a huge EOO of 207,000,000 km². It is a bird of the tropical oceans and breeds off the coasts of Central America, off small areas of western Africa, around Arabia and eastern Africa down to South Africa, off the coast of India, southeast Asia and Australasia (BirdLife International 2025). The EAAA does not overlap the official range of the species, but it is near the breeding range and the species has been recorded in the Aqaba Coast and Mountains KBA/IBA. Within the EAAA there is a high count of 15 individuals recorded on one occasion in August 2023. However, due to the very wide distribution of this species, it is extremely unlikely that the EAAA contains at least 1% of the global population of this migratory and congregatory species at any point. This species therefore does not qualify as CH under Criterion 3.a of IFC PS6 or the equivalent criteria of EBRD PR6 and EIB S4.
Ardenna grisea	Sooty Shearwater	NT		Reported (Aqaba Coast and Mountains KBA; and eBird)	**Not CH** Assessed against C3.a of IFC PS6 (and equivalent criteria of EBRD PR6 and EIB S4)	This NT species is migratory and congregatory. There are ~8,800,000 mature individuals and the species has a huge EOO of 47,700,000 km2. Its wintering range spans much of the Atlantic and Pacific Oceans (BirdLife International 2025). The EAAA does not overlap the official range of the species, but it has been recorded in the Aqaba Coast and Mountains KBA/IBA. There is one eBird record in the EAAA from May 2022. Due to the extremely wide distribution of this species, it is extremely unlikely that the EAAA contains at least 1% of the global population of this migratory and congregatory species at any point. This species therefore does not qualify as CH under Criterion 3.a of IFC PS6 or the equivalent criteria of EBRD PR6 and EIB S4.
Notes:						

Scientific name	Common English name	Global RL status[1]	Regional RL status	Presence in EAAA[2]	CH criteria and conclusion[3]	Justification

[1] Red List (RL) status: CR = Critically Endangered; EN = Endangered; VU = Vulnerable; NT = Near Threatened; LC = Least Concern; DD = Data Deficient; NE = Not Evaluated

[2] Presence in EAAA: Confirmed = presence confirmed through recent field surveys in the relevant EAAA; Reported = presence reported on publicly-available biodiversity databases (e.g., GBIF, eBird); Unconfirmed= presence unconfirmed but considered possible given the overlap between study area and species range and/or suitability of habitats; Unlikely = presence considered unlikely given the lack of suitable habitats or other evidence.

[3] Critical Habitat Result: Confirmed CH = if data demonstrate exceedance of at least one threshold (e.g. numbers confirmed by field verification); Likely CH = if the range overlap, or other evidence (e.g. from publicly-available data or expert consultation), suggests the EAAA is likely to exceed at least one threshold, but where there is no direct field verification; Possible CH = if the range overlap is close to at least one threshold, or potential for the EAAA to have a higher proportion of the population than average (e.g. based on publicly-available data or expert consultation); Unlikely CH = if available evidence is that thresholds are unlikely to be exceeded; Not CH = if available evidence is that thresholds would not be exceeded.

5.2.2 Priority Biodiversity Features (PBFs)

Two VU species have been identified as PBFs for this Project, in alignment with EBRD PR6 criteria, the Curlew Sandpiper and Grey Plover (Table 5-3). The VU Broad-billed Sandpiper is not a PBF as the EAAA is unlikely to support this species.

Table 5-3: Seabird Species Identified as Priority Biodiversity Features (PBFs) for the Project

Scientific name	Common name	Global RL status	Nat/reg RL status	PBF Criteria
Calidris ferruginea	Curlew Sandpiper	VU	-	EAAA supports VU species
Pluvialis squatarola	Grey Plover	VU	-	EAAA supports VU species

6 Conclusion

6.1 Outcomes

Of the 213 biodiversity values considered through CHA screening, 92 were taken forward into the CHA process, which determined CH status for six biodiversity values and identified 13 as PBFs (as presented in Table 5-1 Section 5.1). A summary of the determinations is provided in Table 6-1 and Table 6-2 below.

Table 6-1 Biodiversity Values Determined to Trigger Critical Habitat (CH) and Priority Biodiversity Feature (PBF) status

Biodiversity Value	Species
Turtles (PBFs)	Hawksbill (*Eretmochelys imbricata*) Green (*Chelonia mydas*)
Marine Mammals (PBFs)	Indian Ocean humpback dolphin (*Sousa plumbea*) Indo-Pacific bottlenose dolphin (*Tursiops aduncus*) Pantropical spotted dolphin (*Stenella attenuate* (subspecies: *S. attenuata attenuata*))
Elasmobranchs (PBFs)	Spotted eagle ray (*Aetobatus ocellatus*) Coach whipray (*Himantura uarnak*) Spinetail devil ray (*Mobula mobular*) Oceanic manta ray (*Mobula birostris*) Panther torpedo (*Torpedo panthera*) Pink whipray (*Himantura fai*) Shortfin Mako (*Isurus oxyrinchus*) Tiger shark (*Galeocerdo cuvier*)
Teleosts (Bony fish) (CH)	Humphead wrasse (*Cheilinus undulatus*) Sky emperor (*Lethrinus mahsena*) Red Sea coral grouper (*Plectropomus marisrubri*)
Clams (CH)	Giant clam (*Tridacna squamosina*)
Coral habitat (CH)	All coral reef habitat
Seagrass habitat (CH)	All seagrass habitat

As many biodiversity values met the Criteria of more than one of the Lenders these are summarised by species/species group below for ease of reference within Table 6-2.

Table 6-2 Summary of Critical Habitat and Priority Biodiversity Features Criteria Met

Biodiversity Value	Critical Habitat Criteria	Priority Biodiversity Feature Criteria
Turtles	n/a	EBRD (ESR6 paragraph 12-iii) (a)
Marine Mammals	n/a	EBRD (ESR6 paragraph 12-iii) (a)
Elasmobranchs	n/a	EBRD (PR6 para. 12-ii) (b) EBRD (PR6 paragraph 12-iii) (a)

Biodiversity Value	Critical Habitat Criteria	Priority Biodiversity Feature Criteria
Teleosts (Bony fish)	IFC Criterion 1a and EBRD (ESR6 para. 14-ii)(b) Coral grouper also: IFC Criterion 3a and EBRD (ESR6 para. 14-iv)(b)	n/a
Giant clam	IFC Criterion 1a /EBRD (PR6 para. 14-ii) (b) /EIB Criterion 2a	n/a
Coral	IFC Criterion 4b EBRD (PR6 para. 14-i) (c) EIB Criterion 1c IFC Criterion 5 EIB Criterion 6e	n/a
Seagrass	IFC Criterion 4b EBRD (PR6 para. 14-i) (c) EIB Criterion 1c	n/a

6.2 Outcomes Seabirds

Of the biodiversity values considered through CHA screening, none were considered to qualify as critical habitat (as presented in Table 5-2 and Section 5.2.1). Two seabird species have been identified as PBFs (Table 5-3 and Section 5.2.2) A summary of the determinations is provided in Table 6-3 below.

Table 6-3: Biodiversity Values Determined to Trigger Priority Biodiversity Feature (PBF) status

Biodiversity Value	Species
Seabirds (PBF)	Curlew Sandpiper (*Calidris ferruginea)* Grey Plover (*Pluvialis squatarola)*

6.3 Implications and Next Steps

The CHA process is intended to identify biodiversity values of importance within an area in relation to Lender criteria for CH and PBFs. The presence of biodiversity values that qualify as CH does not necessarily mean that the Project will result in significant impacts upon these values. There is also variability (e.g., habitat preferences, life history traits) between the biodiversity values triggering CH status, which will influence whether and how the Project may impact them directly or indirectly.

The findings of the CHA are intended to inform understanding of the key priorities as the Project design evolves, ensuring the protection and conservation of biodiversity values, drawing on the best available data and expert knowledge while adopting a precautionary approach. As this process progresses, further refinement of the requirements for delineation of CH and PBFs will be confirmed.

As the impact assessment progresses, it will become clear which impacts are negligible, readily avoidable, or temporary, and which may require further iterative application of the Biodiversity Mitigation Hierarchy. The Hierarchy will be applied throughout the design and implementation of the Project to demonstrate No Net Loss (NNL)/Net Gain (NG), respectively, for CH/PBF biodiversity values.

A Biodiversity Management Plan (BMP) and, should a need for offsetting be identified, a Biodiversity Action Plan (BAP) will be developed and subsequently implemented. Prior to this, the current version of

the CHA will be updated to incorporate the findings of the marine survey and any other new data, as required.

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Appendix 1 Screening Lists

Excel file to be provided separately which comprises:

- Initial CHA Screening Long List, worksheet “CHA&PBF Scrng_Initial”
- CHA Screening Long List Part 2, worksheet “CHA&PBF Scrng_Part2”
- Final CHA Screening Long List, worksheet “CHA&PBF Scrng_Final”

Appendix 2 Lender Criteria Comparison Tables

Table 6-4: Definitions and Purpose of Standards

	IFC	EBRD (2024 Environmental and Social Policy (ESP) Draft)	EIB
Purpose	Protecting and conserving biodiversity, maintaining ecosystem services, and sustainably managing living natural resources are fundamental to sustainable development (PS). This Performance Standard addresses how clients can sustainably manage and mitigate impacts on biodiversity and ecosystem services throughout the project's lifecycle (PS).	The conservation of biodiversity and sustainable management of living natural resources are fundamental to environmental and social sustainability (PS). Recognises the importance of maintaining the and valuing core ecological function of habitats, biodiversity and ecosystem services (PS). Biodiversity conservation and sustainable management of living resources must be balanced with the potential for utilising the multiple economic, social and cultural values of biodiversity and living natural resources in an optimised manner (PS).	Protecting and conserving biodiversity and ecosystems and maintaining the ecological functions and processes of such ecosystems are fundamental to environmental and social sustainability (PS). Supports projects that are compatible with maintaining the integrity of areas important for biodiversity as well as the core natural functions, processes, and resilience of ecosystems to halt and reverse biodiversity loss, increase biodiversity and ecosystem benefits and, where required, achieve a Net Positive Impact on biodiversity (PS). The EIB promotes a holistic and human rights-based approach to the conservation and protection of biodiversity and ecosystems as well as to the sustainable use of natural resources (PS).
Objectives	• To protect and conserve biodiversity (PS) • To maintain the benefits from ecosystem services (PS) • To promote the sustainable management of living natural resources through the adoption of practices that integrate conservation needs and development priorities (PS)	• Protect and conserve biodiversity using a precautionary approach (PS) • Safeguard and, when appropriate, enhance ecosystems and the biodiversity they support, so as to contribute to achieving the overall goals and targets of the Kunming-Montreal Global Biodiversity Framework (PS)	This Standard outlines the promoters' responsibilities with regard to the identification, assessment, management and monitoring of the impacts and risks affecting biodiversity and ecosystems that result from the projects that the EIB finances through: • The application of a precautionary approach throughout the project life cycle (PS) • The use of appropriate sectoral, land use and marine spatial planning (PS)

	IFC	EBRD (2024 Environmental and Social Policy (ESP) Draft)	EIB
		• Adopt the mitigation hierarchy in the design and implementation of projects with the aim of achieving no net loss, and where appropriate, a net gain of biodiversity (PS) • Maintain ecosystem services (PS) • Promote good international practice in the sustainable management and use of living natural resources (PS)	• The application of the mitigation hierarchy (PS) • The use of an ecosystem-based approach to assess biodiversity-related impacts and risks (PS) • Seeking opportunities to enhance biodiversity and ecosystems whenever possible (PS)

Lender Biodiversity Criteria and Thresholds

Caveats:

The thresholds presented were obtained from globally standardised numerical thresholds published in the *IUCN's A Global Standard for the Identification of Key Biodiversity Areas and Red List Categories and Criteria*. The thresholds are indicative and serve as a guideline for decision-making only. There is no universally accepted or automatic formula for making determinations on CH. The involvement of external experts and project-specific assessments is of utmost importance, especially when data are limited (as will often be the case) (IFC GN).

Some criteria have no predetermined conditions (that is, significant biodiversity values identified by a broad set of stakeholders or governments, ecological structure and functions needed to maintain the viability of priority biodiversity features, and areas associated with key evolutionary processes. For these criteria, the assessment must rely on expert judgement (EBRD GN).

Table 6-5: Lender Biodiversity Criteria Thresholds (Designated Species)

	IFC (Designated Species)	EBRD (Designated Species) 2024 ESP Draft	EIB (Designated Species)
Criteria	Species threatened with global extinction and listed as CR and EN on the IUCN Red List of Threatened Species. Species that are listed nationally/regionally as CR or EN in countries that adhere to IUCN guidance shall be determined on a project-by-project basis.	Threatened species: 4. Species and their habitats listed in EU Habitats Directive and Birds Directive (EU members only) or Bern Convention (signatory nations only) 5. IUCN global Red List VU, EN, or CR species 6. IUCN national or regional (e.g., Europe) Red List EN or CR species (or analogous national listing)	A habitat of priority and/or significant importance to critically endangered, endangered or vulnerable species, as defined by the IUCN Red List of threatened species and in relevant national legislation.
Critical Habitat Thresholds	Areas that support globally important concentrations of an IUCN Red-listed EN or CR species (≥ 0.5% of the global population AND ≥ 5 reproductive units of a CR or EN species) Areas that support globally important concentrations of an IUCN Red-listed Vulnerable (VU) species, the loss of which would result in the change of the IUCN Red List status to EN or CR and meet the thresholds in As appropriate, areas containing important concentrations of a	EAAA supports species listed in Annex II of Habitats Directive marked as "priority species" EAAA supports ≥ 0.5% of the global population AND ≥ 5 reproductive units of a CR or EN species, or EAAA supports globally significant population of VU species necessary to prevent a change of IUCN Red List status to EN or CR EAAA for important concentrations of species with national or regional status of EN or CR	A population of an IUCN Red-listed endangered or critically endangered species17 that is ≥ 0.5% of the global population and/or ≥ 5 established reproductive units of an endangered or critically endangered species Significant concentration of an IUCN Red-listed vulnerable species or of multiple IUCN Red-listed vulnerable species, especially where the loss of the area would result in the change of the IUCN Red List status to endangered or critically endangered

	IFC (Designated Species)	EBRD (Designated Species) 2024 ESP Draft	EIB (Designated Species)
	nationally or regionally listed EN or CR species		Nationally or regionally-important concentration of a species listed as endangered or critically endangered on a regional/national IUCN Red List, or equivalent on national/regional listing A population of species listed in Annex II and IV of the Habitats Directive
Priority Feature Threshold	n/a	Species in the area of impact listed in Annex II of Habitats Directive, Annex I of Birds Directive, or Resolution 6 of Bern Convention Species in the area of impact with IUCN global Red List status of VU, EN or CR Species in the area of impact with national or regional status of EN or CR	n/a

Table 6-6: Lender Biodiversity Criteria Thresholds (Endemic and Restricted Range Species)

	IFC (Endemic and Restricted Range Species)	EBRD (Endemic and Restricted Range Species) 2024 ESP Draft	EIB (Endemic and Restricted Range Species)
Criteria	For terrestrial vertebrates and plants, restricted-range species are defined as those species that have an Extent of occurrence (EOO) less than 50,000 square kilometers (km2). For marine systems, restricted-range species are provisionally being considered those with an EOO of less than 100,000 km2. For coastal, riverine, and other aquatic species in habitats that do not exceed 200 km width at any point (for example, rivers), restricted range is defined as having a global range of less than or equal to 500 km linear geographic span (i.e., the distance between occupied locations furthest apart).	All Range-restricted species.	A habitat of priority and/or significant importance to a population, range or distribution of endemic or restricted-range species, or highly distinctive assemblages of species. For terrestrial vertebrates and plants, restricted-range species are defined as those species that have an Extent of occurrence (EOO) less than 50,000 square kilometers (km2). For marine systems, restricted-range species are provisionally being considered those with an EOO of less than 100,000 km2. For coastal, riverine, and other aquatic species in habitats that do not exceed 200 km width at any point (for example, rivers), restricted range is defined as having a global range of less than or equal to 500 km linear geographic span (i.e., the distance between occupied locations furthest apart).
Critical Habitat Thresholds	Areas that regularly hold ≥10% of the global population size AND ≥10 reproductive units (the minimum number and combination of mature individuals	EAAA regularly holds ≥ 10 per cent of global population AND ≥ 10 reproductive units of the species	They regularly hold ≥10% of the global population size and support ≥10 reproductive units of an endemic or restricted-range species

	IFC (Endemic and Restricted Range Species)	EBRD (Endemic and Restricted Range Species) 2024 ESP Draft	EIB (Endemic and Restricted Range Species)
	necessary to trigger a successful reproductive event) of a species.		They are considered by relevant specialists to support unique or rare assemblages of species that occur there habitually, predictably or repeatably. The constituent species may not meet other critical habitat thresholds mentioned here in their own right, but may present assemblages that are considered important to maintain high biodiversity in the area
Priority Feature Threshold	n/a	All range-restricted species in the area of impact	n/a

Table 6-7: Lender Biodiversity Criteria Thresholds (Migratory and Congregatory Species)

	IFC (Migratory and Congregatory Species)	EBRD (Migratory and Congregatory Species) 2024 ESP Draft	EIB (Migratory and Congregatory Species)
Criteria	Migratory species are defined as any species of which a significant proportion of its members cyclically and predictably move from one geographical area to another. Congregatory species are defined as species whose individuals gather in large groups on a cyclical or otherwise regular and/or predictable basis.	All migratory and congregatory species.	A habitat required for the survival of migratory species and/or congregatory species.
Critical Habitat Thresholds	Areas known to sustain, on a cyclical or otherwise regular basis, ≥ 1 percent of the global population of a migratory or congregatory species at any point of the species' lifecycle Areas that predictably support ≥10 percent of the global population of a species during periods of environmental stress	EAAA sustains, on a cyclical or otherwise regular basis, ≥ 1 per cent of the global population at any point of the species' lifecycle EAAA predictably supports ≥ 10 per cent of global population during periods of environmental stress	They sustain ≥ 1%of the global population of a migratory or congregatory species at any point of the species' lifecycle on a cyclical or otherwise regular basis They are needed to support migratory or congregatory species during periods of environmental stress
Priority Feature Threshold	n/a	All migratory species in the area of impact	n/a

Table 6-8: Lender Biodiversity Criteria Thresholds (Highly Threatened or Unique Ecosystems)

	IFC (Highly Threatened or Unique Ecosystems)	EBRD (Highly Threatened or Unique Ecosystems) 2024 ESP Draft	EIB (Highly Threatened or Unique Ecosystems)
Criteria	The IUCN is developing a Red List of Ecosystems, this should be used where formal IUCN assessments have been performed. Where formal IUCN assessments have not been performed, make assessments using systematic methods at the national/regional level.	Habitats listed in Annex 1 of EU Habitats Directive (EU member states only) or Resolution 4 of Bern Convention (signatory nations only) IUCN Red List EN or CR ecosystems Ecosystem/habitats listed in national systematic conservation planning	A highly threatened and/or unique ecosystem.
Critical Habitat Thresholds	Areas representing ≥5% of the global extent of an ecosystem type meeting the criteria for IUCN status of CR or EN Other areas not yet assessed by IUCN but determined to be of high priority for conservation by regional or national systematic conservation planning	Habitat type listed in Annex 1 of EU Habitats Directive marked as "priority habitat type" EAAA* ≥5% of global extent of an ecosystem type with IUCN status of CR or EN EAAA for ecosystem/habitat determined to be of high priority for conservation by national systematic conservation planning	Priority Habitats listed in Annex I of the Habitats Directive and habitats considered to be their equivalent in countries outside the EU ≥5% of the global extent of an ecosystem type meeting the criteria for IUCN's Red List of Ecosystems with a status of critically endangered or endangered Examples of ecosystems outside the EU and not yet assessed by IUCN, but determined to be of high priority for conservation on the basis of regional or national level systematic conservation planning or informed specialist input
Priority Feature Threshold	n/a	Habitat type listed in Annex 1 of EU Habitats Directive or Resolution 4 of Bern Convention	n/a

	IFC (Highly Threatened or Unique Ecosystems)	EBRD (Highly Threatened or Unique Ecosystems) 2024 ESP Draft	EIB (Highly Threatened or Unique Ecosystems)
		Ecosystem type with IUCN status of EN or CR	

Table 6-9: Lender Biodiversity Criteria Thresholds (Key Evolutionary Processes)

	IFC (Key Evolutionary Processes)	EBRD (Key Evolutionary Processes)	EIB (Key Evolutionary Processes)
Criteria	The structural attributes of a region, can influence the evolutionary processes that give rise to regional configurations of species and ecological properties. By conserving species diversity within a landscape, the processes that drive speciation, as well as the genetic diversity within species, ensures the evolutionary flexibility in a system, which is especially important in a rapidly changing climate. For illustrative purposes, some potential examples of spatial features associated with evolutionary processes are as follows: • Landscapes with high spatial heterogeneity are a driving force in speciation, as species are naturally selected based on their ability to adapt and diversify • *Environmental gradients*, also known as ecotones, produce transitional habitat, which has been associated with the process of speciation and high species and genetic diversity • *Edaphic interfaces* are specific juxtapositions of soil types (for example, serpentine outcrops, limestone, and gypsum deposits),	n/a	A habitat of key scientific value and/or associated with key evolutionary processes. This may include, but is not limited to, exceptional representations of: Landscapes with high spatial heterogeneity and therefore high levels of species diversity Environmental gradients, also known as ecotones, that produce transitional habitat which is associated with the process of speciation and high species and genetic diversity Edaphic interfaces that juxtapose soil types (e.g., serpentine outcrops, limestone and gypsum deposits), which have led to the formation of unique plant communities Connectivity between habitats (e.g. biological corridors) with importance for species migration and gene flow, which is especially important in fragmented habitats and for the conservation of metapopulations. This also includes biological corridors across altitudinal and climatic gradients and from “crest to coast”

	IFC (Key Evolutionary Processes)	EBRD (Key Evolutionary Processes)	EIB (Key Evolutionary Processes)
	which have led to the formation of unique plant communities characterised by both rarity and endemism • *Connectivity* between habitats (for example, biological corridors) ensures species migration and gene flow, which is especially important in fragmented habitats and for the conservation of metapopulations. This also includes biological corridors across altitudinal and climatic gradients and from "crest to coast" • Sites of demonstrated importance to *climate change adaptation* for either species or ecosystems are also included within this criterion		Sites of demonstrated importance to climate change adaptation for either species or ecosystems
Critical Habitat Thresholds	The significance of structural attributes in a landscape that may influence evolutionary processes will be determined on a case-by-case basis, and the determination of critical habitat will be heavily reliant on scientific knowledge.	Expert Judgement required, no fixed thresholds.	If the possibility of impacts on critical habitat is identified on the basis of the criteria and the indicative thresholds given above, further more detailed work will be needed to confirm the presence of critical habitat, to delineate it and to assess potential risks to its viability.
Priority Feature Threshold	n/a	Expert Judgement required, no fixed thresholds.	n/a

Table 6-10: Lender Biodiversity Criteria Thresholds (Biodiversity of Socio-economic Value)

	IFC (Biodiversity of Socio-economic Value)	EBRD (Biodiversity of Socio-economic Value) 2024 ESP Draft	EIB (Biodiversity of Socio-economic Value)
Criteria	n/a	n/a	Biodiversity and/or an ecosystem of significant social, economic or cultural importance to local communities and indigenous groups.
Critical Habitat Thresholds	n/a	n/a	Areas of semi-natural and natural habitat used by indigenous peoples and local communities to obtain essential or priority benefits will be considered critical from an ecosystem service perspective. Criteria for identifying priority ecosystem services should be developed for each project.
Priority Feature Threshold	n/a	n/a	n/a

Table 6-11: Definitions of Habitat Types

	IFC	EBRD	EIB
Critical Habitat	Critical habitats are areas with high biodiversity value, including (i) habitat of significant importance to Critically Endangered and/or Endangered species; (ii) habitat of significant importance to endemic and/or restricted-range species; (iii) habitat supporting globally significant concentrations of migratory species and/or congregatory species; (iv) highly threatened and/or unique ecosystems; and/or (v) areas associated with key evolutionary processes.	The determination of critical habitat based on other listings is as follows: (i) If the species is listed nationally/regionally as critically endangered or endangered, in countries that have adhered to IUCN guidance, the critical habitat determination will be made on a project by project basis in consultation with competent professionals; and (ii) in instances where nationally or regionally listed species' categorisations do not correspond exactly to those of the IUCN (e.g., some countries more generally list species as "protected" or "restricted"), an assessment will be conducted to determine the rationale and purpose of the listing. In this case, the critical habitat determination will be based on such assessment.	Critical habitat is defined as comprising one of the following: A highly threatened and/or unique ecosystem A habitat of priority and/or significant importance to critically endangered, endangered or vulnerable species, as defined by the IUCN Red List of threatened species13 and in relevant national legislation A habitat of priority and/or significant importance to a population, range or distribution of endemic or restricted-range species, or highly distinctive assemblages of species A habitat required for the survival of migratory species and/or congregatory species Biodiversity and/or an ecosystem of significant social, economic or cultural importance to local communities and indigenous groups A habitat of key scientific value and/or associated with key evolutionary processes
Priority Habitat	n/a	Priority biodiversity features are a sub-set of biodiversity which are irreplaceable or	n/a

	IFC	EBRD	EIB
		vulnerable, but at a lower priority level than critical habitats.	
Natural Habitat	Natural habitats are areas composed of viable assemblages of plant and/or animal species of largely native origin, and/or where human activity has not essentially modified an area's primary ecological functions and species composition.	n/a	Guidance note refers to definitions in the Standard, but there are no definitions presented in the current Standard Document (Guidance refers to previous and superseded issue).
Semi-natural Habitat	n/a	n/a	
Urban habitat	n/a	n/a	
Modified Habitat	Modified habitats are areas that may contain a large proportion of plant and/or animal species of non-native origin, and/or where human activity has substantially modified an area's primary ecological functions and species composition. Modified habitats may include areas managed for agriculture, forest plantations, reclaimed coastal zones, and reclaimed wetlands.	n/a	

Table 6-12: Conditions for Activities in Critical Habitat

IFC	EBRD 2024 ESP Draft	EIB
No other viable alternatives within the region exist for development of the project on modified or natural habitats that are not critical.	no other viable alternatives within the region exist for development of the project in habitats of lesser biodiversity value.	No other viable alternatives for the project exists either in terms of location or design, and there is rigorous justification of overriding public interest based on human health, public safety considerations and/or beneficial consequences of primary importance for the environment.
n/a	Stakeholders are consulted in accordance with ESR 10.	Stakeholders are consulted in accordance with Standards 2 and 7.
n/a	The project is permitted under applicable environmental laws, recognising the priority biodiversity features.	n/a
The project does not lead to measurable adverse impacts on those biodiversity values for which the critical habitat was designated, and on the ecological processes supporting those biodiversity values.	The project does not lead to measurable adverse impacts on those biodiversity values for which the critical habitat was designated.	The project does not lead to measurable adverse impacts that will result in any detrimental effect on the ecological and conservation status of the critical habitat, and impacts are avoided and minimised to the extent possible through changes in footprint or design.
n/a	The project is designed to deliver net gains for critical habitat impacted by the project, with monitoring systems to demonstrate them.	Positive conservation outcomes (Net Positive Impact) and continued ecological functionality are achieved though appropriate compensation measures for residual impacts that would otherwise occur despite impact avoidance, minimisation and restoration measures.
The project does not lead to a net reduction in the global and/or national/regional population of any Critically Endangered or Endangered species over a reasonable period of time.	The project is not anticipated to lead to a net reduction in the population of any endangered or critically endangered species, over a reasonable time period.	The project does not lead to a net reduction14 in the population of any vulnerable, endangered or critically endangered species over a reasonable period of time.
A robust, appropriately designed, and long-term biodiversity monitoring and evaluation programme is integrated into the client's management programme.	A robust and appropriately designed, long-term biodiversity monitoring and evaluation programme aimed at assessing the status of critical habitat is integrated into the client's adaptive management programme.	A robust, appropriately designed and long-term biodiversity monitoring and evaluation programme aimed at assessing the status of the critical habitat is integrated into the promoter's adaptive management programme.

Table 6-13: Lender Definition Habitat Impacts

	IFC	EBRD	EIB
Net Reduction	Net reduction is a singular or cumulative loss of individuals that impacts on the species' ability to persist at the global and/or regional/national scales for many generations or over a long period of time. The scale (i.e., global and/or regional/national) of the potential net reduction is determined based on the species' listing on either the (global) IUCN Red List and/or on regional/national lists. For species listed on both the (global) IUCN Red List and the national/regional lists, the net reduction will be based on the national/regional population.	Net reduction is a singular or cumulative loss of individuals that impacts on the species' ability to persist at the global and/or regional/ national scales for many generations or over a long period of time. The scale (that is global and/or regional/national) of the potential net reduction is determined based on the species' listing on either the (global) IUCN Red List of Threatened Species and/or on regional/national lists. For species listed on both the (global) IUCN Red List of Threatened Species and the national/regional lists, the net reduction will be based on the national/regional population.	n/a
No Net Loss	No net loss is defined as the point at which project-related impacts on biodiversity are balanced by measures taken to avoid and minimise the project's impacts, to undertake on-site restoration and finally to offset significant residual impacts, if any, on an appropriate geographic scale (e.g., local, landscape-level, national, regional).	"No net loss" is defined as the point at which project-related biodiversity losses are balanced by gains resulting from measures taken to avoid and minimise these impacts, to undertake on-site restoration and finally to offset significant residual impacts, if any, on an appropriate geographic scale.	No Net Loss: the point where biodiversity gains from targeted conservation activities match the losses of biodiversity due to the impacts of a specific development project, so that there is no net reduction overall in the type, amount and condition (or quality) of biodiversity over space and time." The concept of no-net biodiversity loss lies at the heart of biodiversity offsetting (Business and Biodiversity Offsets Programme).

	IFC	EBRD	EIB
Net Positive Impact	n/a	n/a	Net Positive Impact (NPI)) on biodiversity is generally defined as a target for project outcomes in which the impacts on biodiversity (i.e. the variety of ecosystems and living things) caused by the project are outweighed by the actions taken to avoid and reduce such impacts, rehabilitate affected species/landscapes and offset any residual impacts (IUCN definition). NPI on biodiversity relies on the application of the mitigation hierarchy to avoid, minimise, restore or compensate for biodiversity losses. It is additional to these approaches, not instead of them. Net Positive Impact on Biodiversity must be defined on a case-by-case basis relative to an appropriate reference scenario. EC Guidance "Managing Natura 2000 Sites - The provisions of Article 6 of the Habitats" Directive 92/43/EEC.
Net Gain	Net gains are additional conservation outcomes that can be achieved for the biodiversity values for which the critical habitat was designated. Net gains may be achieved through the development of a biodiversity offset and/or, in instances where the client could meet the requirements of paragraph 17 of this Performance Standard without a	Net gains are additional conservation outcomes that can be achieved for the biodiversity values for which the critical habitat was designated. Net gains may be achieved through the implementation of programmes that could be implemented in situ (on the ground) to enhance habitat and protect and conserve biodiversity and, where additional mitigation is	Net Gain: a net gain means that biodiversity gains exceed a specific set of losses, i.e an outcome beyond No Net Loss.

	IFC	EBRD	EIB
	biodiversity offset, the client should achieve net gains through the implementation of programmes that could be implemented in situ (on-the-ground) to enhance habitat, and protect and conserve biodiversity.	required to meet the requirements of paragraph 15 of this ESR, by developing a biodiversity offset.	

Appendix 3 Analysis of CHA-related Species Presence/Absence in Protected and Designated Sites

Common Name	Latine Name	Listed within Protected and/or Designated Sites
Indian Ocean humpback dolphin	*Sousa plumbea*	No
Indo-Pacific bottlenose dolphin	*Tursiops aduncus*	Yes, listed by UNESCO 2023 Aqaba Marine Reserve site description.
Pantropical spotted dolphin	*Stenella attenuata (subspecies: S. attenuata attenuata)*	Yes, listed by UNESCO 2023 Aqaba Marine Reserve site description.
Hawksbill turtle	*Eretmochelys imbricata*	Yes, listed by UNESCO 2023 Aqaba Marine Reserve site description.
Green turtle	*Chelonia mydas*	Yes, listed by UNESCO 2023 Aqaba Marine Reserve site description.
Spotted eagle ray	*Aetobatus ocellatus*	No
Coach whipray	*Himantura uarnak*	No
Spinetail devil ray	*Mobula mobular*	No
Oceanic manta ray	*Mobula birostris*	Yes, listed by UNESCO 2023 Aqaba Marine Reserve site description.
Panther torpedo	*Torpedo panthera*	No
Shortfin Mako	*Isurus oxyrinchus*	Yes North Jordan Area of Interest (Candidate) Important Shark & Ray Area (ISRA).
Pink whipray	*Himantura fai*	No
Tiger shark	*Galeocerdo cuvier*	Yes North Jordan Area of Interest (Candidate) Important Shark & Ray Area (ISRA).
Humphead wrasse	*Cheilinus undulatus*	Listed in The Aqaba Marine Reserve Management Plan (AMRMP) 2022 – 2026 & in UNESCO 2023 Aqaba Marine Reserve site description.
Sky emperor	*Lethrinus mahsena*	No
Red Sea coral grouper	*Plectropomus marisrubri*	Groupers are listed in The Aqaba Marine Reserve Management Plan (AMRMP) 2022 – 2026
Giant clam	*Tridacna squamosina*	Yes listed in The Aqaba Marine Reserve Management Plan (AMRMP) 2022 – 2026
n/a	*Acropora squarrosa (Acropora maryae)*	Yes listed in The Aqaba Marine Reserve Management Plan (AMRMP) 2022 – 2026
n/a	*Montipora hemispherica*	Yes listed in The Aqaba Marine Reserve Management Plan (AMRMP) 2022 – 2026
n/a	*Stylophora mamillata*	Yes listed in The Aqaba Marine Reserve Management Plan (AMRMP) 2022 – 2026
n/a	*Acropora pharaonis*	Yes listed in The Aqaba Marine Reserve Management Plan (AMRMP) 2022 – 2026
n/a	*Alveopora allingi*	Yes listed in The Aqaba Marine Reserve Management Plan (AMRMP) 2022 – 2026

Common Name	Latine Name	Listed within Protected and/or Designated Sites
n/a	*Montipora meandrina*	Yes listed in The Aqaba Marine Reserve Management Plan (AMRMP) 2022 – 2026
n/a	*Montipora stilosa*	Yes listed in The Aqaba Marine Reserve Management Plan (AMRMP) 2022 – 2026
n/a	*Acropora arabensis*	Yes listed in The Aqaba Marine Reserve Management Plan (AMRMP) 2022 – 2026
n/a	*Acropora austera*	Yes listed in The Aqaba Marine Reserve Management Plan (AMRMP) 2022 – 2026
n/a	*Acropora digitifera*	Yes listed in The Aqaba Marine Reserve Management Plan (AMRMP) 2022 – 2026
Brush coral	*Acropora hyacinthus*	Yes listed in The Aqaba Marine Reserve Management Plan (AMRMP) 2022 – 2026
n/a	*Acropora secale*	Yes listed in The Aqaba Marine Reserve Management Plan (AMRMP) 2022 – 2026
n/a	*Montipora cryptus*	Yes listed in The Aqaba Marine Reserve Management Plan (AMRMP) 2022 – 2026
n/a	*Alveopora viridis*	Yes listed in The Aqaba Marine Reserve Management Plan (AMRMP) 2022 – 2026
n/a	*Erythrastrea flabellata*	Yes listed in The Aqaba Marine Reserve Management Plan (AMRMP) 2022 – 2026
n/a	*Cyphastrea magna*	Yes listed in The Aqaba Marine Reserve Management Plan (AMRMP) 2022 – 2026
n/a	*Echinophyllia bulbosa*	Yes listed in The Aqaba Marine Reserve Management Plan (AMRMP) 2022 – 2026
n/a	*Cantharellus doederleini*	Yes listed in The Aqaba Marine Reserve Management Plan (AMRMP) 2022 – 2026
n/a	*Oxypora convoluta*	Yes listed in The Aqaba Marine Reserve Management Plan (AMRMP) 2022 – 2026
n/a	*Sclerophyllia margariticola*	Yes listed in The Aqaba Marine Reserve Management Plan (AMRMP) 2022 – 2026
n/a	*Cyphastrea hexasepta*	Yes listed in The Aqaba Marine Reserve Management Plan (AMRMP) 2022 – 2026
n/a	*Cyphastrea kausti*	Yes listed in The Aqaba Marine Reserve Management Plan (AMRMP) 2022 – 2026
n/a	*Echinopora tiranensis*	Yes listed in The Aqaba Marine Reserve Management Plan (AMRMP) 2022 – 2026
n/a	*Merulina scheeri*	Yes listed in The Aqaba Marine Reserve Management Plan (AMRMP) 2022 – 2026
n/a	*Pachyseris inattesa*	Yes listed in The Aqaba Marine Reserve Management Plan (AMRMP) 2022 – 2026
n/a	*Acropora abrotanoides*	No
n/a	*Acropora aculeus*	No
n/a	*Acropora cytherea*	No
n/a	*Acropora downingi*	No
n/a	*Acropora eurystoma*	No
n/a	*Acropora gemmifera*	No
n/a	*Acropora samoensis*	No
n/a	*Acropora variolosa*	No
n/a	*Dipsastraea laxa*	No
n/a	*Goniopora savignyi*	No

Common Name	Latine Name	Listed within Protected and/or Designated Sites
n/a	*Millepora dichotoma*	No
n/a	*Montipora tuberculosa*	No
n/a	*Pocillopora damicornis*	No
n/a	*Pocillopora verrucosa*	No
n/a	*Podabacia Sinai*	No
n/a	*Seriatopora hystrix*	No
n/a	*Halophila stipulacea*	Yes
n/a	*Halodule uninervis*	Yes
n/a	*Halophila ovalis*	Yes

Appendix 4 Ecologically Appropriate Areas of Analysis (EAAA) Maps

Figure 4-1: EAAA Hawksbill Turtle (*Eretmochelys imbricata*)

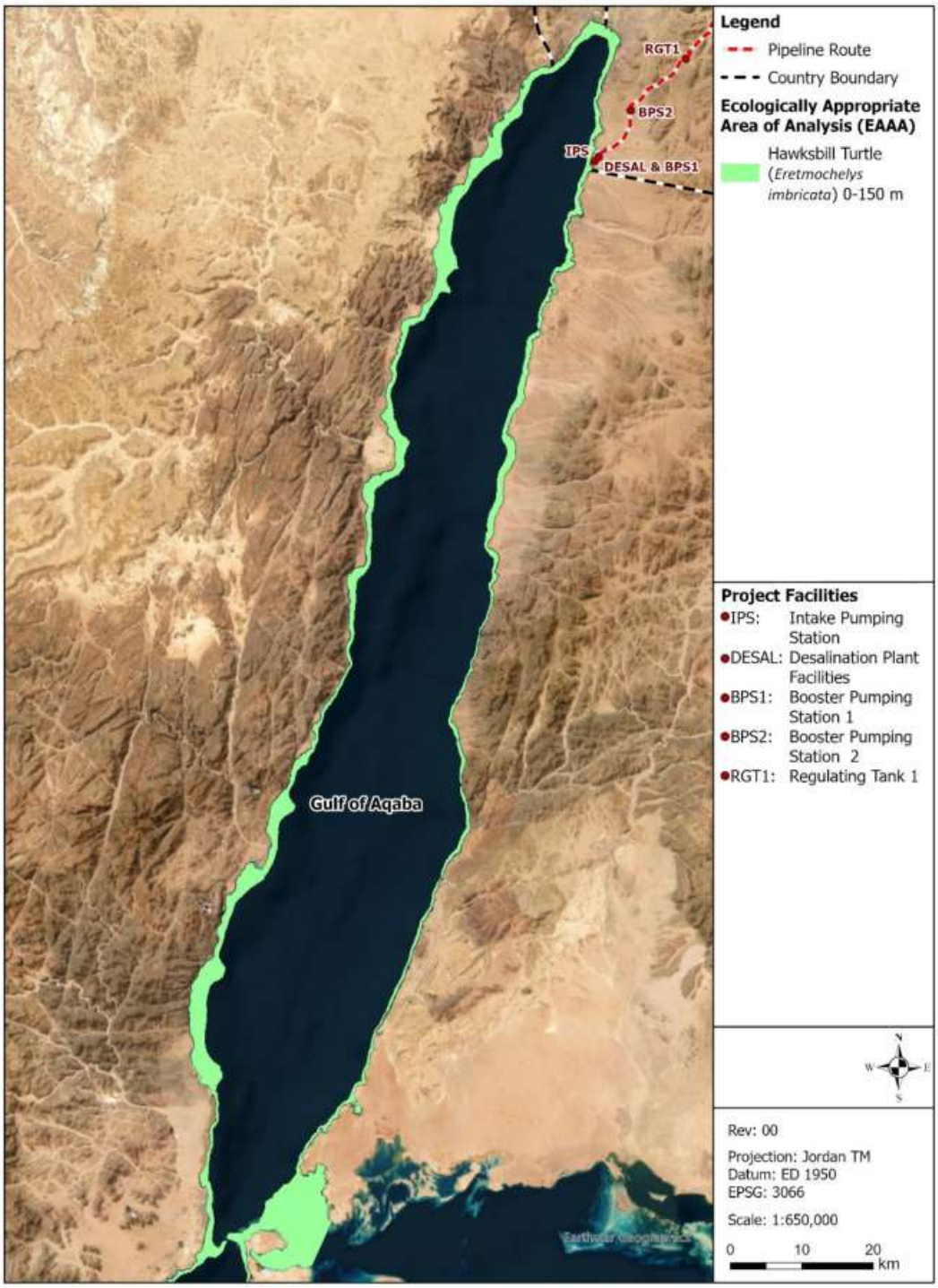


Figure 4-2: EAAA Green Turtle (*Chelonia mydas*)

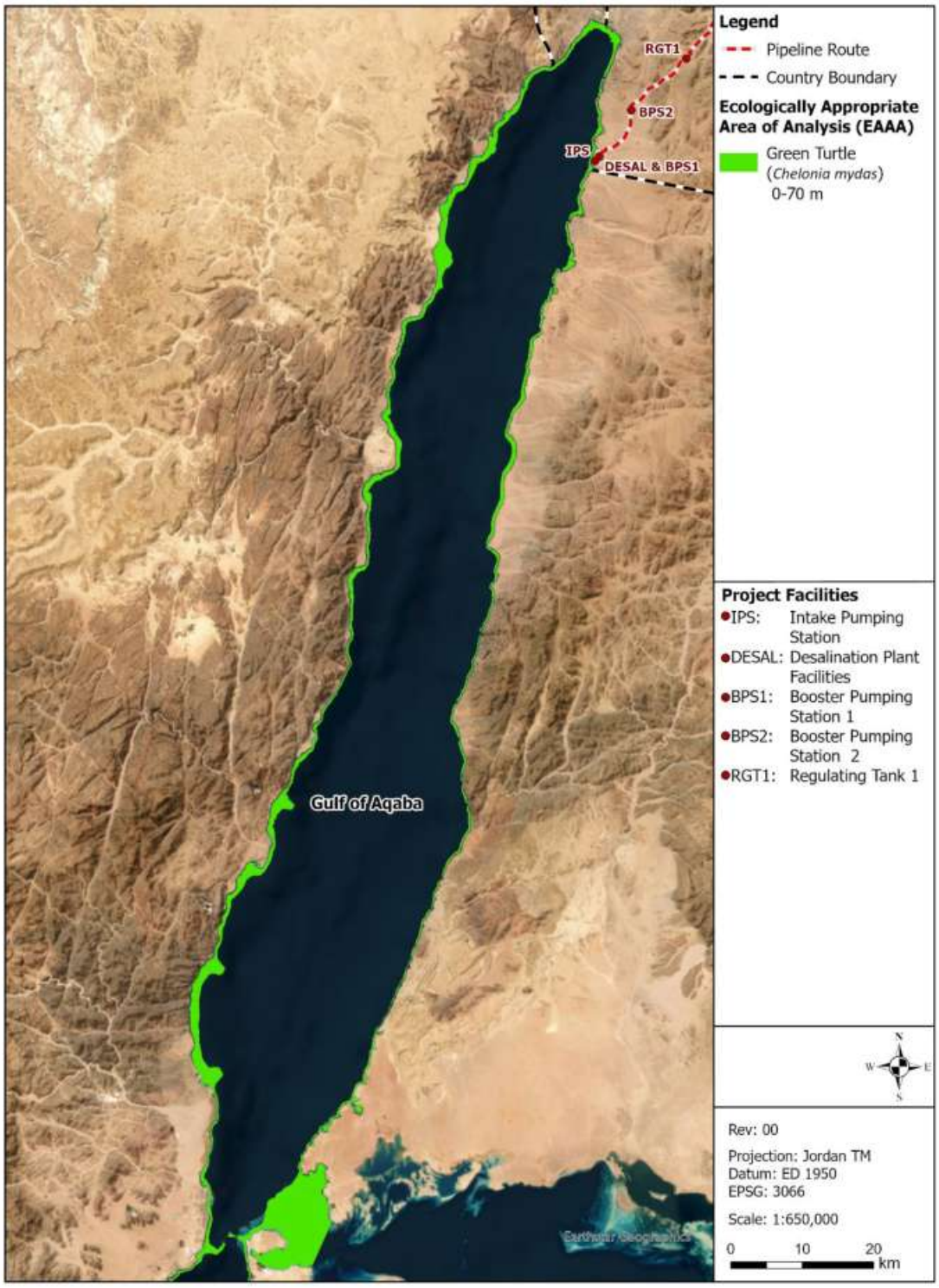


Figure 4-3: EAAA Indian Ocean Humpback Dolphin (*Sousa plumbea*)

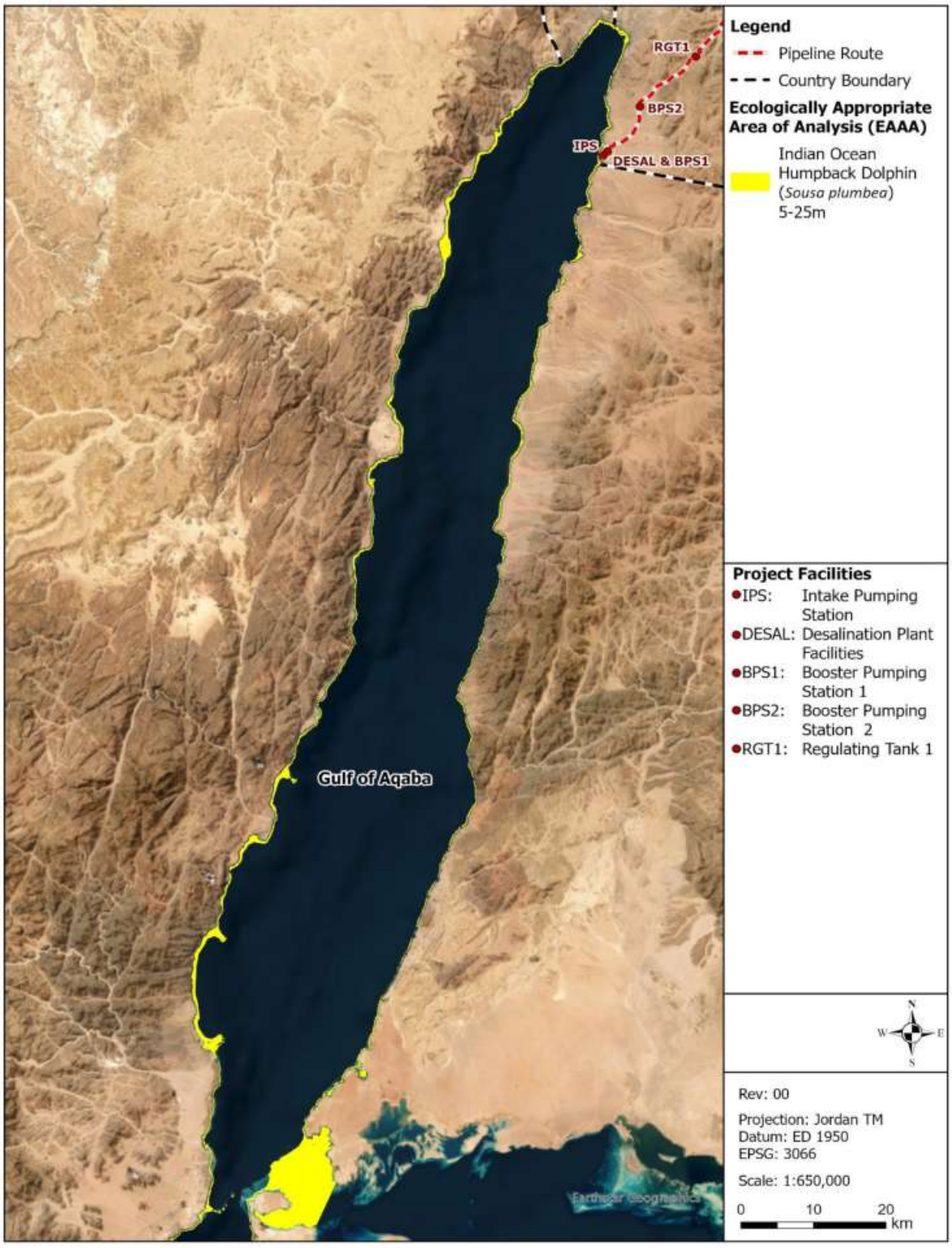


Figure 4-4: EAAA Indo-Pacific Bottlenose Dolphin (*Tursiops aduncus*)

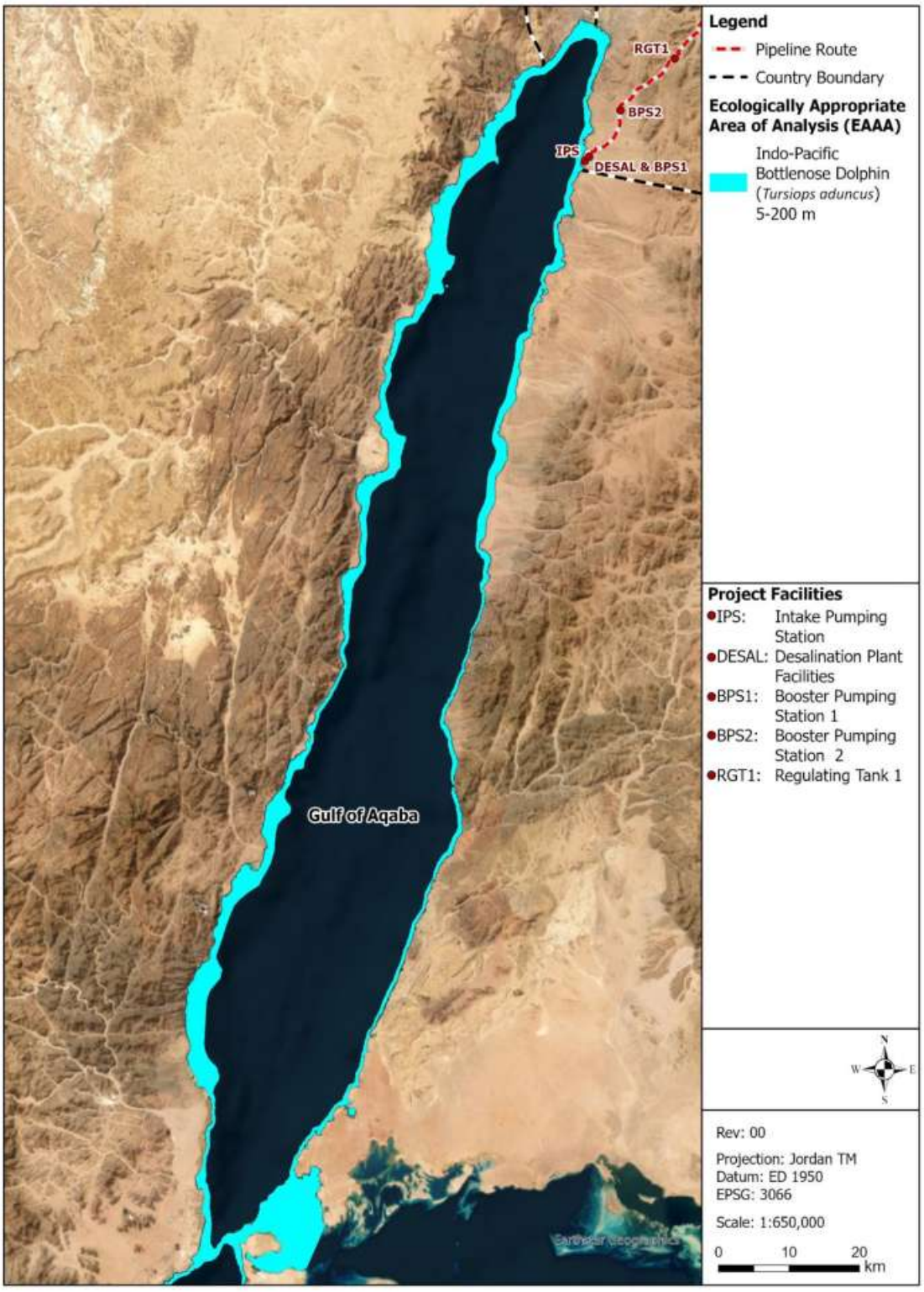


Figure 4-5: EAAA Pantropical Spotted Dolphin (*Stenella attenuate* (subspecies: *S. attenuata attenuata*))

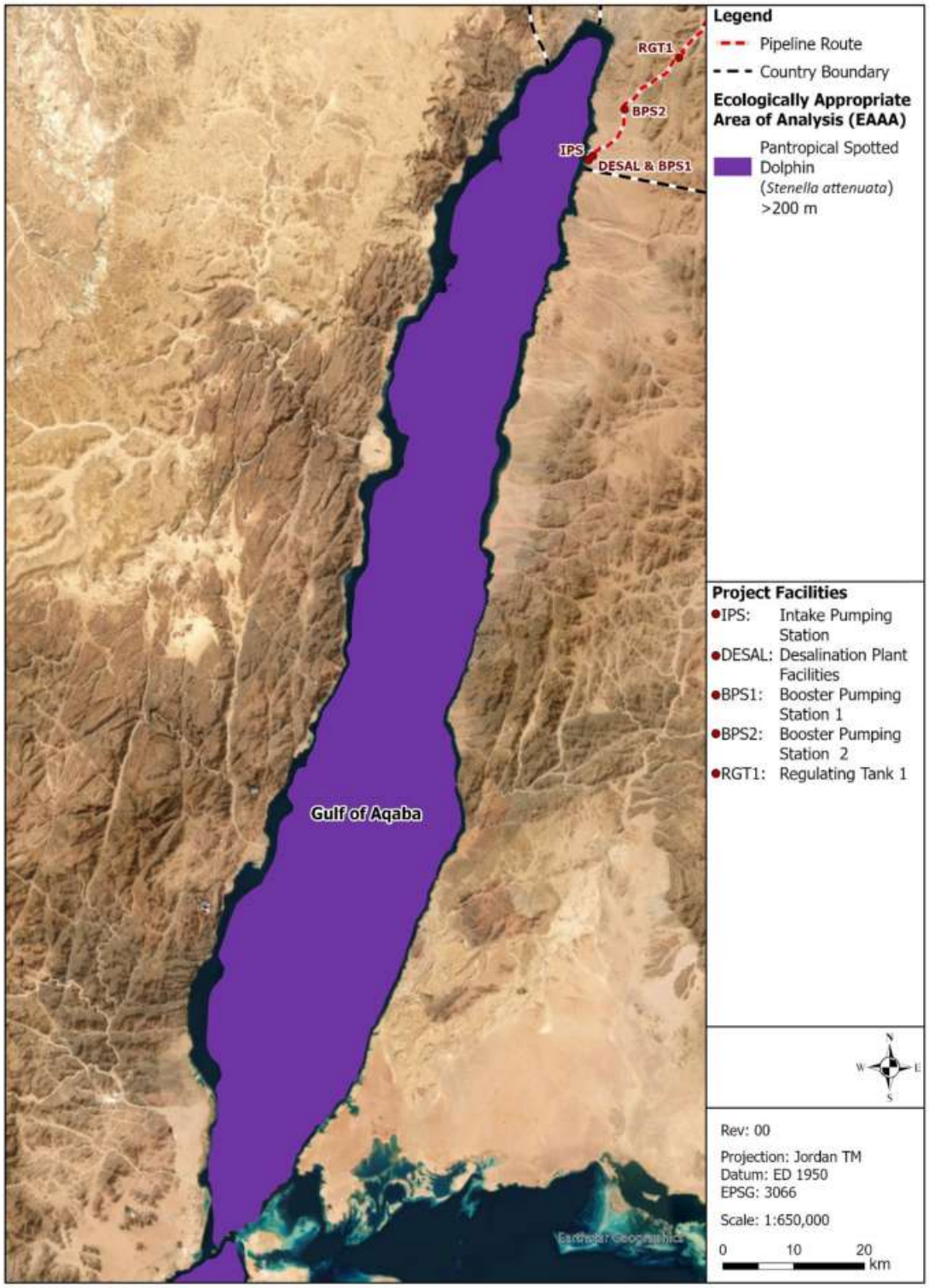


Figure 4-6: EAAA Elasmobranchs

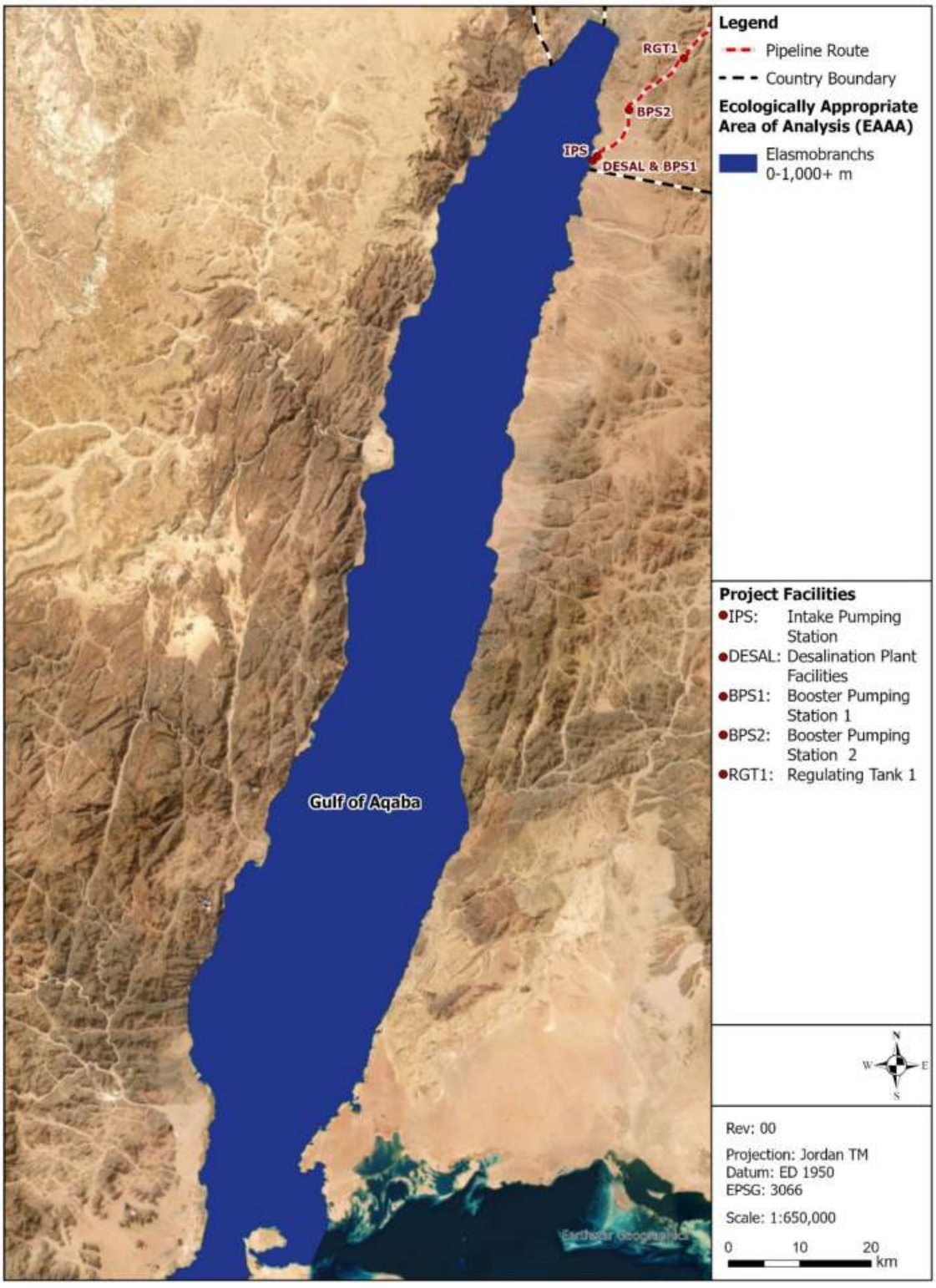


Figure 4-7: EAAA Reef Fish

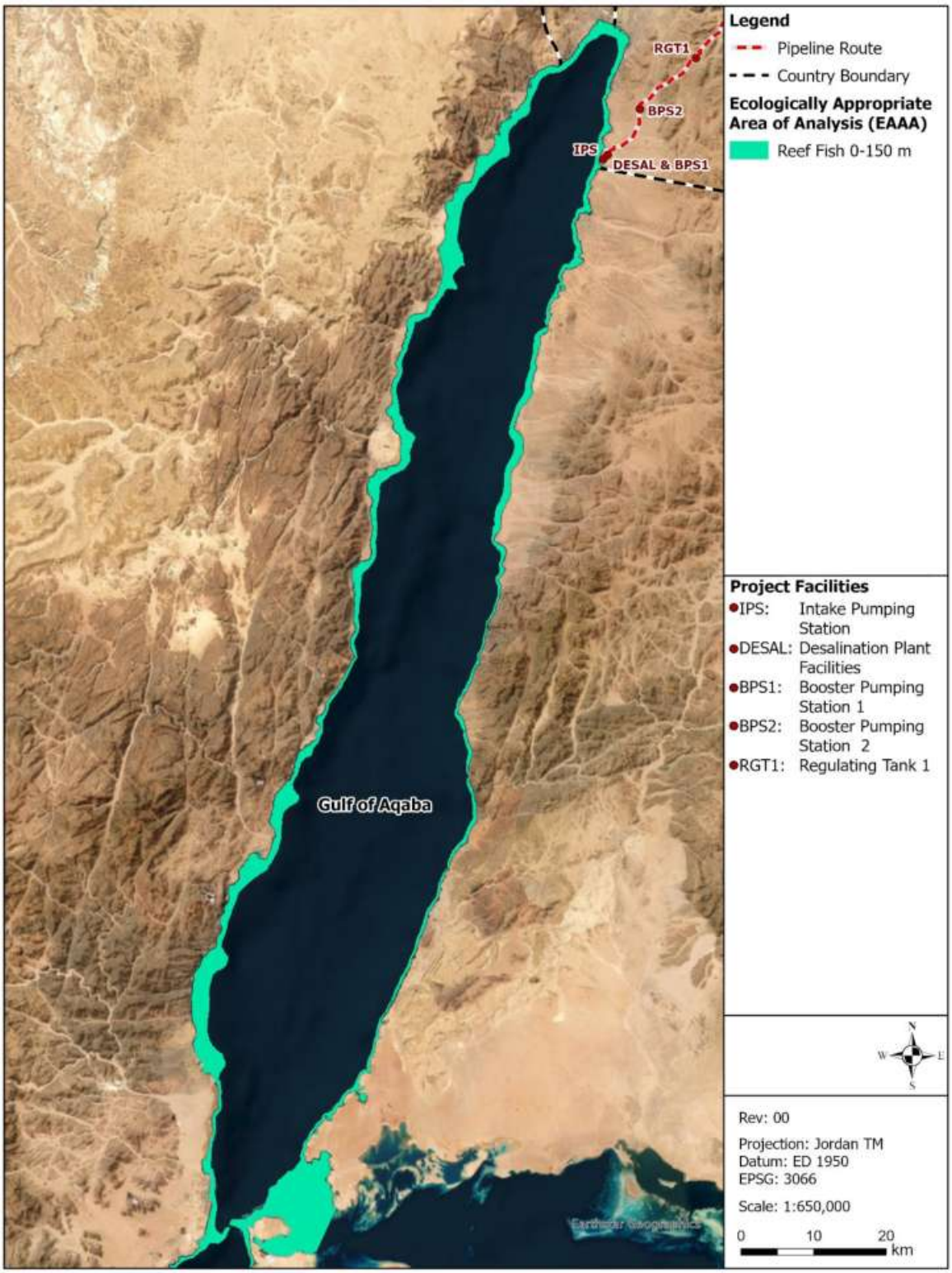


Figure 4-8: EAAA Reef Invertebrates

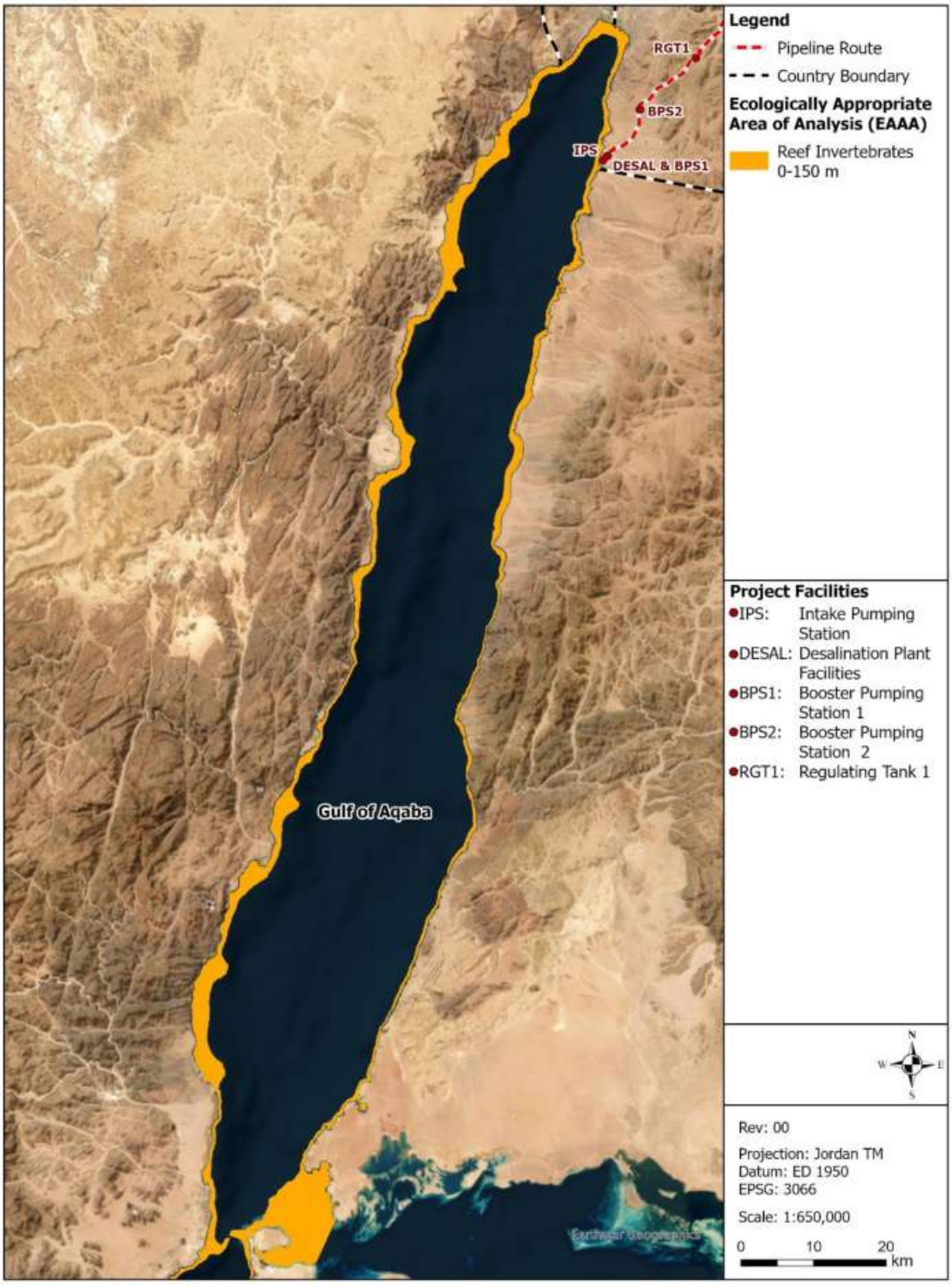


Figure 4-9: EAAA Giant Clam (*Tridacna squamosina*)



Figure 4-10: EAAA Coral Reef

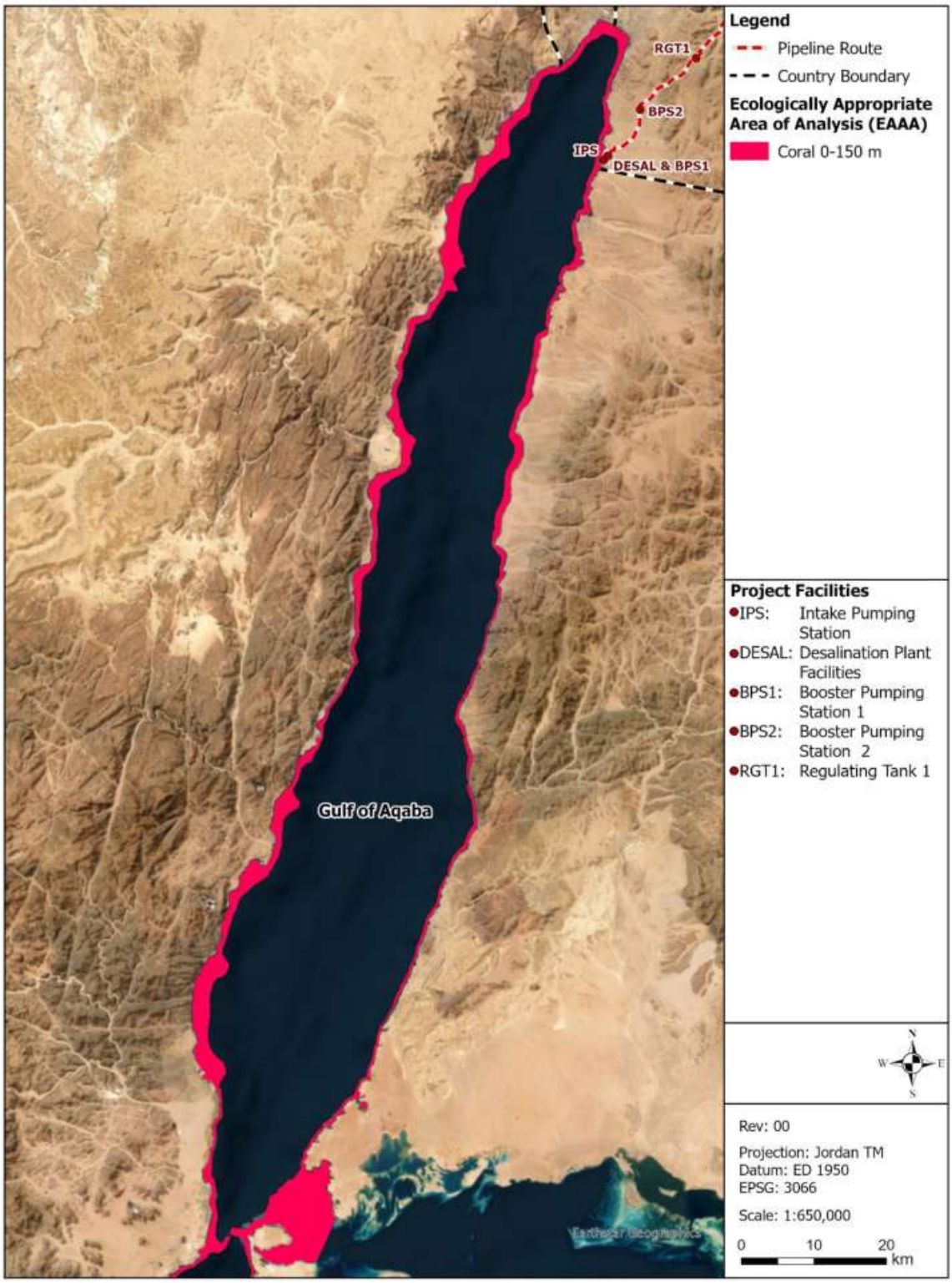
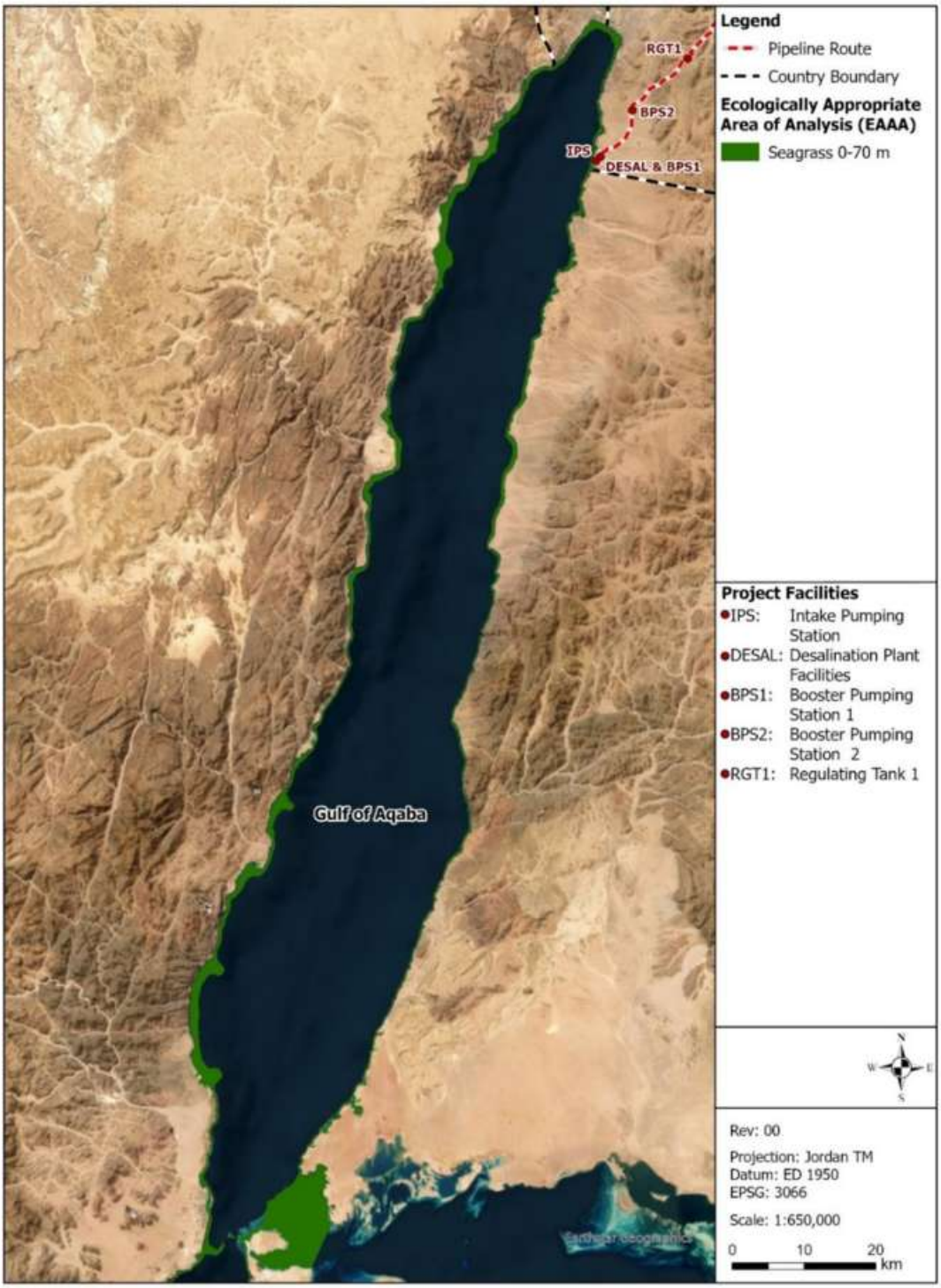


Figure 4-11: EAAA Seagrass



Appendix 5 Critical Habitat (CH) and Priority Biodiversity Feature (PBF) Maps

Figure 5-1: PBF Hawksbill Turtle (*Eretmochelys imbricata*)

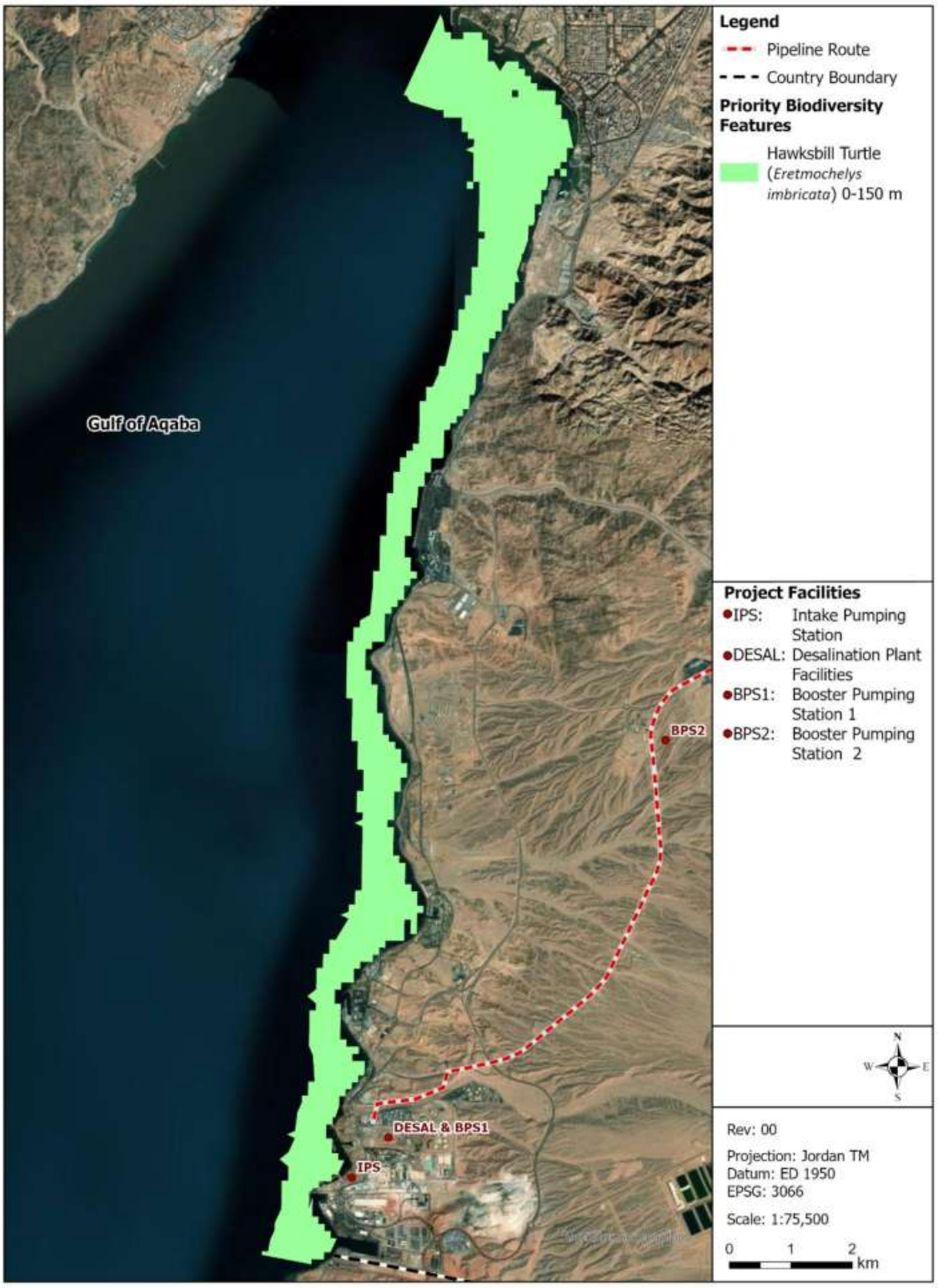


Figure 5-2: PBF Green Turtle (*Chelonia mydas*)

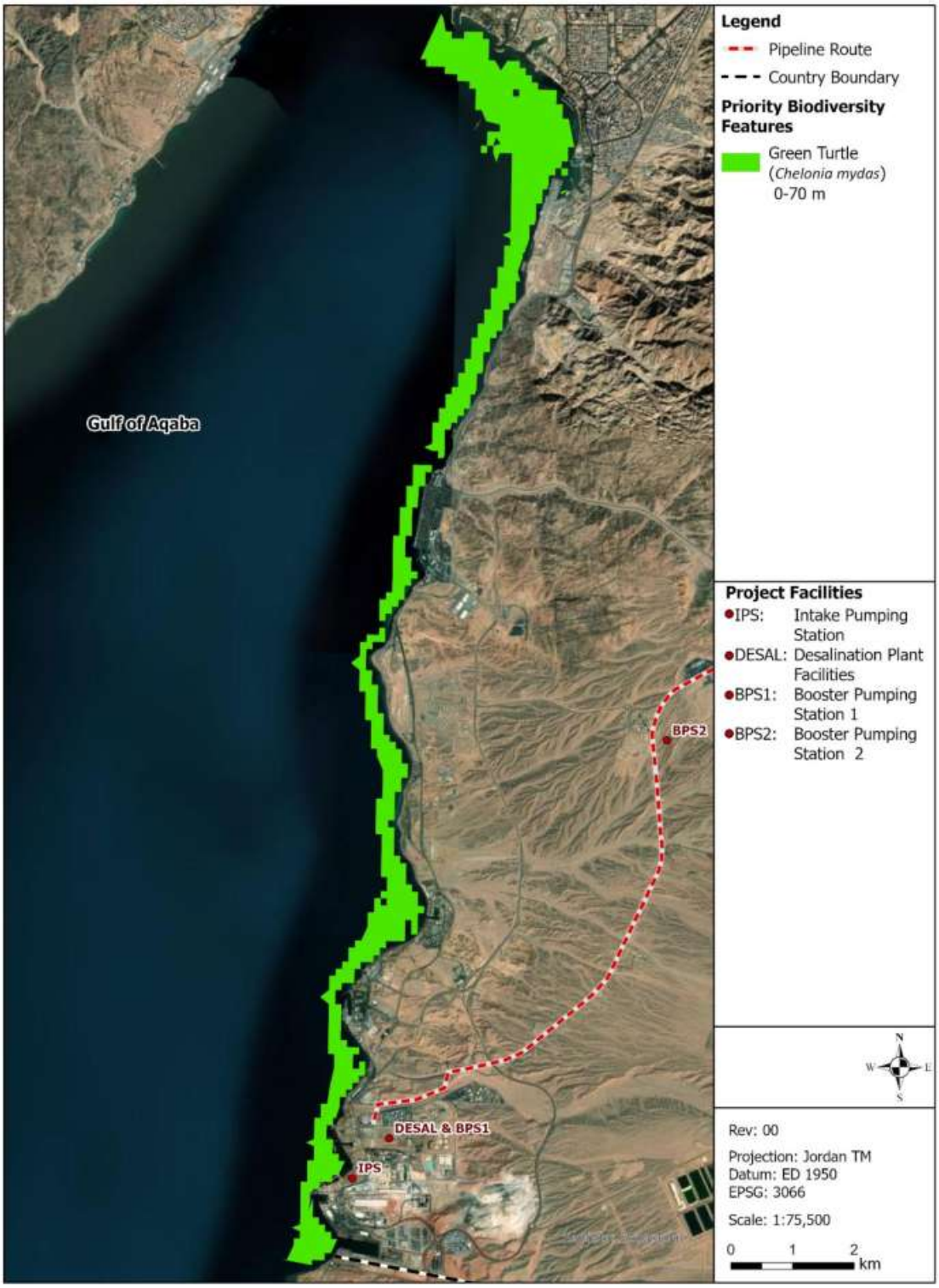


Figure 5-3: PBF Indian Ocean humpback dolphin (*Sousa plumbea*)

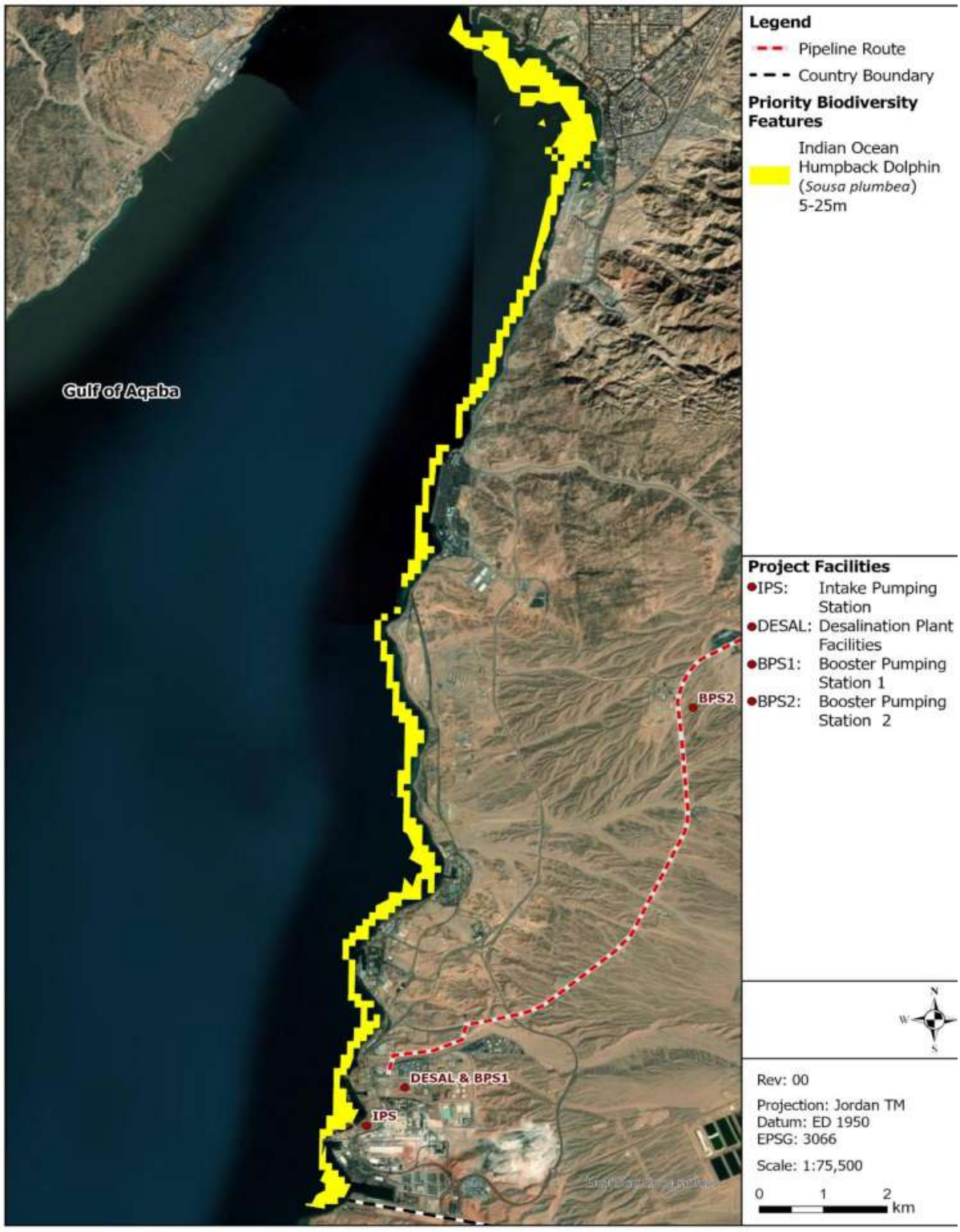


Figure 5-4: PBF Indo-Pacific bottlenose dolphin (*Tursiops aduncus*)

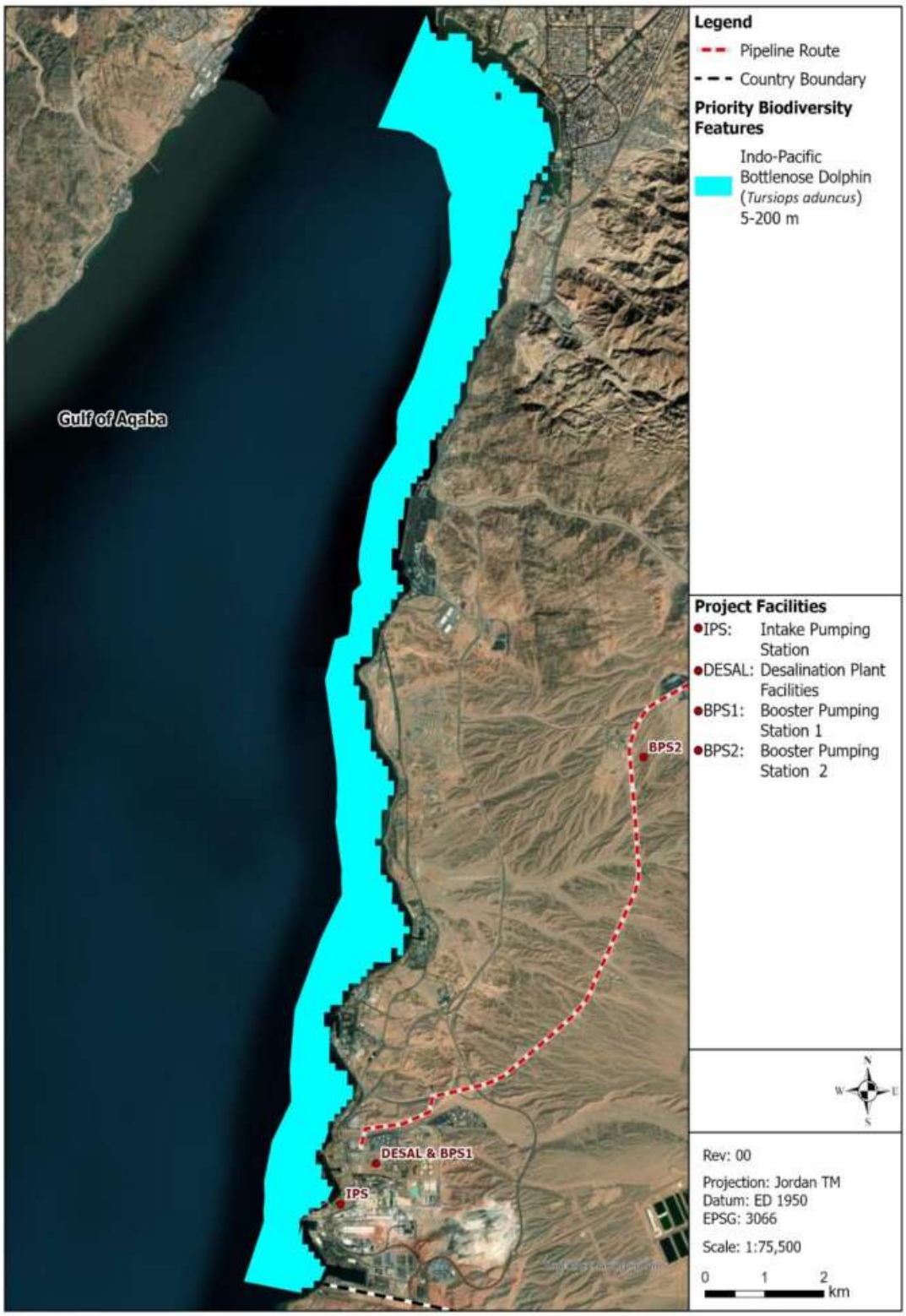


Figure 5-5: Pantropical spotted dolphin (*Stenella attenuate* (subspecies*: S. attenuata attenuata*))

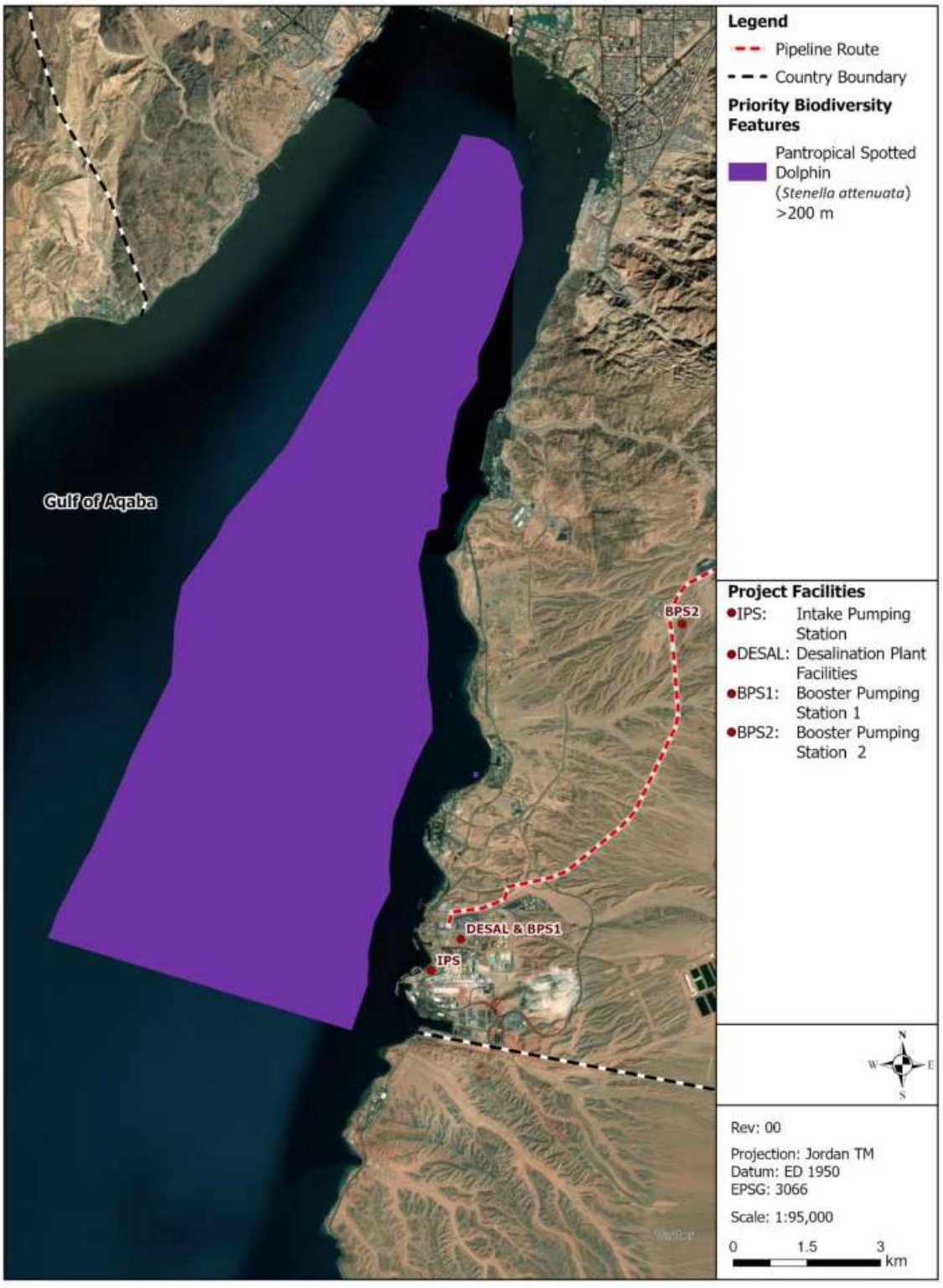


Figure 5-6: PBF Elasmobranchs

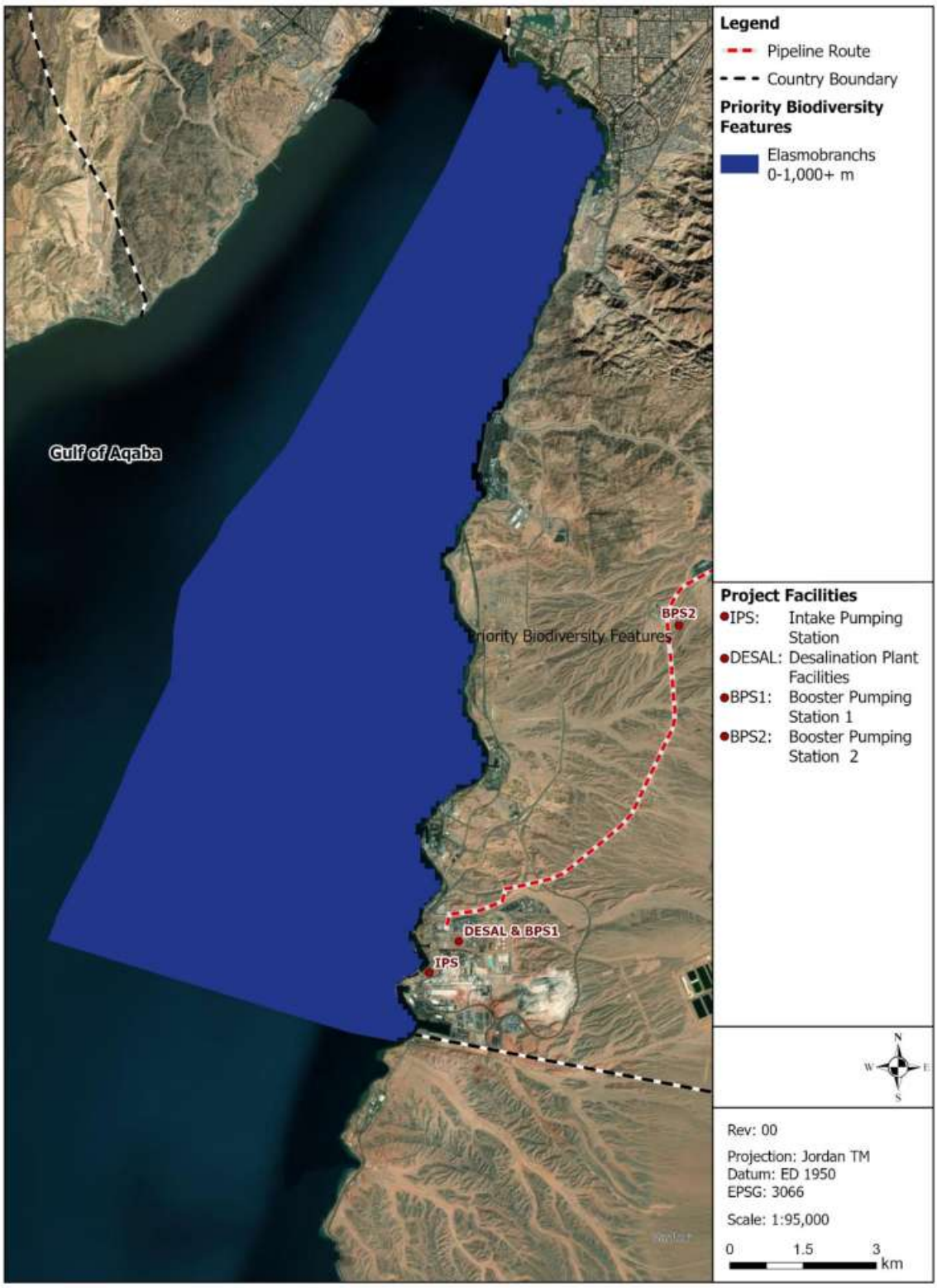


Figure 5-7: CH Humphead Wrasse (*Cheilinus undulatus*)

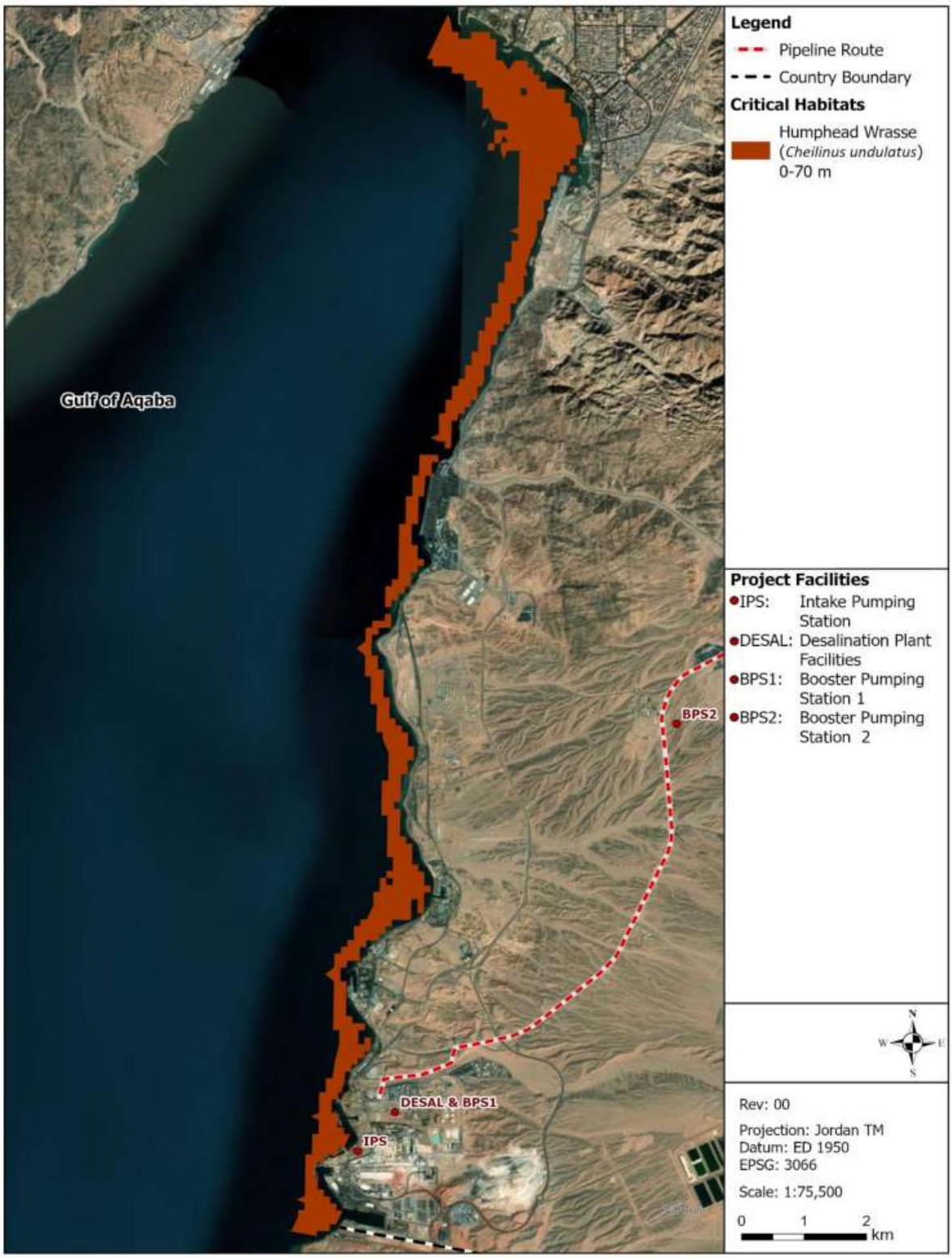


Figure 5-8: CH Sky Emperor (*Lethrinus mahsena*)

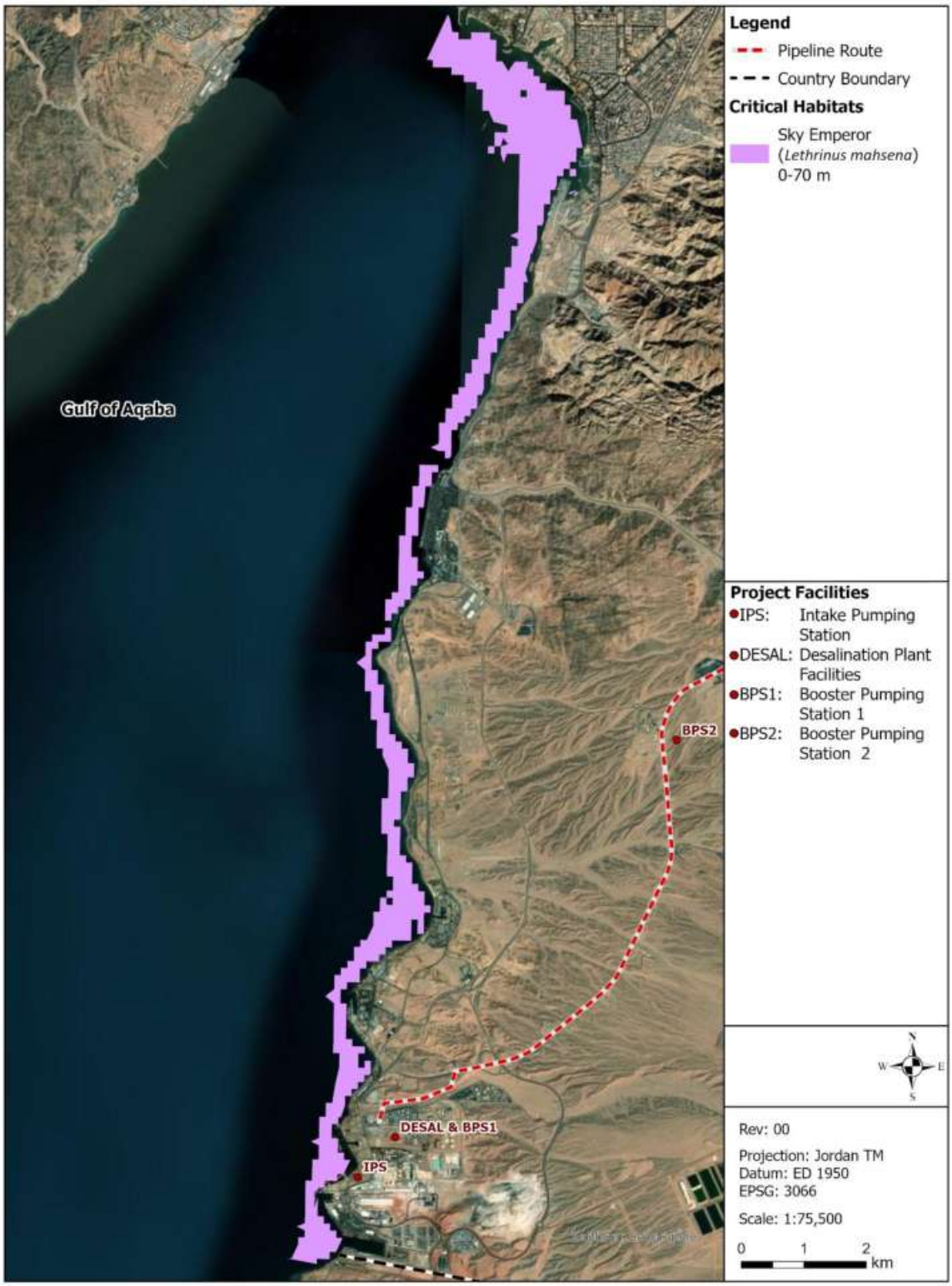


Figure 5-9: CH Red Sea coral grouper (*Plectropomus marisrubri*)

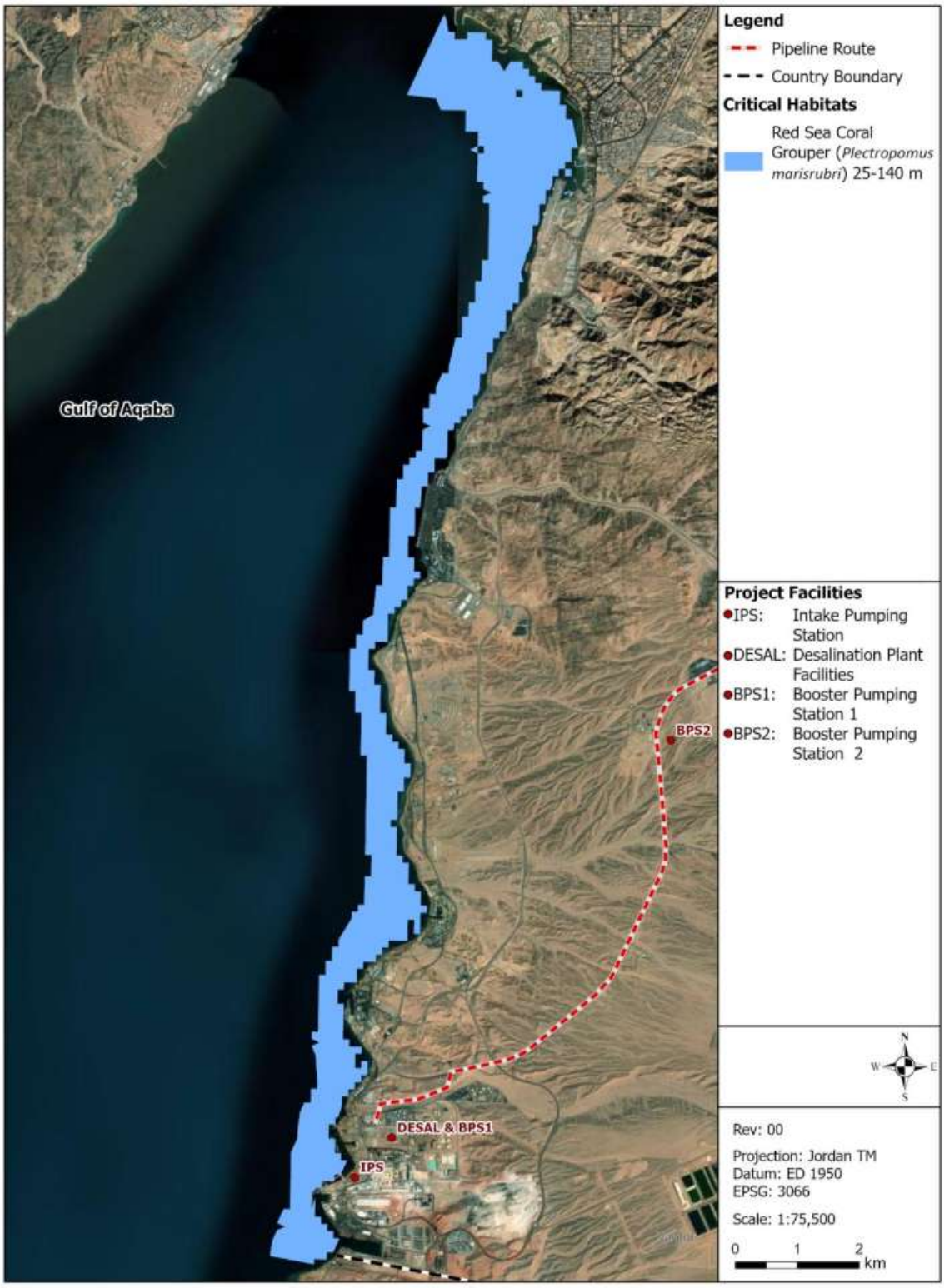


Figure 5-10: CH Giant clam (*Tridacna squamosina*)

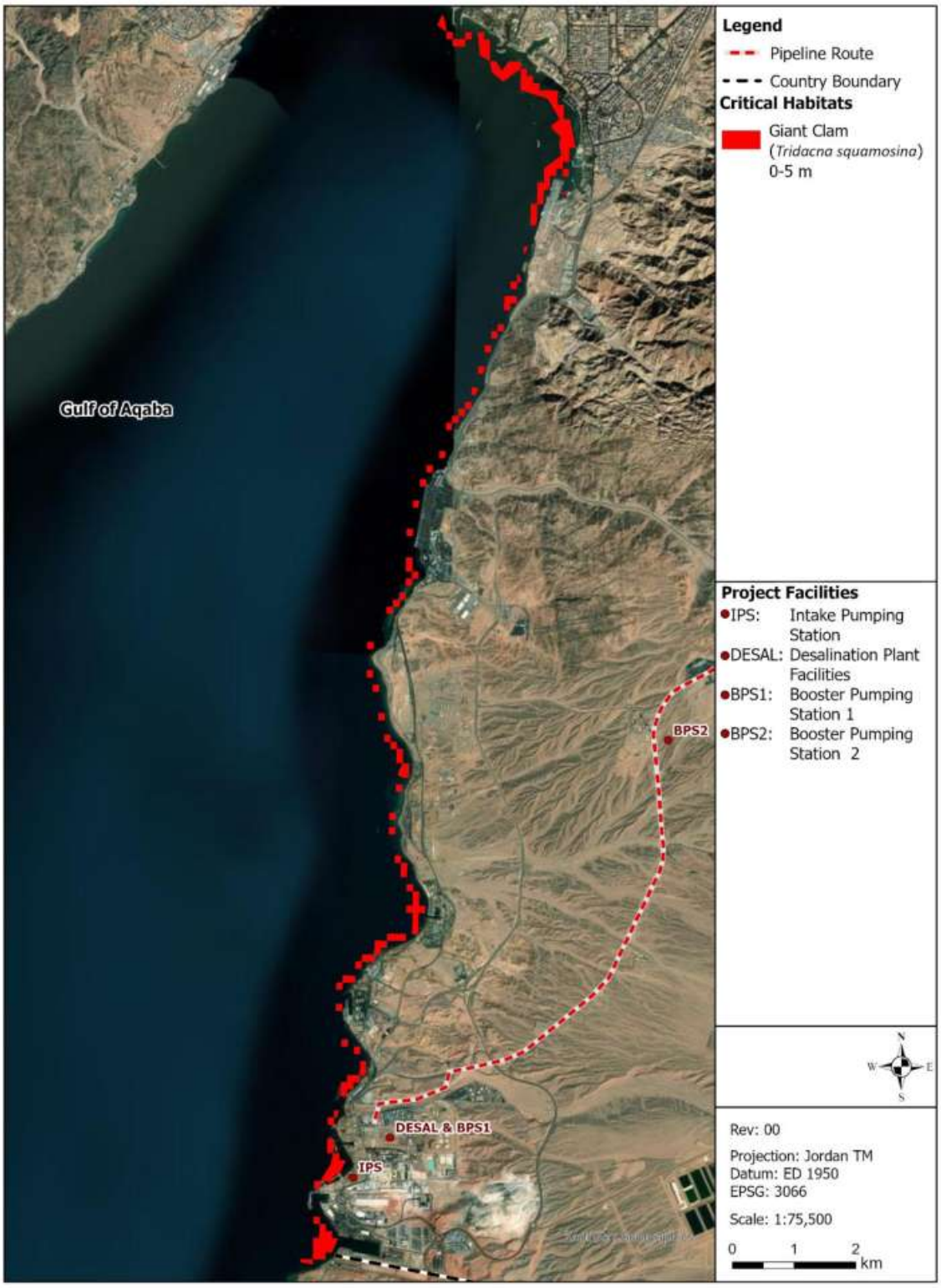


Figure 5-11: CHA Coral Reef

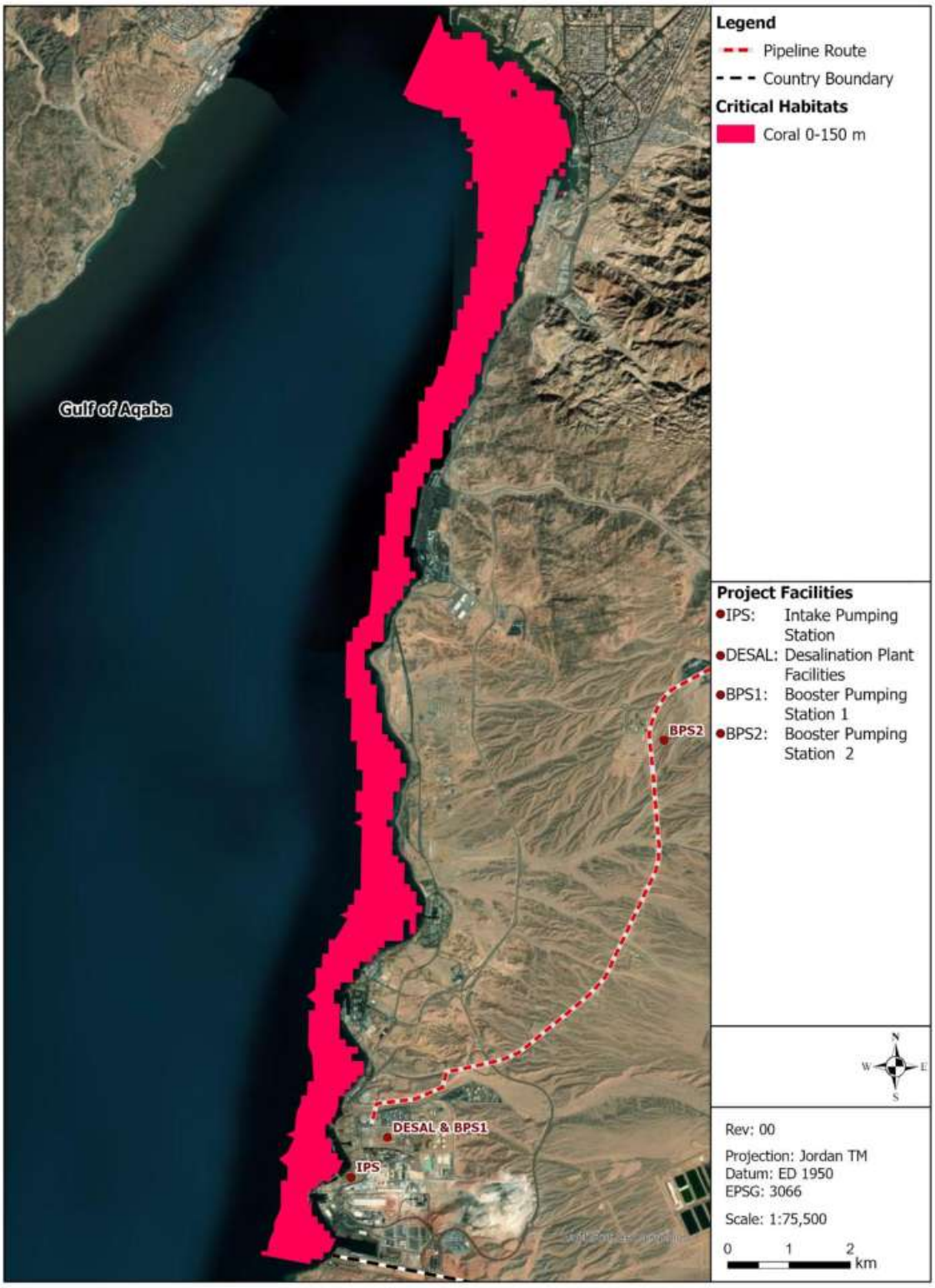
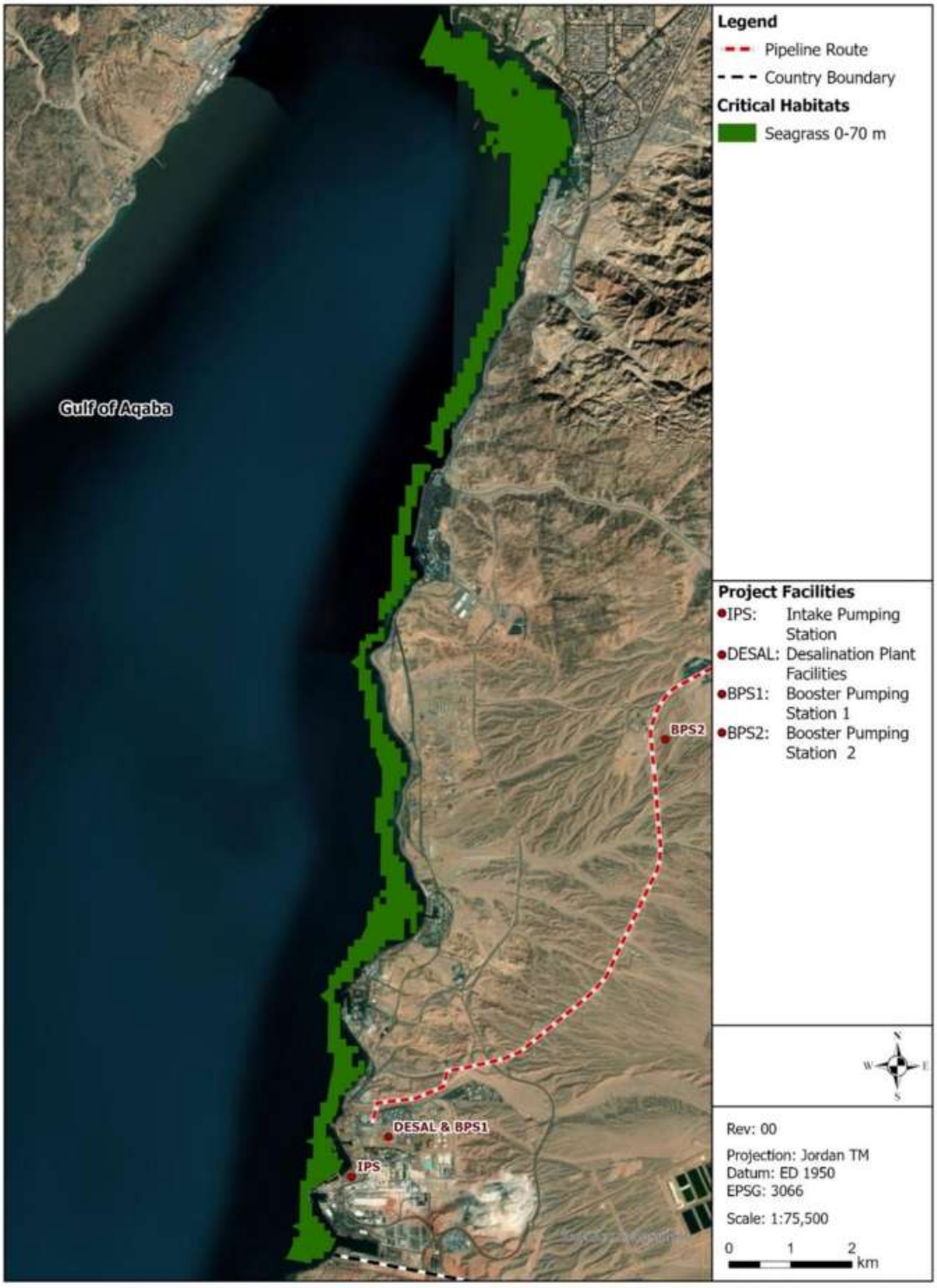


Figure 5-12: CH Seagrass



Appendix 6 Seabirds CHA

Seabirds CHA document to be provided separately “Seabirds CHA”.

Project: Aqaba-Amman Water Desalination and Conveyance (AAWDC)

2025 Environmental and Social Impact Assessment

Appendix 6-3 Terrestrial Baseline Survey Report

Project: Aqaba Amman Water Conveyance and Desalination (AAWDC)
Terrestrial Baseline Survey Report

Report Issue Record

Project: Project: Aqaba Amman Water Conveyance and Desalination (AAWDC)

Title: Terrestrial Baseline Survey Report

Version: Rev 0

Date	Rev	Author	Checked	Approved
6 Nov 2025	0	AdZ	SM / FB	BB

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Abbreviations and Acronyms

AAR	Abu Alanda Reservoir
AAWDC	Aqaba Amman Water Conveyance and Desalination
AMR	Al Muntazah Reservoir
BPS	Booster Pumping Station
BPT	Break Pressure Tank
C	Common
CHA	Critical Habitat Assessment
CR	Critically Endangered
DD	Data Deficient
EDCO	Electricity Distribution Company
EN	Endangered
ESIA	Environmental and Social Impact Assessment
GESP	Genus Species
GIS	Geographical Information Systems
IBA	Important Bird and Biodiversity Areas
IBAT	Integrated Biodiversity Assessment Tool
IPS	Intake Pumping Station
IUCN	International Union for the Conservation of Nature
JEPCO	Jordanian Electrical Power Company
KBA	Key Biodiversity Area
KDE	Kernel Density Estimation
LC	Low Concern
LC	Least Concern
MCM	Million cubic metres

NEPCO	National Electric Power Company
NT	Near Threatened
OECM	Other Effective Area-Based Conservation Measures
OHTL	Overhead Transmission Line
PA	Protected Area
PS ADC	Pump Station Amman Dev Corridor
RA	Rapid Assessment
RE2	Renewable Energy
RGT	Regulating Tank
Solar PV	Solar Photo-Voltaic (PV)
T	Threatened
TBC	The Biodiversity Consultancy
VU	Vulnerable

1 Introduction

This Terrestrial Baseline Survey Report for the Aqaba-Amman Water Desalination and Conveyance Project (AAWDCP), hereafter referred to as the 'Project', was prepared to support the preparation of the terrestrial critical habitat assessment and the 2025 AAWDC Project Environmental and Social Impact Assessment (ESIA).

A Rapid Assessment (RA) field survey of plants and terrestrial animals conducted in July 2025 identified modified and natural habitats along the Conveyance Pipeline route, hereafter referred to as the 'Pipeline', and identified locations to be surveyed during the baseline survey. This baseline survey report has been supported by a standalone Avifauna report (see Appendix 11).

The RA was designed to gain an overview of the habitats and species present along the Project route, including locally important species. It was also designed to identify areas of interest from a biodiversity perspective and to specify the locations to be studied in detail during the Terrestrial Baseline Survey, thereby informing the Critical Habitat Assessment (CHA) and the 2025 AAWDC Project.

Another purpose of the RA was to engage with local stakeholders, especially local biodiversity experts, to gain an understanding of local perspectives on important resources (species, habitats, ecosystems), their distribution, and perceptions on how to manage these in the context of the potential impacts of projects, such as the Project.

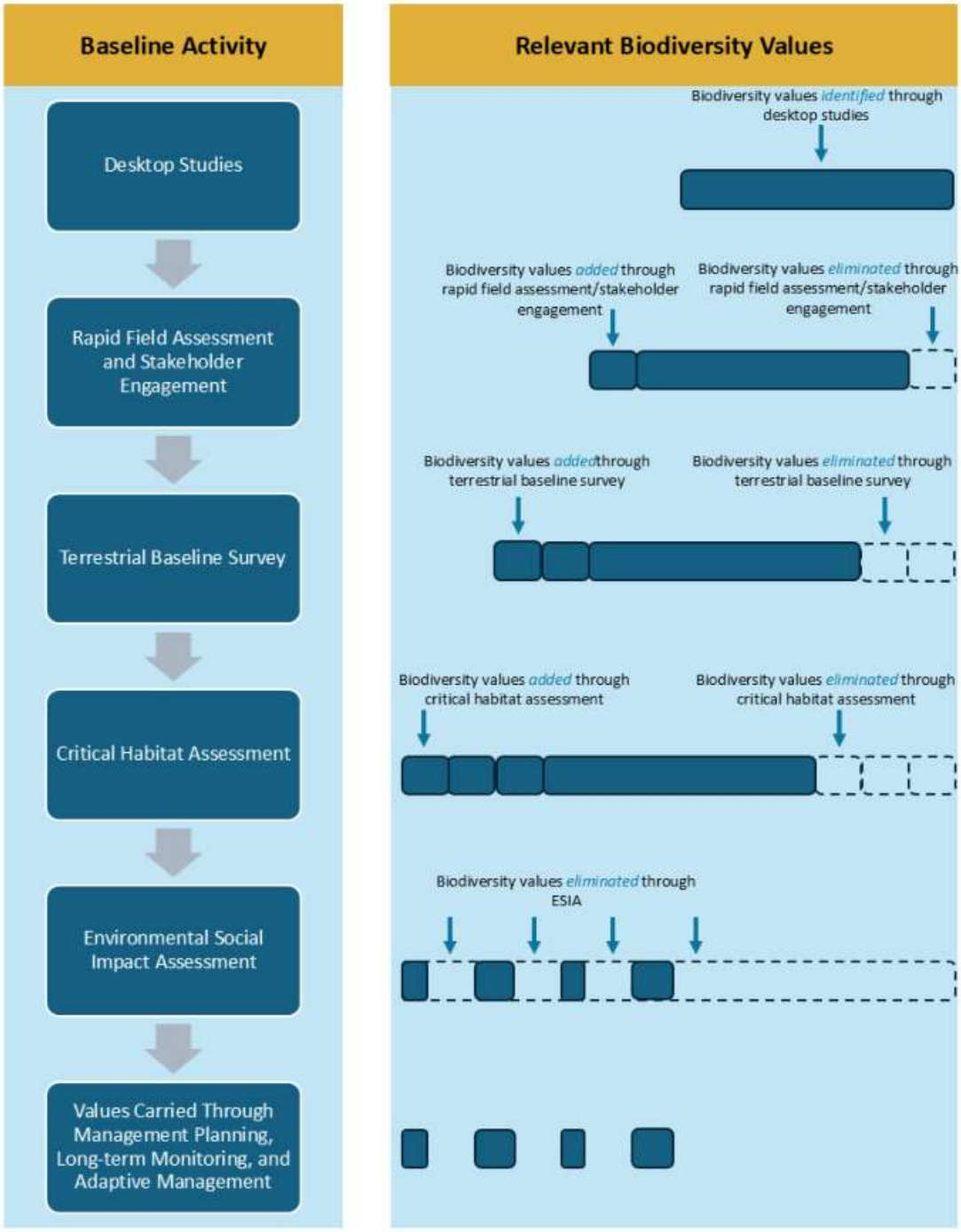
Led by Dr Zuhair Amr, the Jordanian team completed the Terrestrial Baseline Survey quantitative fieldwork and produced a separate report documenting their implementation of the survey methods (described in Chapter 4) and the results of their literature review. Their work was conducted in July and August 2025, has been used to prepare this report.

- Zuhair Amr, ECO Consult, Lead Flora Expert and Local Team Lead
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- Hussian Nassarat, ECO Consult, Fauna Survey support
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- Farah Khouri, ECO Consult, Task Coordinator
- Suhair Hassouneh, ECO Consult, Task support

1.1 Terrestrial Baseline Survey Scope

This report reflects a logical process of gathering and interpreting increasingly accurate biodiversity information, as defined in the guidance Good Practices for Biodiversity Inclusive Impact Assessment and Management Planning (Hardner *et al.,* 2015), summarised in Figure 1.

Figure 1: Process of Identifying Biodiversity Values



The baseline activities completed to date include:

- The Desktop Survey, ostensibly covering a range of 10km either side of the Project (a 20km band)
- The Rapid Assessment that focused on both sides of the Conveyance Pipeline route for approximately 100m, then continued for another 400m beyond the initial 100m, and included a light visual search up to 1km on both sides of the Conveyance Pipeline route
- The Terrestrial Baseline Survey, including:

- Line transects (three 100m transects parallel with the Pipeline route, on both sides, where possible)
- Walking transects (plants, birds, animals and night surveys for terrestrial fauna)
- Quadrats (plants, only in some plots)
- Small mammal traps (select plots)
- Camera traps (select plots)
- Bat roost surveys (select areas)
- Water body counts (birds)
- Carcass surveys (birds).

1.2 Project Description

The proposed AAWDC Project is designed to generate 300 million cubic metres (MCM) of desalinated water per year, supplying Amman (250MCM per year) and Aqaba (50MCM per year) from a new desalination plant located near Aqaba. The Project includes the following components:

Desalination Plant, Intake and Outfall Facilities: A new Desalination Plant will be situated on the coast of the Gulf of Aqaba, within the Aqaba Special Economic Zone, a highly developed industrial area. New facilities to be built include:

- Intake Pumping System (IPS) facilities to extract seawater from the Gulf of Aqaba and deliver it to a new desalination plant
- New Desalination Plant located within the Aqaba Industrial Zone, designed to produce desalinated water that meets applicable national and international drinking water quality standards
- Marine outfall Pipeline to discharge aqueous desalination process by-products (e.g. brine), which will be pre-treated to comply with applicable environmental standards prior to discharge to the Gulf of Aqaba (GoA).

Conveyance System: Comprising an approximately 438km long buried Pipeline to convey desalinated water from the desalination plant to the existing reservoirs of Abu Alanda and Al Muntazah near Amman. Sections of the Conveyance Pipeline will follow the existing Disi Pipeline and the Desert Highway. To support pumping of water and control the pressure within the Pipeline, the Conveyance system design includes:

- Four pumping stations (booster stations BPS1, BPS2 and BPS3 and pumping station PS ADC)
- Two regulating tank facilities (RGT1 and RGT3) and one break pressure tank (BPT)

Renewable Energy Facility: A new Solar photovoltaic (PV) plant and supporting electrical substation will be constructed, located less than 5 km to the east of Qweirah. The Project will use electricity from this Solar PV, as well as from the national electricity transmission and generation companies (National Electrical Power Company (NEPCO), Jordanian Electrical Power Company (JEPCO) and Electricity Distribution Company (EDCO)) through long-term power purchase agreements.

New Overhead Transmission Line (OHTL): to be built and operated by NEPCO. This new electrical transmission line, including an overhead line and fibre optic cable, will connect the renewable energy facility to the desalination plant and one of the pumping stations.

Upgrades to existing water storage reservoirs at Abu Alanda and Al Muntazah in Amman may be required; however, these details have not yet been finalised. It is most probable that at least the Al Muntazah storage reservoir will require expansion.

Based on the current schedule, it is anticipated that AAWDC Project construction activities will commence in 2Q 2026.

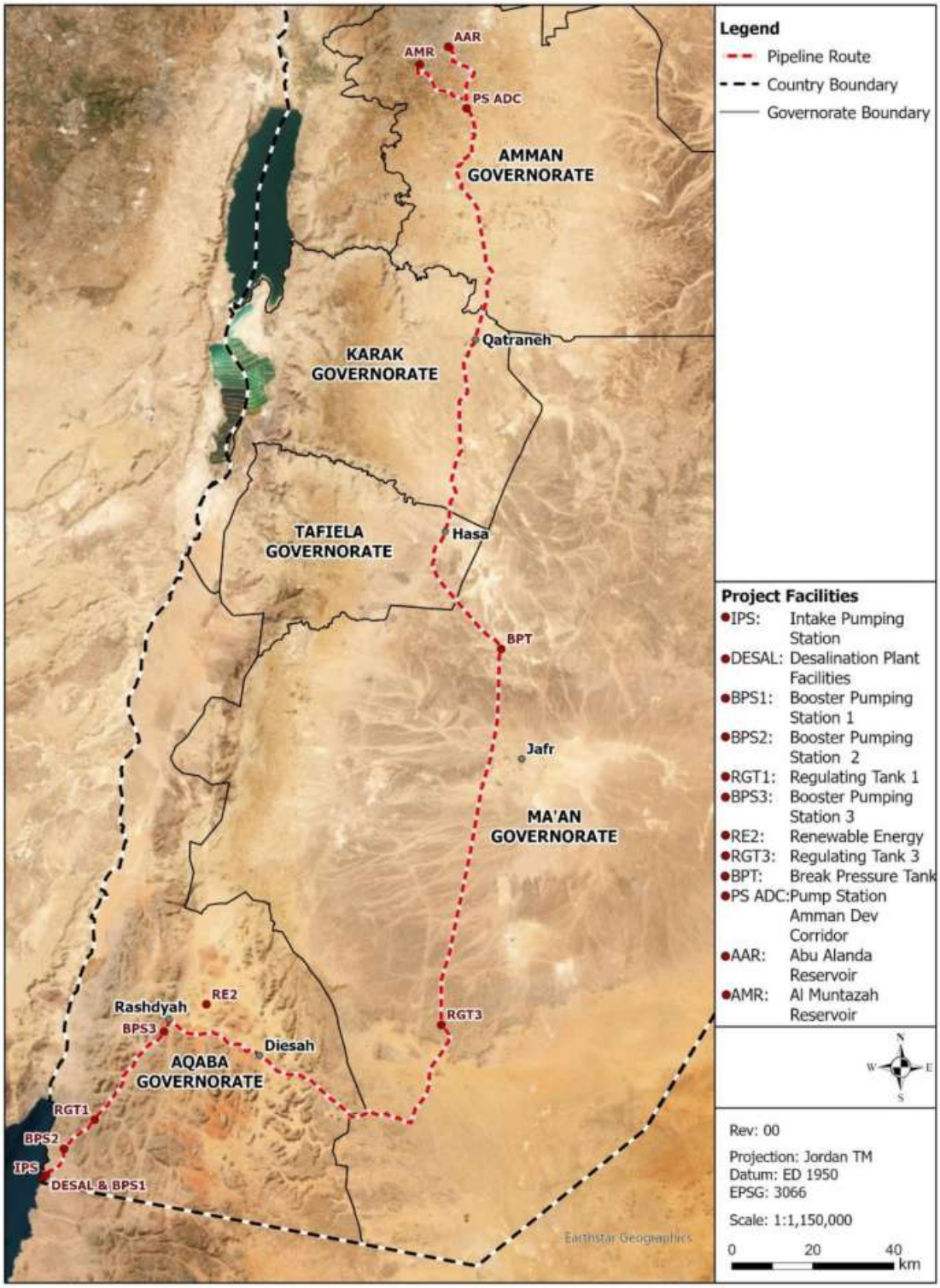
1.3 Stakeholder Engagement

The primary stakeholders that supported the work were:

- Dr Zuhair Amr (Professor of Zoology, Department of Biology, Jordan University of Science and Technology), with over 300 publications in zoology, is one of the foremost zoologists in Jordan. Dr Amr is also a co-author of the National Red Data Book of Mammals in Jordan.
- Dr Hatem Taifour (Director of Conservation, Royal Botanic Garden, Jordan) is also a co-author of the Jordan Red List of Plant Species
- Mr Yaseen Ananbeh leads botanical research efforts at the Royal Society for the Conservation of Nature (RSCN) in Jordan
- Mr Sameh Khatatbeh, a botanical researcher at the Royal Society for the Conservation of Nature (RSCN) in Jordan.

The topics discussed with these stakeholders and integrated into this report and the design of the baseline survey included the biology, occurrence and distribution of locally important species of flora and fauna, especially of species of particular interest, including *Acanthodactylus ahmaddisii,* the Jordanian fringe-fingered lizard, *Iris nigricans,* the Black Iris, *Leopoldia bicolor* and Taccel Hyacinth, identified during the desktop review, past and preferred mitigations, etc.

Figure 2: Project Components and Project Overview



2 Protected Areas, Designated Areas and Proposed Reserves

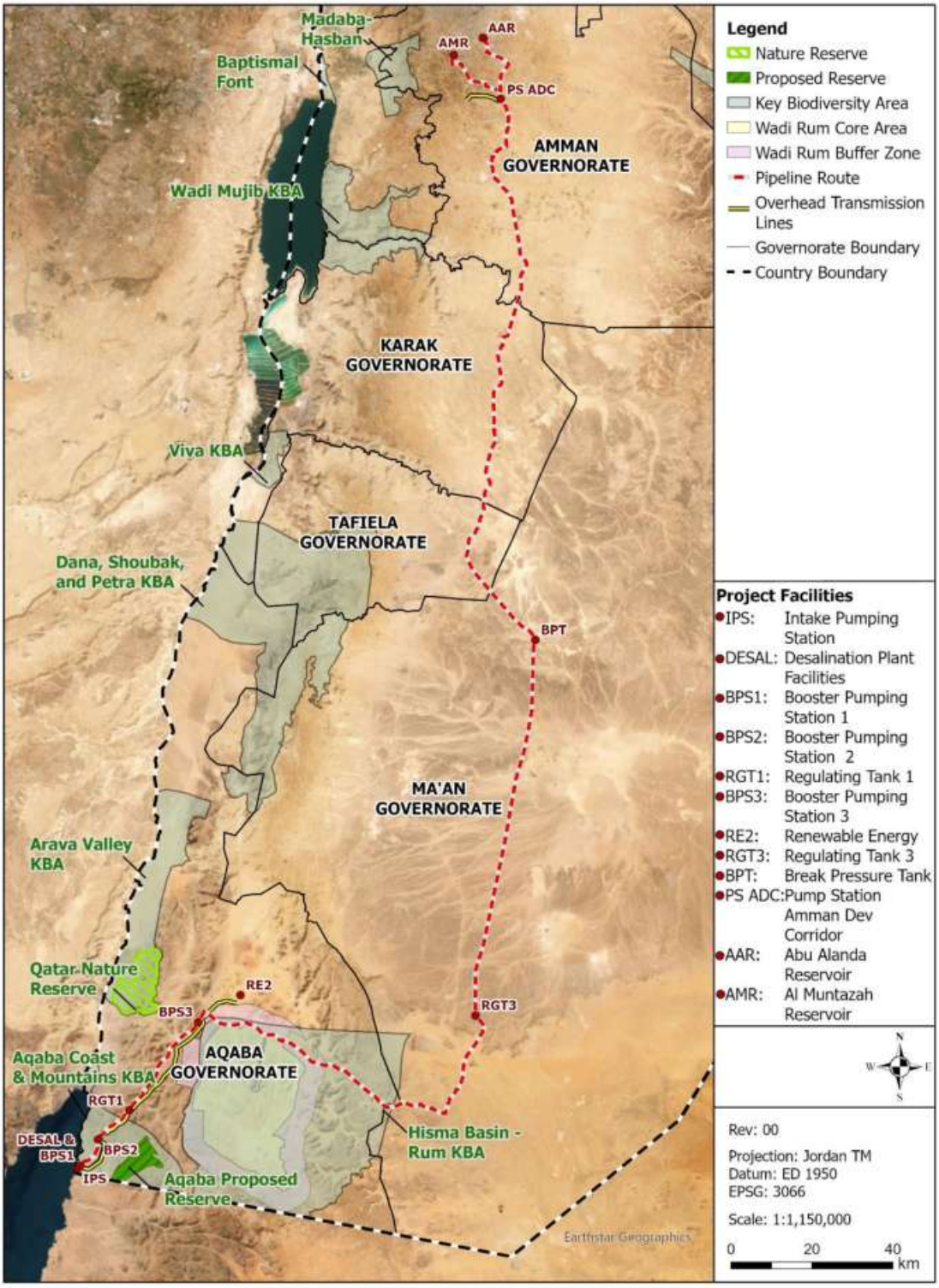
There are five Protected, Designated or Proposed Protected Areas in Jordan that are within 10km of the Project (see Table 1).

The Aqaba Proposed Reserve, the Qatar Nature Reserve, the Wadi Rum Protected Area and the Aqaba Coast and Mountains Key Biodiversity Area (KBA) are all located in the south of Jordan, while the Madaba Hisban KBA is located in the north of Jordan (see Figure 3).

Table 1: Protected Areas, Designated Areas and Proposed Reserves within 10km

Name	Type	Area (sq km)	Distance from Project Facilities and Pipeline	Project Facilities and Pipeline Within the Area
Aqaba Coast & Mountains KBA	KBA (0.6% covered by OECM)	382.5	Within KBA	Sea water reverse osmosis Booster pumping station 1 Booster pumping station 2 Approximately 16.9km of the Pipeline
Aqaba Proposed Reserve	Proposed Protected Area	Unknown	6.4km	No facilities or Pipeline within the area
Hisma Basin – Rum KBA	KBA (34.7% covered by OECM)	2000	Within KBA	Approximately 49km of the Pipeline
Wadi Rum Protected Area	Protected Area	740.0	The Project is immediately adjacent to the northern boundary	Approximately 24km of the Pipeline is within the Wadi Rum buffer area
Qatar Nature Reserve	Nature Reserve	109.94	8.9km	No facilities or Pipeline within the area
Madaba Hisban KBA	KBA (0.0% covered by OECM)	247	8.4	No facilities or Pipeline within the area

Figure 3: Map Showing Location of Protected Areas, Designated Areas and Proposed Reserves



2.1.1 Aqaba Coast and Mountains KBA

The Aqaba Coast and Mountains KBA covers approximately 382.5 km^2 of southeastern Jordan, including all of its coastline (Figure 3), and encompasses an elevation gradient of 1,592m from the GoA coast into the Aqaba Mountains. The Project Desalination Plant site, BPS1 and BPS2, and approximately 16.9km of the Pipeline are located within the KBA. However, only 0.6% of the KBA area is covered by protected areas or Other Effective Area-Based Conservation Measures (OECM). Eight species qualify the area as a KBA (Table 2) (BirdLife International, 2025).

Table 2: Bird Populations in Aqaba Coast and Mountains KBA Meeting IBA/KBA Criteria

Scientific Name	Common Name	Red List category	Season	Year(s) of Population Estimate	Population	Units
Species group – soaring birds/cranes	A4iv	-	Passage	1993	50000-99999	Individuals
Accipter brevipes	Levant Sparrowhawk	Least Concern	Passage	1995 - 2000	3000	Individuals
Falco concolor	Sooty Falcon	Vulnerable	Breeding	1993	present	-
Curraca leucomelaena	Arabian Warbler	Least Concern	Resident	1993	present	-
Araya squamiceps	Arabian Babbler	Least Concern	Resident	1993	present	-
Onychognathus tristamii	Tristram's Starling	Least Concern	Resident	1993	present	-
Oeanthe monacha	Hooded Wheatear	Least Concern	Resident	1993	present	-
Capodacus synoicus	-	-	Winter	1993	present	-

2.1.2 Aqaba Proposed Reserve

The Aqaba Proposed Reserve (Aqaba Mountains Reserve) falls entirely within the footprint of the Aqaba Coast and Mountains KBA, and lies to the east of the Project facilities. The proposed reserve covers an area of 57.7km^2 and is entirely within the Aqaba Mountains, approximately 6.4km distant from the Project at its closest point. The elevated location of the proposed reserve relative to the Project, the intervening mountains, and its distance make it unlikely that construction activities on the Project will have an impact on its protected resources.

2.1.3 Hisma Basin – Rum KBA

The Hisma Basin – Rum KBA consists primarily of a desert ecosystem (97%), approximately 2% shrubland, and 1% artificial (e.g., constructed) land. Twenty-two bird species and three mammal species (*Felis margarita* (Sand Cat), *Capra nubiana* (Nubian Ibex), and *Gazella subgutturosa* (Goitered Gazelle) are

listed as important in the area (BirdLife International, 2025). The Pipeline will transit through the northern extent of the KBA for approximately 49km as it traverses from west to east.

2.1.4 Wadi Rum Protected Area

The Wadi Rum Protected Area (PA) covers an extent of approximately 742km^2 and lies entirely within the Hisma Basin – Rum KBA. It is a mixed site of natural and cultural outstanding values. It is the largest protected area in Jordan, covering almost one per cent of the country's total surface area. It is a major part of the Hisma desert positioned to the east of the Jordan Rift Valley and south of the steep escarpment of the central Jordanian plateau. The Pipeline extends from east to west along the northern perimeter of Wadi Rum, remaining outside the boundary of the PA; however, approximately 24km of its route traverses the Wadi Rum Buffer Zone that encircles the PA.

2.1.5 Qatar Nature Reserve

The Qatar Nature Reserve of Jordan is a Terrestrial and Inland Waters Protected Area with an area of approximately 110km^2, located in the southeast of Jordan, north of Aqaba. The western edge of the protected area is 8.9km from the Pipeline; its position on the western side of the mountain highlands effectively isolates it from potential impacts of the Project construction and operation.

2.1.6 Madaba Hisban KBA

The Madaba Hisban Key Biodiversity Area spans approximately 259 km² at an elevation of around 900 meters and is recognised for its ecological significance, particularly for birds and rare plants. The landscape is primarily former steppe land, now converted to dry cereal cultivation, with areas of irrigated farmland and pasture. It supports notable species, such as the Eastern Imperial Eagle (*Aquila heliaca*), a qualifying species for its designation, as well as rare and endemic plants, including *Colchicum tunicatum*, *Romulea bulbocodium*, and *Globularia arabica*. The site is under pressure from agricultural expansion, groundwater depletion, and urban development. Despite its designation as a KBA, it currently lacks formal protection.

3 Results of Desktop Study

To support the planning of the baseline survey, a review of available literature was conducted with the assistance of stakeholders consulted during the survey planning process.

The earliest records of mammals from Wadi Rum are largely anecdotal from the book "Portrait of a Desert: The Story of an Expedition to Jordan" by Guy Mountfort (1965) and reflect the relatively short 62-year span of studying the biota of Jordan (the expedition was in 1963). While subsequent studies do not specifically identify sites that can be traced back to the Project facilities, records of fauna from the general area of Aqaba and Wadi Rum are considered the most relevant and are presented below.

3.1.1 Mammals

During the past 65+ years (since Moutfort, 1965), studies of mammals of the Aqaba region show that two species of bats, seven small rodents, one hare, one artiodactyl and three carnivores have been recorded from the Aqaba area (Table 3). Only the Nubian ibex (*Capra nubiana*) is considered Vulnerable globally (locally Threatened). The Wolf (*Canis lupus*) and the Sand Fox (*Vulpes rueppellii*) are also considered Threatened locally.

Of the species in Table 3**,** *Lepus lepus*, *Capra nubiana*, and *Canis lupus* populations are considered to be decreasing, *Gerbillus gerbillus* populations are considered to be stable, while *Vulpes vulpes* populations are increasing, and the status of *Vulpes rueppellii* is unknown (Eid, *et al*., 2020).

Table 3: Terrestrial Mammals Recorded From the General Vicinity of Aqaba and Their Status

Common Name	Scientific Name	Location	Reference	IUCN Status*	Local Status*
European Free-tailed Bat	*Tadarida teniotis*	Aqaba	(Benda *et al*., 2010)	LC	C
Kuhl's Pipistrelle	*Pipistrellus kuhli*	Aqaba	(Benda *et al*., 2010)	LC	C
Wagner's Gerbil	*Dipodillus dasyurus*	Al Jafr	(Qumsiyeh *et al*., 1986; Disi & Amr, 1988)	LC	C
Eastern Spiny Mouse	*Acomys dimidiatus*	Aqaba	(Allen, 1915; Disi & Amr, 1988)	LC	C
Golden Spiny Mouse	*Acomys russatus*	Aqaba	(Amr, 2012)	LC	C
Lesser Egyptian Gerbil	*Gerbillus gerbillus*	Aqaba	Allen (1915)	LC	C
Baluchistan Gerbil	*Gerbillus nanus*	Aqaba	Allen (1915; Kock & Nader, 1983)	LC	C
Sundevall's Jird	*Meriones crassus*	Aqaba	(Disi & Amr, 1988)	LC	C
Fat Sand Jird	*Psammomys obesus*	Aqaba	(Amr, 2012)	LC	C

Common Name	Scientific Name	Location	Reference	IUCN Status*	Local Status*
Arabian Hare	*Lepus capensis*	Aqaba Highway	(Amr & Disi, 1988)	LC	C
The Nubian Ibex	*Capra nubiana*	Aqaba Mountains	(Amr, 2012)	V	T
The Wolf,	*Canis lupus*	Aqaba	(Bromage, 1954)	LC	T
Sand Fox	*Vulpes rueppellii*	2km SE Aqaba	(Qumsiyeh *et al*., 1993)	LC	T
Red Fox	*Vulpes vulpes*	observed	Amr observation	LC	C
*IUCN: LC = Least concern, V = Vulnerable; Local: C = Common, T = Threatened					

In the Wadi Rum area, 27 species of mammal, represented by 12 families, have been recorded (Table 4), of which the Nubian Ibex (*Capra nubiana*) is listed as Vulnerable globally and Endangered locally. Of the other species recorded in the area of Wadi Rum, the Sand Cat (*Felis margarita*) is listed as Critically Endangered in Jordan, and an additional five species are listed as Endangered in Jordan (*Canis Lupus*, *Vulpes cana*, *Lepus capensis*, and *Procavia capensis*), and three species are listed as Near Threatened in Jordan (*Rhinolophus hipposideros*, *Barbastella leucomelos*, and *Ellomys melanurus*). All locally listed species mentioned above also have declining populations (Eid *et al*., 2020). The remaining species found to occur in the Wadi Rum area, listed in Table 4, are considered to be of Least Concern and their populations are considered to be increasing, stable (*Sekeetomys calurus*, *Jaculus jaculus*, *Hypsugo ariel*, *Paraechinus aethiopicus* and *Rhinolopus clivosus*) or decreasing in the case of one species, *Acomys russatus*, the Golden Spiny Mouse (Eid *et al*., 2020).

A summary on the Arabian Leopard in Jordan by Qarqaz & Abu Baker (2006) confirms the historical presence of leopards in the vicinity of Wadi Rum, but stated the last confirmed sighting of a leopard from 1987 and mentioned anecdotal rumours of leopards recently crossing into Jordan from the southeastern border with Saudi Arabia. In the absence of recent confirmed sightings, leopards have been omitted from the list in Table 4.

Chiroptera (bats) are represented by eight desert-adapted species within three families. Horseshoe bats are represented by two species: Geoffroy's Horseshoe Bat (*Rhinolophus clivosus*) and the lesser horseshoe bat (*Rhinolophus hipposideros*). The Lesser Horseshoe Bat was observed near Al Ghal village (at approximately 29.52891° N, 35.60094° E.) east of Wadi Rum and approximately 8 km southwest of the Pipeline. The family Vespertilionidae comprises five species, including the rare Asian Barbastelle, *Barbastella leucomelas*. The family Molossidae is represented by a single species, the European Free-tailed Bat, which has a wide distribution range. Benda *et al*. (2010) recorded eight species of bats from Wadi Rum and its vicinity. Bates & Harrison (1989) recorded two bat species, Eptesicus bottae and Otonycteris hemprichii, at Lawrence's Pool in the Wadi Rum.

Abu Baker & Amr (2018) studied the rodents of Wadi Rum, recording a total of 10 species. Records of the Afghan Fox, *Vulpes cana*, and its distribution in Wadi Rum was documented by Abu Baker *et al*. (2004).

Family Erinaceidae is represented by a single species, the Ethiopian Hedgehog, *Paraechinus aethiopicus*, a true desert species adapted to survive in arid habitats.

Table 4: Terrestrial Mammals Recorded From the General Vicinity of Wadi Rum and Their IUCN Status

Common Name	Scientific Name	Location	Reference	IUCN Status*	Local Status*
Ethiopian Hedgehog	*Paraechinus aethiopicus*	Wadi Rum	Eid, *et al*., 2020	LC	LC
Asiatic Jackal	*Canis aureus*	Wadi Rum	Amr *et al*., 2004	LC	LC
Wolf	*Canis lupus*	Wadi Rum	Qumsiyeh *et al*., 1993	LC	EN
Blanford's Fox	*Vulpes cana*	Wadi Rum	Abu Baker *et al*. (2004).	LC	EN
The Red Fox	*Vulpes vulpes*	Wadi Rum	Eid, *et al*., 2020	LC	LC
The Sand Cat	*Felis margarita*	Wadi Rum	Mountfort,1965, Hemmer, 1978	LC	CR
Geoffroy's Horseshoe Bat	*Rhinolophus clivosus*	Wadi Rum	Benda *et al*. (2010)	LC	LC
Lesser Horseshoe Bat	*Rhinolophus hipposideros*	Wadi Rum	Benda *et al*. (2010)	LC	NT
Hemprich's Long eared Bat	*Otonectris hemprichii*	Wadi Rum	Bates & Harrison (1989), Benda *et al*. (2010)	LC	LC
Desert Pipistrelle	*Hypsugo ariel*	Wadi Rum	Benda *et al*. (2010)	DD	LC
Asian Barbastelle	*Barbastella leucomelas*	Wadi Rum	Benda *et al*. (2010)	LC	NT
Botta's Serotine Bat	*Eptesicus bottae*	Wadi Rum	Bates & Harrison (1989), Benda *et al*. (2010)	LC	LC
Northeast African Long Ear Bat	*Plecotus christii*	Wadi Rum	Benda *et al*. (2010)	DD	LC
European Free-tailed Bat	*Tadarida teniotis*	Wadi Rum	Benda *et al*. (2010)	LC	LC
The Southwest Asian Garden Dormouse	*Eliomys melanurus*	Wadi Rum	Abu Baker & Amr (2018)	LC	NT
Three-toed Jerboa	*Jaculus jaculus*	Wadi Rum	Abu Baker & Amr (2018)	LC	LC
Golden Spiny Mouse	*Acomys russatus*	Wadi Rum	Abu Baker & Amr (2018)	LC	LC
Eastern Spiny Mouse	*Acomys dimidiatus*	Wadi Rum	Abu Baker & Amr (2018)	LC	LC

Common Name	Scientific Name	Location	Reference	IUCN Status*	Local Status*
Baluchistan Gerbil	*Gerbillus nanus*	Wadi Rum	Abu Baker & Amr (2018)	LC	LC
Chessman's Gerbil	*Gerbillus cheesmani*	Wadi Rum	Abu Baker & Amr (2018)	LC	LC
Wagner's Gerbil	*Gerbillus dasyurus*	Wadi Rum	Abu Baker & Amr (2018)	LC	LC
Sand evall's Gerbil	*Merionus crassus*	Wadi Rum	Abu Baker & Amr (2018)	LC	LC
Fat Sand Rat	*Psammomys obesus*	Wadi Rum	Abu Baker & Amr (2018)	LC	LC
The Bushy-tailed Jird	*Sekeetamys calurus*	Wadi Rum	Abu Baker & Amr (2018)	LC	LC
Arabian Hare	*Lepus capensis*	Wadi Rum	Eid, *et al*., 2020	LC	EN
Rock Hyrax	*Procavia capensis*	Wadi Rum	Eid, *et al*., 2020	LC	EN
Nubian Ibex	*Capra nubiana*	Wadi Rum	Hays & Bandak (1997) and Catullo *et al*. (1996)	VU	EN
*IUCN: LC = Least concern, VU = Vulnerable, NT = Near Threatened, EN = Endangered, CR = Critically Endangered, DD = Data Deficient					

Carnivores are represented by four species. The Afghan Fox (*Vulpes cana)* is a rare species of Jordan with limited distribution in sandstone deserts. Cats are represented by a single species, the Sand Cat (*Felis margarita*) listed as Near Threatened by the IUCN. The remaining carnivores are the Asiatic Jackal (*Canis aureus*) and the Wolf (*Canis lupus*).

Order Rodentia is represented by three families. The Southwest Asian Garden Dormouse (*Eliomys melanurus*), a member of the family Gliridae, is a relict species characterised by a remarkable distribution pattern, despite being originally an arboreal species. Populations of this species may represent relics in the deserts of Jordan. Family Muridae includes eight species. The Bushy-tailed Jird (*Sekeetamys calurus*) has a limited distribution in Jordan, with all records coming from its southern part. The Three-toed Jerboa, (*Jaculus jaculus*) is the only representative of jerboas in Wadi Rum.

In more urban areas, small mammals have been reported from around Ghamadan and Amman National parks, including the house mouse (*Mus musculus*), Tristram's Jird (*Meriones tristrami*), the Levant vole (*Microtus guentheri*) and the invasive Brown Rat (*Rattus norvegicus*) (Obuch, 2018).

3.1.2 Reptiles

There are a few published studies on reptiles in the vicinity of the Project and the information on reptiles presented below in Table 5 is from three publications (Disi *et al*., 2001, Amr & Disi, 2011 and Melnikov *et al*., 2012) and supplemented by information on IUCN and local status and trends from Eid *et al*., (2020).

Of all the species identified to occur in the general area of the Project (Table 5), the Aqaba Agama (*Pseudotrapelus aqabensis*) was not listed in the IUCN Red List and its conservation status is unclear. Of the remaining reptiles identified as likely to occur in the area of the Project, the Egyptian Spiny-Tailed

Lizard (*Uromastyx aegyptia*) was the only species with a conservation status (Vulnerable) other than Least Concern. *U. aegyptia* is also recorded as having a declining population globally, while all other reptile species in Table 5 had a stable (or unknown) population profile.

Table 5: Terrestrial Mammals Recorded in the General Vicinity of Wadi Rum and Their IUCN Status

Species	Common Name**	Location	Reference	IUCN Status*	Local Status*
Family Gekkonidae					
Bunopus tuberculatus	The Baluch Ground Gecko	Southern Jordan, including Aqaba & Wadi Rum	Disi *et al*. (2001),	LC	C
Cyrtopodion scabrum	Rough Bent-Toed Gecko	Southern Jordan, including Aqaba & Wadi Rum	Disi *et al*. (2001),	LC	LC
Pristurus guweirensis	Blanford's Semaphore Gecko	Southern Jordan, including Aqaba & Wadi Rum	Disi *et al*. (2001),	LC	C
Ptyodactylus guttatus	Spotted/Sinai Fan-fingered Gecko	Southern Jordan, including Aqaba & Wadi Rum	Disi *et al*. (2001),	LC	C
Ptyodactylus hasselquistii	Hasselquist's Fan-footed Gecko	Southern Jordan, including Aqaba & Wadi Rum	Disi *et al*. (2001),	LC	C
Tropiocolotes nattereri	Natterer's Pigmy Gecko	Southern Jordan, including Aqaba & Wadi Rum	Disi *et al*. (2001),	LC	C
Family Agamidae					
Pseudotrapelus aqabensis	Aqaba Agama	Southern Jordan, including Aqaba & Wadi Rum	Disi *et al*. (2001), Melnikov *et al*. (2012)	Not Listed	NE
Uromastyx aegyptia	Egyptian Spiny–tailed Lizard	Southern Jordan, including Aqaba & Wadi Rum	Disi *et al*. (2001),	VU	NT
Family Lacertidae					
Acanthodactylus boskianus	Bosk's Fringe-toed Lizard	Southern Jordan, including Aqaba & Wadi Rum	Disi *et al*. (2001),	LC	C

Species	Common Name**	Location	Reference	IUCN Status*	Local Status*
Mesalina brevirostris	Blanford's Short-nosed Desert Lizard	Southern Jordan, including Aqaba & Wadi Rum	Disi *et al*. (2001),	LC	C
Mesalina olivieri	Olivier's Sand Lizard	Southern Jordan, including Aqaba & Wadi Rum	Disi *et al*. (2001),	LC	C
Family Scincidae					
Chalcides ocellatus	Ocellated Skink	Southern Jordan including Aqaba & Wadi Rum	Disi *et al*. (2001),	LC	C
Family Colubridae					
Platyceps elegantissimus	Elegant Racer	Southern Jordan, including Aqaba & Wadi Rum	Disi *et al*. (2001), Amr & Disi (2011)	LC	T
Platyceps rhodorachis	Wadi Racer	Southern Jordan, including Aqaba & Wadi Rum	Disi *et al*. (2001), Amr & Disi (2011)	LC	C
Psammophis schokari	Forskål's Sand Snake	Southern Jordan, including Aqaba & Wadi Rum	Disi *et al*. (2001), Amr & Disi (2011)	LC	C
Spalerosophis diadema	Diadem Snake	Southern Jordan, including Aqaba & Wadi Rum	Disi *et al*. (2001), Amr & Disi (2011)	LC	C
Telescopus dhara	Arabian Cat Snake	Southern Jordan, including Aqaba & Wadi Rum	Disi *et al*. (2001), Amr & Disi (2011)	LC	C
Family Viperidae					
Echis coloratus	Hajar Saw-Scaled Viper	Southern Jordan, including Aqaba & Wadi Rum	Disi *et al*. (2001), Amr & Disi (2011)	LC	C
*IUCN: LC = Least concern, NT = Near Threatened, DD = Data Deficient; Local: C = Common, NT = Near Threatened, T = Threatened, NE = Not Evaluated ** Based on the IUCN Red List					

3.1.3 Vegetation

The review of vegetation is based entirely on "A State-of-the-Art Vegetation map for Jordan: A New Tool for Conservation in a Biodiverse Country" (Taifoor et al., 2022) and covers primarily the area of Southern Jordan, including Aqaba, Wadi Rum, and the Al-Jafr depression.

Southern Jordan lies primarily within the Saharo-Arabian (Saharo-Sindian/Nubo-Sindian) regional subzone, with embayments of Sudanian (thermophilous) elements along the Dead Sea–Aqaba corridor and localised Mediterranean enclaves on high, cooler slopes (e.g., the Ras an–Naqab–Sharah range). This juxtaposition produces a mosaic of desert, halophytic, and enclavic woodland/shrubland communities.

Plant cover is typically sparse ranging from 1–15%. Early successional grasses (e.g., *Stipellula capensis*) and sedges (*Carex divisa*) yield to dune-binding shrubs, such as *Panicum turgidum* and *Zilla spinosa*, with a late-successional/edaphic climax dominated by *Haloxylon persicum* (white saxaul). Frequent associates include *Retama raetam*, *Hammada salicornica*, *Anabasis articulata*, and *Caroxylon tetrandrum*; characteristic annuals include *Neurada procumbens*. Dune stabilisation depends on episodic wet years and protection from trampling. Saxaul and Retama serve as keystone nurse shrubs, enhancing microsite moisture and facilitating herbaceous diversity.

Canopy is typically discontinuous, with shrub and annual layers responding to episodic rainfall pulses. Dominant trees are *Vachellia tortilis* subsp*. tortilis* and *V. tortilis* subsp*. raddiana*. Frequent shrub/herb associates include Hammada salicornica, *Anabasis articulata*, *Senna italica*, and *Asteriscus graveolens*. Where groundwater is accessible, Phoenix dactylifera and *Tamarix* spp. may interface with riparian pockets. Recruitment is episodic and tightly linked to rare wet years; grazing pressure and fuelwood cutting reduce sapling survival. Long inter-recruitment intervals render populations vulnerable to climate-driven aridification.

The area is interspersed with salt flats composed of fine-grained silt and clay pans with saline–alkaline tendencies, often inundated after major storms and desiccating to form polygonal crusts. Vegetation, where present, is typically limited to the edges of the pans and to micro-elevations.

Halophytic shrubs and subshrubs dominate edges and hummocks. Common large shrubs include *Capparis ovata/leucophylla*, *Nitraria retusa*, and *Tamarix* spp.; smaller halophytes include *Frankenia hirsuta* and *Suaeda* spp.; *Aeluropus littoralis* may form graminoid patches.

Halophytic communities occupy saline alluvium and sabkha margins within halophytic and *thermophilous enclaves* of the Dead Sea-Araba Corridor with *Tamarix* spp., *Atriplex* spp., *Suaeda fruticosa*, and *Nitraria retusa*. *Thermophilous enclaves—Ziziphus spina-christi*, *Balanites aegyptiaca*, *Calotropis procera*, and *Moringa peregrina*—occur in warm wadis and south-facing slopes, particularly toward Aqaba.

In riparian pockets (typically Wadis), highly localised perennial-flow habitats support *Populus euphratica*, *Tamarix* spp., *Nerium oleander*, *Phragmites australis*, and *Phoenix dactylifera*. These systems provide critical drought refuges and corridors for fauna and flora, but are extremely sensitive to groundwater abstraction and flash-flood scouring.

While absolute species richness is lower than in northern Mediterranean districts, southern desert habitats host specialised xerophytes and several regionally significant taxa. Indicator species include *Haloxylon persicum* and *Retama raetam* for stabilised dunes; *Vachellia tortilis* (s.l.) for desert woodlands; *Frankenia hirsuta* and *Suaeda* spp. for saline pans; and *Ziziphus spina-christi* and *Balanites aegyptiaca* for thermophilous enclaves. Local endemics and Mediterranean relicts persist in granite–sandstone refugia.

Key pressures include:

- Grazing and browsing (especially acacia seedling/sapling removal) that was widely observed in some areas during the field surveys, often in tandem with expanding agricultural fields
- Fuelwood cutting, which is a natural extension of expanding agriculture
- Off-road vehicle disturbance on dunes observed in parts of the Wadi Rum Buffer Zone during the field surveys
- Groundwater abstraction reducing riparian refugia
- Climate-driven aridification that lengthens inter-recruitment intervals for keystone shrubs and trees.

Projected futures suggest relative persistence of Rum's dunes, localised contraction of granite–sandstone shrublands, and retreat of acacia woodlands from the hottest, driest exposures by late century, particularly under high-emission climate scenarios.

3.1.4 The Biodiversity Consultancy Desktop Review

A desktop study was conducted by The Biodiversity Consultancy in 2024 using the Integrated Biodiversity Assessment Tool (IBAT), which revealed additional terrestrial species that could be present in the area of the Project that may qualify as Potential Critical Habitat Values. The non-avian terrestrial species of concern, based on the desktop study, are shown in Table 6.

Table 6: Plant and Reptile Species Identified as Potential Critical Habitat Values

Scientific Name	Common Name	Global Red List Status	National RL Status	Presence in RA Area	Project Component / Potential Impacts	Preferred Habitat (IUCN Red List)
Plants						
Iris nigricans	Black Iris	VU	EN	Unconfirmed	Pipeline: Potential impacts from direct habitat loss and disturbance during construction	Fallow fields and steppe habitat in the central Mediterranean Jordan (approximately Karak to As Salt)
Leopoldia bicolor	Taccel Hyacinth	NT	LC	Unconfirmed		This species occurs in sandy habitats, such as stabilised sand-dunes and in loamy sands. Usually, coastal Mediterranean, but with several unconfirmed records from western Jordan
Reptiles						
Acanthodactylus ahmaddisii	Jordanian fringe-fingered lizard	EN	-	Unconfirmed	Pipeline: Potential impacts from direct mortality,	Hard clay soils, with small shrubs, in a semi-desert

Scientific Name	Common Name	Global Red List Status	National RL Status	Presence in RA Area	Project Component / Potential Impacts	Preferred Habitat (IUCN Red List)
					habitat loss and disturbance during construction	

4 Rapid Assessment

4.1 Approach

The full extent of the Project, from the IPS and Desalination Plant in the Port of Aqaba to the two receiving reservoirs in Amman, was split into nine Segments, based on geomorphological features (Figure 4). These nine Segments were developed based on the Stakeholder Consultation and Rapid Assessment (Surveillance Survey) conducted in July 2025.

To determine the habitat type, the team traversed the entire length of the Conveyance Pipeline route from the Port of Aqaba up to the two reservoirs in Amman, where the water will be delivered. The team observed both sides of the Conveyance Pipeline route for approximately 100m, then continued for another 400m beyond the initial 100m, and conducted a light visual search up to 1km on both sides of the Conveyance Pipeline route. The team stopped at over 160 locations (waypoints) when a habitat feature of interest (a habitat that appeared different from the preceding habitat) was present; however, fewer than 50% of these locations were selected for the Terrestrial Baseline Survey (Flora and/or Fauna).

In areas that were inaccessible due to safety concerns (e.g. cliffsides), natural areas that were composed of salt pan (no vegetation), and some sites that were off-route (due to the inaccessibility of the Conveyance Pipeline route) were not selected for the survey. These areas included:

- The currently selected location of the Desalination Plant in the Port of Aqaba
- A 7 km part of the Conveyance Pipeline route in Segment 5, which is not traversed by a road. Satellite imagery indicates that this area is a natural habitat, consisting mainly of flat salt pans (Playa)
- A 7.5km part of the Conveyance Pipeline route in Segment 4, which is inaccessible due to 1.5 – 2m tall soil berms, presumably used to demarcate areas of agricultural activities. This inaccessible area was conclusively identified as agricultural land using satellite imagery.

Site observation waypoints included stops to verify assessment of areas, particularly in urban and agricultural areas, and stops to gain a landscape overview and stops to investigate areas set back from the travel route to identify species or other features of interest (e.g. “green” areas that appeared anomalous relative to the overall landscape).

The selection of sites for further detailed surveys during the Terrestrial Baseline Survey was based on the plant and animal species observed at each site, or those thought likely to occur at a particular site (e.g., potential bat roosts; mini-wetlands). Areas with IUCN Red-List species were given priority.

4.2 Habitat Classification

The habitats encountered were categorised as shown in Table 7. Areas that were changed due to human intervention (urban areas, agricultural areas) were classified as “Modified Habitat” and further sub-categorised based on the main type of urban setting (residential vs. commercial/industrial vs. a mixture of residential and commercial/industrial); or Agricultural which includes areas currently actively being farmed and “mixed” areas that were farmed and fallow i.e. farmed in the past but were inactive at the time of the assessment (with visible furrows, and often with irrigation infrastructure, etc.). Agricultural areas that were fallow and possibly abandoned were either bereft of vegetation (reflecting the need for

added water to support vegetation) and, in some cases, had reverted to native vegetation usually dominated by Anabasis articulata.

The "Natural Habitat" main class was subdivided into two secondary categories:

- "Natural", to include those areas that were >95% natural (e.g. areas adjacent to the Disi Pipeline with no other major infrastructure or urban/agricultural development)
- "Semi-Natural/Degraded" for areas where primarily natural, but where anthropogenic activity (such as a paved road exists that changes the natural aeolian and fluvial processes of that area.

Table 7: Habitat Classes Identified During the Rapid Assessment

Main Habitat Class	Secondary	Tertiary	Description
Modified Habitat	Urban	Residential	Mainly a residential area
		Commercial/industrial	Mainly commercial/industrial
		Mixed	Mixed residential with commercial/industrial
	Agricultural	Active	Agricultural fields/orchards are actively cultivated
		Mixed	Agricultural fields, both active and fallow/ abandoned
Natural Habitat	Natural		No observable changes to the naturally occurring habitat
	Semi-Natural/Degraded		Limited change to habitat considered to be >75% natural

The decision to include in the baseline survey was based on several criteria (see Table 8), including species present, the extent of habitat, uniqueness of habitat, and likely importance of habitat, suitability of habitat for red-listed species, and physical features such as soil/surface material properties.

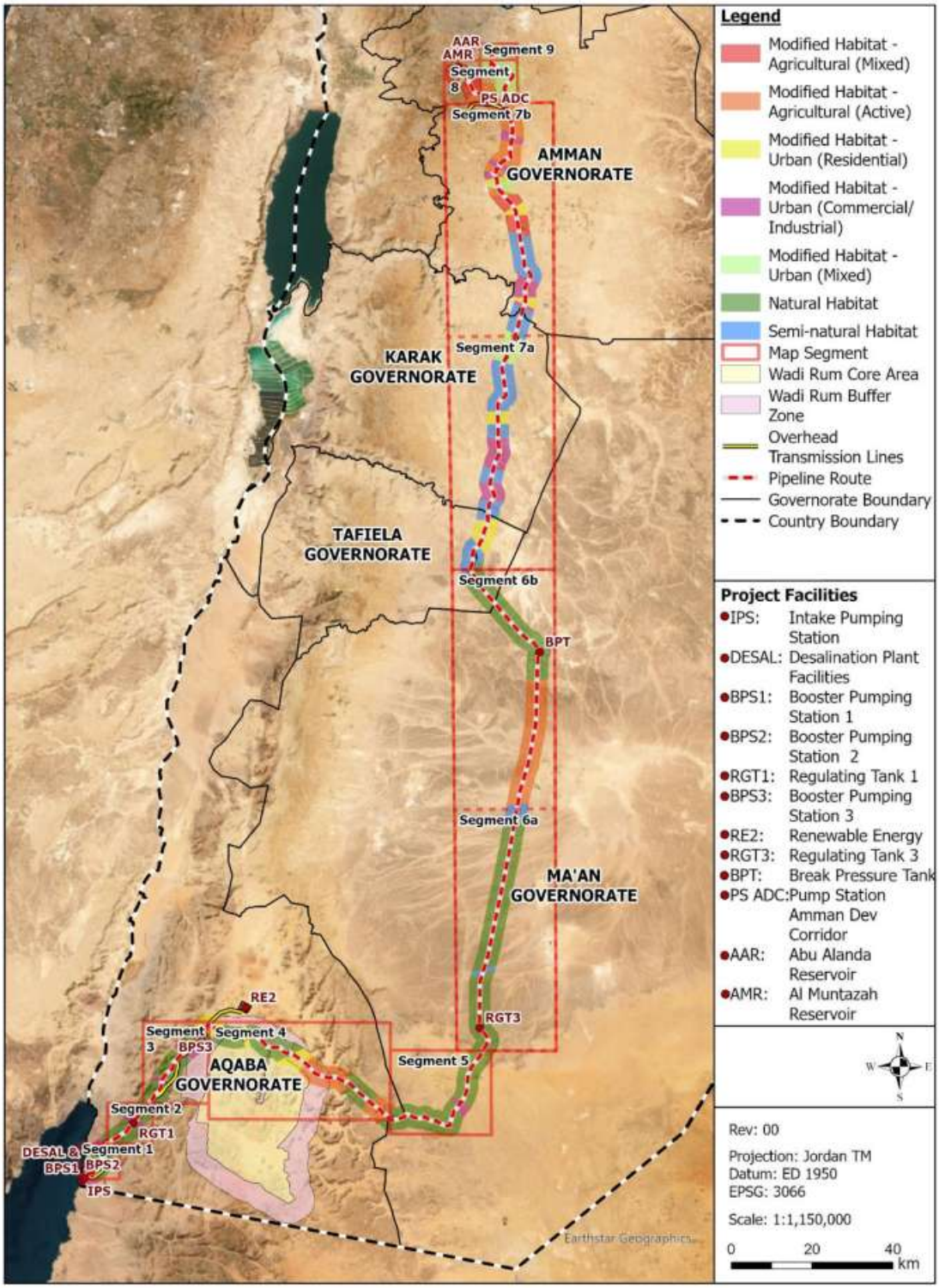
Soil stability was very low throughout the natural habitat areas of the conveyance; therefore, this was not a factor in determining whether or not to include a site in the upcoming Terrestrial Baseline Survey. Similarly, the pH was alkaline, ranging from 7.01 to 7.98 for the soil and between 7.14 and 8.00 for the standing water (leakage from the Disi Pipeline), with no significant effect on the selection of sites for the Terrestrial Biodiversity Survey. Full results of the soil stability findings are provided in Appendix 12.

Table 8: Criteria and Parameters Used to Decide Inclusion of Sites for the Full Survey

Criteria	Site Inclusion Parameter	Optional Inclusion Parameter	Site Inclusion Modifier
Soil pH	Acid range (pH<7)		Selectively exclude if very common
Water pH	Acid range (pH<7)		Selectively exclude if very common
Water	Standing or flowing water present	Mandatory inclusion if from a natural source	Selectively exclude if very common or if water is from a non-natural source
Soil stability	Medium – High stability class (>4)		Selectively exclude if very common
Habitat Class	Natural Habitat	Semi-Natural/Degraded Habitat	
Substrate	Deep caves or large abandoned buildings	Evidence of bats (e.g. Guano)	
	Footprints, scat, etc. of animals		
	Active burrows/ middens of small mammals		
	Presence of substrate associated with (habitat for) red-listed animal species		
Red-list species (plants and animals)	Presence of IUCN Least Concern, Near Threatened, Vulnerable, Endangered, Critically Endangered, Extinct in the Wild, or Extinct species		Selectively exclude only if very common
Plant species & composition	Unique species or High species richness or species different from the adjacent community/ feature		Selectively exclude only if very common
	Presence of species associated with (habitat		

Criteria	Site Inclusion Parameter	Optional Inclusion Parameter	Site Inclusion Modifier
	for) red-listed animal species		
Plant density/canopy cover	High density/cover	Under-canopy plants present	

Figure 4: Map of Habitat Classification Along the Terrestrial Baseline Survey Route



5 Terrestrial Baseline Survey Methods

5.1 Vegetation Survey Methods

The Line Intercept Method, a slightly modified version of the method first described by Canfield (1941) and now widely used for characterising and monitoring various ecosystems, was employed to quantify vegetation.

A 100m long surveyor's tape was attached at the start point (0m) of the transect and extended out in a straight line to the 100m end point. The Terrestrial Baseline Survey employed two types of transect orientations:

- For linear features, such as the Conveyance Pipeline, transect lines were oriented perpendicular to the Pipeline and parallel to each other. For the proposed Conveyance Pipeline corridor, the line intercept transects were positioned on both sides of the Pipeline route, as shown in Figure 5.
- When line intercept transects are used to survey a Project facility (e.g. Solar PV, pump stations, etc.), a three-spoked design was also used, as shown in Figure 6 for a more accurate representation of the area being surveyed.

Figure 5: Survey Site Transects

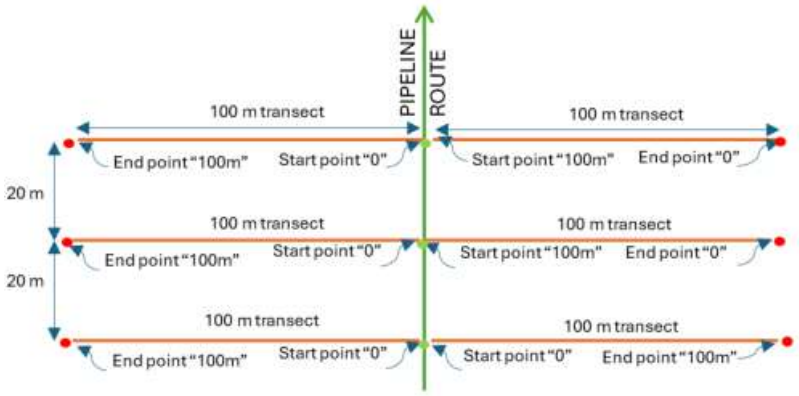
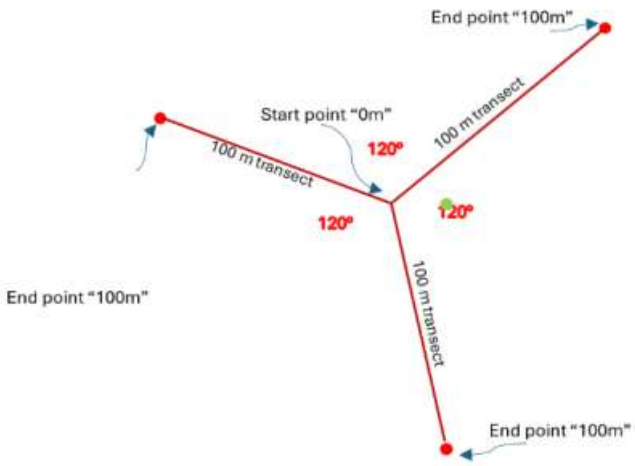
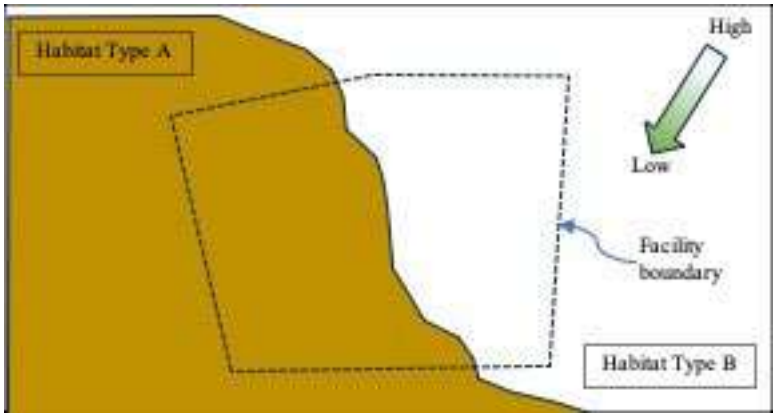


Figure 6: Three Spoked Line Intercept Transect



Facility line transect plots took into account any obviously visible differences in vegetation, or soil differences that occur within the area boundary, and additional survey plots were established if there was an obvious heterogeneity within the plot (Figure 7).

Figure 7: Example of Facility Vegetation/Habitat Monitoring Plot Location for Two Habitat Types Within a Facility Boundary



5.1.1 Line Intercept Method

Site descriptive data and location coordinates, etc., were recorded on the Vegetation/Habitat Line Intercept Datasheet (Appendix 3), and vegetation features were measured, beginning from the start of the transect line at 0m until reaching the end of the 100m tape.

The team used 4-letter CODEs (first two letters of the Genus and first two letters of the species; for example, Genus species = GESP) to optimise the time taken to record vegetation. Where there was no plant cover, it was recorded as “BARE”.

If plants of a different species were detected under the canopy of the dominant species, this was also recorded, but in data columns dedicated to under-canopy plants. This allowed the sequence of dominant canopy measurements to be used to calculate site descriptors.

While this method works well for estimating plant canopy cover, it does not account for individual plants when their canopies overlap. In areas with a high density of overlapping individual plants or seedlings, plant density was measured using a quadrant.

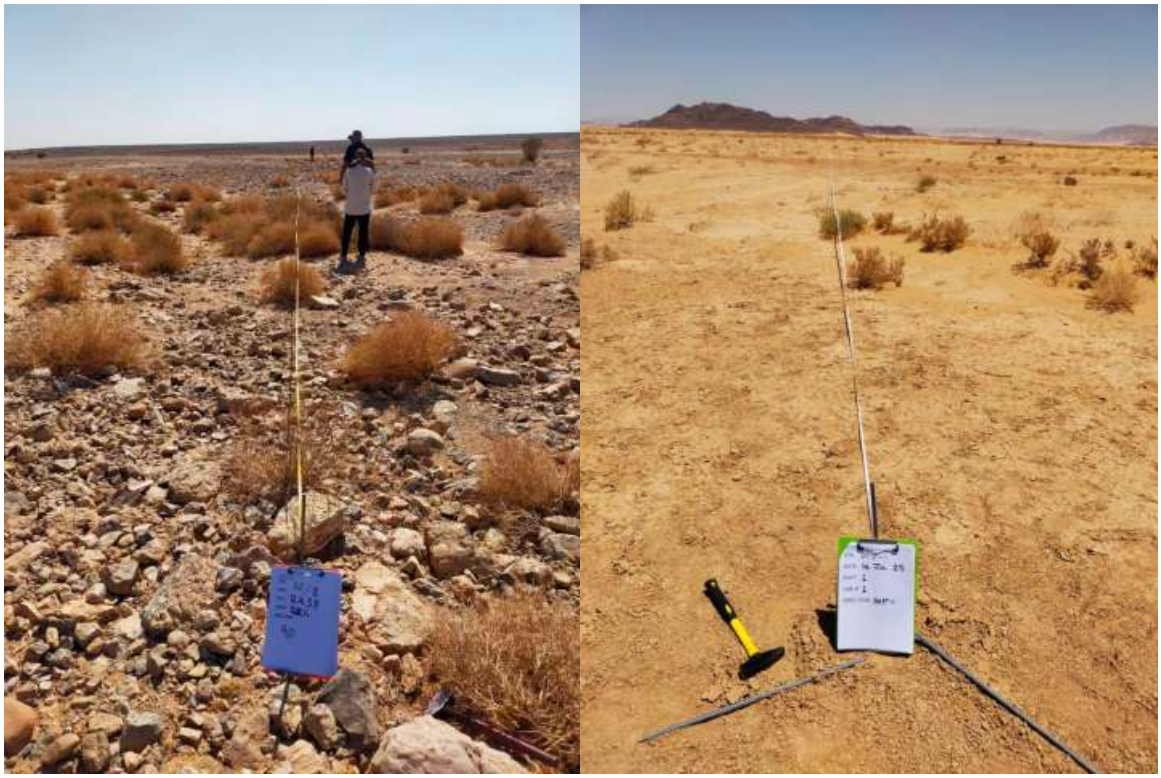
5.1.2 Quadrant Measurements

At sites with dense vegetation, transect measurements may not accurately record the number of individuals due to canopy overlap, where several individuals may contribute to a continuous canopy that is recorded as a single measurement on the transect. To account for this, a 0.5 m x 0.5m quadrat (Gleason *et al.*, 1918) was used to record the number of individual plants by sampling every 10m the length of each transect. After completing (or during) a line intercept transect, the survey team selected 10 random locations to sample plant density. The number of different species of plants whose base occurred inside each quadrat was recorded on the Vegetation Density Datasheet (Appendix 4).

5.1.3 Site Characteristics and Transect Photograph

A compass was used to measure the direction of each transect line, which was recorded on a Vegetation/Habitat Line Intercept Datasheet. A photograph was taken of every transect with a Transect Photo Sheet (Appendix 2) placed in the foreground to identify the transect, see the example in Figure 8.

Figure 8: Examples of Parallel Transects and Triangular Transects



5.1.4 Walking Transect Measurements (Flora)

Walking transects were used to expand the survey area for a further 400m beyond the end of the line transects. These transects provided descriptive data that captured any differences that may exist in the areas outside the primary survey area (the area surveyed using line transects). The Walking Transect

Datasheet (Appendix 5) was used to record observations (flora species encountered and their number) when implementing a walking transect. Any special features encountered along the walking transect were also recorded, including plants (such as plant species not encountered along the line transects), animals, and landscape features.

5.2 Fauna Survey Methods

5.2.1 Small Mammal Trapping

Small mammal traps (Sherman Traps) were placed at locations that reflect the composition and structure of the habitat. Where shrubs and grasses were present, the traps were positioned under shrubs, among grasses, and in the bare areas. Where co-dominant shrubs were present, the traps were positioned under the co-dominant shrub species. Where visual signs of small mammal activity were observed (e.g., tracks, scat/excreta, nests, middens), these signs were used to guide the selection of suitable areas for positioning the traps.

The traps were baited with a suitable food, such as oats and peanut butter, placed at the back of the trap to encourage small mammals to fully enter the trap. Traps were primed and set out later in the day at dusk, when temperatures began to cool. They were collected early in the morning at dawn, before temperatures rose significantly, to avoid heat stress to any trapped small mammals.

The Small Mammals Datasheet (Appendix 6) was used to record general information on the site and location of traps when they were set out at dusk, and later to record information on the species and number of small mammals trapped at each site. Trapped animals were photographed before being released unharmed.

5.2.2 Walking Transect Surveys (Mammals & Reptiles)

Walking transects were used to visually survey for the presence of mammals and reptiles in the Project footprint areas. These surveys were conducted during the daytime and, at some sites, at night. The surveys were conducted by selecting a start point and a planned end point, and then walking between the points while observing any animal species encountered along the transect. Faunal observations were made in a band, approximately 10m on both sides of the transect. The survey focused on all species present and also identified and recorded signs of animal presence, including droppings/scat, footprints, active dens/middens, and other indicators.

Data were recorded for each site using the Fauna Walking Transect Datasheet (Appendix 7). The information gathered included species, location observed, sex, maturity, and any signs of animal presence. A photograph was taken wherever possible.

5.2.3 Camera Trap Survey (Mammals)

Camera traps were used to target larger mammals for which the small mammal traps would be ineffective. Camera traps were only deployed overnight (with the survey team camped in the area but far enough away to not impact the site being surveyed) because of theft and high daytime temperatures that were beyond the operating range of the camera traps, to prevent either loss of cameras or loss of data.

When setting out camera traps, a site description was also recorded on the Camera Trapping Datasheet (Appendix 8), and any animals observed were recorded on the same sheet when evaluating the camera results.

5.2.4 Bat Roost Survey

Potential roosting habitats include rocky outcrops, cliffs, deep caves, and human structures such as culverts, abandoned buildings, mines and tunnels. Potential roost sites were identified through a combination of remote sensing and Geographical Information Systems (GIS) mapping to locate geological and anthropogenic features likely to support natural roosts, and field reconnaissance to visually inspect potential roosting areas/structures for evidence of bat roosting. Evidence that a site is/was being used by bats (e.g. the presence of guano, staining or rub marks, odour, etc.) was recorded on the Bat Roosting Survey Datasheet (Appendix 9).

6 Terrestrial Baseline Survey

6.1 Site Selection

Potential sites for the Terrestrial Baseline Survey were initially identified during the Rapid Assessment, during which the team assessed over 168 locations, recommending the collection of more detailed survey data for quantitative biodiversity assessment (Appendix 1).

The assessment process is shown in Table 9 and the assessment criteria were applied in the sequence shown. The assessment process began with all sites. If a site was de-selected (e.g., because it was an industrial area), it was removed from further consideration (i.e., it was discarded as a potential Terrestrial Baseline Survey location). Similarly, if a site was selected (e.g., due to the presence of an IUCN Red List species), it was also removed from further evaluation; however, in this case, the site was selected for a more detailed quantitative survey during the Terrestrial Baseline Survey.

After completing the site selection process, 79 sites were chosen for the survey. An additional site was included due to a significant sighting of fauna, bringing the total to 80 sites. Of the 80 survey sites, 65 were used for plant surveys and 73 for terrestrial fauna surveys. Among these, 58 sites were surveyed for both plants and fauna.

Table 9: Terrestrial Baseline Survey Site Selection Criteria

Criterion No.	Assessment Criteria (Questions)	Biodiversity Site Selection based on response to Assessment Question	
		Yes	No
1	Has the area been impacted by anthropogenic activity such as permanent residential, commercial or industrial buildings?	Do not conduct the Terrestrial Baseline Survey	Proceed to the next question
2	Has the area been impacted by anthropogenic activity such as current or former agricultural activities?	Do not conduct the Terrestrial Baseline Survey	Proceed to the next question
3	Can the area be accessed safely?	Proceed to the next question	Do not conduct the Terrestrial Baseline Survey
4	Does the area have stable soils? (i.e. Soil Stability Class > 3)	Conduct the Terrestrial Baseline Survey for at *least* 3 locations	Proceed to the next question
5	Does the area have acidic soils? (i.e. pH>7)	Conduct the Terrestrial Baseline Survey for at *least* 3 locations	Proceed to the next question
6	Does the area have any important flora or fauna? (e.g. IUCN or Jordan Red-Listed species)	Conduct the Terrestrial Baseline Survey for at *least* 3 locations (per important species)	Proceed to the next question
7	Is the habitat common and contiguous? (i.e. relatively large	Conduct the Terrestrial Baseline Survey for at *least* 3 locations (per important species)	Proceed to the next question

Criterion No.	Assessment Criteria (Questions)	Biodiversity Site Selection based on response to Assessment Question	
		Yes	No
	expanses of the same plant community)		
8	Is the habitat unique? (i.e. is the plant or animal community discrete and surrounded by a different community type?)	Conduct the Terrestrial Baseline Survey for at *least* 3 locations (per habitat, if possible)	

6.2 Segment 1

6.2.1 General Description and Rapid Assessment Results

The Segment begins at the seaport in the south, where water is abstracted from the GoA, piped to the Desalination Plant for treatment, and thereafter pumped northward to Aqaba. In Segment 1, the Conveyance Pipeline initially climbs rapidly for approximately 12 km toward the southern edge of the Aqaba Mountains, then runs parallel to the Aqaba Truck Road, serving freight entering and leaving the Port of Aqaba.

This Segment is characterised by wadi systems that cross from east to west and is composed of a sand-and-gravel surface over a limestone bedrock. The Aqaba Proposed Reserve lies to the south-east of the Pipeline route and at its closest point is approximately 6km distant.

The central part of the Segment is considered to be a Natural Habitat, while the southern and the northern ends of the Segment were classified as Modified Habitat, Urban (commercial/industrial) due to the Port and an industrial facility, respectively (Figure 10).

Natural Habitat is very sparsely vegetated, with most vegetation occurring along the physically disturbed roadsides and in the wadis. A summary of the habitat classification is provided in Table 10:

Table 10: Habitat Classification Summary, Segment 1

Main Habitat	Secondary	Tertiary	Description	Kilometres	% of the Segment
Modified	Urban	Commercial/Industrial	Mainly commercial/industrial	5.6	49.5
Natural	Natural	Low Value	No observable changes to the naturally occurring habitat	5.7	50.5
Total Segment 1 Length				**11.3km**	

Biodiversity in this area was relatively low, with disturbed roadside verges and wadi environments possessing the greatest (albeit low) biomass and species richness. The roadsides are covered with a dusting of yellow-coloured phosphorus, blown off from trucks transporting the material between the mines and the Port.

A total of nine plant species were observed in Segment 1 (*Acacia* spp., *Hammada salicornica*, *Iphiona scabra*, *Morettia canescens*, *Ochradenus baccatus*[1], *Panicum turgidum*, *Salsola baryosma*, *Stipagrostis* spp., *Zilla spinosa*). All plants were present in very low abundance.

No reptile or mammal species (excluding domesticated species) were observed in Segment 1 during the Rapid Assessment.

6.2.2 Terrestrial Baseline Survey Results

North of the Port area, vegetation was measured at four sites in Segment 1. Photographs of the biodiversity measurement sites are included in Appendix 10 and clearly show the sparse and fragmented vegetation distribution observed at the survey sites. The measured sites are considered representative of the overall floristic characteristics of this Segment (Table 11).

Table 11: Segment 1 Summary of Results

Site ID	Plant Cover (%)	Species Richness	Plant Species Abundance	Plant Diversity (H')	Animal Species	Animal "Signs"
FA1	0.40	1	1	0.000	-	-
FA2	1.03	4	7	1.277	-	-
FA3	6.85	3	17	0.709	-	-
FA-PS1	0.27	1	1	0.000	1	1

The Terrestrial Baseline Survey encountered and recorded six plant species (*Vachellia tortilis*, *Aizoon canariense*, *Cleome droserifolia*, *Ochradenus baccatus*, *Polycarpaea repens*, and *Salsola baryosma*) at the Segment 1 sites. Site FA2 had 1.03% plant cover and the highest diversity (Shannon-Weaver) H' = 1.2770, while site FA3 (with a higher per cent cover of 6.85%) had a H' = 0.7087, which is a lower diversity because the vegetation at the site was dominated by *Salsola baryosma* (14 individuals). The remaining site vegetation cover was low (FA1 = 0.41% & FA-PS1 = 0.27%) and H' = 0 (i.e. only one species present = no diversity).

The differences in plant species composition between the Rapid Assessment and the Terrestrial Baseline Survey are due to invasive species often occupying a narrow, scattered band immediately adjacent to the roadside, which were observed during the Rapid Assessment but not within the quantitative survey footprint, which extends 100m away from the roadside. It should also be noted that for safety reasons, the survey avoided the area immediately adjacent to a road.

A plant of the species *Cleome droserifolia*, which is listed as locally Endangered in Jordan, was encountered at site FA2, and plants of *Vachellia tortilis* (the Umbrella Thorn Accacia), which is listed as locally Vulnerable (globally "Least Concern"), occurred in three sites (FA1, FA2, and FA-PS1).

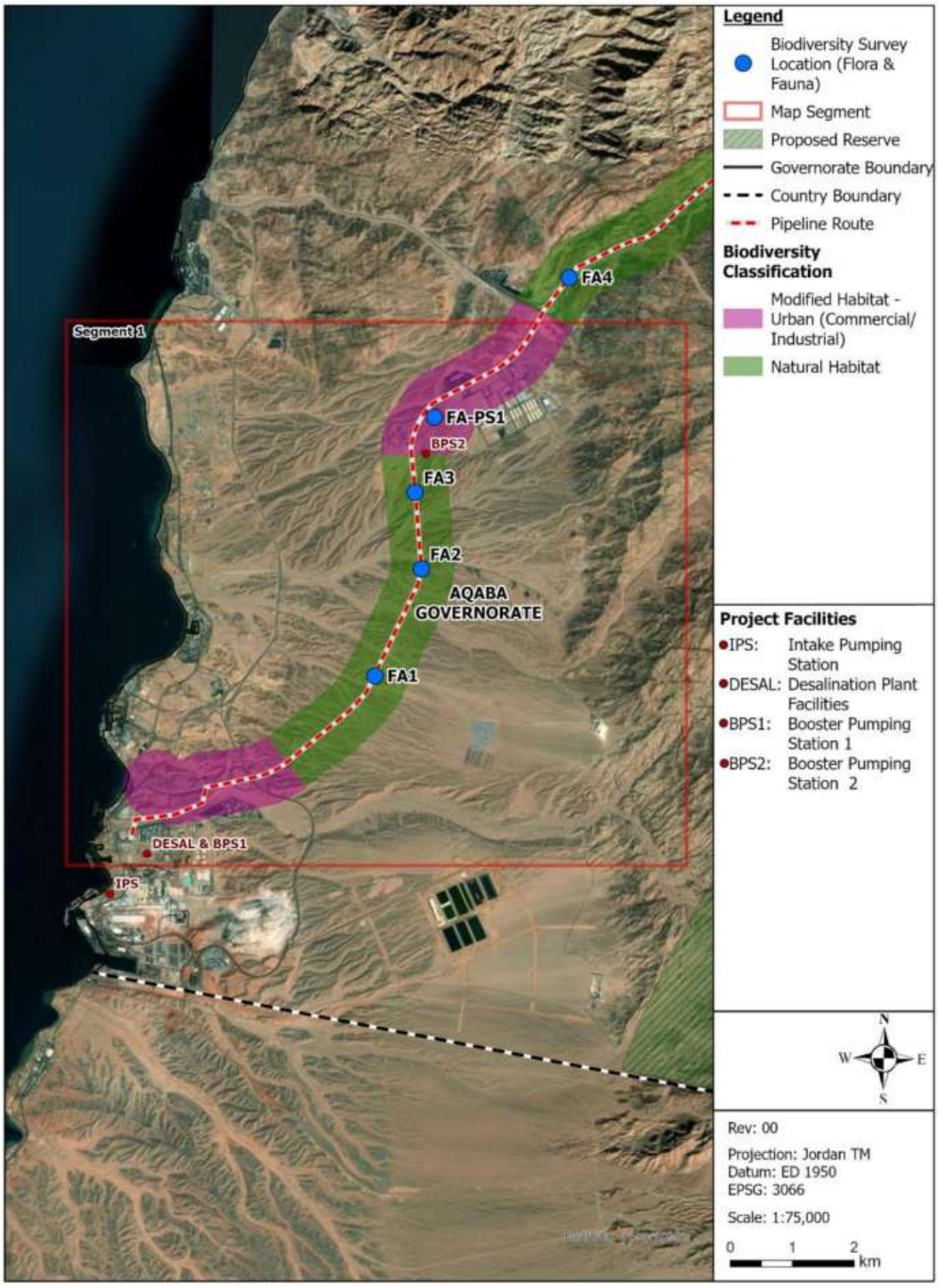
One animal species (reptile) was observed in the Segment, at the FA-PS1 site, an Aqaba Agama (*Pseudotrapelus aqabensis*). It is notable that this site had the lowest vegetation cover of the sites measured in the Segment, and only one plant species, *Vachellia tortillis*. The other notable feature of FA-PS1 site is the observation of a possible burrow (Figure 9) of the IUCN listed (Vulnerable) Egyptian Dub lizard (*Uromastyx aegyipticus*).

[1] Jordan Red List Species: Least Concern

Figure 9: Likely Burrow of an Egyptian Dub Lizard (Left) and an Aqaba Agama (Right) Observed at Site FA-PS1



Figure 10: Segment 1 Map



6.3 Segment 2

6.3.1 General Description and Rapid Assessment Results

The second Segment extends for approximately 15km through the Aqaba Mountains, gaining altitude as it travels northward parallel to the Aqaba Port Truck Road (Figure 11). Granite mountains dominate the landscape, with wadi systems that cross the route and sometimes run parallel to the Conveyance Pipeline route. For much of the proposed route in this Segment, the road is bordered by steep granite cliffs. There are occasional industrial and commercial businesses along the route, as well as other infrastructure for transport trucks and other vehicles. Vegetation is mostly limited to disturbed areas (e.g., roadsides) and wadi environments. A summary of the habitat classification is provided in Table 12:

Table 12: Habitat Classification Summary, Segment 2

Main habitat	Secondary	Tertiary	Description	Kilometres	% of the Segment
Modified	Urban	Commercial/Industrial	Mainly commercial/industrial	2.6	18
Natural	Natural	Low Value	No observable changes to the naturally occurring habitat	11.9	82
Total Segment 2 Length				**14.5km**	

Plant diversity in this Segment was relatively high, at least partly due to the large number of species (8) observed at one location (see FA6-PS2 on Figure 11), which is a highly disturbed area located behind a commercial/industrial area where RGT1 is located, and the disturbed roadside verges and wadi environments in this Segment.

Sixteen plant species were identified (*Anabasis setifera*, *Acacia* spp., *Arthrocnemum macrostachyum*, *Capparis cartilaginea*, *Citrullus colocynthis*, *Cleome droserifolia*, *Fagonia mollis*, *Forsskaolea tenacissima*, *Hammada salicornica*, *Heliotropium bacciferum*, *Launaea spinosa*, *Ochradenus baccatus*, *Pergularia tomentosa*, *Retama raetam*, *Salsola baryosma*, and *Zilla spinosa*) during the Rapid Assessment. However, as with Segment 1, plant abundance was very low, with only single representatives of some species, and this finding is subject to confirmation during the Terrestrial Baseline Survey.

As with Segment 1, the roadsides are covered with a dusting of phosphorus from trucks transporting the material between the mines and the Port. No reptile or mammal species (excluding domesticated species) were observed in this Segment.

6.3.2 Terrestrial Baseline Survey Results

Plant diversity and richness were also relatively low, though higher than those in Segment 1. The differences in plant species composition between the Rapid Assessment and the Terrestrial Baseline Survey are due to invasive species often occupying a narrow, scattered band immediately adjacent to the roadside, which were observed during the Rapid Assessment but not within the quantitative survey footprint, which extends 100m away from the roadside. It should also be noted that for safety reasons, the survey avoided the area immediately adjacent to a road.

Photographs of the plant survey transects clearly show the low plant cover of the survey sites (Appendix 10). The measured sites are representative of the overall floristic characteristics of this Segment (Table 13).

Table 13: Segment 2 Summary of Results

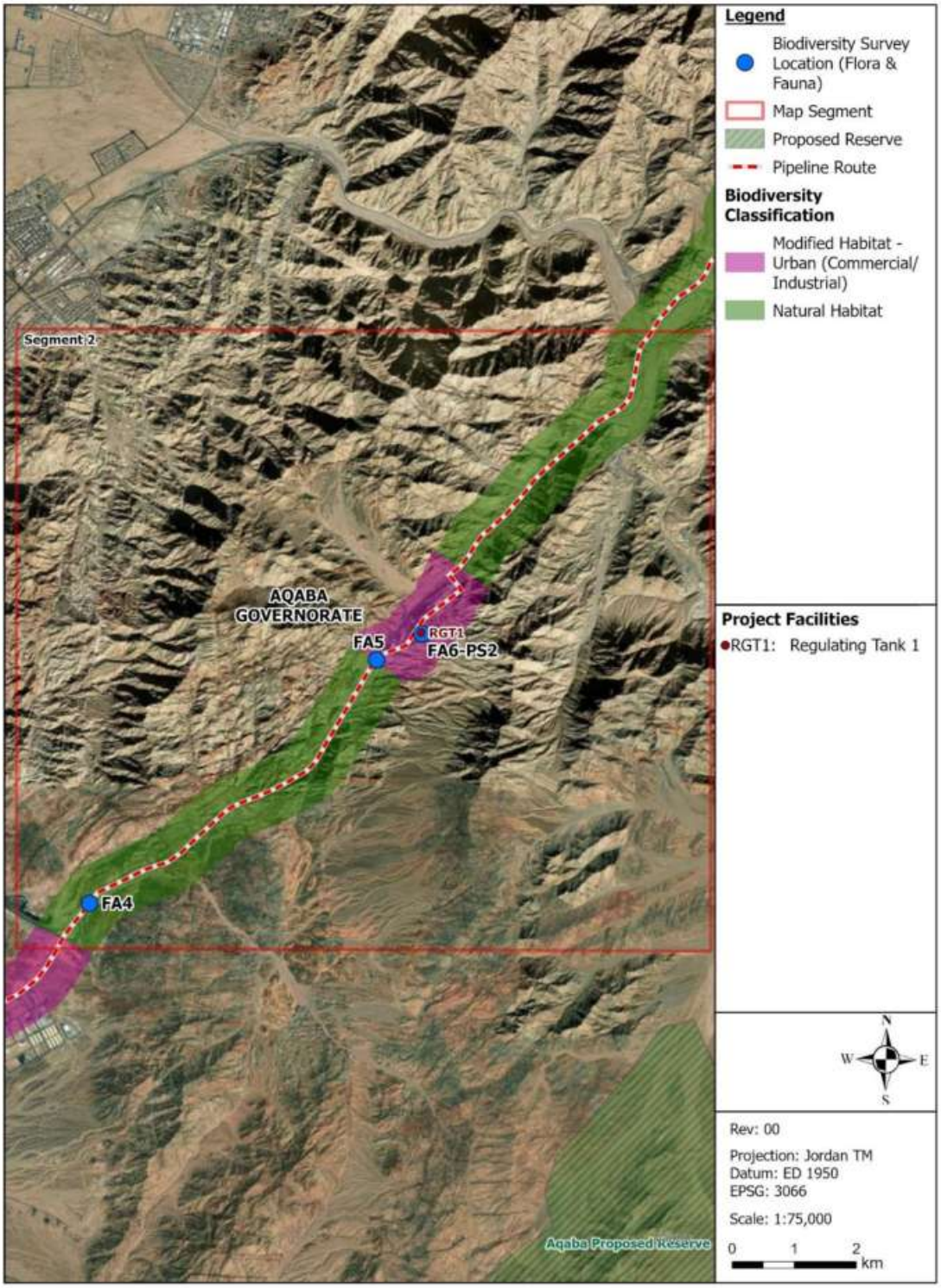
Site ID	Plant Cover (%)	Species Richness	Plant Species Abundance	Plant Diversity (H')	Animal Species	Animal "Signs"
FA4	2.28	4	9	1.215	-	-
FA5	2.61	6	13	1.519	-	-
FA6-PS2	0.00	0	0	0.000	-	-

Nine plant species (*Vachellia tortilis*, *Anabasis setifera*, *Cleome droserifolia*, *Crotalaria aegyptiaca*, *Haloxylon scoparium*, *Lavandula coronopifolia*, *Ochradenus baccatus*, *Salsola baryosma*, and *Zilla spinosa)* were recorded in Segment 2. Of these, *Vachellia tortilis*, *Cleome droserifolia*, and *Lavandula coronopifolia* are red-listed in Jordan. No species occurring within these biodiversity measurement plots were listed as globally or locally important for conservation.

The proposed location for the pump station (FA6-PS2) also did not contain any measurable plant material and appeared to have been used as a site for disposing of waste materials and trash.

No animal species or signs were observed at any of the three sites in this Segment.

Figure 11: Segment 2 map



6.4 Segment 3

6.4.1 General Description and Rapid Assessment Results

In Segment 3, the topography begins to level off, especially in the northern parts of the route, where a large (wide) wadi system crosses the route on the western side, and is part of a wadi that runs parallel to the route for much of its length on the eastern side of the highway.

There is sparse, relatively widely distributed development in the area, including customs checkpoints, residential developments, and agricultural areas, which increase as the route progresses northward. While there are some trees in the Wadis, vegetation is widely spaced, and it is still very much a desert ecosystem with no riparian species evident. At some locations, larger wadis have been slightly modified by human intervention, such as the construction of dams, to slow water flow and temporarily collect water.

The Buffer Zone of the Wadi Rum Protected Area is immediately adjacent to the eastern edge of the Project at the far north of Segment 3, and in the same area, the Wadi Rum PA Core Area itself is only 4km to the east of the Project.

The majority of this Segment is classified as a Natural Habitat, with small areas of Modified Habitat – Urban (commercial/industrial) that include a customs checkpoint and small areas of Modified Habitat – Urban (residential), including Al-Rashadiyah junction, where the Pipeline turns east (Figure 13). A summary of the habitat classification is provided in Table 14.

Table 14: Habitat Classification Summary, Segment 3

Main habitat	Secondary	Tertiary	Description	Kilometres	% of the Segment
Modified	Urban	Commercial/Industrial	Mainly commercial/industrial	3.8	14.5
Modified	Urban	Residential	Mainly a residential area	3.5	13.5
Natural	Natural	Low Value	No observable changes to the naturally occurring habitat	18.6	72
Total Segment 3 Length				**25.9km**	

Plant diversity and abundance are low in this Segment, and roadside disturbance is less (but not absent), perhaps because it is less enclosed by steep cliffs, and the road is also wider (additional traffic lanes) due to the Port Highway joining with the Desert Highway.

Only seven plant species were observed along Segment 3 during the Rapid Assessment (*Acacia radiana, Anabasis setifera, Hammada salicornica, Ochradenus baccatus, Pergularia tomentosa, Salsola baryosma*, and *Zilla spinosa)*, all of which are native to arid and semi-arid ecosystems. These typically occurred with a low abundance throughout the Segment. No reptile or mammal species (excluding domesticated species) were observed in this Segment.

6.4.2 Terrestrial Baseline Survey Results

One new (previously unidentified during the Rapid Assessment) site (FA7-EX) for fauna observations was added to the Terrestrial Baseline Survey based on a recent sighting of an IUCN-listed (Vulnerable) species, Nubian Ibex (*Capra nubiana*) by a member of the survey team in March 2025, four months before the baseline survey (see Figure 12).

Figure 12: Nubian Ibex Observed on 29 March 2025 (Courtesy of Sameh Khtatbeh) (left) and the Dam Accessed by the Ibex (right)



Photographs of the biodiversity measurement sites are included in Appendix 10 and clearly show the sparse, fragmented vegetation distribution observed at the survey sites. The measured sites are representative of the overall floristic characteristics of this Segment. Plant biodiversity was measured at three sites within the Segment, and site FA8 had the greatest % cover, species richness, abundance and diversity. The summarised results of the plant baseline survey for these sites are shown in Table 15.

Table 15: Segment 3 Summary of Results

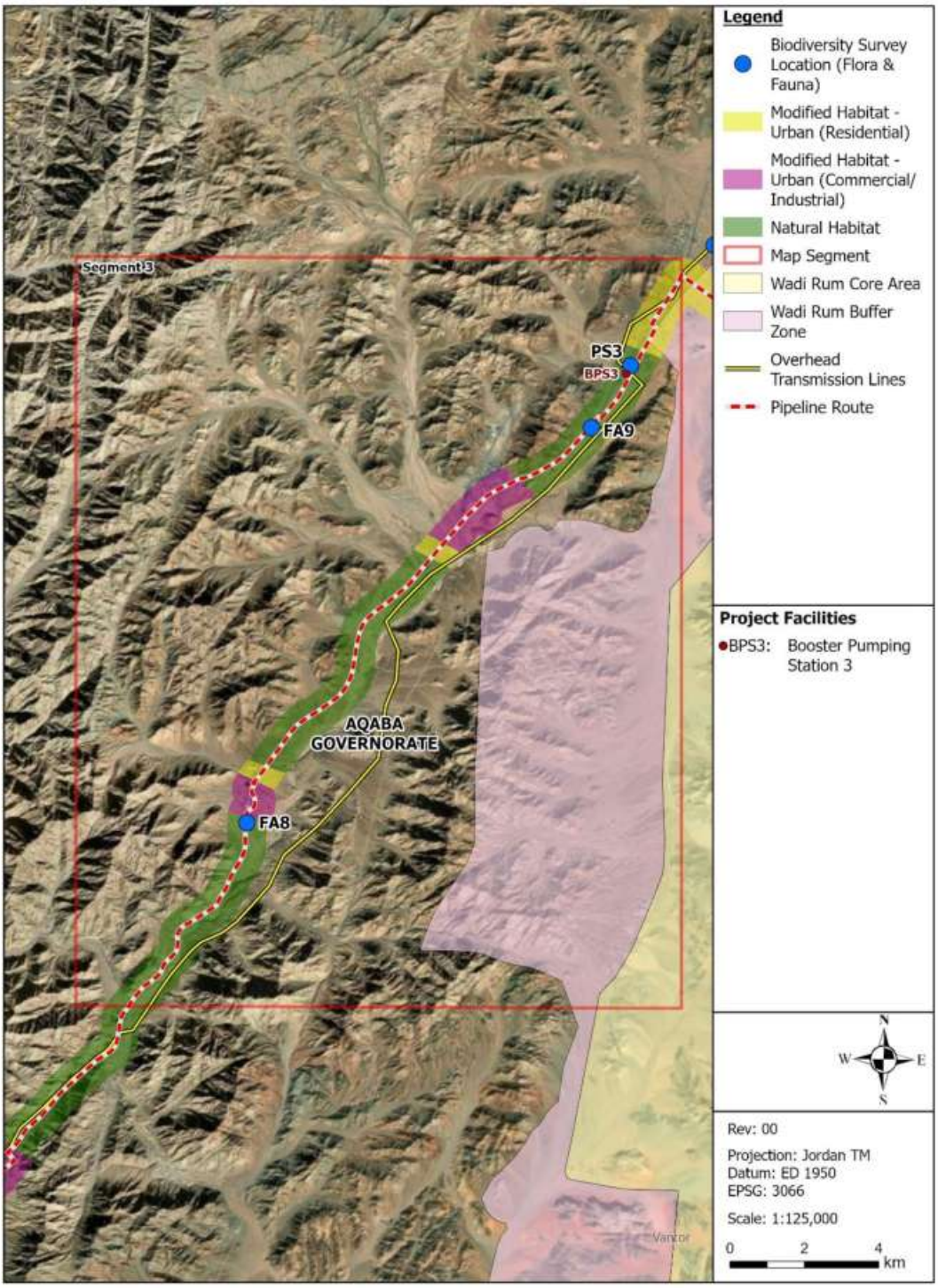
Site ID	Plant Cover (%)	Species Richness	Plant Species Abundance	Plant Diversity (H')	Animal Species	Animal "Signs"
FA7-EX	No flora measurements, new site based on fauna observation				1*	-
FA8	4.48	8	31	1.667	-	-
FA9	0.08	1	2	0.000	-	-
PS3	2.67	2	12	0.287	-	-
**Capra nubiana* Nubian Ibex) IUCN Red List Vulnerable						

Nine plant species (*Aizoon canariense*, *Artemisia sieberi*, *Fagonia mollis*, *Haloxylon salicornicum*, *Launaea spinosa*, *Ochradenus baccatus*, *Retama raetam*, *Salsola baryosma,* and *Zilla spinosa*) were recorded at the biodiversity measurement sites in Segment 3. No plant species occurring in this Segment were listed for conservation globally or locally.

The causes of differences in species richness between the Terrestrial Baseline Survey and the Rapid Assessment are the same as in Segments 1, 2, and 3.

No other animal species or signs (including potential bat roosting sites) were observed at the sites in this Segment.

Figure 13: Segment 3 Map



6.5 Segment 4

6.5.1 General Description and Rapid Assessment Results

Segment 4 begins where the Conveyance Pipeline route diverges from the Desert Highway at Al-Rashadiyah Junction. The Segment is approximately 55km in length, and is oriented from east to west, with the Wadi Rum Protected Area lying to its south. The eastern two-thirds of the Pipeline route's length lies within the Buffer Zone for Wadi Rum PA, as does the proposed site for the Solar PV site, located near the western end of the route on its northern side.

The route of the proposed OHTL joins the Pipeline route in a southward direction near Al-Rashadiyah Junction. At the western end of the route, especially to the north, it is relatively heavily agricultural (with both active and inactive/abandoned fields throughout the area), although the Solar PV site itself may not have been farmed. However, because these agricultural areas are set back and away from the Project Pipeline route, the route itself was mostly designated as Natural Habitat (Figure 15). As the route progresses eastward, agricultural activity tapers off.

Upon reaching the town of Disah, agricultural activity resumes and is most dense outside the Wadi Rum Buffer Zone. The intervening area along the Conveyance Pipeline route is largely Natural Habitat, although there are areas of light Modified Habitat – Urban (residential) and the Wadi Rum Railway, the small township of Shakaria, and some small tourist camping businesses. From Disah westward, there are agricultural fields, an approximately 7km long salt flat, followed by another agricultural area at the far Eastern end of the Segment. The Conveyance Pipeline route is inaccessible in some eastern areas due to agriculture-related berms (1.5–2 m tall) that have been constructed across a pre-existing unpaved road. However, satellite imagery clearly shows that these areas are/were agricultural and represent Modified Habitat. A summary of the habitat classification is provided in Table 16:

Table 16: Habitat Classification Summary, Segment 4

Main habitat	Secondary	Tertiary	Description	Kilometres	% of the Segment
Modified	Urban	Residential	Mainly a residential area	8.9	16.5
Modified	Agricultural	Active	Agricultural fields/orchards actively cultivated	18.1	33.5
Natural	Natural	Low Value	No observable changes to the naturally occurring habitat	27	50
Total Segment 4 Length				**54km**	

Non-agricultural plant species were observed in this Segment (*Vachellia gerrardii*, *Citrullus colocynthis*, *Haloxylon persicum*, *Haloxylon salicornica*, *Haloxylon scoparia*, *Pulicaria crispa*, *Salsola baryosma*, *Typha* spp., and *Zilla spinosa*).

With only nine non-agricultural plant species observed, the relatively low species richness in this area likely reflects the presence of undisturbed natural habitats in Segment 4. It also indicates the dominance of drought, heat, and salt-tolerant species that characterise undisturbed warm arid desert ecosystems, further supported by the Protected Area status of Wadi Rum and the Protected Area Buffer Zone, which encompasses much of the Segment.

No reptile or mammal species (except domesticated species, which were present, sometimes in large numbers, in agricultural areas) were observed in this Segment.

6.5.2 Terrestrial Baseline Survey Results

The Terrestrial Baseline Survey results were separated into the Pipeline route, Solar PV, and OHTL. With regard to plant species, although the species richness observed during the Rapid Assessment (9) and the Baseline Survey (8) are very similar, the species themselves were only 44% similar, again reflecting the impacts of roadside disturbance and the artificial pond that creates an artificial mini-habitat with unique but exotic flora.

6.5.2.1 Conveyance Pipeline Route

Nine survey sites were characterised for biodiversity along the Pipeline route (which follows and is adjacent to the Wadi Rum Road) in Segment 4, of which site FA15A was only surveyed for Fauna. The Segment was mostly classified as a Natural Habitat, but some agricultural areas in the west, as well as small residential and commercial developments (especially tourism-based), are interspersed with the natural areas along the length of the Pipeline, which is located adjacent to the northern boundary of Wadi Rum for much of its length.

Photographs of the plant survey transects clearly show the relatively low plant cover of the survey sites (Appendix 10). The measured sites are representative of the overall floristic characteristics of this Segment. Terrestrial Baseline Survey results for Segment 4 are provided in Table 17.

Table 17: Segment 4 Summary of Results

Site ID	Plant Cover (%)	Species Richness	Plant Species Abundance	Plant Diversity (H')	Animal Species	Animal "Signs"
FA10	3.07	1	14	0.0000	2	-
FA11	1.42	2	10	0.3251	-	-
FA12	0.20	2	3	0.6365	1	1
FA13A	2.91	1	12	0.0000	1	-
FA13-B	0.00	0	0	0.0000	-	-
FA14A	1.17	4	9	1.1491	-	-
FA14B	1.45	4	5	1.3322	-	-
FA15	0.00	0	0	0.0000	-	-
FA15A	Flora not surveyed, Fauna only survey location				12	-

Although Segment 4 is immediately adjacent to the northern boundary of the Wadi Rum Protected Area for much of its length, only eight plant species were recorded in the eight survey sites measured

(*Vachellia gerrardi*, *Haloxylon persicum*, *Haloxylon salicornicum*, Retama raetam, *Salsola baryosma*, *Salsola tragus*, *Tamarix nilotica*, and *Zilla spinosa)*.

V. gerrardii and *H. persicum* are both red-listed (Vulnerable) for conservation in Jordan.

H. persicum dominated the survey site FA13A, while single plants of *V. gerrardii* and *H. persicum* were found at site FA14B.

Two survey sites (FA13-B and FA15) did not have measurable quantities of plants, and the highest species richness, with four species each, occurred at sites FA14A and FA14B. The highest plant canopy cover occurred at site FA10, which is at the western end of the Segment, and the cover was composed of a single species (3.07% cover, *Haloxylon salicornicum*). This site also hosted two species of animals, Bosc's Fringe-toed lizard (*Acanthodactylus boskianus,* 2 individuals), and one Wagner's Gerbil (*Gerbillus dasyurus*).

A Red Fox (*Vulpes vulpesI*) and signs of a bushy-tailed Jird (*Sekeetamys calurus*) were observed at site FA12, and a Schmidt's Fringe Fingered lizard (*Acanthodactylus schmidti*) was observed at site FA13A.

Eleven species of bird were observed at survey site FA15A (*Columba livia*, *Ammomanes deserti*, *Galerida cristata*, *Ptyonoprogne fuligula*, *Oenanthe deserti*, *Oenanthe lugens*, *Onychognathus tristramii*, *Passer domesticus*, *Carpodacus synoicus*, *Vanellus spinosus*, *Acrocephalus scirpaceus*, *Streptopelia decaocta*). This site is an artificial wetland (Figure 14), fed by water from adjacent farms and the ponded water also supported individuals of the amphibian *Bufotes sitibundus*. Because the site is intentionally maintained and not directly on the Pipeline route, a formal plant survey was not conducted (anecdotally, Typha elephantina, Cynodon dactylon, and Carex pachystylis were present); however, its potential to attract and support wildlife near the Pipeline route led to a faunal survey being conducted.

Overall, while Segment 4 is within the Hisma Basin – Rum KBA and is immediately north of the Wadi Rum Protected Area and within its boundary area, the diversity of plant species was comparable to or less than that encountered in Segments 1, 2, or 3.

Figure 14: Artificial Water Source at Survey Site FA15A



6.5.2.2 Solar PV and OHTL

The proposed Solar PV site is located approximately 8.5km to the northeast of the Conveyance Pipeline route at Al-Rashadiyah Junction, at the western end of Segment 4, from where the OHTL will carry generated electricity to the desalination project components in the Port of Aqaba.

The Solar PV site is approximately 2km x 2.3km and appears to consist of three distinct habitats; therefore, three sets of three (triangular) transects were used to survey plants, and two additional sets of transects were used to quantify biota at locations along the proposed OHTL. The results of the surveys are presented in Table 18.

Table 18: Segment 4 Summary Results

Site ID	Plant Cover (%)	Species Richness	Plant Species Abundance	Plant Diversity (H')	Animal Species	Animal "Signs"
S4-SPV1	11.92	1	48	0.0000	-	3
S4-SPV2	0.93	1	4	0.0000	-	3
S4-SPV3	4.90	1	13	0.0000	-	3
S4-OHTL-4	8.00	1	35	0.0000	1	1
S4-OHTL-5	4.25	1	26	0.0000	-	-

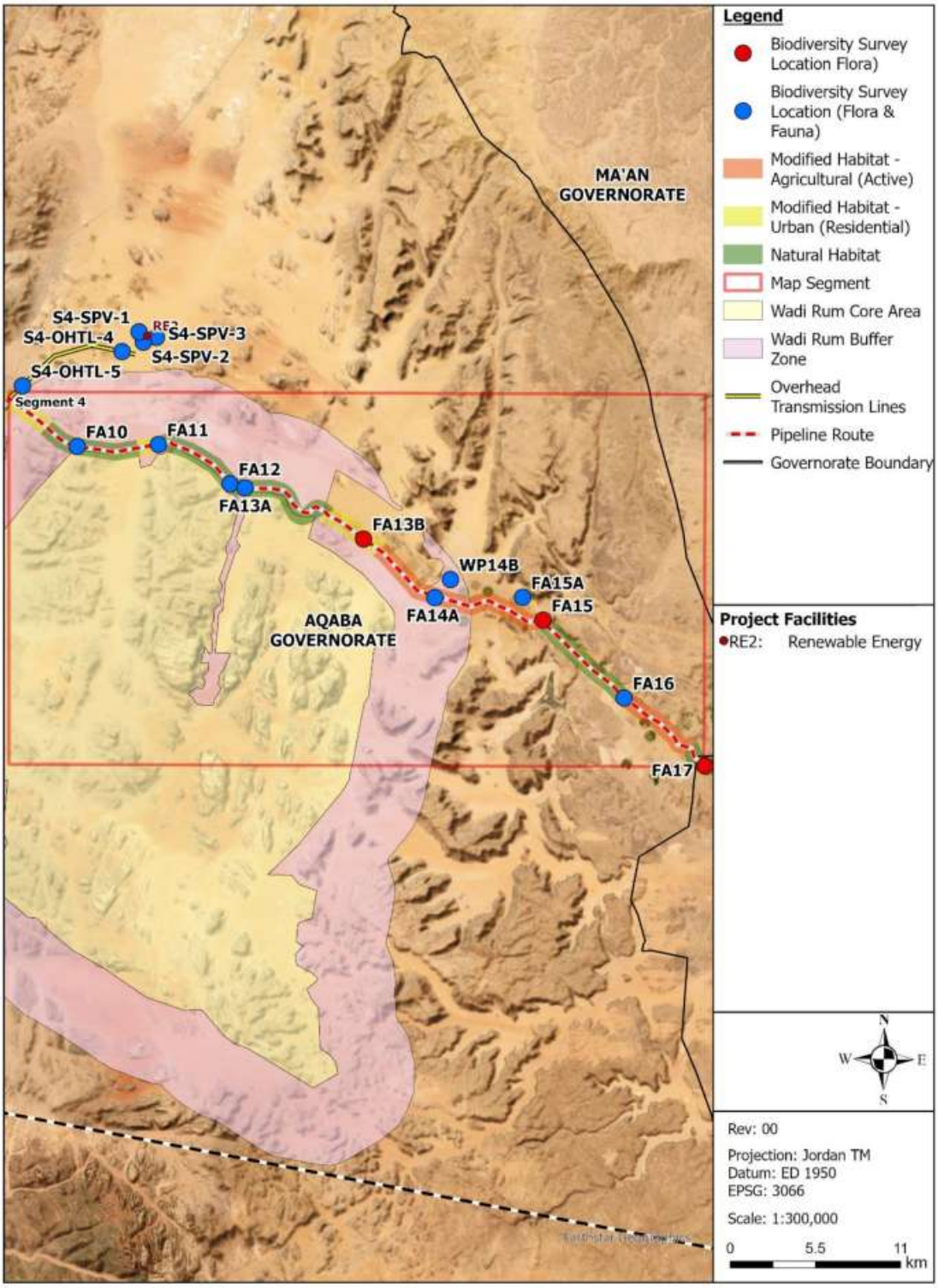
The area of the Solar PV and OHTL is dominated by Saxaul (*Haloxylon salicornicum*), and no other plant species was recorded in any of the five sites in this area. Most of this area appears to have been farmed

in the past, now appearing to be abandoned, and is often littered with the remnants of plastic sheets and tubing, indicating its agricultural past.

One individual of Bosc's fringe-fingered lizard (*Acanthodactylus boskianus)* was detected at site S4-OHTL-4, and signs of its presence were found at all other sites in the Solar PV+OHTL group sites. Additionally, there were signs of the presence of Sundeval's Jird (*Meriones crassus*) at S4-OHTL-4.

At the other sites of the Solar PV+OHTL group, signs were also found of the presence of Fat Sand Rat (*Psammomys obesus*) and *Meriones crassus,* although live specimens were not observed. No globally listed or Jordan red-listed species were encountered in this area.

Figure 15: Segment 4 Map



6.6 Segment 5

6.6.1 General Description and Rapid Assessment Results

Segment 5 is unusual in that it is the only Segment that consists of a section of the Pipeline route that is oriented west to east, and another section that is oriented south to north, and also features a significant gain in altitude in its northernmost reaches, where it crosses and runs parallel to some sizeable wadi systems. A summary of the habitat classification is provided **in Table 19:**

Table 19: Habitat Classification Summary, Segment 5

Main habitat	Secondary	Tertiary	Description	Kilometres	% of the Segment
Modified	Urban	Commercial/Industrial	Mainly commercial/industrial	2.4	6
Natural	Natural	Low Value	No observable changes to the naturally occurring habitat	35	94
Total Segment 5 Length (km)				**37.4km**	

This geographic diversity is also reflected by the Segment having the most plant biodiversity of all the Segments, with a total of 25 plant species observed during the Rapid Assessment. Segment 5 is primarily a Natural Habitat (Figure 16), and the south-easternmost corner of the Conveyance Pipeline route is inaccessible (there is no road or track). Satellite imagery shows that this area consists of salt flats (Playa) and desert pavement, which, typically in this environment, has a very low density of flora.

However, at the eastern end, the route aligns with the Disi Pipeline. It turns northward, passing a large Solar PV facility and associated infrastructure, classified as Modified Habitat – Urban (Commercial/Industrial). Also, the Disi Pipeline integrates a series of wells, likely designed for pressure management and operational efficiency.

Many of these wells are leaking water into the surface environment, creating artificial mini-wetlands that support a greater diversity and density of plants than are typically found in this desert environment year-round. It is unclear if the water leakage is a natural feature of how the pressure relief valves function or if it is the result of human intervention. The mini-wetlands created by these Disi structures likely attract fauna and flora species that would otherwise not occur in these areas. While the above-ground structures associated with the Disi Pipeline are obvious to the naked eye, the buried Pipeline itself appears not to have left a lasting impression on the environment.

The 25 species observed in this Segment during the Rapid Assessment were *Acacia gerrardii*, *Anabasis articulata*, Anvillea garcin*ii*, *Artemisia judaica*, *Artemisia monosperma*, *Calotropis procera*, *Citrullus colocynthis*, *Conyza canadensis*, *Fagonia mollis*, *Haloxylon persica*, *Hammada salicornica*, *Hammada scoparia*, *Hyoscyamus desertorum*, *Hyoscyamus muticus*, *Launaea spinosa*, *Ononis spinosa*, *Pergularia tomentosa*, *Phragmites australis*, *Pulicaria crispa*, *Retama raetam*, *Ricinus communis*, *Salsola baryosma*, *Tamarix* spp., *Traganum nudatum*, and *Zilla spinosa*, and were subject to confirmation by the Terrestrial Baseline Survey. Of these species, only Ricinus communis (the Castor Bean Plant) is widely cultivated, but it can also grow wild in the presence of water. No reptile or mammal species were observed in this Segment during the Rapid Assessment.

6.6.2 Terrestrial Baseline Survey Results

Eight survey locations were studied in Segment 5, of which one (FA24) was surveyed for fauna only. With the exception of an area where the Pipeline passes near a Solar PV and associated Project Facilities, the entire route was classified as Natural Habitat. There is an area of the Pipeline that was not accessible due to the absence of a road (and being escorted by Police personnel) and was therefore not surveyed, but from satellite imagery, it appears to mostly consist of mud or salt flats, which are expected to be largely bereft of plants. Terrestrial Baseline Survey results for Segment 5 are shown in Table 20.

Table 20: Segment 5 Summary of Results

Site ID	Plant Cover (%)	Species Richness	Plant Species Abundance	Plant Diversity (H')	Animal Species	Animal "Signs"
FA16	0.00	0	0	0.0000	1	-
FA17	1.13	3	19	0.7080	0	-
FA20-1	1.28	3	8	0.9003	0	-
FA21	6.08	6	36	1.3298	2	-
FA22	5.50	8	23	1.5377	1	-
FA23	1.43	2	5	0.5004	1	-
FA24	-	-	-	-	2	-
FA25	9.27	3	16	0.6019	0	-

This survey Segment displayed a higher plant biodiversity than did the previous Segments, with 13 plant species, of which five are red-listed for Jordan: *Artemisia judaica* (VU), *Calligonum comosum* (EN), *Artemisia monosperma* (NT), *Haloxylon rotundifolium* (NT), and *Hyoscyamus muticus* (CR), but less diversity than was observed during the Rapid Assessment. The causes of differences in species richness between the Terrestrial Baseline Survey and the Rapid Assessment are the same as in previous Segments, where invasive species occupying a narrow band and scattered distribution immediately adjacent to the roadside were observed during the Rapid Assessment, but could easily be missed in a quantitative survey that extends 100 m away from the roadside. The roads were not busy in this Segment, and surveys could more closely approach the roadside edges, but the highly fragmented distribution of soil disturbance-loving plants along the edges nonetheless makes them less likely to be recorded.

The two survey locations on the West-East Segment of the Pipeline were a mud/salt flat with no recorded vegetation (FA16), but included an observation of a Sainai Agama lizard (*Pseudotrapelus sinaitus*) that appears to prefer unvegetated areas and consolidated (non-sandy) soils, presumably thereby enabling burrowing by that species. Survey site FA17 consisted of three plant species: *Artemisia judaica, Fagonia mollis*, and *Haloxylon salicornicum*, respectively, and was dominated by *A. Judaica* but nonetheless had a plant canopy cover of only 1.13%.

Along the south–north section of Segment 5, the survey site FA20-1 was located near a Solar PV facility (not a Project facility) and had a similar plant canopy cover to FA17 with 1.28% cover, and a similar plant species composition of *Artemisia judaica, Calligonum comosum*, and *Fagonia mollis* (66% similarity). No fauna species were recorded at this site.

Survey sites FA21 and FA22 had high vegetation species richness with 6 and 8 species, respectively. *Artemisia judaica, Cynodon dactylon, Fagonia mollis, Haloxylon salicornicum, Phragmites australis*, and

Retama raetam were recorded by the plant survey and two species of reptile were also recorded at the site, *Acanthodactylus boskianus*, *Acanthodactylus opheodurus* (Arnold's Fringe-Fingered Lizard).

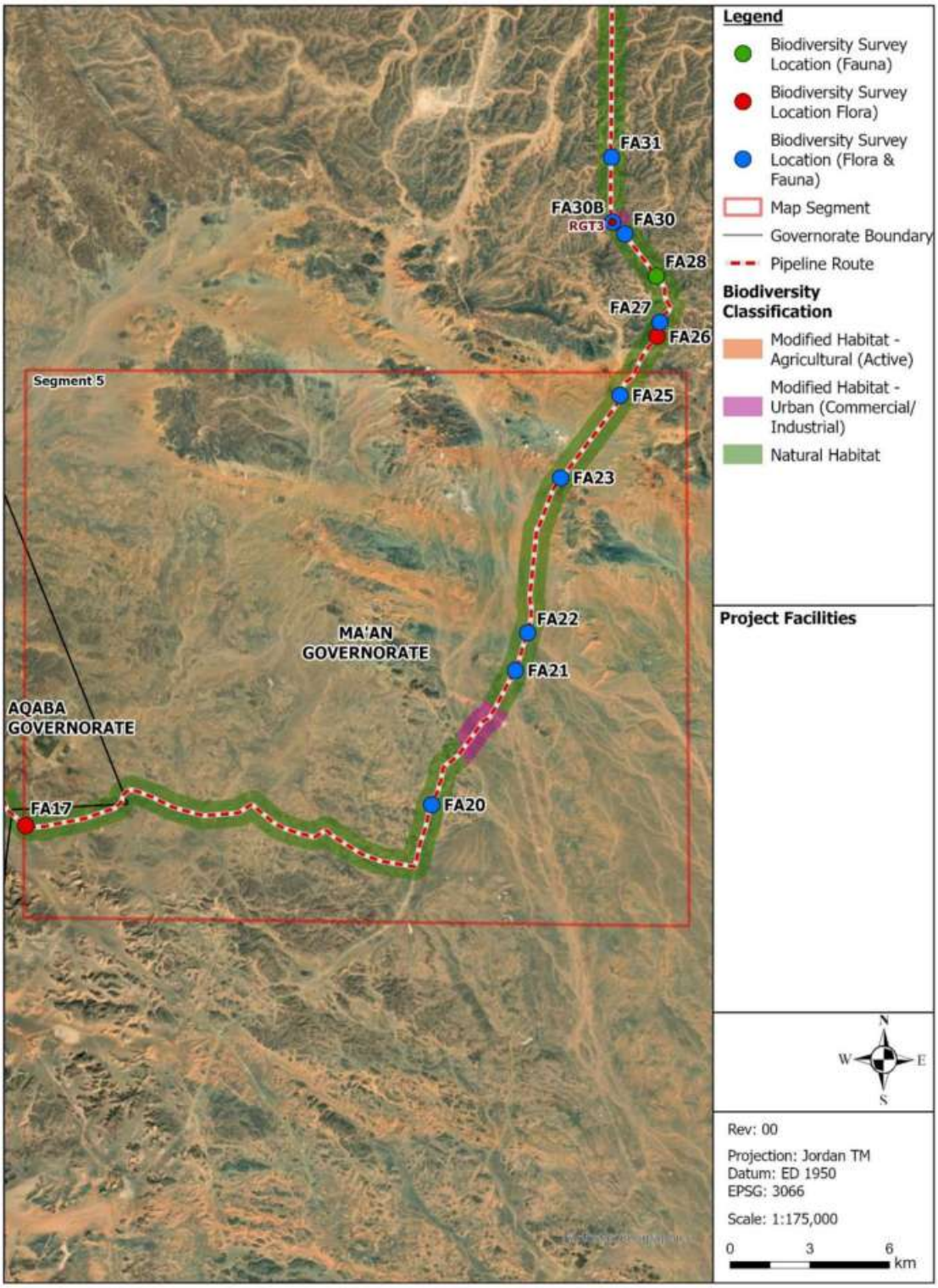
Terrestrial Baseline Survey site FA22 had a higher species richness (8 species), of which four were in common with FA21 (*Artemisia judaica* (VU), *Fagonia molis, Haloxylon salicornicum*, and *Retama reatam*), and the other four species were not (*Artemisia monosperma* (NT), *Haloxylon rotundifolium* (NT), *Hyoscyamus muticus* (CR), and *Zilla spinosa*). Despite the higher species richness, plant canopy cover and plant species abundance were lower than at site FA21. However, with a more even distribution of plant species, its diversity index was slightly higher (H' = 1.5377). One reptile species, the Fan-footed Gecko (*Ptyodactylus hasselquistii*) was recorded at FA22. At the same site, abandoned structures (bridges) with potential to be bat roosting sites were investigated, but lacked evidence of ever having been used for roosting.

Only two plant species were recorded at FA23 (*Artemisia monosperma* (NT), and *Pulicaria undulata*) together with one reptile species *Acanthodactylus boskianus* (Bosc's Fringe-Toed lizard) and the site canopy cover was 1.43%.

The Terrestrial Baseline Survey site FA24 was used solely as a camera trap location for larger mammals, capturing nighttime images of two red foxes (*Vulpes vulpes*) and one desert hedgehog (*Paraechinus aethiopicus*).

The final Terrestrial Baseline Survey site in this Segment, FA25, was notable due to the relatively high plant canopy cover (9.27%) and relatively low plant species richness with just three species (*Artemisia monosperma* (NT), *Citrullus colocynthis*, and Zilla spinosa).

Figure 16: Segment 5 Map



6.7 Segment 6

6.7.1 General Description and Rapid Assessment Results

Segment 6 is oriented north-south, and is approximately 130+ km long, beginning at the intersection of the unpaved track paralleling the Disi Pipeline and of the (new) paved road leading to the Jordan–India Phosphoric Acid Plant (29°51'0.11"N; 35°58'57.16"E) in the south and ending at the intersection with the Desert Highway in the North.

This is the longest of the nine Segments, and it is the second most diverse in terms of plant biodiversity, with 19 species of plants. Most of the route in this Segment passes through a Natural Habitat in the south (Figure 20) and the north and in the north-central sub-Segment, there is an area with significant Modified Habitat classified as Modified Habitat – Agricultural (Active) (Figure 21). The effects of the Disi Pipeline leakage are most visible, particularly in the central and southern areas. When the Pipeline route swings to the west to align with the Desert Highway, the leakage is largely absent, suggesting that there may be an anthropogenic driver for the leakage, as the more southern areas also appear to experience more human interaction. While there is little development in the southernmost section of the Segment, agricultural activities can be observed near (but not adjacent to) the Pipeline route beginning at approximately 30°13'3.05"N/ 36° 4'0.23"E.

In the centre of the Segment (northern edge of Figure 20 and the southern edge of Figure 21There is also an Air Force base and town (Jafr) to the northeast of the route. Intense agricultural activity, including immediately adjacent to the Pipeline route, is present but tapers off, and the Segment returns to largely natural habitat in the northernmost areas as the route swings westward. A summary of the habitat classification is provided in Table 21.

Table 21: Habitat Classification Summary, Segment 6

Main habitat	Secondary	Tertiary	Description	Kilometres	% of the Segment
Modified	Urban	Commercial/Industrial	Mainly commercial/industrial	0.8	0.6
Modified	Agricultural	Active	Agricultural fields/orchards actively cultivated	32	25
Natural	Natural	Low Value	No observable changes to the naturally occurring habitat	91	70.8
Natural	Semi-Natural/Degraded	Low Value	Limited change to habitat considered to be >75% natural	4.7	3.6
Total Segment 6 Length				**128.5km**	

The 19 species observed in the area include *Acacia gerrardii*, *Achillea fragrantissima*, *Anabasis articulata*, *Citrullus colocynthis*, *Diplotaxis acris*, *Diplotaxis harra*, *Euphorbia retusa*, *Farsetia aegyptiaca*, *Hammada scoparia*, *Hyoscyamus desertorum*, *Peganum harmala*, *Pergularia tomentosa*, *Phragmites australis*, *Pulicaria crispa*, *Retama raetam*, *Seidlitzia rosemarinus*, *Tamarix aphylla*, *Typha* spp, and *Zilla spinosa*,

three reptile (lizard) species *Uromastyx aegyptia*. B. *Trapelus agnetae* and *Pseudotrapelus sinaitus*, and one amphibian (toad) species (species to be identified) that are subject to confirmation by the Terrestrial Baseline Survey. Species abundance is variable, with some areas of relatively dense vegetation.

No wild mammal species were observed in this Segment during the Rapid Assessment.

6.7.2 Terrestrial Baseline Survey Results

A total of 39 sites were surveyed in the Segment, with results shown in Table 22. Twenty-three plant species were recorded in this Segment, making it the most diverse of all the Segments (but bearing in mind that it also covered the greatest distance and area). This Segment is different from Segments 1 to 5 in that a greater number of plants were detected by the Terrestrial Baseline Survey (23) than were detected by the Rapid Assessment (19). The cause of this difference is likely due to the fact that the road in this Segment is unpaved and not raised above the surrounding landscape. In the absence of distinct roadside verges, where water collects, the species composition and density are very similar to those of the surrounding landscape. Additionally, the frequent Wadi systems with denser vegetation effectively hid some species from sight during the Rapid Assessment but were revealed with the more precise Terrestrial Baseline Survey. The high species richness in some wadis serves as confirmation.

Table 22: Segment 6 Summary of Results

Site ID	Plant Cover (%)	Species Richness	Plant Species Abundance	Plant Diversity (H')	Animal Species	Animal "Signs"
FA26	0.00	0	0	0.0000	-	-
FA27[2]	5.23	4	6	1.3297	3	-
FA29	Fauna survey only				2	
FA30	3.80	4	21	1.0738	-	-
FA30B	0.00	0	0	0.0000	-	-
FA31[3]	8.67	6	50	1.1288	-	-
FA32[3]	2.81	3	10	0.8979	1	-
FA33[3]	Fauna survey only				1	
FA35[3]	1.80	4	9	1.2730	-	-
FA36[3]	11.28	4	19	0.8264	-	-
FA37[3]	2.20	8	19	1.8858	-	1
FA38[3]	2.88	6	32	0.9089	1	-
FA39[3]	2.15	5	17	1.3130	-	-
FA40[3]	5.76	6	43	0.8998	1	-
FA41[3]	7.91	6	22	1.2996	2	1
FA42[3]	7.73	9	52	1.5729	5	-
FA43	4.03	3	33	0.9267	-	2

[2] Site with water leakage from the Disi Pipeline
[3] Wadi site with trees of *Vachellia gerrardii*

Site ID	Plant Cover (%)	Species Richness	Plant Species Abundance	Plant Diversity (H')	Animal Species	Animal "Signs"
FA44[3]	3.68	5	47	1.0088	1	-
FA45	0.00	0	0	0.0000	-	-
FA46	0.12	1	5	0.0000	1	-
FA46A	2.92	4	31	0.5187	1	-
FA47	Fauna survey only				1	1
FA48	0.45	2	10	0.6931	1	-
FA50	Fauna survey only				3	
FA51A	4.29	1	29	0.0000	Flora survey only	-
FA51B	0.03	1	1	0.0000	Flora survey only	-
FA52	Fauna survey only					2
FA53	0.62	5	25	1.1873	3	1
FA54	Fauna survey only				1	-
FA55	0.85	2	-	0.6365	1	
FA56	Fauna survey only				2	-
FA57	Fauna survey only				-	-
FA58	Fauna survey only				2	-
FA59	Fauna survey only				-	-
FA60	Fauna survey only				1	-
FA-PS4	Fauna survey only				-	-
FA61	0.92	3	6	1.0114	Flora survey only	
FA62	0.28	2	2	0.6931	Flora survey only	
FA63	0.05	1	1	0.0000	Flora survey only	

Most of the extent of the Pipeline falls within the Saharo-Sindian-Arabian geographic region (Taifour *et al*. 2022). A small stretch of the Pipeline at the northern end of the Segment has vegetation that is more characteristic of the Irano-Turanian Region. The vegetation composition is enriched by the many leaking pressure management wells (Figure 17) of the Disi Pipeline, which parallels the proposed Conveyance Pipeline route throughout this Segment.

Another notable feature of the Segment is the numerous wadis that flow from east to west, intersecting with the south–north-oriented pipeline route. The Wadis range in size from shallow channels a few centimetres deep (Figure 18), to others that may have a wadi bed of over a hundred meters wide, to deep wadis cutting a channel that is several meters deep into the soil (Figure 19). A characteristic of the larger wadis in the area between Terrestrial Baseline Survey sites FA31 and FA42 is the presence of *Vachellia gerrardii* trees, a Jordan red-listed species (Vulnerable).

Figure 17: Artificial Ponds Due to Leakage from Disi Pipeline Infrastructure (FA48)



Figure 18: Shallow Wadi with Trees of *Vachellia gerrardii* and Shrubs of *Zilla spinosa* (FA38)



Figure 19: A Deep Wadi at FA36, *Retama reatam* in the Foreground *Vachellia gerrardii* in the Distant Background



At the southern-most survey point in Segment 6, FA26, the survey did not encounter any vegetation. Vegetation at site FA27, where there was a small leakage of water from the Disi Pipeline, included *Phragmites australis*, *Tamarix aphylla*, *T. nilotica*, and *Fagonia molis*. As the Pipeline continues northward, a general pattern of increasing species richness is observed, particularly at the frequent wadis that intersect this area. The area between Terrestrial Baseline Survey sites FA31 and FA44 is characterised by relatively high species richness and features frequent Wadis (and intervening desert), including the locally red-listed species *Vachellia gerrardii*. Species richness was highest at FA42, where nine species were recorded (*Phragmites australis*, *Astragalus spinosus*, *Pulicaria undulata*, *Zilla spinosa*, Vachellia gerrardi (VU), *Fagonia bruguieri, Achillea fragrantissima*, *Haloxylon scoparium*, and *Cynodon dactylon*).

Further north along the Pipeline route, species richness decreases, and there is no measurable vegetation between survey sites FA54 and FA PS4. At FA PS4, the Pipeline route changes direction to a northwesterly orientation until the Pipeline route joins Desert Highway. The Disi Pipeline takes the same route. The northwesterly section of the Pipeline route in Segment 6 is also very barren, with many shallow wadis, more reminiscent of surface flows that have scoured the soil, with no vegetation cover except for a few plants along the disturbed roadsides. Additionally, where vegetation is present, it is more typical of the Irano-Turanian Biogeographic Region, often dominated (although sparsely) by Anabasis articulata and *Diplotaxis harra*.

Faunal species in this Segment included *Pseudotrapelus aqabensis* (at FA33), an IUCN red-listed *Uromastyx aegyptia* (FA50 and a burrow at FA53), *Acanthodactylus boskianus* at several survey locations (FA38, FA40, FA41, FA42, FA44, FA46A, FA47, FA53, FA54, FA55, FA56, and FA58); *Pseudotrapelus sinaitus* at FA27 and FA50; *Ptyodactylus hasselquistii* at FA27 and FA29; *Stenodactylus grandiceps* at FA29 and FA32, *Trapelus agnetae* at FA41, FA46, FA48, FA50, FA53, FA58, and FA60, signs of Varanus griseus at survey sites FA43 and FA52. While reptile species and abundance were especially high in the region of FA38 to FA47, which also reflected the greater vegetation cover and diversity present in that area, various reptile species were also present at other survey sites, including those with low or even no vegetation. *Uromastyx aegyptia*, *Acanthodactylus boskianus*, and *Trapelus agnetae* appeared to be particularly attracted to the low/unvegetated sites.

Mammal species were less common with “signs” (burrows) of *Meriones crassus* observed at four survey sites (FA37, FA41, FA43 and FA52) and Red Fox (*Vulpes vulpes*) observed during a night transect survey; a desert hedgehog (*Paraechinus aethiopicus*) observed at FA53, and signs of Gerbil species at survey site FA47.

Birds were observed at one survey site in Segment 6, at site FA42 (*Galerida cristata, Carpodacus synoicus, Acrocephalus scirpaceus*, and *Streptopelia decaocta*) which is a plant species-rich wadi site.

Amphibians (*Bufotes sitibundus*) were present in standing water from a Disi Pipeline leakage at Survey site FA56.

Figure 20: Segment 6a Map

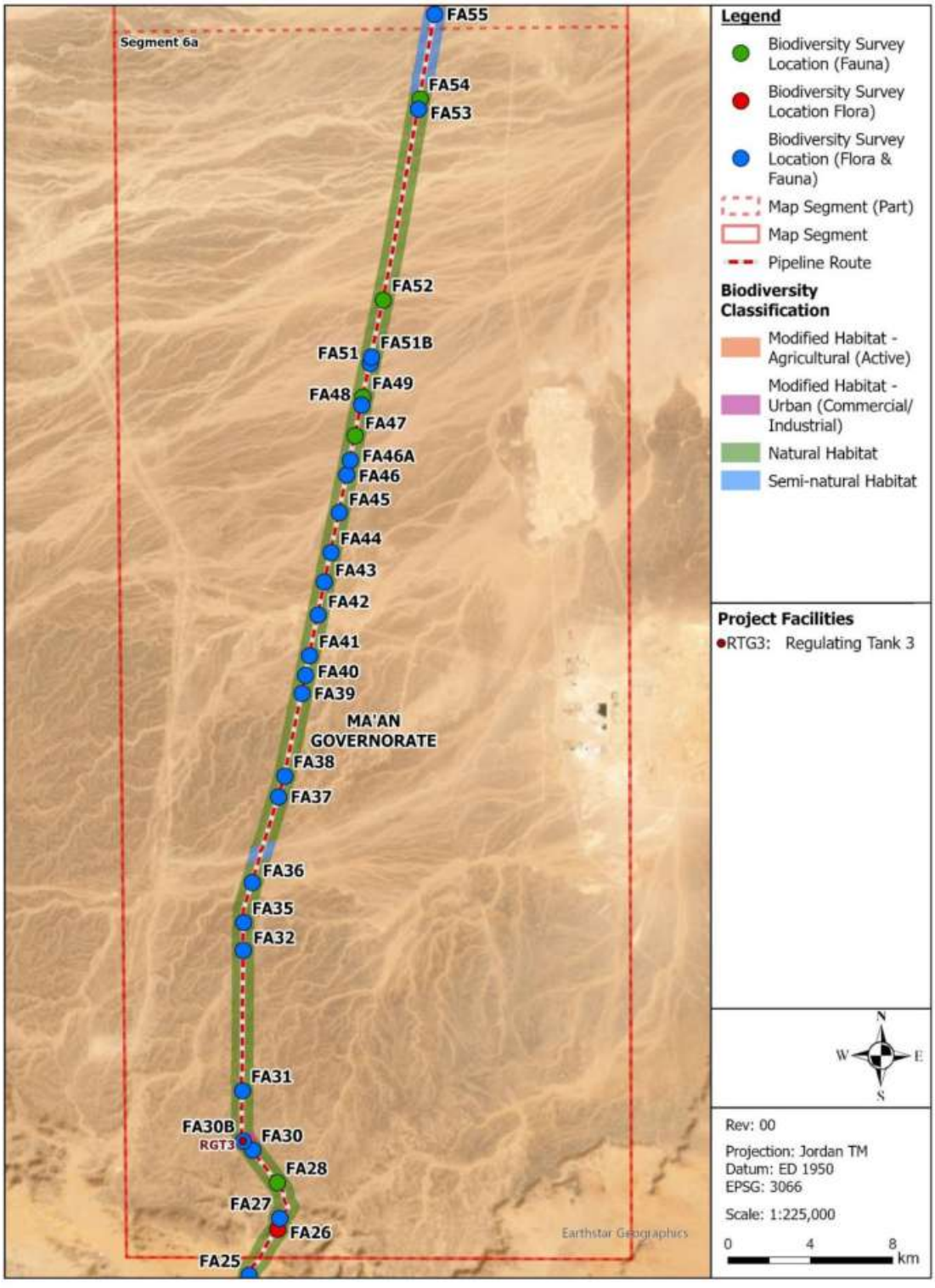
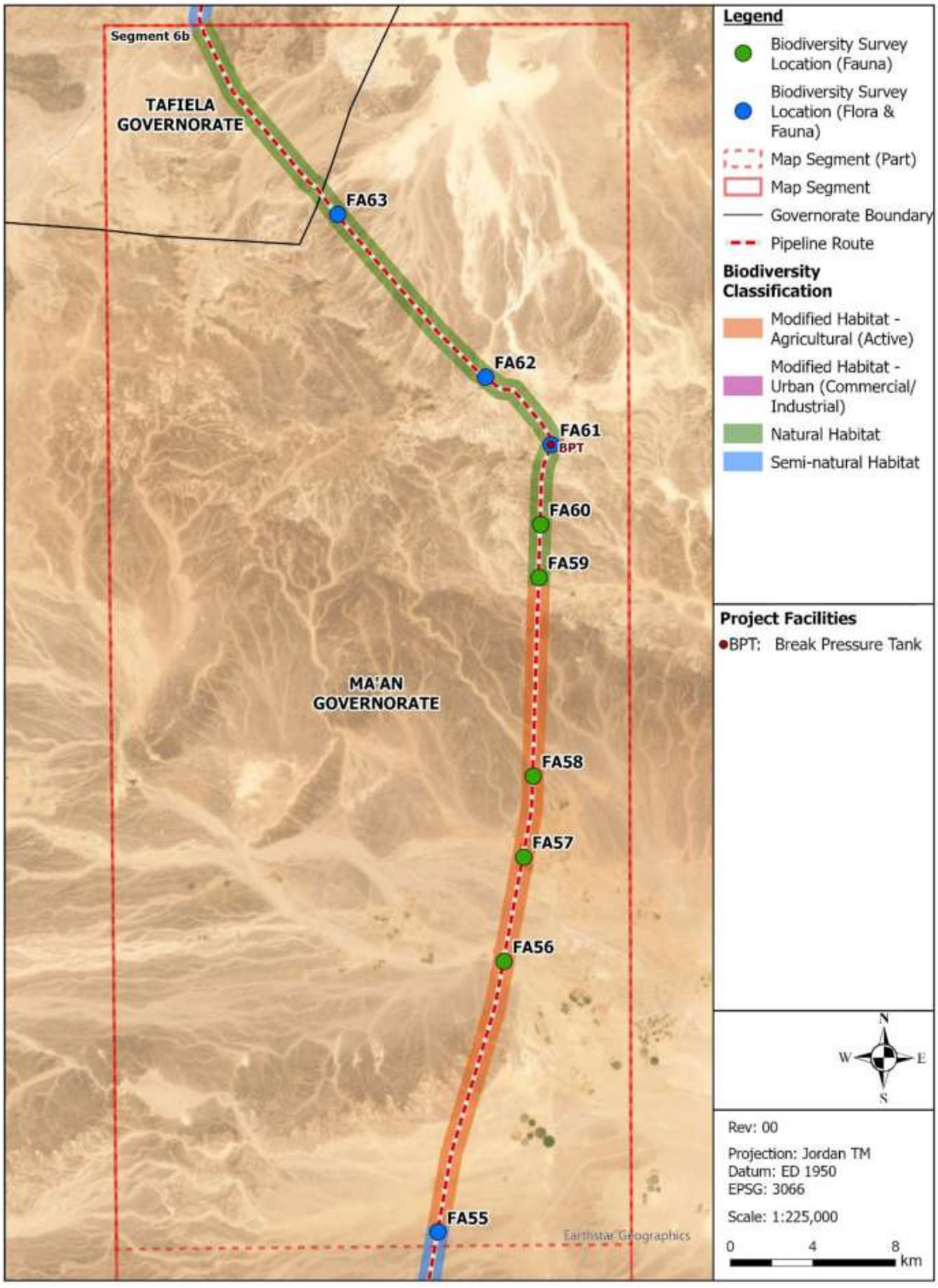


Figure 21: Segment 6b Map



6.8 Segment 7

6.8.1 General Description and Rapid Assessment Results

Segment 7 is another long Segment of approximately 128+ km length, stretching along the Desert Highway until it reaches the outer limits of Amman (Figure 26, Figure 27). This Segment is the most heterogeneous of all the Segments, with areas of Semi-Natural/Degraded Habitat interspersed with Modified Habitat – Agricultural (Mixed), Modified Habitat – Agricultural (Active), Modified Habitat – Urban (Residential), and Modified Habitat – Urban (Mixed). There was no significant stretch of the Pipeline route that could be classified as Natural Habitat in this Segment.

In the south, the route passes through areas of seemingly natural habitats but frequently interspersed with urban areas (residential, commercial and industrial) and areas of farmland; large-scale potash mining operations (Global International Fertiliser Factory) have also significantly impacted the landscape in some areas most notably through the creation of piles of mine tailings and processed water discharge ponds with associated non-natural vegetation.

Further north (Figure 27), the Pipeline route continues to parallel the Desert Highway for much of its length, only diverging from the highway for a short distance between 31°34'16.27"N / 36° 1'33.29"E and 31°36'23.13"N / 36° 0'0.20"E (following the Disi Pipeline and transiting through an area of abandoned agricultural fields). However, soon thereafter, it diverges permanently from the Desert Highway and the Disi Pipeline at 31°37'30.22"N / 35°59'40.75"E when the Project Pipeline route takes a more easterly route around the Queen Alia International Airport.

The Pipeline diverges through an area of agricultural land with both active and inactive farms. Some of this area appears to be in the process of being transitioned to industrial or housing estates, with new roads built but relatively few completed structures. The entire area is a Modified Habitat with *Anabasis articulata* dominating the fallow agricultural landscape, with a few other scattered plant species, particularly in areas that have been recently disturbed. A summary of the habitat classification is provided in Table 23.

Table 23: Habitat Classification Summary, Segment 7

Main habitat	Secondary	Tertiary	Description	Kilometres	% of the Segment
Modified	Urban	Commercial/Industrial	Mainly commercial/industrial	24	18.7
Modified	Urban	Residential	Mainly a residential area	16.7	13
Modified	Urban	Mixed	Mixed residential with commercial/industrial	10.1	7.9
Modified	Agricultural	Active	Agricultural fields/orchards actively cultivated	21.3	16.6

Main habitat	Secondary	Tertiary	Description	Kilometres	% of the Segment
Modified	Agricultural	Mixed	Agricultural fields, both active and fallow/abandoned	9.6	7.4
Natural	Semi-Natural/Degraded	Low Value	Limited change to habitat considered to be >75% natural	46.8	36.4
Total Segment 7 Length				**128.5km**	

As in many landscapes, the highway and other infrastructure appear to have had a significant impact on the habitat, through interrupting the natural east-west surface water flow and the disturbance associated with the road itself, and partly through encouraging urban and agricultural development by providing easy access to the main north-south transport corridor. While the Disi Pipeline is buried, a gas Pipeline on the west side of the highway incorporates an approximately 50cm tall above-ground linear berm that likely interrupts the free flow of surface water. Blocked culverts may also trap water, albeit temporarily, due to high evaporation rates, which encourages the growth of plants, some of which are not native to the area.

Fifteen plant species were observed during the Rapid Assessment: *Acacia cyanophylla*, *Achillea fragrantissima*, *Anabasis articulata*, *Astragalus spinosus*, *Atriplex leucoclada*, *Casuarina equisetifolia*, *Hordeum murinum*, *Malva parviflora*, *Peganum harmala*, *Phragmites australis*, *Retama raetam*, *Salsola* sp, *Tamarix* sp, *Xanthium spinosum*, and *Zilla spinosa*, and are subject to confirmation by the Terrestrial Baseline Survey. All plant species listed above are wild occurring (not cultivated). No reptile or mammal species (excluding domesticated species) were observed in this Segment during the Rapid Assessment.

6.8.2 Terrestrial Baseline Survey Results

In this Segment, the Pipeline transits south to north along the eastern edge of the Irano-Turanian biogeographical region. However, much of its length has undergone or is undergoing change due to anthropogenic activities, largely because of the existence of the Desert Highway, which affords easy access to the north and south of Jordan.

Because of the ongoing development and modification of the habitat, only nine sites were selected for the Terrestrial Baseline Survey (Table 24). While 15 plant species were observed during the Rapid Assessment, only 5 plant species were observed during the Terrestrial Baseline Survey, largely driven by the roadside effect also seen in Segments 1 – 5 and compounded by the need to avoid the busy Desert Highway that parallels the Pipeline route. Species abundance was the lowest of any Terrestrial Baseline Survey Segment, with no more than three plant species recorded on transect surveys at any survey site (but two additional seedling species were observed via quadrat surveys at FA68), and only five species overall (*Achillea fragrantissima, Anabasis articulata, Peganum harmala, Tamarix nilotica* and *Atriplex leucoclada*) in the Natural Habitat sites.

A notable feature of the vegetation is that *Anabasis articulata*, which is a characteristic species of the Irano-Turanian Region, was present in every site, while the remaining species were present in one survey site each (Achillea fragrantissima and *Peganum harmala* in FA68; and *Atriplex leucoclada* and *Tamarix nilotica* in FA65).

Table 24: Segment 7 Summary of Results

Site ID	Plant Cover (%)	Species Richness	Plant Species Abundance	Plant Diversity (H')	Animal Species	Animal "Signs"
FA64	0.50	1	5	0.0000		
FA64B						1
FA65	12.17	3	19	0.9592		
FA66	0.45	1	5	0.0000	2	
FA68	15.73	3 (+2)	81	0.1329	4	
FA69A	1.20	1	18	0.0000		1
FA69B	1.47	1	16	0.0000		
FA70	0.71	1	16	0.0000	1	
PS5	0.70	1	14	0.0000		

Site FA64 is a wadi site, and due to surface water scouring, only a few plants of *Anabasis articulata* were recorded at the site, resulting in low canopy cover, richness, and abundance. Fauna was monitored nearby, about 400m to the east of this site (recorded as site FA64B), where there were signs of rodent activity (several burrows), but no fauna species were observed.

Site FA65 was somewhat of an outlier because it was dominated by plants of T. nilotica, the only Segment 7 site where *A. Articulata* was not the dominant species, although it was present. The large shrub/small tree form of *T. nilotica* gave the site a relatively high per cent plant cover of 12.17% (Figure 22).

Figure 22: Survey Site FA65 with *T. nilotica* as the Dominant Plant Species



Plant species richness (only *A. articulata*) and cover were low at site FA66 near the town of Qatraneh, but two reptile species, the Snake-eyed Lizard (*Ophisops elegans*) and a Baluch rock gecko (*Bunopus tuberculatus*), were observed at the site during day and night surveys, respectively (Figure 23).

Figure 23: Snake-eyed Lizard (*Ophisops elegans*) at Survey Site FA65



Species richness was highest at survey site FA68, which also had the highest plant canopy cover (15.73%) of all sites in this Terrestrial Baseline Survey, as well as the highest plant species abundance. Survey site FA68 also has the distinction of being the only site where 1m x 1m quadrat measurements were applied because of the presence of seedling plants. The seedlings belonged to two annual species, M*alva parviflora* (Little mallow/Cheeseweed) and *Hordeum marinum* (Mediterranean barley), which have a low stature and can often be found on disturbed ground, suggesting that this area may not be a virgin Natural Habitat. Both species are native to Jordan. The distribution of the seedlings was uneven and appeared to be related to the presence of soil moisture (possibly due to leaks/discharges of water from a nearby pump station) and a somewhat more clay-rich soil texture. The distribution of vegetation was patchy, with areas of dense vegetation and other large areas devoid of vegetation, resulting in 15.73% vegetation cover over the entire area surveyed (Figure 24).

Figure 24: Landscape View of Site FA68



Four species of reptiles were observed at FA68, including one snake species, most probably a Forskal sand snake (*Psammophis schokari*), and a Snake-eyed Lizard (*Ophisops elegans*), during daytime, and two geckos, a Baluch rock gecko (*Bunopus tuberculatus*) and a *Hemidactylus dawudazraqi* during the night walking transects, giving this site the highest richness of animal species.

Survey site 69A was initially selected because it was located within the known range of the endemic species *Acanthodactylus ahmaddisii* (Jordanian Fringe-fingered Lizard), which was closest to the Pipeline route. The area's vegetation consisted of only *A. articulata*, with a relatively low canopy cover and abundance. No reptiles were observed along a 300m transect.

The area surveyed lies near the entrance to Daba'a Village (off the Desert Highway) and may have been subject to anthropogenic impacts since *A. ahmaddisii* was identified by Werner (2004). Therefore, to gain a more thorough understanding of the potential for the species to occur in the vicinity of the Pipeline, the survey team extended the survey to the Daba'a Rangeland Reserve, a fenced protected area (31°02'22"N, 36°00'28"E). A thorough survey of the area revealed the presence of three species of lizards (*Ophisops elegans, Eumeces schneideri*i, and *Pseudotrapelus sinaitus*), but *Acanthodactylus ahmaddisii* was not observed. Of the three species present, *Ophisops elegans* was the most common, with 25 individuals recorded, while the remaining two species were represented by a single individual each.

Survey site 69B was dominated by *A. articulata*, but other species in the area (not captured by the transects) included *Tamarix aphylla* and *Pulicaria undulata* in a wadi. Two walking transects did not reveal any reptiles or small mammal species within the survey site.

Survey site 70 is located at the northern end of Segment 7, and there are nearby signs of urbanisation with residential developments encroaching on former agricultural land. The site surveyed had very low cover of *Anabasis articulata* only. Walking surveys of three transects for fauna revealed two individuals of Egyptian Rock Agama (*Laudakia vulgaris*).

The northernmost survey location for Segment 7 was PS5, the proposed location for the Pipeline pump station. The area shows clear signs of past agricultural activity (furrows, old irrigation material, etc.). Occasional plants of *Anabasis articulata* dotted the landscape, resulting in a low vegetation cover and abundance (Figure 25), and no fauna or signs of fauna were evident at the site.

Figure 25: Survey Site PS5 a Fallow Field with Little Vegetation



Figure 26: Segment 7a Map

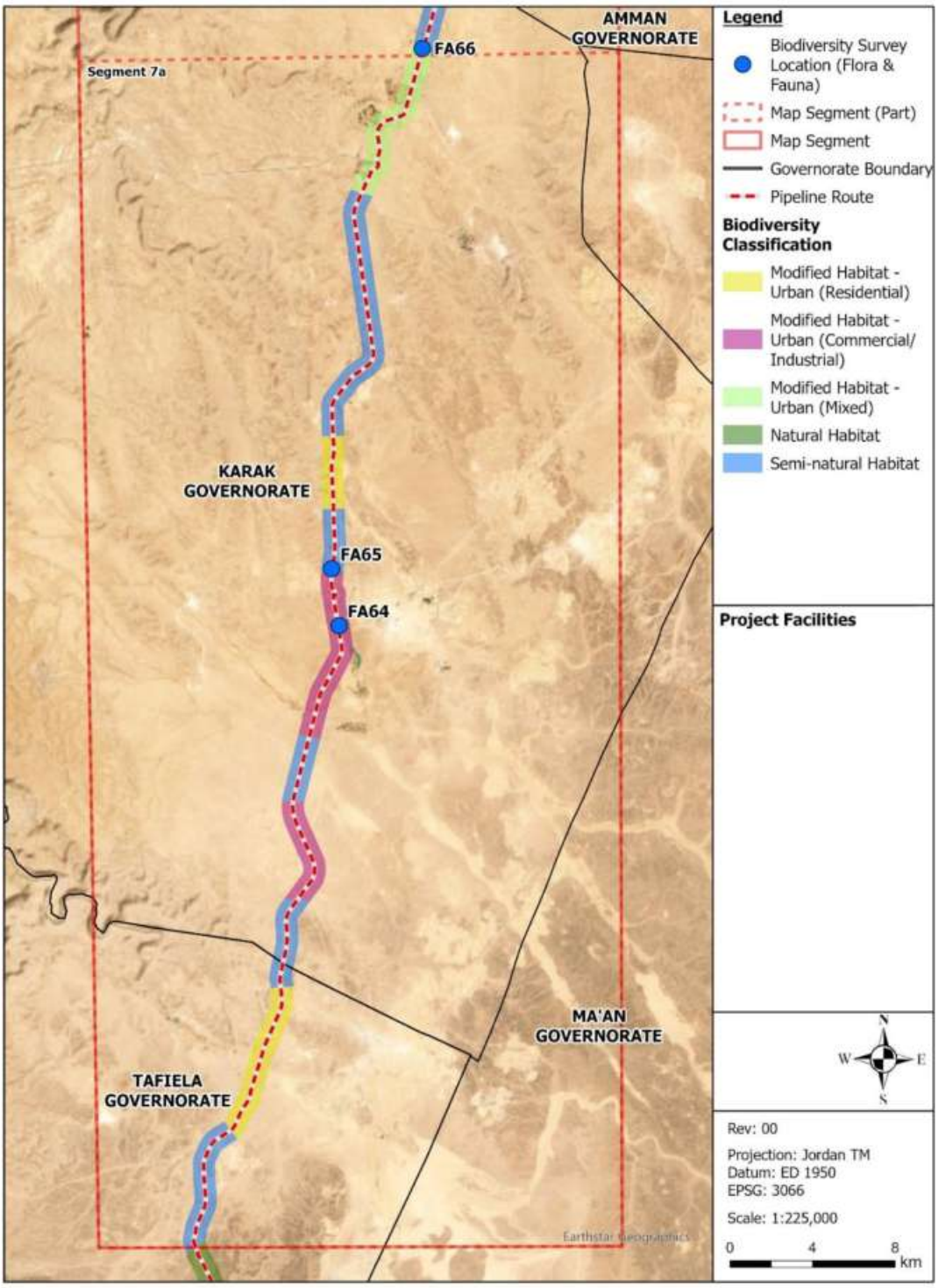
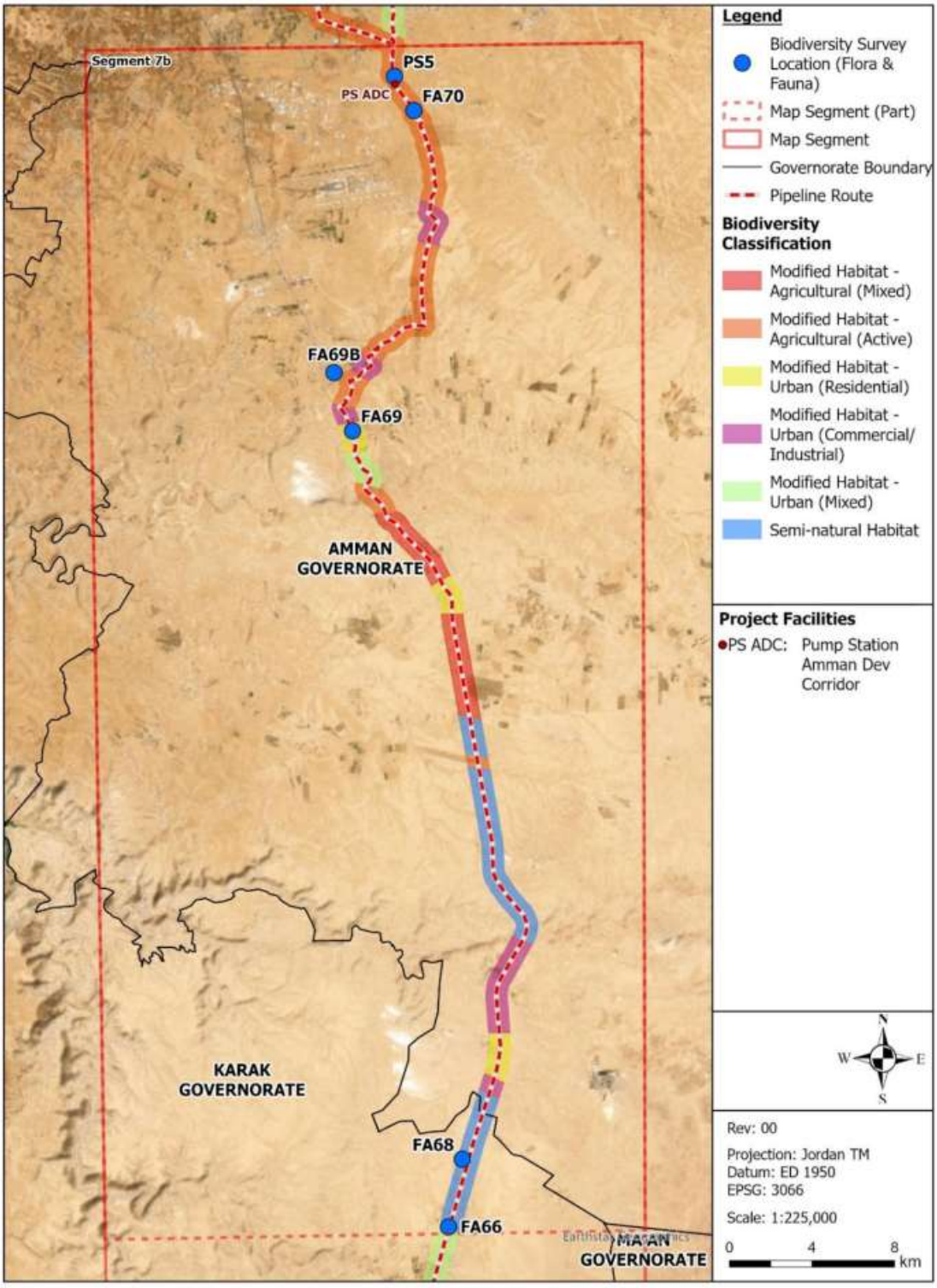


Figure 27: Segment 7b Map



6.9 Segment 8

6.9.1 General Description and Rapid Assessment Results

This Segment is a relatively short Segment of approximately 19km that extends from the northern end of Segment 7 in a west and north-westerly direction, initially through abandoned farmland, followed by actively cultivated farmland into a suburban setting comprising some residential and commercial areas (Figure 30). The first approximately 14km of the Pipeline route until it reaches the Madaba Highway is primarily farmland with occasional residences. A more densely populated but short (approximately 750 m) section of multi-family housing soon gives way to agriculture for the remaining 4km, with a 250 m forest frontage along the Airport Road (Highway) and the Ghamadam National Park. The park is also elevated by an embankment of approximately 2m from the level of the frontage road that the Pipeline will follow. The Amman National Park is about 200m from the Pipeline route, similarly elevated, but on the west side of Airport Road, while the Pipeline is planned for the east side of the Airport Road frontage road.

The Segment was reviewed from 13 locations, but none were chosen for application of the full survey because there were no Natural Habitats or Semi-Natural Habitats within this Segment. A summary of the habitat classification is provided in Table 25.

Table 25: Habitat Classification Summary, Segment 8

Main habitat	Secondary	Tertiary	Description	Kilometres	% of the Segment
Modified	Urban	Mixed	Mixed residential with commercial/industrial	0.6	3
Modified	Agricultural	Mixed	Agricultural fields both active and fallow/abandoned	9.3	49
Modified	Agricultural	Active	Agricultural fields/orchards actively cultivated	9.2	48
Total Segment 8 Length				**19.1km**	

Ten plant species were identified growing in this Segment: *Achillea fragrantissima*, *Anabasis articulata*, *Capparis spinosa*, *Cupressus sempervirens*, *Eucalyptus camaldulensis*, *Noaea mucronata*, *Olea europaea*, *Pinus halepensis*, *Sarcopoterium spinosum, Verbascum* sp., several of which are cultivated and/or used for landscaping. as species, and none of them are Red Listed. Although no Biodiversity Survey sites were selected for this Segment (due to the prevalence of Modified Habitat), the species listed will be confirmed during the Terrestrial Baseline Survey.

While *Anabasis articulata* occurred along disturbed roadside verges and abandoned agricultural fields, the remaining “wild” species occurred primarily along roadsides in disturbed areas.

No reptile or mammal species (excluding domesticated species) were observed in this Segment. The survey did not reveal any structures that could serve as roosting locations for bats.

The entire length of the Pipeline in this Segment and the reservoir location were not suitable for quantitative survey methods due to the presence of busy roads, private properties lining the roads, and the extent of modified habitat.

The quantitative surveys were also rendered moot due to the preponderance of agricultural and urban developments that occupied the entire route (Figure 28 and Figure 29).

Figure 28: Examples of Habitats in the Southern Areas of Segment 8



The western part of the Pipeline, including the area of the receiving reservoir (Al Muntazah) and the Ghamadan National Park, is in the Mediterranean biotope. From southeast to northwest, land use transitions from abandoned agriculture to active field crop agriculture to mixed field crop agriculture, residential to mixed orchard agricultural-residential-commercial (Figure 29).

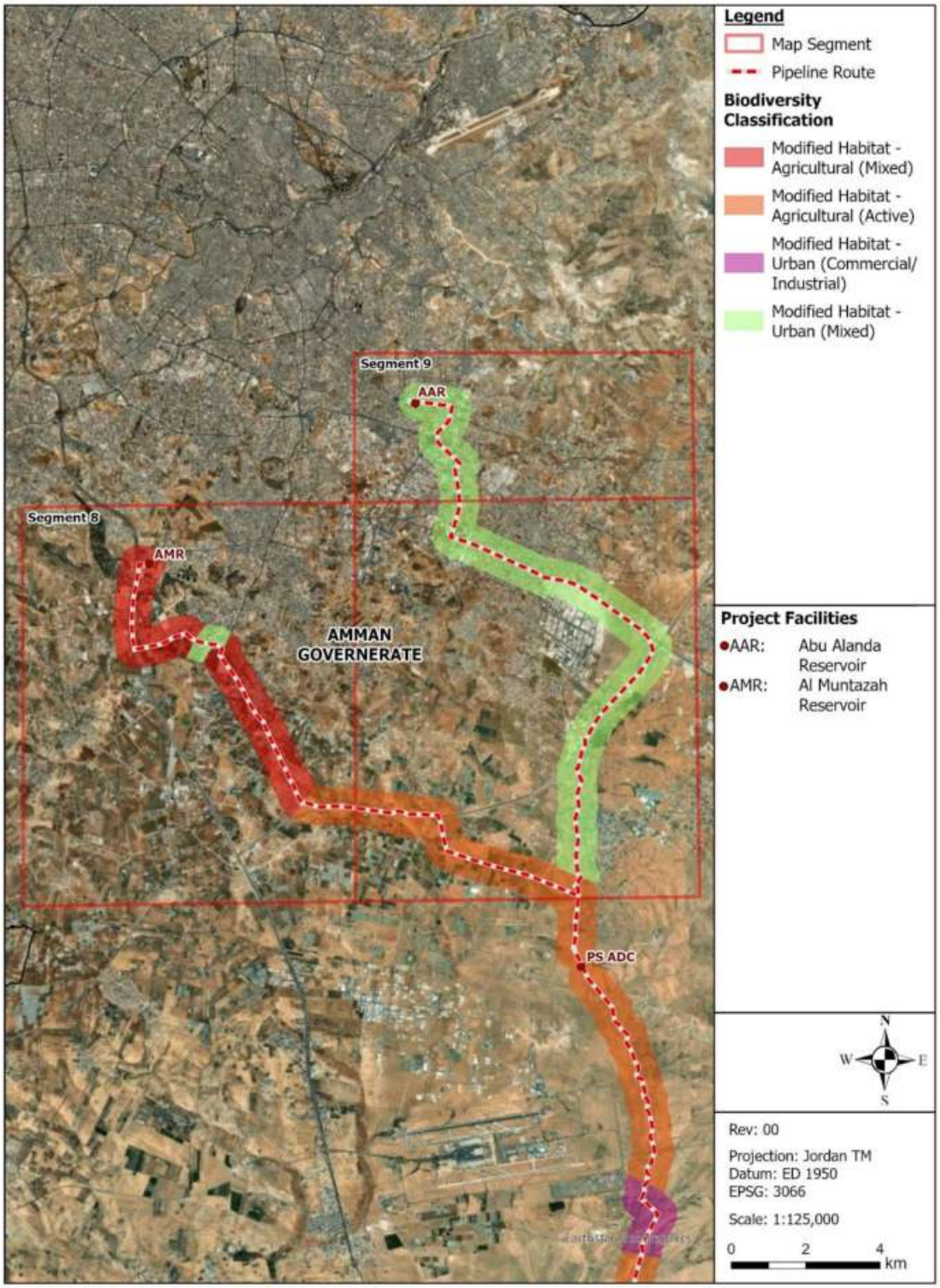
Signs (mounds) of the Middle Eastern blind mole rat (*Spalax ehrenbergi*) were observed in some fields, approximately midway along the Pipeline route in Segment 9, during the survey. Both *M. musculus* and *R. norvegicus* are known to occur in urban areas in Jordan, in close association with human habitations.

There were no natural or anthropogenic structures likely to support bat roosts in the entire area of Segment 8.

Figure 29: Examples of Habitats in the Central and Northern Areas of Segment 8



Figure 30: Segment 8 (Left Arm) and 9 (Right Arm) Map



6.10 Segment 9

6.10.1 General Description and Rapid Assessment Results

Segment 9 is the most densely urbanised of all the Rapid Assessment Segments (Figure 30). The density of urbanisation was somewhat lower in the south, but even in areas with significant remnant agricultural fields, the area was clearly undergoing transition to urbanisation, most of which appeared to be industrial/commercial. As a result, we classified the entire area as Modified Habitat - Urban (Mixed). A summary of the habitat classification is provided Table 26.

Table 26: Habitat Classification Summary, Segment 9

Main habitat	Secondary	Tertiary	Description	Kilometres	% of the Segment
Modified	Urban	Mixed	Mixed residential with commercial/ industrial	18.4	100
Total Segment 9 Length				**18.4km**	

The plant species identified in this area included ornamental species used for landscaping (*Cupressus sempervirens*, *Eucalyptus camaldulensis*, and *Pinus halepensis*) and Anabasis articulata, which colonises disturbed areas, including fallow fields. These species will also be confirmed during the Baseline Survey, even though no formal Baseline Survey points are planned for this Segment. This Segment terminates at the Abu Alanda Water Reservoir, which is situated in a densely urbanised area of Amman.

No natural features or anthropogenic structures that could serve as bat roosts were observed in Segment 9.

Segment 9 lies in the easternmost area of the Mediterranean biotope. South of this area, the Irano-Turanian Biotope dominates across the remainder of the Pipeline. Native species, such as Aleppo pine (*Pinus halepensis*), are scattered throughout the area, as well as trees of Carob (*Ceratonia siliqua*) that are planted along Highway 40.

The entire length of the Pipeline and the reservoir location in this segment were not suitable for quantitative survey methods due to busy roads, private property along them, and the extent of urban developments and agricultural fields that occupied the entire route.

Regarding faunal species, invasive species such as the House Mouse (Mus musculus) and the Brown Rat (Rattus norvegicus) are known to occur in urban and commercial areas. However, in areas such as Adh Dhuhaybah and Al Sharqiyah, the Fat Sand Rat (*Psammomys obesus)*, Wagner's Gerbil (*Gerbillus dasyurus)*, and the Grey Hamster (*Cricetulus migratorius)* were reported from the vicinity of Mowaqqar (Amr & Saliba, 1986); however, recent studies, to reflect the increased extent of human activity, are lacking.

Residential, commercial, and industrial areas are common in this area, which is also a major trucking corridor to the Iraqi border and the desert highway. The full extent of Segment 8 is impacted by anthropogenic activities and cannot be considered to be a Natural Habitat (Figure 31).

Figure 31: Examples of Development in Segment 9



7 Key Findings

7.1 Desktop Summary

The desktop studies in this report included the collection and collation of existing data on Protected Areas, mammals, vegetation and Reptiles. A desk study covering birds was undertaken separately and is included in the report covering ornithological data for the project route (Appendix 11).

There are six Protected, designated or Proposed Protected Areas within 10km of the Project:

- The Aqaba Proposed Reserve
- The Qatar Nature Reserve
- The Wadi Rum Protected Area
- The Coastal and Aqaba Mountains KBA
- Hisma Basin – Rum KBA
- Madaba Hisban KBA

Published records of mammals in Jordan date back only to the early 1960s and generally focus on the mammalian fauna of broad regions in Jordan, rather than attempting to map distribution. Wadi Rum has been the focus of more detailed investigations of certain mammalian groups, such as bats.

Similarly, records for reptiles are sparse and represent a generalised distribution only.

The desktop study was successful in providing a broad context for the potential reptilian and mammalian fauna along the route, but failed to offer any location-specific guidance on areas requiring detailed study.

Existing information on the vegetation of the proposed route covers primarily Southern Jordan, which comprises a mosaic of desert, halophytic, and enclavic woodland/shrubland communities.

7.1.1 Habitat Overview

The habitats encountered that were altered due to human intervention were classified as Modified Habitats and further subcategorised based on the main type of urban setting or agricultural activity.

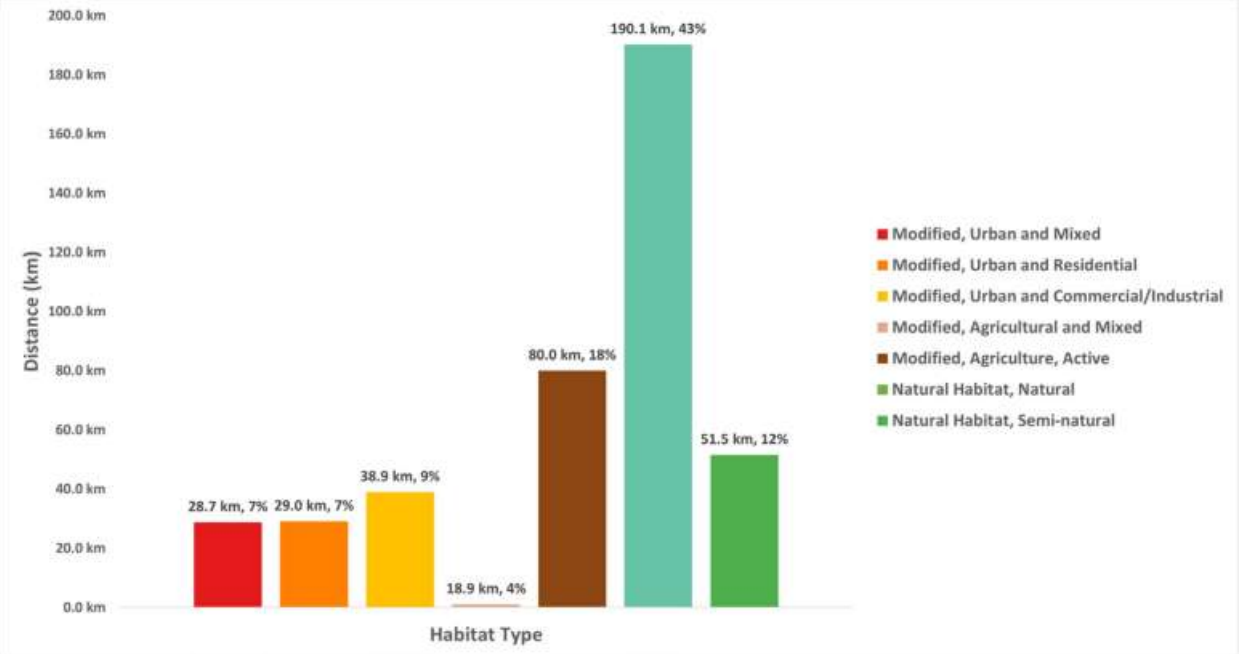
The Natural Habitat class was subdivided into Natural, which includes areas that are>95% unaffected by human activity, and Semi-Natural/Degraded, for areas where anthropogenic activity has resulted in some habitat alteration.

The majority of survey segments 1-6 comprise Natural Habitat, with some areas of active agricultural land. Parts of Segment 1 have been modified through industrial and urban development associated with the Port and its infrastructure. Segments 7-9 are predominantly degraded Natural Habitats and areas modified by agriculture and urban/commercial uses.

Table 27: Habitat Classification Summary of All Segments

Main habitat	Secondary	Tertiary	Description	Kilometres	% of the Pipeline
Modified	Urban	Commercial/Industrial	Mainly commercial/industrial	38.9	8.9
Modified	Urban	Mixed	Mixed residential with commercial/industrial	28.7	6.6
Modified	Urban	Residential	Mainly residential area	29.0	6.6
Modified	Agricultural	Active	Agricultural fields/orchards actively cultivated	80.0	18.3
Modified	Agricultural	Mixed	Agricultural fields both active and fallow/abandoned	18.9	4.3
Natural	Natural	Low Value	No observable changes to naturally occurring habitat	190.1	43.5
Natural	Semi-Natural/Degraded	Low Value	Limited change to habitat considered to be >75% natural	51.5	11.8
Total Length of All Segments				**437.1km**	

Figure 32 Habitat Classification Summary for All Segments, Including Renewable Energy



7.1.2 Flora Overview

Along the southern part of the Pipeline route, disturbed roadside verges and wadi environments possess the greatest (albeit low) plant biomass and species richness.

As the Pipeline route proceeds east, away from the Port area, and then to the north, the vegetation becomes more natural in character, with a composition typical of arid and semi-arid ecosystems. Initially occurring with a low abundance, the diversity and abundance of vegetation increased as the route began to turn towards the north (although still very sparse, as is typical of arid ecosystems).

Towards the central portion of the Pipeline route, the north-south axis of the Pipeline route is crossed by east-west-oriented wadis, which vary in depth and definition. An increase in plant species richness occurs where wadi crossings are most frequent.

To the north of the route, the vegetation is typical of modified agricultural land and degraded natural habitats.

7.1.3 Fauna Overview

Faunal records in the southern part of the Pipeline route were generally negligible, but some notable indications were recorded in individual segments (see below).

Records of reptiles and mammals became more frequent in the areas along the route designated as natural habitat, but the majority of records were of species which are common and widespread in Jordan. Any exceptions are highlighted in the relevant Segment below.

Towards the north, as habitat quality decreases, the number of records of faunal species declines.

There were no suitable locations likely to support bat roosts throughout the entire length of the Pipeline route.

7.1.3.1 Key Sensitivities Segment 1

This segment supported examples of the plants *Cleome droserifolia*, which is listed as locally Endangered in Jordan and *Vachellia tortilis* (the Umbrella Thorn Accacia), which is listed as locally Vulnerable.

A single reptile species was observed in the Segment, Aqaba Agama (*Pseudotrapelus aqabensis*) recorded in an area of low vegetation cover.

In addition, a potential burrow of the IUCN-listed (Vulnerable) lizard *Uromastyx aegyptia*, Egyptian Spiny–tailed Lizard, was recorded in this Segment.

7.1.3.2 Key Sensitivities Segment 2

Nine plant species were recorded in Segment 2. Of these *Vachellia tortilis*, *Cleome droserifolia*, and *Lavandula coronopifolia* are red-listed in Jordan.

The proposed location for the pump station (FA6-PS2) also did not contain any measurable plant material and appeared to have been used as a site for disposing of waste materials and trash.

No animal species or signs were observed in this Segment.

7.1.3.3 Key Sensitivities Segment 3

No plant species occurring in this Segment were listed for conservation globally or locally

A recent sighting of an IUCN-listed (Vulnerable) species, *Capra nubiana*, the Nubian Ibex, by a member of the survey team in March 2025 (four months before the baseline survey) was made in this Segment.

7.1.3.4 Key Sensitivities Segment 4

Eight plant species were recorded in the eight survey sites of this segment, two of which, *Vachellia gerrardii* and *Haloxylon persicum,* are red-listed (Vulnerable) for conservation in Jordan.

Eleven species of birds were observed at an artificial wetland, fed by water from adjacent farms and the ponded water. This also supported individuals of the amphibian *Bufotes sitibundus* Variable Green Toad. Although not directly on the Pipeline route, due to its potential to attract and support wildlife near the Pipeline route, a faunal survey was conducted at this location.

The area of the Solar PV and OHTL is dominated by *Haloxylon salicornicum* (Saxaul) on what appears to be abandoned farmland. A few common reptile and mammal signs (tracks) were recorded within the area, but no globally listed or Jordan red-listed species were encountered in this area.

7.1.3.5 Key Sensitivities Segment 5

This survey Segment supported 13 plant species, of which five are red-listed for Jordan: *Artemisia judaica* (VU), *Calligonum comosum* (EN), *Artemisia monosperma* (NT), *Haloxylon rotundifolium* (NT), and *Hyoscyamus muticus* (CR)

Occasional records of common reptiles and mammals were made in this Segment.

7.1.3.6 Key Sensitivities Segment 6

This Segment is notable for the many wadis that flow from east to west, intersecting with the south–north–oriented Pipeline route. A characteristic of the larger wadis is the presence of *Vachellia gerrardii* trees, a Jordan red-listed species (Vulnerable).

Faunal species in this Segment included a number of common reptile species, together with the presence of IUCN red-listed *Uromastyx aegyptia,* Egyptian Spiny–tailed Lizard, which appeared to be particularly attracted to the low/unvegetated areas.

Mammal species were less common, with indications of common and widespread species only.

Birds were observed at one survey location in Segment 6, at a plant species-rich wadi site.

In addition, the amphibian Variable Green Toad (*Bufotes sitibundus*) were present in standing water from a Disi Pipeline leakage.

7.1.3.7 Key Sensitivities Segment 7

Plant species abundance was the lowest of any Terrestrial Baseline Survey Segment, with no more than three plant species recorded at any survey location

This Segment includes areas close to the known range of the endemic reptile species *Acanthodactylus ahmaddisii* (Jordanian Fringe-fingered Lizard). However, no reptiles were observed in this vicinity.

The area surveyed for this species lies near the entrance to Daba'a Village (off the Desert Highway) and may have been subject to anthropogenic impacts since it was first recorded. The survey was then extended to the Daba'a Rangeland Reserve, a fenced and protected area. This resulted in the observation of three species of lizards, but *Acanthodactylus ahmaddisii* (Jordanian Fringe-fingered Lizard) was not present.

7.1.3.8 Key Sensitivities Segment 8

This Segment comprises abandoned farmland, actively cultivated farmland and a suburban setting comprising some residential and commercial areas.

The Segment was reviewed from 13 locations, but none were chosen for application of the full survey because there were no Natural Habitat or Semi-Natural Habitat areas within this Segment.

No reptile or mammal species (excluding domesticated species) were observed in this Segment.

7.1.3.9 Key Sensitivities Segment 9

The entire Segment is considered to be a Modified Habitat - Urban (Mixed). No flora or fauna of significance was recorded.

7.1.4 Summary of Terrestrial Environmental Sensitivities

The following table presents a summary of the key species (Global and national RDB species) which were recorded during the baseline surveys.

Table 28: Summary of Key Species

Species	Global Status	National Status	Segment	Abundance
Mammals				
Capra nubiana the Nubian Ibex	VU	VU		Single record
Reptiles				
Uromastyx aegyptia Egyptian Spiny–tailed Lizard	VU	NT	1,6	Suspected (Burrow), Single record
Plants				
Artemisia judaica	-	VU	5	N/A
Artemisia monosperma	-	NT	5	N/A
Calligonum comosum	-	EN	5	N/A
Cleome droserifolia	-	EN	1,2	N/A
Haloxylon persicum	LC	VU	4	N/A
Haloxylon rotundifolium	-	NT	5	N/A
Hyoscyamus muticus	-	CT	5	N/A
Lavandula coronopifolia	-	NT	2	N/A
Vachellia gerrardii	-	VU	4,6	N/A
Vachellia tortilis	LC	VU	1,2	N/A

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Appendix 1 Rapid Survey Summary Table

List of all locations reviewed during Rapid Assessment, Habitat Classification, and inclusion in the Full Terrestrial Baseline Survey.

DATE	Segment	Waypoint	Selected for Baseline Survey (NA = Not selected)	SURVEYS	
				FLORA	FAUNA
13-Jul-25	1	1	NA	MODIFIED HABITAT - URBAN (COMMERCIAL/INDUSTRIAL)	
13-Jul-25	1	2	NA	MODIFIED HABITAT - URBAN (COMMERCIAL/INDUSTRIAL)	
13-Jul-25	1	3	NA	MODIFIED HABITAT - URBAN (COMMERCIAL/INDUSTRIAL)	
13-Jul-25	1	4	NA	MODIFIED HABITAT - URBAN (COMMERCIAL/INDUSTRIAL)	
13-Jul-25	1	5	NA	MODIFIED HABITAT - URBAN (COMMERCIAL/INDUSTRIAL)	
13-Jul-25	1	6	FA1	Survey Flora	Survey Fauna
13-Jul-25	1	7	NA	MODIFIED HABITAT - URBAN (COMMERCIAL/INDUSTRIAL)	
13-Jul-25	1	8	FA2	Survey Flora	No
13-Jul-25	1	9	FA3	Survey Flora	No
13-Jul-25	1	10	FA-PS1	Survey Flora	Survey Fauna
13-Jul-25	2	11	NA	MODIFIED HABITAT - URBAN (COMMERCIAL/INDUSTRIAL)	
13-Jul-25	2	12	FA4	Survey Flora	Survey Fauna
13-Jul-25	2	13	NA	NATURAL HABITAT - INACCESSIBLE (SAFETY)	
13-Jul-25	2	14	NA	NATURAL HABITAT - INACCESSIBLE (SAFETY)	
13-Jul-25	2	15	NA	NATURAL HABITAT - INACCESSIBLE (SAFETY)	
13-Jul-25	2	16	FA5	Survey Flora	Survey Fauna
13-Jul-25	2	17	FA6-PS2	Survey Flora	Survey Fauna
13-Jul-25	2	18	NA	MODIFIED HABITAT - URBAN (COMMERCIAL/INDUSTRIAL)	
13-Jul-25	2	19	FA7	HABITAT NOT OF INTEREST / ACCESSIBILITY LIMITED	
13-Jul-25	2	20	NA	MODIFIED HABITAT - URBAN (MIXED)	
14-Jul-25	3	1	NA	HABITAT NOT OF INTEREST / ACCESSIBILITY LIMITED	
14-Jul-25	3	2	NA	HABITAT NOT OF INTEREST / ACCESSIBILITY LIMITED	
14-Jul-25	3	3	NA	HABITAT NOT OF INTEREST / ACCESSIBILITY LIMITED	
14-Jul-25	3	4	NA	HABITAT NOT OF INTEREST / ACCESSIBILITY LIMITED	

DATE	Segment	Waypoint	Selected for Baseline Survey (NA = Not selected)	SURVEYS	
				FLORA	FAUNA
14-Jul-25	3	5	NA	HABITAT NOT OF INTEREST / ACCESSIBILITY LIMITED	
14-Jul-25	3	6	FA8	Survey Flora	Survey Fauna
14-Jul-25	3	7	FA9	Survey Flora	Survey Fauna
14-Jul-25	3	8	PS3	Survey Flora	Survey Fauna
14-Jul-25	4	9	S4-SPV1	Survey Flora	Survey Fauna
14-Jul-25	4	10	S4_SPV2	Survey Flora	Survey Fauna
14-Jul-25	4	11	S4-SPV3	Survey Flora	Survey Fauna
14-Jul-25	4	12	S4-OHTL-4	Survey Flora	Survey Fauna
14-Jul-25	4	13	S4-OHTL-5	Survey Flora	Survey Fauna
14-Jul-25	4	14	NA	MODIFIED HABITAT - URBAN (RESIDENTIAL)	
14-Jul-25	4	15	NA	MODIFIED HABITAT - URBAN (RESIDENTIAL)	
14-Jul-25	4	16	FA10	Survey Flora	Survey Fauna
14-Jul-25	4	17	FA11	Survey Flora	Survey Fauna
14-Jul-25	4	18	FA12	Survey Flora	No
14-Jul-25	4	18	FA13A	Survey Flora	No
14-Jul-25	4	19	FA13B	Survey Flora	Survey Fauna
14-Jul-25	4	20	FA14A	Survey Flora	Survey Fauna
14-Jul-25	4	21	FA14B	Survey Flora	Survey Fauna
14-Jul-25	4	22	FA15	Survey Flora	No
14-Jul-25	4	23	FA15A	No	Survey Fauna
15-Jul-25	5	1	FA16	Survey Flora	Survey Fauna
15-Jul-25	5	2	RA17	Survey Flora	No
15-Jul-25	5	3	NA	NATURAL HABITAT - SALT PAN	
15-Jul-25	5	4	NA	NATURAL HABITAT - SALT PAN	
15-Jul-25	5	5	NA	NATURAL HABITAT - SALT PAN	
15-Jul-25	5	6	FA18	OFF ROUTE	
15-Jul-25	5	7	FA19	OFF ROUTE	
15-Jul-25	5	8	NA	MODIFIED HABITAT - URBAN (COMMERCIAL/INDUSTRIAL)	
15-Jul-25	5	9	FA20	Survey Flora	Survey Fauna

DATE	Segment	Waypoint	Selected for Baseline Survey (NA = Not selected)	SURVEYS	
				FLORA	FAUNA
15-Jul-25	5	10	FA21	Survey Flora	Survey Fauna
15-Jul-25	5	11	FA22	Survey Flora	Survey Fauna
		12	NA	ROUTE MARKER ONLY	
15-Jul-25	5	13	FA23	Survey Flora	Survey Fauna
15-Jul-25	5	14	FA24	HABITAT NOT OF INTEREST / ACCESSIBILITY LIMITED	
15-Jul-25	5	15	FA25	Survey Flora	
15-Jul-25	5	16	FA26	Survey Flora	
15-Jul-25	5	17	FA27	Survey Flora	Survey Fauna
15-Jul-25	5	18	FA28	HABITAT NOT OF INTEREST / ACCESSIBILITY LIMITED	
15-Jul-25	5	19	FA29	HABITAT NOT OF INTEREST / ACCESSIBILITY LIMITED	
15-Jul-25	5	20	FA30	Survey Flora	Survey Fauna
15-Jul-25	5	21	FA30B	Survey Flora	Survey Fauna
15-Jul-25	5	22	FA31	Survey Flora	Survey Fauna
15-Jul-25	5	23	FA32	Survey Flora	Survey Fauna
15-Jul-25	5	24	FA33	HABITAT NOT OF INTEREST / ACCESSIBILITY LIMITED	
15-Jul-25	5	25	FA34	HABITAT NOT OF INTEREST / ACCESSIBILITY LIMITED	
15-Jul-25	5	26	FA35	Survey Flora	No
15-Jul-25	5	27	FA36	Survey Flora	Survey Fauna
15-Jul-25	end5	28	NA	MARKER ONLY	
17-Jul-25	6-Jan	1	NA	HABITAT NOT OF INTEREST / ACCESSIBILITY LIMITED	
17-Jul-25	6	2	FA37	Survey Flora	Survey Fauna
17-Jul-25	6	3	FA38	Survey Flora	Survey Fauna
17-Jul-25	6	4	FA39	Survey Flora	Survey Fauna
17-Jul-25	6	5	FA40	Survey Flora	Survey Fauna
17-Jul-25	6	6	FA41	Survey Flora	Survey Fauna
17-Jul-25	6	7	FA42	Survey Flora	Survey Fauna
17-Jul-25	6	8	FA43	Survey Flora	Survey Fauna
17-Jul-25	6	9	FA44	Survey Flora	Survey Fauna
17-Jul-25	6	10	FA45	Survey Flora	Survey Fauna

DATE	Segment	Waypoint	Selected for Baseline Survey (NA = Not selected)	SURVEYS	
				FLORA	FAUNA
17-Jul-25	6	11	FA46	Survey Flora	Survey Fauna
17-Jul-25	6	12	FA46A	Survey Flora	Survey Fauna
17-Jul-25	6	13	FA47	Survey Flora	Survey Fauna
17-Jul-25	6	14	FA48	Survey Flora	Survey Fauna
17-Jul-25	6	15	FA49	No	Survey Fauna
17-Jul-25	6	16	FA50	No	Survey Fauna
17-Jul-25	6	17	FA51	Survey Flora	Survey Fauna
17-Jul-25	6	18	FA51B	Survey Flora	Survey Fauna
17-Jul-25	6	19	FA52	No	Survey Fauna
17-Jul-25	6	20	FA53	Survey Flora	Survey Fauna
17-Jul-25	6	21	FA54	No	Survey Fauna
17-Jul-25	6	22	FA55	Survey Flora	Survey Fauna
17-Jul-25	6	23	FA56	No	Survey Fauna
17-Jul-25	6	24	FA57	No	Survey Fauna
17-Jul-25	6	25	FA58	No	Survey Fauna
17-Jul-25	6	26	FA59	No	Survey Fauna
17-Jul-25	6	27	FA60	No	Survey Fauna
17-Jul-25	6	28	FA61	Survey Flora	Survey Fauna
17-Jul-25	6	29	FA62	Survey Flora	Survey Fauna
17-Jul-25	6	30	FA63	Survey Flora	Survey Fauna
12-Jul-25	7	20	NA	SEMI-NATURAL/DEGRADED HABITAT - No features of interest	
12-Jul-25	7	19	NA	SEMI-NATURAL/DEGRADED HABITAT - No features of interest	
12-Jul-25	7	18	NA	SEMI-NATURAL/DEGRADED HABITAT - No features of interest	
12-Jul-25	7	17	NA	SEMI-NATURAL/DEGRADED HABITAT - No features of interest	
12-Jul-25	7	16	NA	SEMI-NATURAL/DEGRADED HABITAT - No features of interest	
12-Jul-25	7	15	NA	SEMI-NATURAL/DEGRADED HABITAT - No features of interest	

DATE	Segment	Waypoint	Selected for Baseline Survey (NA = Not selected)	SURVEYS	
				FLORA	FAUNA
12-Jul-25	7	14	FA64	Survey Flora	Survey Fauna
12-Jul-25	7	13	FA65	Survey Flora	Survey Fauna
12-Jul-25	7	12	NA	MODIFIED HABITAT - URBAN (RESIDENTIAL)	
12-Jul-25	7	11	NA	MODIFIED HABITAT - URBAN (RESIDENTIAL)	
12-Jul-25	7	10	NA	SEMI-NATURAL/DEGRADED HABITAT - No features of interest	
12-Jul-25	7	9	NA	SEMI-NATURAL/DEGRADED HABITAT - No features of interest	
12-Jul-25	7	8	FA66	Survey Flora	No
12-Jul-25	7	7	FA67	SEMI-NATURAL/DEGRADED HABITAT - No features of interest	
12-Jul-25	7	6	FA68	Survey Flora	No
12-Jul-25	7	5	NA	SEMI-NATURAL/DEGRADED HABITAT - No features of interest	
12-Jul-25	7	4	NA	SEMI-NATURAL/DEGRADED HABITAT - No features of interest	
12-Jul-25	7	3	NA	SEMI-NATURAL/DEGRADED HABITAT - No features of interest	
12-Jul-25	7	2	NA	SEMI-NATURAL/DEGRADED HABITAT - No features of interest	
12-Jul-25	7	1	NA	MODIFIED HABITAT AGRICULTURE (MIXED)	
11-Jul-25	8	1	NA	MODIFIED HABITAT AGRICULTURE (MIXED)	
11-Jul-25	8	2	NA	MODIFIED HABITAT AGRICULTURE (MIXED)	
11-Jul-25	8	3	NA	MODIFIED HABITAT AGRICULTURE (MIXED)	
11-Jul-25	8	4	NA	MODIFIED HABITAT AGRICULTURE (MIXED)	
11-Jul-25	8	5	NA	MODIFIED HABITAT AGRICULTURE (MIXED)	
11-Jul-25	8	6	NA	MODIFIED HABITAT - URBAN (MIXED)	
11-Jul-25	8	7	NA	MODIFIED HABITAT AGRICULTURE (MIXED)	
11-Jul-25	8	8	NA	MODIFIED HABITAT AGRICULTURE (MIXED)	
11-Jul-25	8	9	NA	MODIFIED HABITAT AGRICULTURE (MIXED)	
11-Jul-25	8	10	NA	MODIFIED HABITAT AGRICULTURE (ACTIVE)	
11-Jul-25	8	11	NA	MODIFIED HABITAT AGRICULTURE (ACTIVE)	

DATE	Segment	Waypoint	Selected for Baseline Survey (NA = Not selected)	SURVEYS	
				FLORA	FAUNA
11-Jul-25	8	12	NA	MODIFIED HABITAT AGRICULTURE (ACTIVE)	
11-Jul-25	8	13	NA	MODIFIED HABITAT AGRICULTURE (ACTIVE)	
11-Jul-25	7	14	FA69	Survey Flora	Survey Fauna
11-Jul-25	7	15	FA69B	Survey Flora	Survey Fauna
11-Jul-25	7	16	NA	MODIFIED HABITAT - URBAN (COMMERCIAL/INDUSTRIAL)	
11-Jul-25	7	17	NA	MODIFIED HABITAT - AGRICULTURAL (MIXED)	
11-Jul-25	7	18	NA	MODIFIED HABITAT - AGRICULTURAL (MIXED)	
11-Jul-25	7	19	NA	MODIFIED HABITAT - URBAN (MIXED)	
11-Jul-25	7	20	NA	MODIFIED HABITAT - URBAN (MIXED)	
11-Jul-25	7	21	NA	MODIFIED HABITAT - URBAN (RESIDENTIAL)	
10-Jul-25	9	1	NA	MODIFIED HABITAT - URBAN (MIXED)	
10-Jul-25	9	2	NA	MODIFIED HABITAT - URBAN (MIXED)	
10-Jul-25	9	3	NA	MODIFIED HABITAT - URBAN (MIXED)	
10-Jul-25	9	4	NA	MODIFIED HABITAT - URBAN (MIXED)	
10-Jul-25	9	5	NA	MODIFIED HABITAT - URBAN (MIXED)	
10-Jul-25	9	6	NA	MODIFIED HABITAT - URBAN (MIXED)	
10-Jul-25	9	7	NA	MODIFIED HABITAT - URBAN (MIXED)	
10-Jul-25	9	8	NA	MODIFIED HABITAT - URBAN (MIXED)	
10-Jul-25	9	9	NA	MODIFIED HABITAT - URBAN (MIXED)	
10-Jul-25	9	10	NA	MODIFIED HABITAT - URBAN (MIXED)	
10-Jul-25	9	11	NA	MODIFIED HABITAT - URBAN (MIXED)	
10-Jul-25	9	12	NA	MODIFIED HABITAT - URBAN (MIXED)	
10-Jul-25	9	13	NA	MODIFIED HABITAT - URBAN (MIXED)	
10-Jul-25	9	14	NA	MODIFIED HABITAT - URBAN (MIXED)	
10-Jul-25	9	15	NA	MODIFIED HABITAT - URBAN (MIXED)	
10-Jul-25	9	16	NA	MODIFIED HABITAT - URBAN (MIXED)	
10-Jul-25	9	17	NA	MODIFIED HABITAT - URBAN (MIXED)	
10-Jul-25	9	18	NA	MODIFIED HABITAT - URBAN (MIXED)	
10-Jul-25	9	19	NA	MODIFIED HABITAT - URBAN (MIXED)	

DATE	Segment	Waypoint	Selected for Baseline Survey (NA = Not selected)	SURVEYS	
				FLORA	FAUNA
10-Jul-25	9	20	NA	MODIFIED HABITAT - URBAN (MIXED)	
10-Jul-25	7	21	FA70	Survey Flora	Survey Fauna
10-Jul-25	7	22	PS5	Survey Flora	Survey Fauna
10-Jul-25	7	23	NA	MODIFIED HABITAT - AGRICULTURAL (MIXED)	
10-Jul-25	7	24	NA	MODIFIED HABITAT - URBAN (COMMERCIAL/INDUSTRIAL)	
10-Jul-25	7	25	NA	MODIFIED HABITAT - AGRICULTURAL (MIXED)	
10-Jul-25	7	26	NA	MODIFIED HABITAT - AGRICULTURAL (MIXED)	

Appendix 2 AAWDCP Photo Sheet

SITE:

DATE:

PLOT:

LINE #:

DIRECTION:

Appendix 3 AAWDCP Vegetation/Habitat Line Intercept Datasheet

Appendix 4 AAWDCP Vegetation Density Datasheet

Appendix 5 AAWDCP Walking Transect Datasheet (Flora)

Appendix 6 AAWDCP Small Mammals Datasheet

Appendix 7 AAWDCP Fauna Walking Transect Datasheet

Appendix 8 AAWDCP Camera Trap Datasheet

Appendix 9 AWDCP Bat Roost Survey Datasheet

Appendix 10 Terrestrial Baseline Survey Line Transect Photographs

Appendix 11 Avifauna Survey

Appendix 12 Soil Stability Testing

pH measurements were included specifically to determine if the environment was suitable to support the Black Iris (*Iris nigricans*) or Tassel Hyacinth (*Leopoldia bicolor*)[4], identified by IBAT as possibly present in the area.

Table 29 displays the results of surface and sub-surface soil stability tests, soil pH, and surface (standing) water pH tests. Soil stability classes range from 1 (unstable, no biological crust) to 6 (highly stable, strong biological crust), while pH values are based on the standard pH ranges of 0 – 6.9 is acidic, 7 is neutral, and 7.1 – 14 is alkaline.

Table 29: Surface and Sub-surface Soil Stability Tests

FA Point	Surface Soil Stability	Sub-surface Soil Stability	Soil pH	Surface Water pH
FA1	-	-	-	-
FA2	1*	1*	7.95	-
FA3	1*	1*	7.52	-
FA-PS1	-	-	-	-
FA4	1*	1*	7.04	-
FA5	-	-	-	-
FA6-PS2	-	-	-	-
FA7	1*	1*	7.31	-
FA8	-	-	-	-
FA9	1*	1*	7.73	-
PS3	-	-	-	-
SPV site (S4-SPV)	1*	1*	7.49	-
S4-OHTL-5	1*	1*	7.43	-
FA10	1*	1*	7.42	-
FA11	1*	1*	7.20	-
FA12	1*	1*	7.34	-
FA13A	-	-	-	-
FA13B	1*	1*	7.35	-
FA14A	1*	1*	7.39	-
FA14B	1*	1*	7.62	-
FA15	-	-	-	-
FA15A	1*	1*	7.67	-

[4] Inconsistency in IBAT data: *Leopoldia bicolor* does not have an accepted common name whereas *Leopoldia comosa* is commonly known as the Tassel Hyacinth.

FA Point	Surface Soil Stability	Sub-surface Soil Stability	Soil pH	Surface Water pH
FA16	1*	1*	7.58	-
FA17	1*	1*	7.56	-
FA20	1*	1*	7.84	-
FA21	-	-	-	-
FA22	1*	1*	7.59	-
FA23	1*	1*	7.11	-
FA25	1*	1*	7.94	7.10
FA26	-	-	-	-
FA27	1*	1*	7.65	-
FA30	1*	2	7.94	7.32
FA30B	1*	1*	7.67	-
FA31	1*	1*	7.14	7.03
FA32	1*	2	7.30	7.42
FA35	1*	2	7.73	7.79
FA36	1*	1*	7.33	7.88
FA37	1*	1*	7.66	7.42
FA38	1*	1*	7.87	-
FA39	1*	1*	7.41	-
FA40	1*	1*	7.45	7.97
FA41	1*	2	7.38	7.11
FA42	1*	1*	7.76	7.52
FA43	1*	1*	7.38	-
FA44	1*	2	7.30	7.85
FA45	1*	1*	7.70	-
FA46	1*	1*	7.67	-
FA46A	1*	1*	7.12	7.70
FA47	1*	1*	7.72	-
FA48	1*	1*	7.50	-
FA49	1*	1*	7.99	7.68
FA50	1*	1*	7.83	-
FA51	1*	1*	7.74	-
FA51B	1*	1*	7.43	7.73
FA52	1*	1*	7.26	7.73

FA Point	Surface Soil Stability	Sub-surface Soil Stability	Soil pH	Surface Water pH
FA53	1*	1*	7.35	-
FA54	1*	1*	7.18	-
FA55	1*	1*	7.27	-
FA56	1*	1*	7.14	-
FA57	1*	1*	7.63	-
FA58	1*	1*	7.48	-
FA59	1*	1*	7.58	-
FA60	1*	1*	7.17	-
FA61	1*	1*	7.13	-
FA62	-	-	-	-
FA63	1*	1*	7.56	-
FA64	1*	1*	7.53	-
FA65	1*	1*	7.19	-
FA66	1*	1*	7.18	-
FA68	1*	1*	7.80	-
FA69	-	-	-	-
FA69B	1*	1*	7.40	-
FA70	1*	1*	7.47	-
PS5	1*	1*	7.74	-
FA39	1*	1*	7.41	-
FA40	1*	1*	7.45	7.97
FA41	1*	2	7.38	7.11
FA42	1*	1*	7.76	7.52
FA43	1*	1*	7.38	-
FA44	1*	2	7.30	7.85
FA45	1*	1*	7.70	-
FA46	1*	1*	7.67	-
FA46A	1*	1*	7.12	7.70
FA47	1*	1*	7.72	-
FA48	1*	1*	7.50	-
FA49	1*	1*	7.99	7.68
FA50	1*	1*	7.83	-
FA51	1*	1*	7.74	-

FA Point	Surface Soil Stability	Sub-surface Soil Stability	Soil pH	Surface Water pH
FA51B	1*	1*	7.43	7.73
FA52	1*	1*	7.26	7.73
FA53	1*	1*	7.35	-
FA54	1*	1*	7.18	-
FA55	1*	1*	7.27	-
FA56	1*	1*	7.14	-
FA57	1*	1*	7.63	-
FA58	1*	1*	7.48	-
FA59	1*	1*	7.58	-
FA60	1*	1*	7.17	-
FA61	1*	1*	7.13	-
FA62	-	-	-	-
FA63	1*	1*	7.56	-
FA64	1*	1*	7.53	-
FA65	1*	1*	7.19	-
FA66	1*	1*	7.18	-
FA68	1*	1*	7.80	-
FA69	-	-	-	-
FA69B	1*	1*	7.40	-
FA70	1*	1*	7.47	-
PS5	1*	1*	7.74	-
*The soil disintegrated before it could be tested = microbiological component is absent				

Project: Aqaba-Amman Water Desalination and Conveyance (AAWDC)

2025 Environmental and Social Impact Assessment

Appendix 6-4 Marine Baseline Survey Report

The National Carrier Project

Marine Baseline Survey

Draft Report # 01

November, 2025



- **Cover picture:** *Goniopora* Coral with retracted tentacles.

Executive Summary

1. Overview of the report

This draft report presents the results of the marine baseline survey conducted to characterize the environment at the proposed desalination project site. The survey included nine stations, each comprising six transects, to study the benthic habitat using the Reef Check method. In addition, 55 sites were surveyed using an ROV to conduct a rapid assessment of the seabed habitat, while 18 sites were sampled for sediment and infauna analysis. Furthermore, 30 in-situ spot measurements were taken to determine the physicochemical parameters of seawater in the study area. Plankton sampling was carried out at 14 sites, and solid waste was assessed along the 54 transects used for the Reef Check survey. Coral identification was performed along the same 54 belt transects, where corals were photographed and identified.

2. Reef Check Survey Summary

- Nine stations (TA01–TA08, TB01) surveyed at 5–30 m depths.
- There was spatial variation in coral cover, substrate, and seagrass. Low Coral Cover (12–23%) characterized stations TA01, TA07, TA08, which were dominated by sand, rock, and rubble from past disturbances.
- High Coral Cover (55–84%) characterized stations TA03, TA04, TA05, where diverse and healthy coral reefs are found at the deep sections, while seagrass meadows dominated the shallow depths. Moderate reef health and density was encountered at stations TA06 (~22%) and TB01 (up to 44% at 30 m).
- In some areas. The coral reefs are damaged, where high densities of rocks and rubbles characterized stations TA01, TA07, and TA08.

3. Coral Taxonomy Summary

- Surveys across nine stations (TA01–TA08, TB01) recorded 26,050 coral colonies, representing 15 families and 49 genera, indicating high overall diversity with spatial variation in abundance.

- Highest densities occurred at TA05 (5,735), TA04 (4,569), and TA03 (4,050)—showing well-developed assemblages between 10–20 m, where light and conditions were optimal.
- Lower densities were found at TA07, TA08, and TB01 (1,150–1,500 colonies), though taxonomic diversity remained high; these sites showed signs of stress from sedimentation and human activities.
- Dominant genera: *Porites, Acropora, Montipora, Dipsastrea, Goniastrea,* and *Stylophora*; deeper zones (25–30 m) featured *Leptoseris* and *Pachyseris*, adapted to low-light habitats.
- Overall pattern: Mid-depth zones (10–20 m) supported the richest and most abundant coral communities, while some stations showed degradation—highlighting the need for continued monitoring and targeted conservation.

4. Infauna

- Two main benthic zones identified:
    - Large Benthic Foraminifera (LBF)-dominated habitats (Stations G01, G03–G05, G07, G08, G10): rich in LBF (Amphistegina, Sorites, Operculina) — indicators of healthy, clear, oligotrophic reef environments.
    - Mollusk-dominated habitats (Stations G02, G06, G09, G11–G18): mainly gastropods and bivalves, typical of deeper, softer, lower-light sediments.
- Overall community: Foraminifera (45.6%) and Gastropoda (35.6%) dominate; biodiversity varies with substrate stability and heterogeneity.

5. Plankton

- Three spatial community groups:
    - Group A (S1–S2): Low-abundance Sagitta enflata communities.
    - Group B (S3–S11): Mixed copepods and meroplankton.
    - Group C (S15–S17): High-abundance gastropod larvae (larval retention zones).
- Core species: Small copepods (Paracalanus parvus, Oithona nana).

- Ecological pattern: Moderate diversity, high evenness — stable and resilient planktonic ecosystem influenced by local hydrography.

6. Marine Sediments

- Texture**:** Mostly sand and silt; mud content (>25%) at G01, G02, G09, G15 indicates low-energy zones.
- Organic matter: TOC low (0.06–1.08 g/kg); high carbonate content from reef influence.
- Pollutants**:** Organotins, PCBs, and oils below detection; PAHs slightly elevated at G04 and G08 (likely shipping-related).
- Metals**:** Generally low; Ni and Cr locally elevated (G03, G10, G12).
- Risk assessment**:** Most parameters below *Lowest Effect Levels*; localized moderate ecological risk from Ni, Cr, and PAHs.

7. In situ physico-chemical Seawater characteristic

- Conditions**:** Clear, stable, oligotrophic environment.
- Turbidity**:** 0.039–0.320 NTU (higher near surface).
- pH**:** 8.25–8.30;
- DO**:** 6.49–6.61 mg/L (well-oxygenated).
- Salinity**:** 39.35–41.19 PSU (increasing with depth).
- Temperature**:** 26.2°C surface → 23.3°C deep; lower temps at G06, G08 likely from cooling discharges.

8. Marine waste

Diver imagery from nine stations (5–30 m) revealed distinct seabed litter patterns, peaking at mid-depths (15–20 m) due to debris convergence. Metals dominated (44.6%)**,** followed by tyres, plastics, and rubber from maritime and port activities. Hotspots (TA08, TA07, TB01) showed the highest accumulation, shaped by currents and human influence. The findings highlight persistent metallic debris and the need for targeted management and clean-up actions**.**

9. Habitat Mapping

Seabed habitats were mapped to illustrate the distribution and density of key components, including healthy coral, seagrass meadows, sandy bottoms, damaged reefs, and solid waste. Additionally, maps were produced showing major marine taxa—coral, infauna, and plankton—highlighting their families, genera, and individual counts. ROV quick survey results were also visualized, along with the spatial distribution of seawater physico-chemical parameters across the study area.

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1. Introduction

1.1. Overview

Jordan is recognized globally as one of the countries with the most limited drinking water resources. To address this critical challenge, the national government has prioritized the implementation of an effective solution within a defined timeframe. The proposed initiative involves the construction of a desalination facility along Jordan's Gulf of Aqaba coast. The desalinated freshwater will then be transported to other parts of the country—particularly Amman and other densely populated cities in central and northern Jordan. Accordingly, the project has been named the National Carrier Project, and its implementation is being managed by the National Carrier Project Company (NCPC)**,** indicating its significance at the national level.

The proposed project involves the construction of a desalination facility along the Jordanian coast of the Gulf of Aqaba. The desalinated freshwater will then be transported to the other parts of the country, particularly Amman and the other densely populated cities in the central and northern parts of Jordan. Accordingly, the project has been named the National Carrier Project, and its implementation is being managed by the National Carrier Project Company (NCPC), indicating its significance at the national level.

1.2.Objectives

Within the scope of this project, seawater will be extracted, desalinated, and the resulting brine will be returned back to the sea. As part of the current work order, a team of specialized experts and several specialized laboratories have been contracted to conduct a comprehensive baseline study with a primary objective of helping to assess and identify potential impacts of the project implementation (construction and operation phases) on the most sensitive and fragile marine ecosystems, represented by coral reefs and seagrass ecosystems, which are present in the nearby marine area. The detailed objectives of the current study are as follows:

1. Baseline assessment of marine biota at the intake and discharge sites, as well as in surrounding areas and a designated control site for future comparative studies. The

assessment covers sensitive seabed organisms such as coral reefs, infaunal species living within the sediment, and plankton communities.

2. Analysis of selected physical and chemical parameters of seawater using CTD measurements, complementing previously collected water quality data.
3. Marine sediment analysis to determine the presence of specific pollutants and evaluate selected physical characteristics.
4. Development of a comprehensive baseline dataset to support long-term environmental monitoring and the design of appropriate mitigation measures.
5. Habitat mapping to identify and delineate the most sensitive seabed habitats, thereby assisting project developers in selecting optimal routes for the intake and discharge pipelines.

1.3. Coral reefs and Seagrass Ecosystems

1.3.1. Coral Reefs

Coral reefs are diverse marine ecosystems found in shallow tropical and subtropical waters where sunlight enables photosynthesis. Their structure is formed by scleractinian corals, which secrete calcium carbonate to build hard skeletons. Corals live symbiotically with zooxanthellae—photosynthetic algae that provide them with nutrients and oxygen in exchange for carbon dioxide and protection (Knowlton, 2001).

Coral reefs are among the most productive ecosystems on Earth, comparable to tropical rainforests in biodiversity and productivity. They provide critical ecosystem services, including biodiversity support, carbon sequestration, and coastal protection, and hold substantial economic and cultural value through fisheries, tourism, and heritage (Roberts et al., 2002; Spalding et al., 2017; Perry et al., 2015). Despite their importance and long-life expectances, the coral reefs are highly vulnerable to global climate change, ocean warming, and acidification, which lead to coral bleaching and structural weakening (Hoegh-Guldberg, 1999, 2007). Local stressors such as bad fishing practices, pollution, and coastal development further accelerate degradation (Pandolfi et al., 2003; Hughes et al., 2017). Since the 1970s, global coral cover has declined drastically (Wilkinson, 2006).

In Jordan, the Gulf of Aqaba serves as the country's only marine outlet, encompassing a relatively short coastline of about 27 km. As such, the coastal area has plenty of users with often competing interests and sometime conflicting activities. The coral reefs hold significant socioeconomic value for local communities and investors, particularly within the tourism and fisheries sectors. However, increasing urbanization and coastal development in recent years have placed growing pressure on these fragile ecosystems. Consequently, it is crucial to apply best environmental practices in the planning and operation of coastal projects. Continuous with often competing interests and effective planning are essential to ensure successful coastal management and the long-term sustainability of marine resources for all users.

1.3.2. Seagrasses

Seagrasses are marine flowering plants that form productive underwater meadows providing essential ecosystem services such as habitat provision, sediment stabilization, nutrient cycling, and carbon sequestration (Duarte et al., 2010). They support numerous species, including fish, invertebrates, and turtles, and help reduce turbidity, improving water clarity (De Boer, 2007). Despite their importance, seagrass meadows are declining globally due to pollution, sedimentation, coastal development, and climate change (Waycott et al., 2009). In the Gulf of Aqaba, as is the case with other seas, the seagrasses play crucial ecological and economic roles. Although, only three species were recorded in the Jordanian Gulf of Aqaba, but they occupy significant parts of the shallow seabed and as coral reefs they are significant for the health status of the marine environment.

1.4. Plankton Survey

Plankton form the foundation of oceanic food webs, linking primary producers of energy to larger marine organisms and serving as rapid indicators of environmental change. Because most plankton have short generation times, their community composition can shift within days to weeks in response to variations in hydrodynamics, nutrient availability, temperature, and salinity. Consequently, plankton surveys offer an effective way to assess ecosystem health, measure biodiversity, and infer the ecological processes shaping coastal communities. They are also directly relevant to

fisheries and conservation: the abundance of meroplanktonic larvae (e.g., gastropods, decapods, fish) reflects benthic reproductive activity and larval transport, while mesozooplankton (e.g., calanoid and cyclopoid copepods, chaetognaths) facilitate energy transfer to juvenile fish and gelatinous predators.

The specific objectives of this task include; (i) quantify total abundance (N), species richness (S), and family richness for each station; (ii) compare diversity and evenness across the sampling domain; (iii) describe taxonomic composition with emphasis on the dominant copepod and meroplankton groups; (iv) evaluate among-station similarity and derive an ecologically interpretable cluster structure; and (v) identify indicator taxa that characterize distinct station groups. These objectives are framed to produce management-relevant insight even from a single survey: for example, stations with persistent meroplankton dominance may highlight areas of larval retention or local spawning hotspots, whereas even, mixed assemblages may indicate transitional water masses or stronger exchange with offshore waters.

1.5. Infauna Communities

The infauna organisms that live within marine sediments play a vital role in ecosystem processes by facilitating sediment turnover, driving nutrient cycling, and serving as an essential component of the marine food web (Snelgrove, 1999). Due to their high sensitivity to environmental variations, they serve as effective bioindicators for evaluating the ecological health of marine systems (Borja et al., 2000). Their abundance and diversity are shaped by both natural factors, such as depth and substrate composition, and human-induced pressures including coastal development, shipping activities, and industrial discharges such as cooling water (Qurban et al., 2019). Consequently, these communities provide valuable insight into the quality of marine environments and are essential for long-term ecological monitoring.

This survey aims to document the diversity, spatial distribution, and ecological roles of macro-benthic infauna within the study area, while also assessing their responses to environmental gradients and anthropogenic influences. The resulting dataset will

establish a baseline for evaluating potential impacts associated with the discharge of cooling water into the marine environment.

The use of infaunal communities as monitoring tools offers several advantages: they have relatively long and stable lifespans, exhibit moderately rapid responses to stress, and are primarily composed of sessile or slow-moving species that are particularly susceptible to sediment contamination. Moreover, many of these invertebrates bioaccumulate pollutants over time, providing a reliable measure of long-term environmental change.

1.6. Marine Sediment

Coastal environments are heavily affected by pollution from both human activities (e.g., land-based runoff, industrial discharges, ... etc.) and natural sources. Over time, these pollutants accumulate in suspended particles and eventually settled and preserved in the bottom surface sediments (Al-Rousan et al., 2016; Barbier 2019). Therefore, marine sediments can provide an important long-term record of the environmental quality of the marine ecosystem (Baudo, et.al., 1999; Nikolaou et al., 2009; Al-Rousan et al., 2024) and can be used to assess and track changes in environmental quality.

Pollution in the marine environment caused by heavy metals, organic matter, hydrocarbons, and pesticides (including organochlorine chemicals) poses serious threats to marine ecosystems and human health. These substances are highly toxic, they can accumulate in the tissues of marine organisms affecting their health, reducing their reproductive, and disturbing marine food chains and biodiversity.

In aquatic environments, sediment graine size plays an important role in storing, transporting and releasing pollutants. Fine sediments (silt and clay) which have a high surface area, can adsorb and trap more pollutants (i.e., heavy metals, organic pollutants) that can be easily released to the water column (Ewis et al., 2022). In contrast, coarse sediment can adsorb less pollutants and reduce their mobility.

The present survey is part of the Marine Baseline Survey component. It focuses on studying the physicochemical properties of the marine sediments obtained from grab sampling at 18 stations (G01-G18) within the project area, detailing their chemical composition as well as their particle size distribution (PSA). Furthermore, the report

assessed the key physico-chemical parameters of seawater obtained from multiple sampling stations within the study area.

1.7. In situ physico-chemical properties of seawater

Seawater in the Gulf of Aqaba is characterized by high salinity (ranges between 40-41 PSU), warm temperatures (20°C-27°C), and generally stable water physicochemical properties due to limited freshwater input and high evaporation rates (Manasrah et al., 2019). The Gulf water is also known for its high transparency and low nutrient concentrations, classifying it as an oligotrophic environment. These characteristics make the Gulf of Aqaba a unique marine environment sensitive to climate change and anthropogenic impacts (Rasheed et al., 2002). In recent decades, coastal developments and human activities in the Gulf of Aqaba have increased pollutants in marine ecosystem harming water quality and marine life.

Therefore, monitoring seawater physicochemical properties (e.g., temperature, salinity, pH, dissolved oxygen, nutrient levels, and contaminants) play a crucial role in assessing environmental quality since they can directly influence the health and functioning of marine ecosystems. Making continuous monitoring of the physicochemical properties of both seawater and marine sediments is crucial for understanding, assessing, identifying, and mitigating the long-term effects of pollution on marine life.

The present report is part of the Marine Baseline Survey component. It focuses on studying the spatial and vertical variations of the physicochemical properties of seawater from 10 sampling stations (G01-G18), at three depths representing the surface, the mid-depth, and the bottom layers.

1.8. Marine Waste

Marine litter includes all materials released, lost, or discarded into the sea outside normal waste channels. While surface accumulations are most visible, much of the debris eventually sinks as it loses buoyancy, becomes biofouled, or is driven downward by waves and currents. On the seabed, litter interacts with benthic habitats—altering structure, trapping sediments, and providing artificial surfaces for opportunistic

species. Lost gear continues to entangle, and bulky debris such as tyres can persist for years, leaving both mechanical and biological impacts.

Seabed litter arises from varied sources. Light plastics come from coastal leakage, runoff, and vessels, while heavier items like metal and tyres often reflect port activities and dumping. Their distribution depends on hydrodynamics, seabed form, and man-made features, creating depth-specific hotspots rather than uniform fields. Capturing this pattern requires spatially explicit, depth-resolved sampling.

2. Materials and Methods

2.1. Study Site

The study site is located in the industrial area, close to the Phosphate Jetty and the gas pipeline. To site was subdivided into zones (Fig. 2.1). It has an approximate area of 500,000 m^2. This area allows the project area to be studied and the adjacent areas to be considered. It considers more than one option for being used for water intake and brine discharge purposes. In addition to an area that can be used as control site for future comparisons and monitoring purposes. The site is well known for hosting important coral reef sites, in addition to the seagrass meadows existing in close proximity with the coral reefs. The site has also been used by many other industrial and ports facilities, therefore, a number of locations are known for being damaged by previous dredging activities.

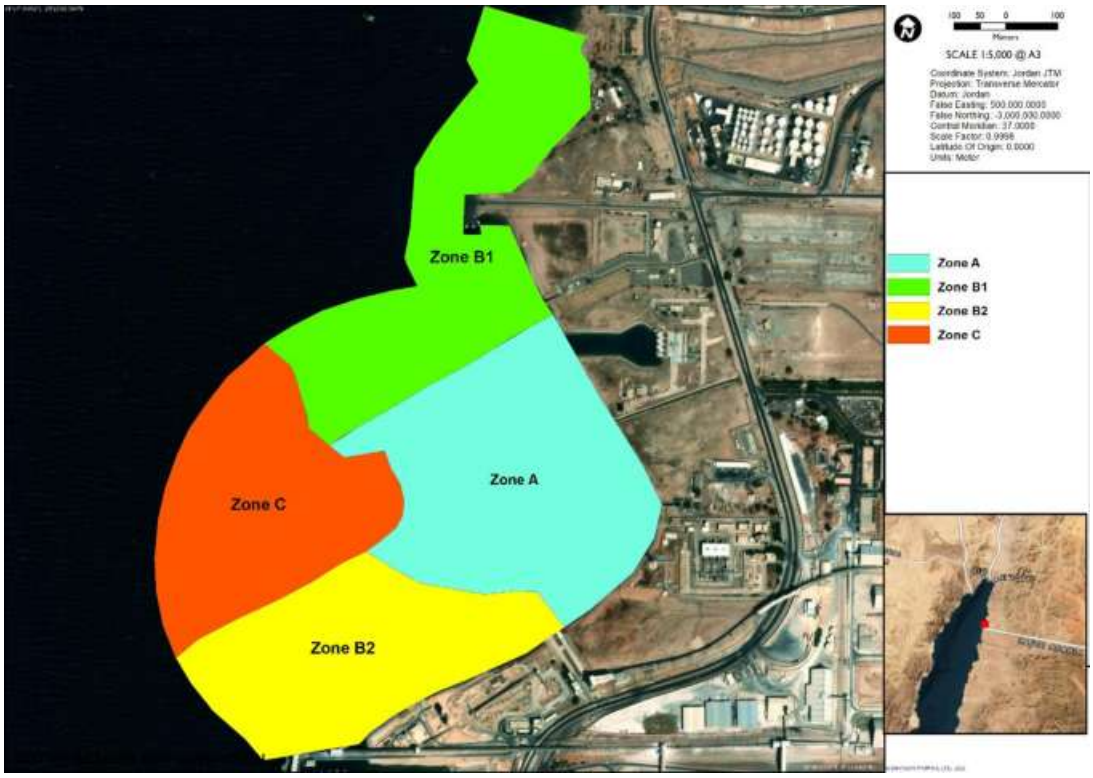


Figure 2 1: Study area showing the different zones

2.2. Bottom Habitat Survey site

To characterize the seabed habitat, nine stations were marked for conducting the reef check survey. Eight of which are located in zone A, and one more station is located in Zone B1 (Fig. 2.2).

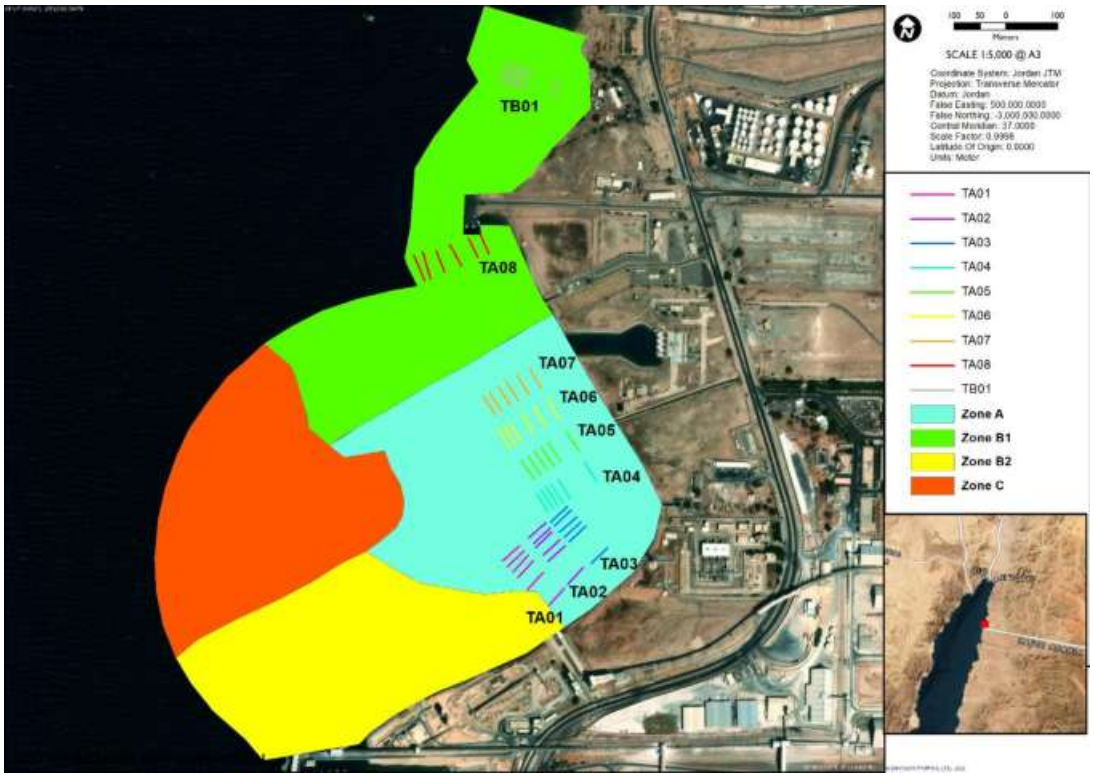


Figure 2 2: Location of the nine stations used to conduct the reef check transect survey.

2.3. ROV survey locations

To conduct a quick survey, a specialized remotely operated vehicle (ROV, type Video Ray pro4) was used to scan the bottom surface of the sea at 54 locations (Fig. 2.3).

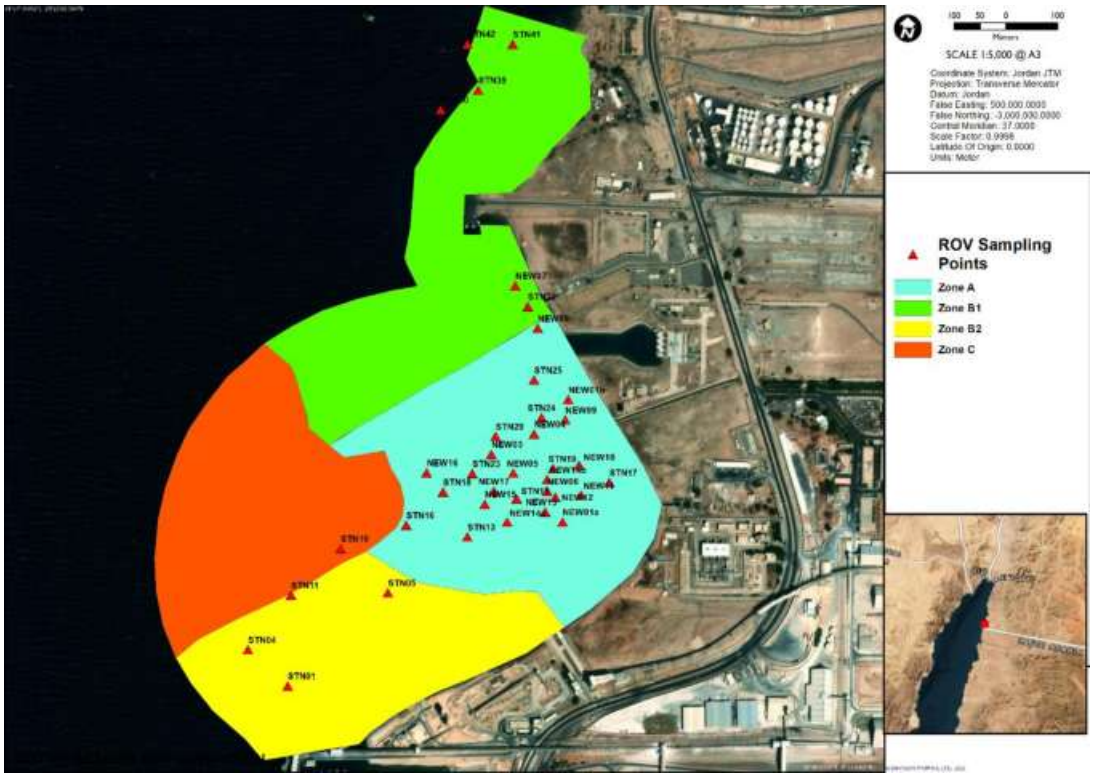


Figure 2 3: ROV sampling sites.

2.4. Sediment sampling locations

Sediment and infauna sampling locations were distributed to ensure efficient coverage of the entire study area. A total of 18 sites were selected for collecting sediment samples to meet both objectives (Fig. 2.4).

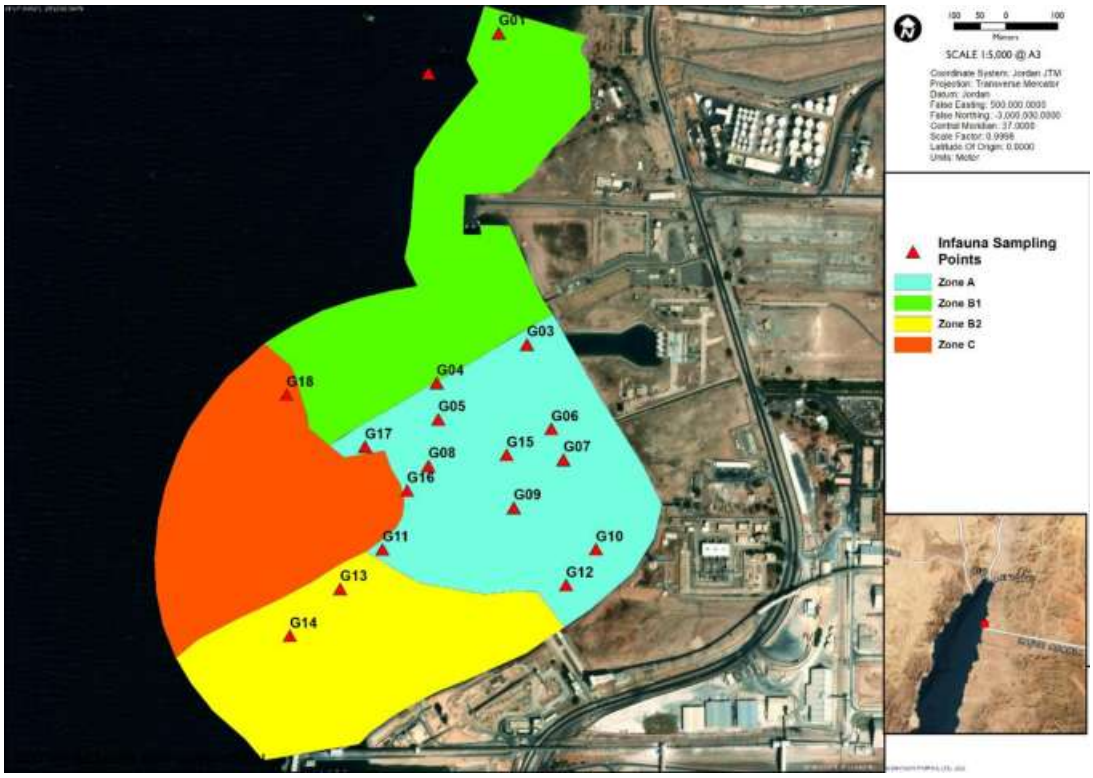


Figure 2 4: Sampling locations of the sediment and infauna studies.

2.4.1. In situ physico-chemical waterproperties

The in situ measurements of the physical and chemical parameters of seawater was done in 14 locations, distributed in the study area (Fig. 2.5).

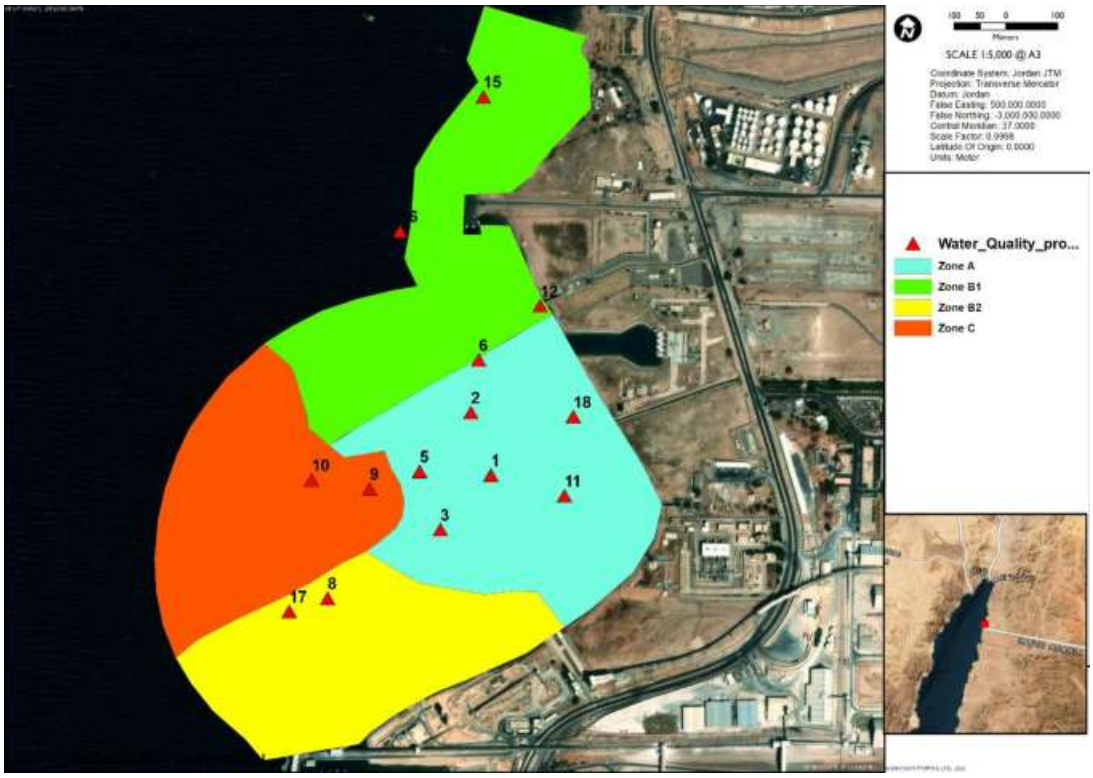


Figure 2 5: Sampling locations for the in situ CTD measurements,

2.4.2. Plankton sampling locations

For plankton survey, 14 sampling locations were used to collect plankton samples (Fig. 2.6).

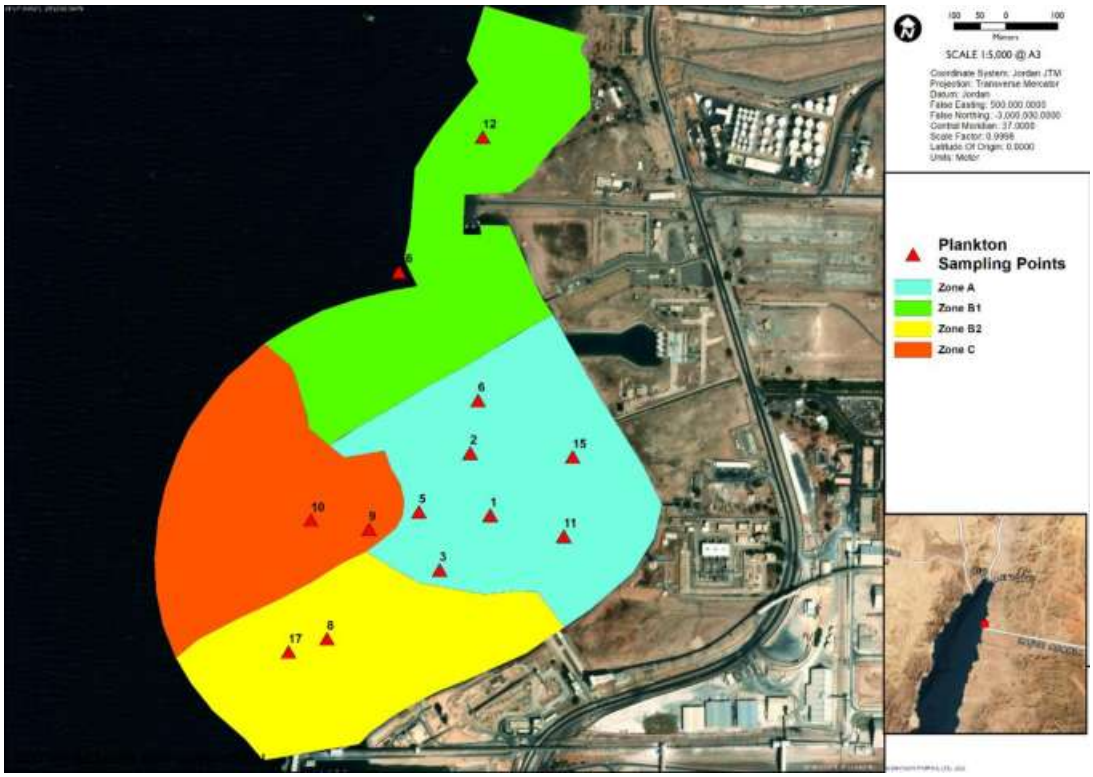


Figure 2 6: Location of the plankton sampling sites.

2.5. Reef Check

To estimate the percent cover of the main coral reef components, surveys were conducted in the study areas using a modified version of the Reef Check method (Reef Check Worldwide), adapted from the Reef Check Organization and the point intercept method (English et al., 1994; Hodgson et al., 2004). Both methods are widely recognized and accepted for assessing coral reef habitats. During the survey, a 50 m transect line was laid at each site, and point readings were recorded at 0.5 m intervals, yielding a total of 100 data points per transect. The key coral reef components included in the survey are listed in Table 2.1.

Table 3 1: Substrate components surveyed and the codes used for each item surveyed

Substrate component	Code
Hard coral	HC
Soft coral	SC
Recently dead coral	RKC
Algae	AG
Sponge	SP
Rock	RC
Rubble	RB
Sediment	SD
Seagrass	SG
other	OT
Hard coral	HC
Soft coral	SC
Recently dead coral	RKC

The study area was divided into nine stations, as previously described. At each station, surveys were conducted at six depths: 5 m, 10 m, 15 m, 20 m, 25 m, and 30 m, to examine the bottom habitat. A transect line was laid parallel to the shoreline at each depth. Additionally, one transect was placed perpendicular to the shoreline, extending from a depth of 30 m up to the shoreline, regardless of its total length. Point readings were recorded every 0.5 m along each transect. The collected data were then analyzed using Excel software and presented as graphs to show the percent cover of each of the surveyed items. These data were also used to the mapping of bottom habitats within the surveyed area.

2.6. Coral Taxonomy

The same transects established at the six depths described in the previous section were used to photograph coral colonies within a belt transect approximately 5 m wide and 50 m long by SUBA divers. All observed coral colonies were photographed using a digital camera equipped with an appropriate underwater housing. The photographs were later

analyzed by a team of coral experts to identify the colonies to the genus level. The data were then processed and presented to illustrate coral diversity at each depth and station. Additionally, the total number of individual colonies representing each genus was counted for every depth.

2.7. Plankton Survey

The report summarizes plankton identification and quantitative analysis from 14 coastal stations, using standardized methods for cross-comparison. Species-level identification was achieved for key mesozooplankton and broader categories for larvae. Diversity was assessed using Shannon, Simpson, and Pielou indices, while Bray–Curtis and clustering analyses revealed distinct community groupings linked to environmental gradients. Indicator species analysis highlighted taxa such as *Sagitta enflata* and gastropod larvae as markers of specific station conditions.

2.7.1. Sampling Design

A fixed-station survey design was implemented along an inshore–nearshore gradient encompassing 14 stations (S1, S2, S3, S5, S6, S8–S12, S15–S18). Stations were positioned to capture variability in exposure and hydrography; site coordinates, depth, and distance to shore were recorded in the field log (Table 2.2).

Table 3 2: Geographic coordinates and water depths of sampling stations (S1–S18) in the study area.

Station	Depth	Latitude	Longitude
S1	60	29.37238	34.96263
S2	59	29.37346	34.96221
S3	43	29.37141	34.96164
S5	70	29.37242	34.96121
S9	68	29.37210	34.96022
S10	100	29.37224	34.95906
S6	30	29.37438	34.96235
S8	33	29.37018	34.95942
S16	40	29.3766	34.96073
S17	53	29.36994	34.95866
S11	13	29.37204	34.96410

S12	7	29.37534	34.96355
S15	19	29.37897	34.96235
S18	7	29.37342	34.96425

2.7.2. Sample Collection

Sampling followed international best practice for mesozooplankton. A conical plankton net (WP2-style; 48 cm mouth diameter, 150 μm mesh) was deployed for vertical or oblique tows. Haul speed was approximately 0.5 m s^{-1}. The filtered volume (m^3) was calculated from the net mouth area and the tow distance. The theoretical filtered volume was calculated as: V=AD

where A is the mouth area (πr^2) and D is the vertical tow length (m). All gear was rinsed thoroughly between stations to avoid cross-contamination. Cod-end contents were gently washed with filtered seawater into pre-labeled jars, narcotized on ice to minimize autotomy, and preserved in 4% buffered formaldehyde (final concentration).

Field metadata including GPS coordinates, tow depth, temperature (when available), and sea state were recorded for each haul to support accurate contextual interpretation and reproducibility, see the CTD result section.

2.7.3. Laboratory Processing and Identification

Samples were allowed to settle and then rinsed to remove residual fixative. Each sample was thoroughly homogenized by gentle inversion, and a subsample for identification was obtained using a Folsom plankton splitter. Subsamples were examined under a microscope. Identification followed standard regional keys and current taxonomic nomenclature; taxa were resolved to species level where feasible (e.g., *Paracalanus parvus*, *Oithona nana*, *Clausocalanus furcatus*, *Sagitta enflata*), while meroplanktonic larvae were categorized into major groups (e.g., gastropod, decapod, fish) to maintain consistency. Count data were normalized to individuals per sample to enable between-station comparisons.

2.7.4. Data Compilation and Analysis

For each station, total abundance (N), species richness (S), and family richness were recorded. Diversity metrics—Shannon–Wiener diversity (H′), Simpson's diversity (1−D), and Pielou's evenness (J)—were computed using the vegan package in R. Community composition and similarity among stations were assessed using Bray–Curtis dissimilarity and UPGMA hierarchical clustering. Indicator Value (IndVal) analysis (Dufrêne & Legendre, 1997) was used to identify taxa significantly associated with stations.

2.7.5. Pre-processing

To minimize the influence of extreme dominants, abundance data were square-root transformed before Bray–Curtis computation. Dissimilarity matrices were clustered with UPGMA; cophenetic correlation was inspected to assess clustering fidelity. Where applicable, IndVal p-values were obtained from 999 permutations with Benjamini–Hochberg correction across taxa.

2.7.6. Statistical Tests

Between-station differences in H′ and J were evaluated using Kruskal–Wallis tests, followed by Dunn's post-hoc tests with Holm adjustment when overall effects were significant (α=0.05). Cluster robustness was explored via multiscale bootstrap resampling (where sample size permitted) to provide approximate support for major nodes. All analyses were conducted in R; reproducible scripts and raw matrices are available upon request.

2.8. Infauna and marine sediment samples

2.8.1. Sampling Design

Eighteen benthic grab samples (Stations G01–G18) were collected within the AAWDCP Marine Baseline Survey Area in the northern Gulf of Aqaba (Table 2.3). Stations were selected to represent the full range of nearshore benthic habitats—including sandy substrates, mixed sediment, and patch-reef environments—spanning both natural and anthropogenically influenced zones. Sampling locations were georeferenced and positioned outside the boundaries of the Aqaba Marine Protected Area.

Table 3 3: Geographic Coordinates of sediment sampling stations (Decimal Degrees).

Station	Latitude (°N)	Longitude (°E)
G01	29.38079	34.96264
G02	29.38007	34.96125
G03	29.37537	34.96331
G04	29.37468	34.96153
G05	29.37405	34.96158
G06	29.37391	34.96383
G07	29.37337	34.96408
G08	29.37323	34.96139
G09	29.37253	34.96311
G10	29.37182	34.96475
G11	29.37176	34.96051
G12	29.37120	34.96418
G13	29.37106	34.95968
G14	29.37022	34.95869
G15	29.37345	34.96295
G16	29.37279	34.96098
G17	29.37354	34.96012
G18	29.37443	34.95854

2.8.2. Sediment sample Collection

Sediment samples were obtained using a stainless-steel Van Veen grab sampler (0.05 m^2 surface area, Fig. 2.7). Each grab recovered the upper 5–10 cm of surface sediment, targeting the biologically active layer where macrofaunal and foraminiferal assemblages are concentrated. At each station, sediment grab samples were divided into two portions: one for infaunal analysis and the other for chemical analysis. For faunal study, visible debris and coarse fragments were removed on site, and the remaining material was preserved in 5% buffered formalin–seawater solution for laboratory processing. Sediment samples for the chemical analysis were kept in plastic bags in the refrigerator until analysis. Prior to chemical analysis, the samples were dried to a constant weight (60°C), and representative subsamples were obtained from the dried ones by quartering method.

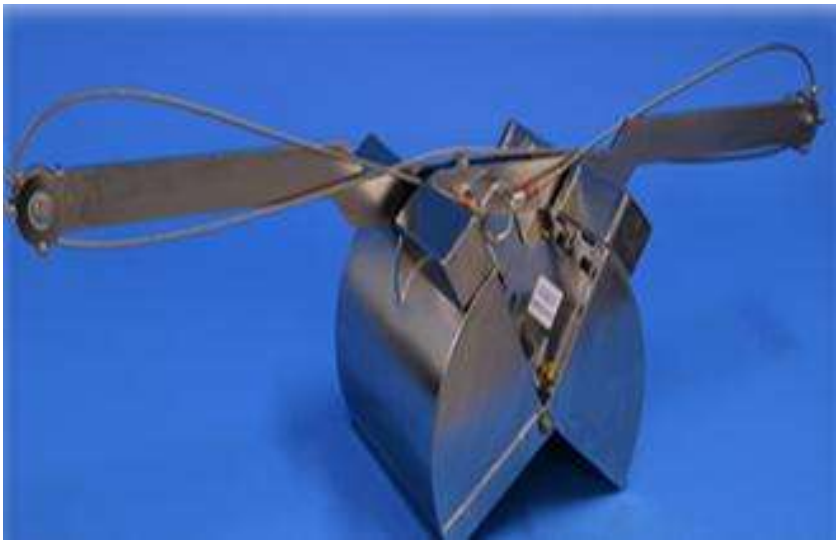


Figure 2 7: Van Veen grab sampler to collect sediment samples from study area.

2.9. Infauna survey

2,9,1, Laboratory Processing and Identification

Samples were gently washed through a 500 µm sieve to retain the macrofaunal and large foraminiferal fractions. The retained material was transferred to 70% ethanol, stained with Rose Bengal to distinguish living or recently living organisms, and examined under a stereomicroscope. All benthic macrofauna and foraminifera were identified to the lowest practical taxonomic level (species or family) using regional identification keys and reference collections housed at the Marine Science Station (MSS). Representative taxa were photomicrographed for documentation (Appendix F).

2.9.2. Data Compilation and Analysis

For each station, total abundance (N), species richness (S), and family richness were recorded. Diversity metrics—Shannon–Wiener diversity (H′), Simpson's diversity (1−D), and Pielou's evenness (J)—were computed using the vegan package in R. Relative abundances were calculated by higher taxonomic group (Foraminifera, Gastropoda, Bivalvia, etc.) and by family. Community composition and similarity among stations were assessed using Bray–Curtis dissimilarity and UPGMA hierarchical clustering. Indicator Value (IndVal) analysis (Dufrêne & Legendre, 1997) was used to identify taxa significantly associated with stations characterized by the presence or absence of Large Benthic Foraminifera (LBF).

2.9.3. Statistical Tests

To compare LBF-present (n = 7) versus LBF-absent (n = 11) stations, Mann–Whitney U tests were performed for total abundance (N), species richness (S), and diversity indices, with $\alpha = 0.05$ as the significance threshold.

2.9. Sediment physicochemical properties

Sediment samples were subjected to particle size analyses (PSA) and were analyzed for selected organic and inorganic pollutants, covering total organic matter, heavy metals, and hydrocarbon-based compounds.

2.10.1. Particle size analysis (PSA)

Particle size analysis was determined according to the Standard Test Method for Particle-Size Analysis (PSA) of Soils. After collecting, sediment samples were dried in an oven at 60°C until complete dryness is obtained. Analysis method involves using sieves greater than 0.063mm. During sieve analysis, sediment sample (100 gm) is passed through a series of sieves with different mesh sizes (0.063, 0.18, 0.125, 0.50, 1.0, and 2.0 mm), and the mass of sediment retained on each sieve is measured. Results of the analysis were then plotted as a cumulative weight percentage against particle size (mm).

2.10.2. Chemical analysis of sediment

The chemical analysis of the sediment samples includes total organic carbon (TOC), Ignition on Loss (IOL), metals (As, Hg, Cd, Cr, Cu, Ni, Pb, Zn, and Sn), organotin (TBT and DBT), Polychlorinated Biphenyls (PCBs, Aroclor 1242, 1254, 1260), Polycyclic Aromatic Hydrocarbons (PAHs, Benzo (a) pyrene, Acenaphtylene, Phenanthrene, Fluoranthene, Dibenzo (a,h) anthracene, Benzo (b) fluoranthene, Chrysene, Pyrene, Naphthalene, Acenaphthene, Benzo (g,h,i) perylene, Benzo (k) fluoranthene, Indeno (1,2,3-cd) pyrene, Anthracene, Benzo (a) anthracene, Fluorene) and Total Petroleum Hydrocarbons (TPHs, mineral oils).

Total Organic carbon (TOC) was determined in sediment using titration method (Gaudette et al. 1974), while ignition at 550°C was employed to measure the IOL. Metals were analyzed using ICP-Mass according to standard procedures. Whereas, organotin, PCBs, PAHs, and TPHs in sediments were analyzed using a GC-MS detector following the standard methods. All chemical analyses were carried out at the accredited labs of the Royal Scientific Society (RSS).

2.10. Seawater in situ physico-chemical properties

Seawater samples were obtained at 10 sampling stations (G01-G18), at three depths representing the surface, the mid-depth, and the bottom layers (above the sea bottom). These

samples can provide critical insights into spatial and vertical variations in seawater parameters. For each sample, the physicochemical parameters were examined on board (in-situ). The seawater temperature and salinity were measured using a CTD instrument, while pH and dissolved oxygen (DO) were recorded with a portable aquameter. Turbidity, on the other hand, was determined using a Secchi disk, with results expressed in Nephelometric Turbidity Units (NTU).

2.11. Marine Waste Survey

Sampling consisted of diver imagery collected at multiple stations with target depths of 5, 10, 15, 20, 25 and 30 m. Each image record contained a descriptive field of observed contents. Items were then reclassified to a small standard list of categories (e.g., Tyre; Plastic bottle; Plastic cap/lid/cover; Plastic bag/film; Foam/Polystyrene; Fishing gear – net/line/rope; Metal can; Metal rod/beam/plate; Metal wire/cable; Metal fragment; Plastic pipe/tube; Pipe/tube (unspecified); Glass bottle/fragment; Wood piece; Textile; Barrel/Container; Other/Unknown) and to material classes (Plastic; Metal; Rubber; Glass; Wood; Textile; Unknown). Depth was treated as a categorical factor in analysis.

Counts were assembled into a four-dimensional cube (Station × Depth × Standardized Category × Material). From this cube we formed roll-ups by station, depth, category and material; generated figures that depict depth profiles, station totals, material balance and the leading categories; and built per-station tables that show how composition changes down the profile. To evaluate structure in simple terms, we calculated familiar community-style metrics (richness S; Shannon index H; Pielou evenness J; Simpson dominance D; Hill numbers N1 and N2). To test differences, we ran analysis of variance. In a factorial model, item counts were regressed on Station, Depth and Category as categorical predictors; one-way ANOVAs were also computed for each factor using the remaining dimensions as replicates. Given that counts were not transformed and the design is unbalanced, these tests are read as direction-finding diagnostics; significance is interpreted with care and alongside the figures and tables. All plots use plain matplotlib; captions and figure numbers are provided for traceability.

2.12. Mapping and GIS Methodology

Spatial analysis and mapping were conducted to visualize and interpret the spatial distribution of key ecological and physico-chemical parameters within the study area.

Geographic Information System (GIS) processing was performed using ArcMap 10.8.1 (Esri, USA), under the Jordan Transverse Mercator (JTM) coordinate system to ensure spatial consistency with national datasets and other EIA spatial products.

2.12.1. Spatial Data Preparation

Field surveys provided geo-referenced coordinates for multiple environmental parameters, including benthic habitats (hard corals, sand, seagrass, and damaged habitats), plankton communities (classified by families, genera, and individual counts), infauna (by families, genera, and individuals), and water quality indicators — dissolved oxygen, pH, salinity, temperature, and turbidity (Zeu and NTU). Each parameter was collected across several stations distributed along the coastline to capture vertical and horizontal gradients in marine conditions.

2.12.2. Benthic Habitat Mapping

The benthic habitat survey was designed as a series of transects, covering nine stations at six depth intervals (5 m, 10 m, 15 m, 20 m, 25 m, and 30 m). Each transect was delineated by drawing a line feature between the recorded start and end GPS coordinates in ArcMap. The habitat types were then digitized and attributed accordingly. This approach provided a structured representation of benthic composition and facilitated depth-based spatial analysis of habitat distribution.

2.12.3. Water Quality and Biological Parameters

Other environmental parameters — namely plankton, infauna, and water quality — were mapped as point data. Each sampling location contained parameter values measured at the surface, mid-depth, and bottom layers. These point datasets were imported into ArcMap, converted to geodatabase feature classes, and symbolized according to their respective parameter values.

2.12.4. Spatial Interpolation and Surface Generation

To estimate values in unsampled locations and visualize spatial gradients, the Inverse Distance Weighted (IDW) interpolation technique was applied to each parameter. This deterministic method assumes that nearby points have greater influence on estimated values than distant ones, producing a continuous raster surface for each variable. The

interpolation parameters (power value and search radius) were optimized to balance spatial smoothness and accuracy.

2.12.5. Clipping and Area of Interest Extraction

Following interpolation, the “Extract by Mask” tool was applied to confine each raster layer to the predefined Area of Interest (AOI) — ensuring that only spatial data within the project boundary were retained for visualization and analysis. This step reduced data redundancy and maintained the spatial focus on the relevant coastal and marine zones.

2.12.6. Visualization and Classification

Each interpolated raster was symbolized using a classified symbology with 10 equal-interval classes. A gradient color ramp was used to represent increasing or decreasing values of each parameter, enhancing interpretability and visual consistency across maps. Final map layouts included standard cartographic elements such as scale bars, north arrows, coordinate grids, legends, and metadata, ensuring adherence to professional EIA mapping standards.

3. Results and Discussion

3.1. Reef Check

3.1.1. Station TA01

The results obtained from the bottom habitat survey in station TA01 have shown that at 5m depth contour, sandy bottoms covered 68% of the seabed, while hard corals occupied only 15% of the seabed, indicating that this transect area is mainly sandy habitat (Fig. 3.1 top). It can also be noted that the rock component had 11% coverage, which indicates that there were some negative impacts that have affected coral reef at this depth and resulted in coral death in the past. The seabed at 10 m depth contour had 21% of its bottom covered by healthy corals, while rock and rubble components covered 45% of the bottom surface, indicating that this area is relatively damaged in terms of coral health (Fig.3.1 middle). The 15m depth contour had 23% of its bottom habitat occupied by healthy corals, while the damage indicators (i.e. rock and rubble) comprised 36% of the bottom (Fig. 3.1 bottom).

The deeper sections of this station were also characterized being coral reef areas, although there were high percentages of damaged reef areas. The healthy corals covered from 15%-23%, while the rock and rubble components covered more than 50% of the bottom (Fig. 3.2). This indicates a past event that has caused massive coral damage in this station, probably due to construction activities.

Overall, the average coral cover was about 21% in all depths of this station, while the 41% of the bottom surface was covered by dead coral, represented by the rock and rubble components (Fig. 3.3). The vertical transect revealed that the percent cover of the sediment component was higher than the average percent cover obtained from the parallel transects, which indicates that the areas among the transects are sandy in comparison with the healthy corals (Fig. 3.3).

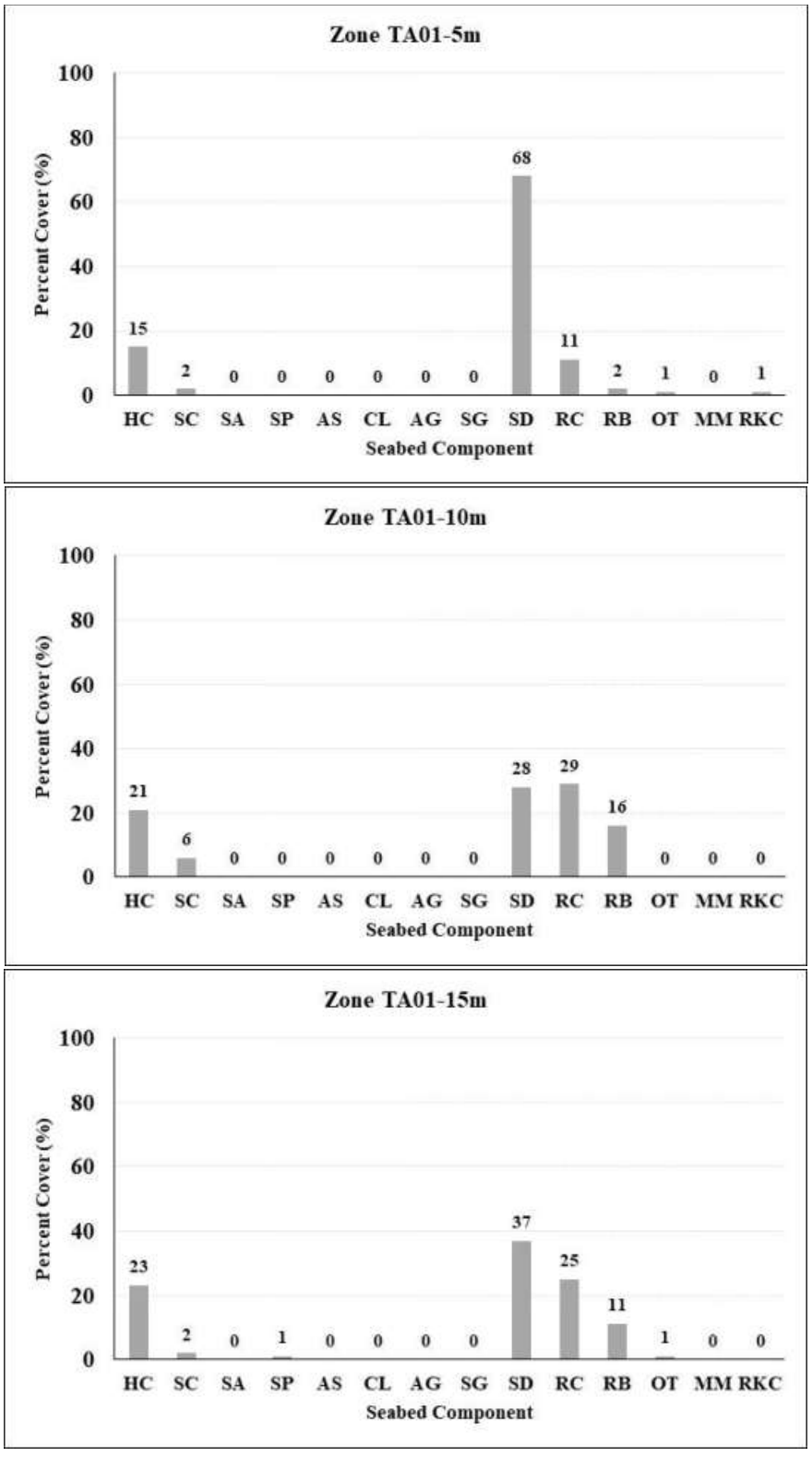


Figure 3 1: Cover percentages of the seabed habitat components at 5m (top), 10m (middle), and 15m (bottom) (Station TA01).

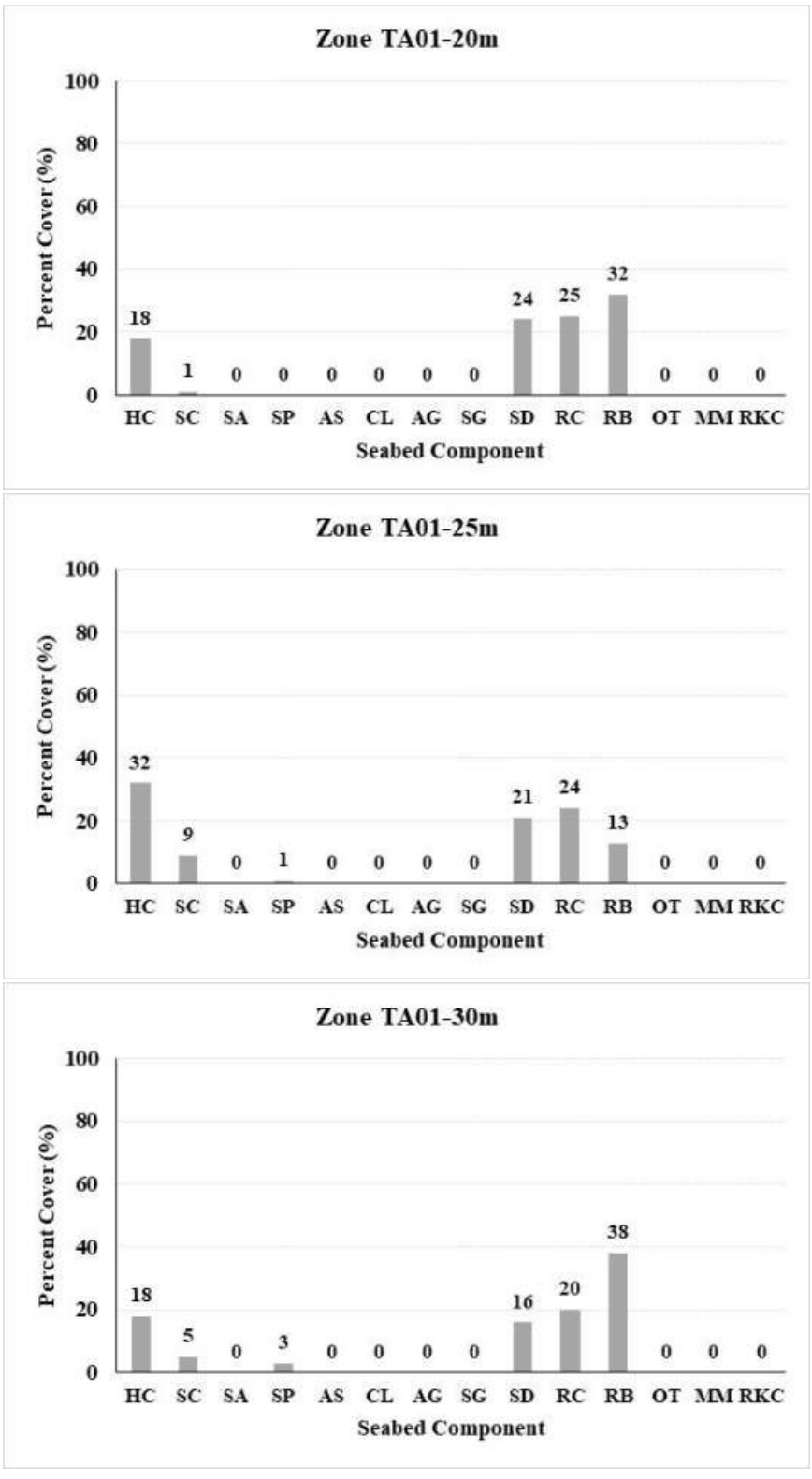


Figure 3 2: Cover percentages of the seabed habitat components at 20m (top), 25m (middle), and 30m (bottom) (Station TA01).

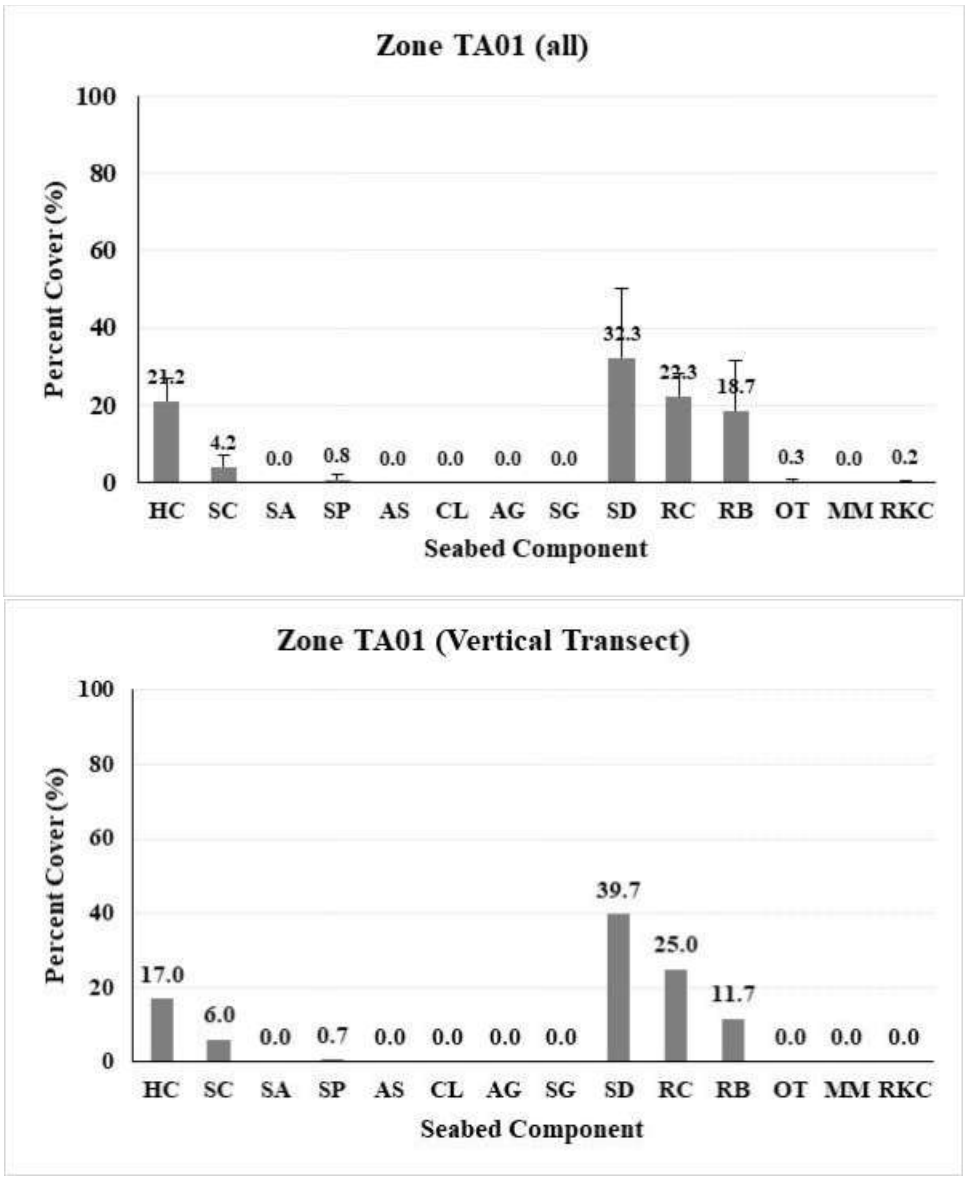


Figure 3 3: Average cover percentages of the seabed habitat components in all depths (top) and the vertical transect (bottom) (Station TA01).

3.1.2. Station TA02

The results of benthic habitat survey at 5m depth have shown that this depth is mostly sandy bottom (68%), with the low percentages of the other bottom habitat components, including the hard corals, which had only 5% coverage. This depth has some seagrass covering the bottom habitat, with a 6% coverage (Fig. 3.4 top). The 10m

depth contour had 21% hard corals covering its bottom surface, with the remaining area being occupied by sandy bottom (36%), and rocks and rubbles (21 combined) (Fig. 3.4 middle). The 15m depth contour had much healthier corals compared with the shallower depths, where the hard corals covered 42% of the bottom surface. The rocks and rubble covered 31% of the bottom surface (Fig. 3.4 bottom).
The deeper depth contours in this station (i.e. 20m, 25m, and 30m transects), had much of their bottom surfaces being covered by health corals, especially the 25m and 30m depth contours, which had about 60% of their bottom surface covered by healthy corals (Fig. 3.5).
Overall, when all depths were averaged, the station had about 38% of its bottom surface covered by healthy corals (Fig. 3.6), while the coral damage indicators (i.e. rock and rubble items) covered about 48% of the bottom surface. When a vertical transect was conducted, the hard corals had about 22% coverage, while the sandy bottoms covered 37% of the bottom, indicating that the areas between the transects had sandy surfaces (Fig. 3.6).

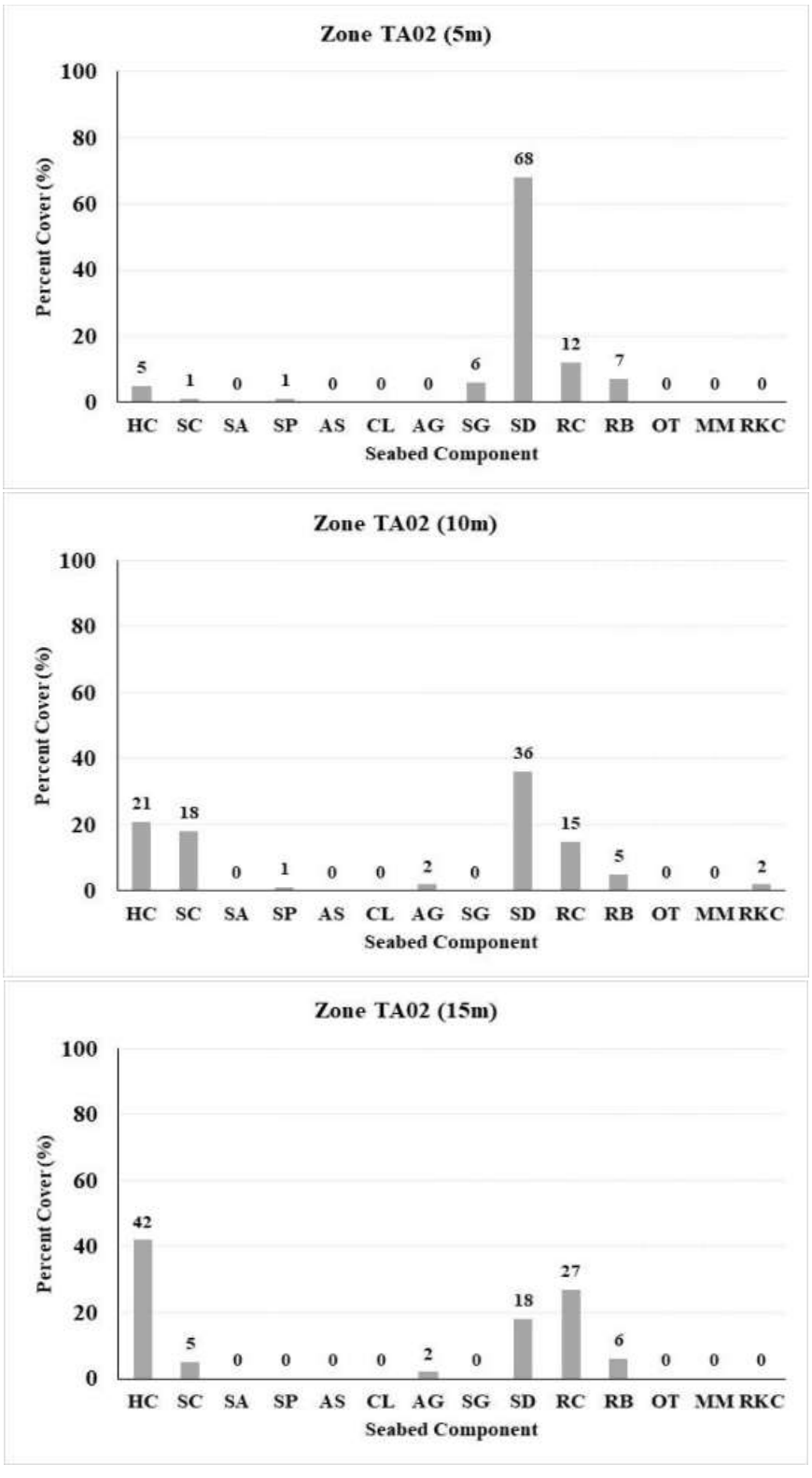


Figure 3 4: Cover percentages of the seabed habitat components at 5m (top), 10m (middle), and 15m (bottom) (Station TA02).

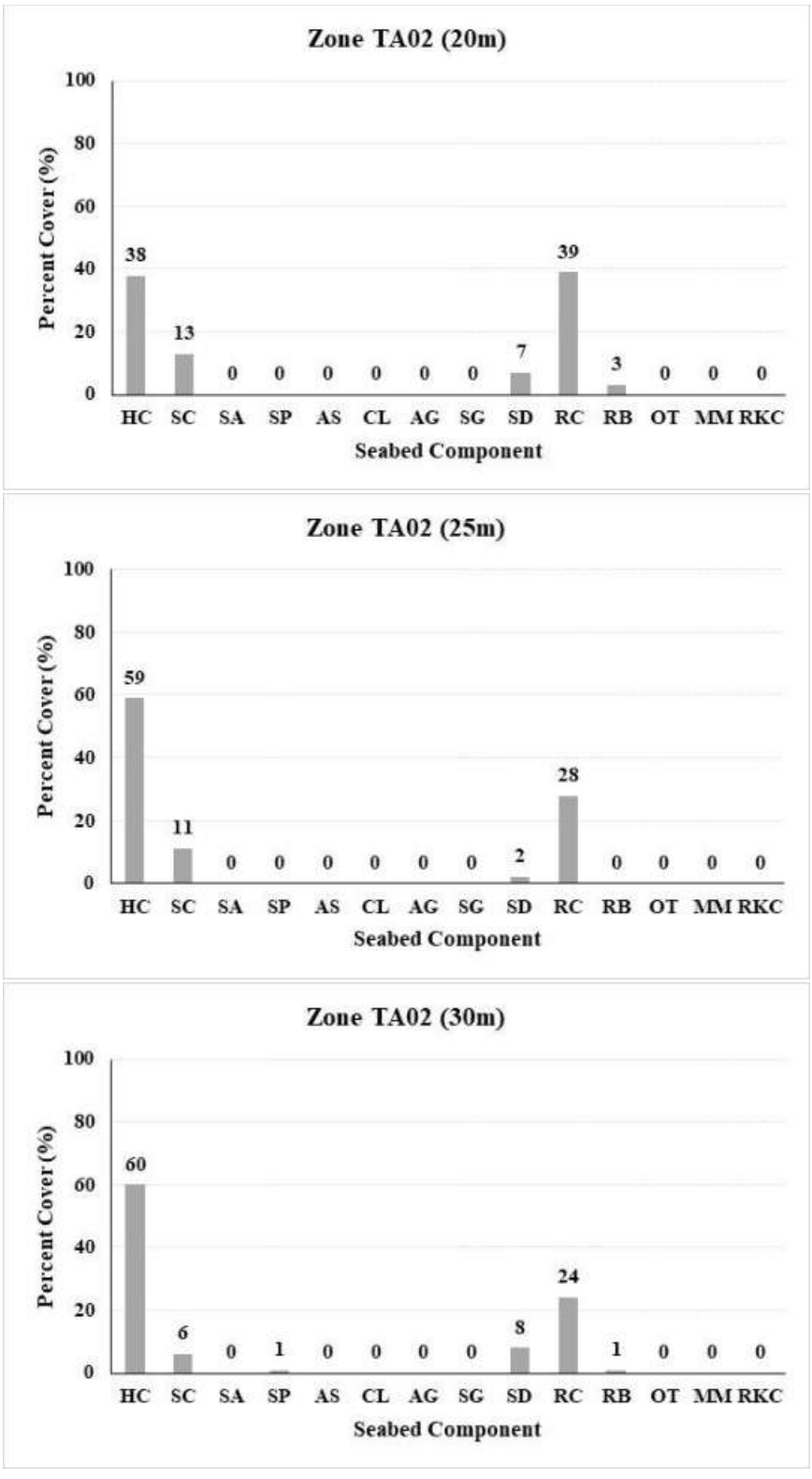


Figure 3 5: Cover percentages of the seabed habitat components at 20m (top), 25m (middle), and 30m (bottom) (Station TA02).

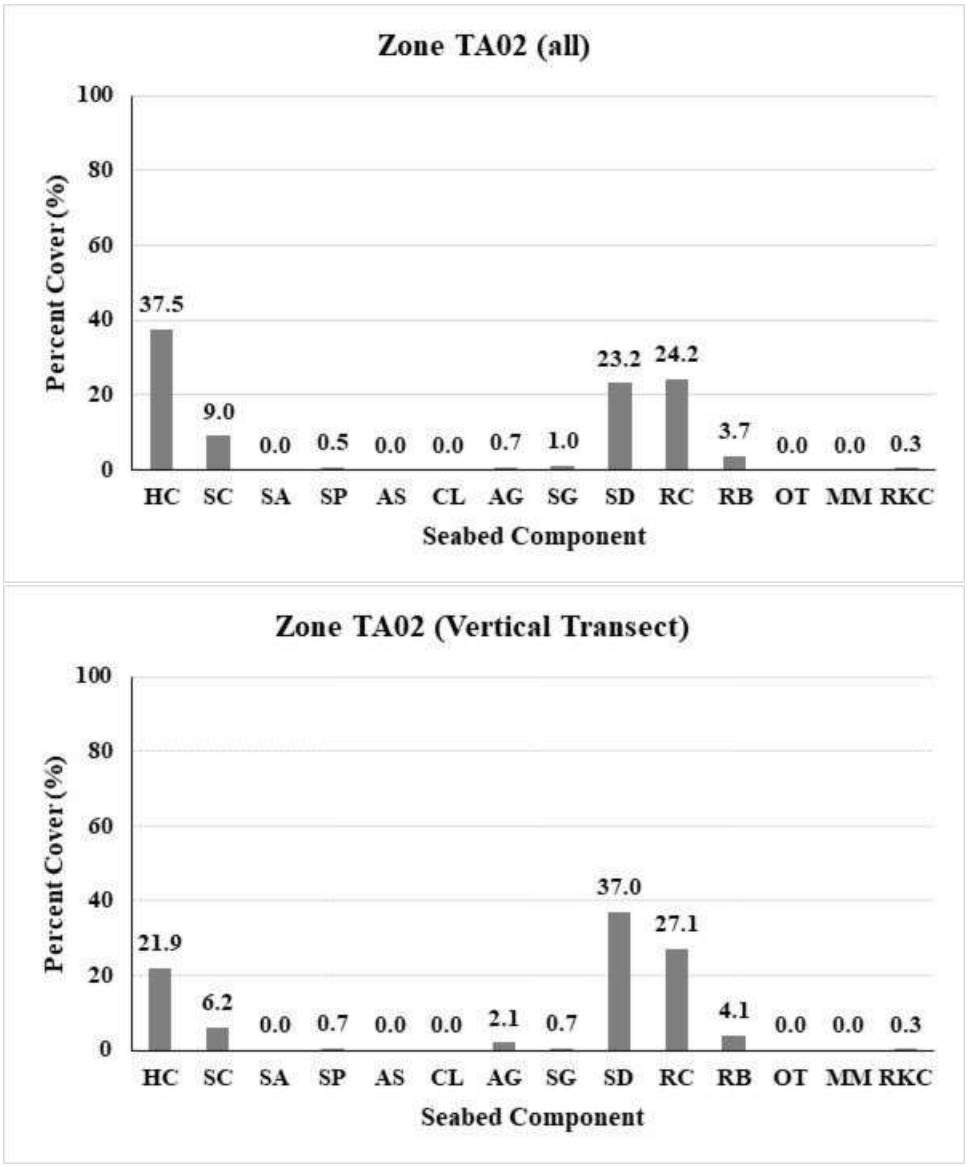


Figure 3 6: Average cover percentages of the seabed habitat components in all depths (top) and the vertical transect (bottom) (Station TA01).

3.1.3. Station TA03

In station TA03, the bottom surface at the 5m and 10m depth contours are mostly sandy, with 76% and 42% cover percentages in the two depths, respectively (Fig. 3.7). At 15m depth contour, the healthy corals had significantly higher percent cover (38%), with the sand, rock and rubble components covering about 50% of the bottom surface at this depth (Fig. 3.7).

The deeper sections in this station (i.e. 20m, 25m, and 30m transects), had relatively high cover percentages of the healthy corals in them, with a percent cover of 44%, 55%, and 55%, in each one of them, respectively. The rock component in the three depth contours was moderate with about 30% cover of less (Fig. 3.8).

Overall, when all depths were averaged, the station had about 35% of its bottom surface covered by healthy corals, while the sand and rock items covered about 50% of the bottom surface (Fig. 3.9). In the vertical transect, the sandy bottoms covered about 53% of the bottom surface, while the corals covered about 24% of the bottom surface (Fig. 3.9).

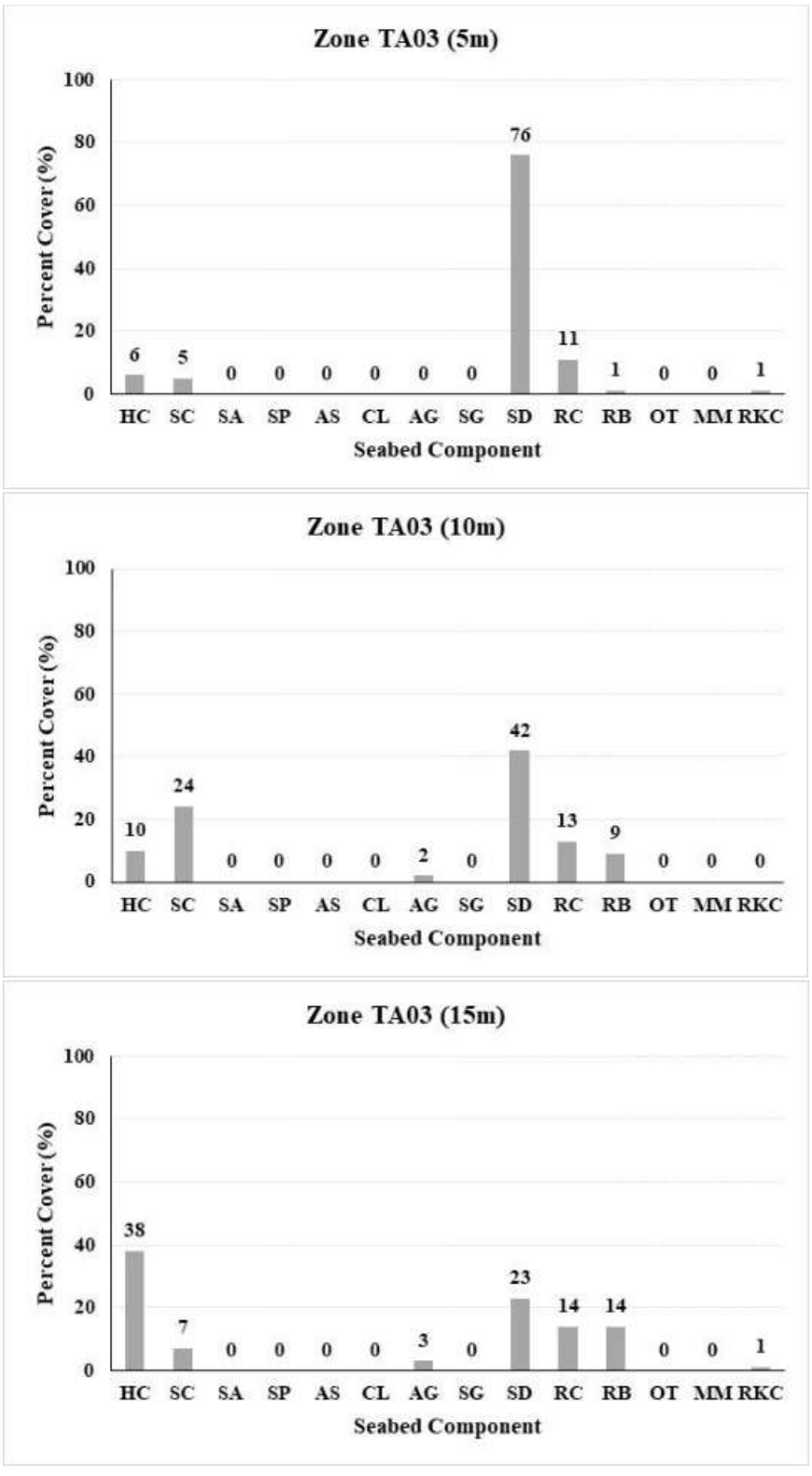


Figure 3 7: Cover percentages of the seabed habitat components at 5m (top), 10m (middle), and 15m (bottom) (Station TA03).

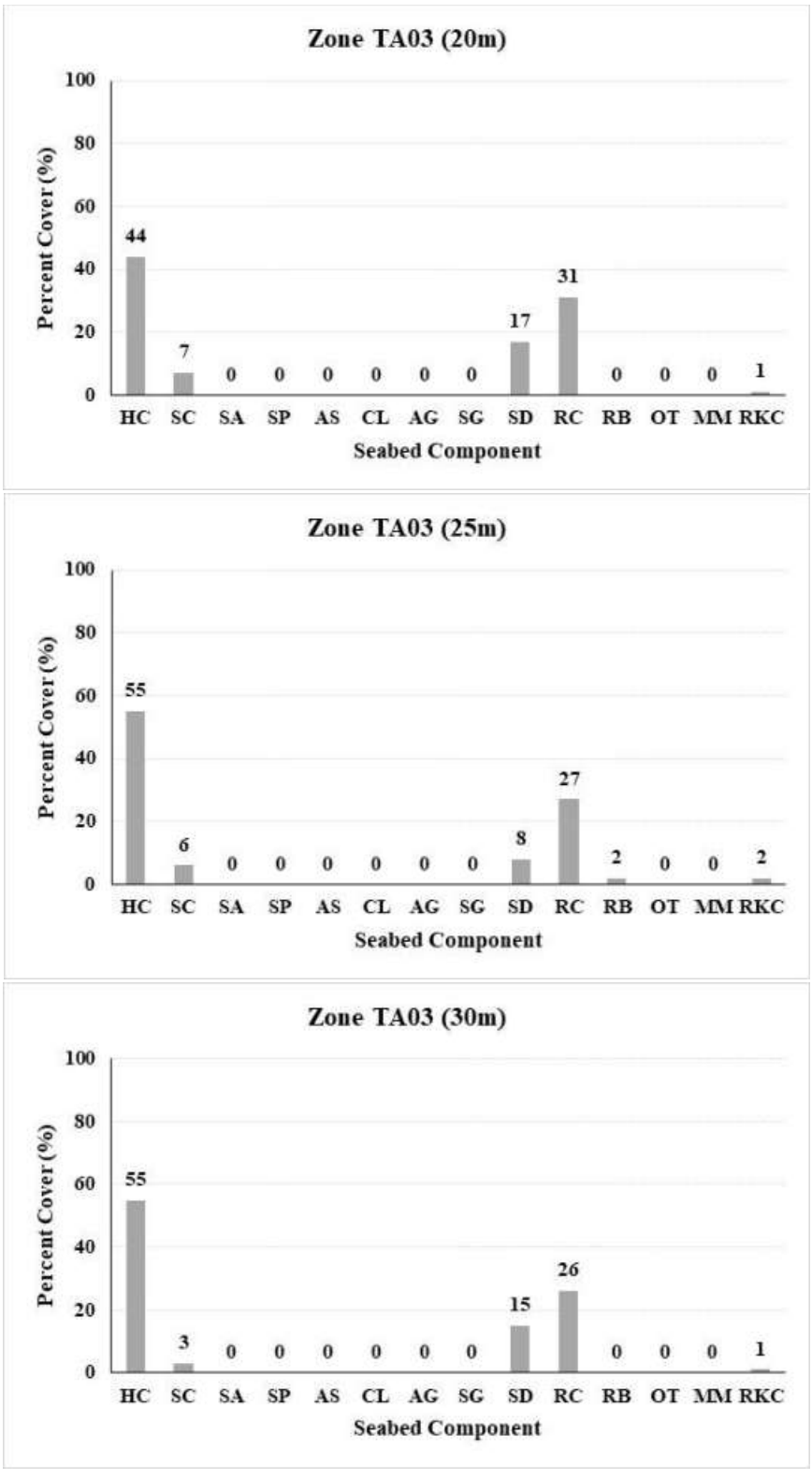


Figure 3 8: Cover percentages of the seabed habitat components at 20m (top), 25m (middle), and 30m (bottom) (Station TA03).

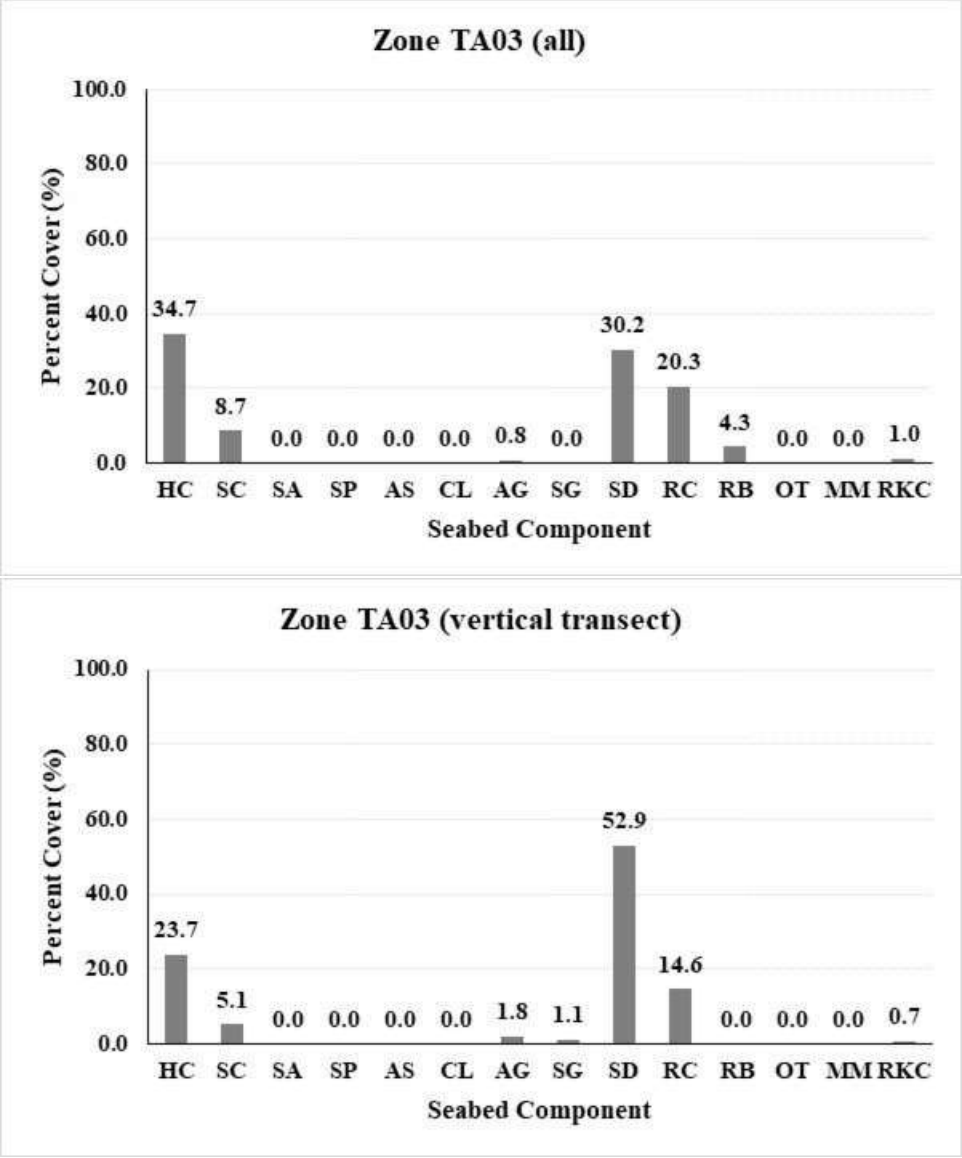


Figure 3 9: Cover percentages of the seabed habitat components at 5m (top), 10m (middle), and 15m (bottom) (Station TA03).

3.1.4. Station TA04

In station TA04, the shallow depths had 0-11% of their bottom surface covered by corals at the shallowest depth contours (5m and 10m), while the hard cover increased significantly with increasing the depth starting from the 15m depth (21% corals) (Fig. 10), and going deeper to the deepest transects, which had 64-75% healthy coral cover at the 20m-30m transects (Fig. 11). When the average percent cover was calculated for all depths, the hard coral item covered more than 40% of the bottom surface (Fig. 12).

In the vertical transect, the hard corals covered about 26%, while the sandy bottom occupied about 40% of the bottom surface, which indicates gaps of coral cover among the depth contours (Fig. 12).

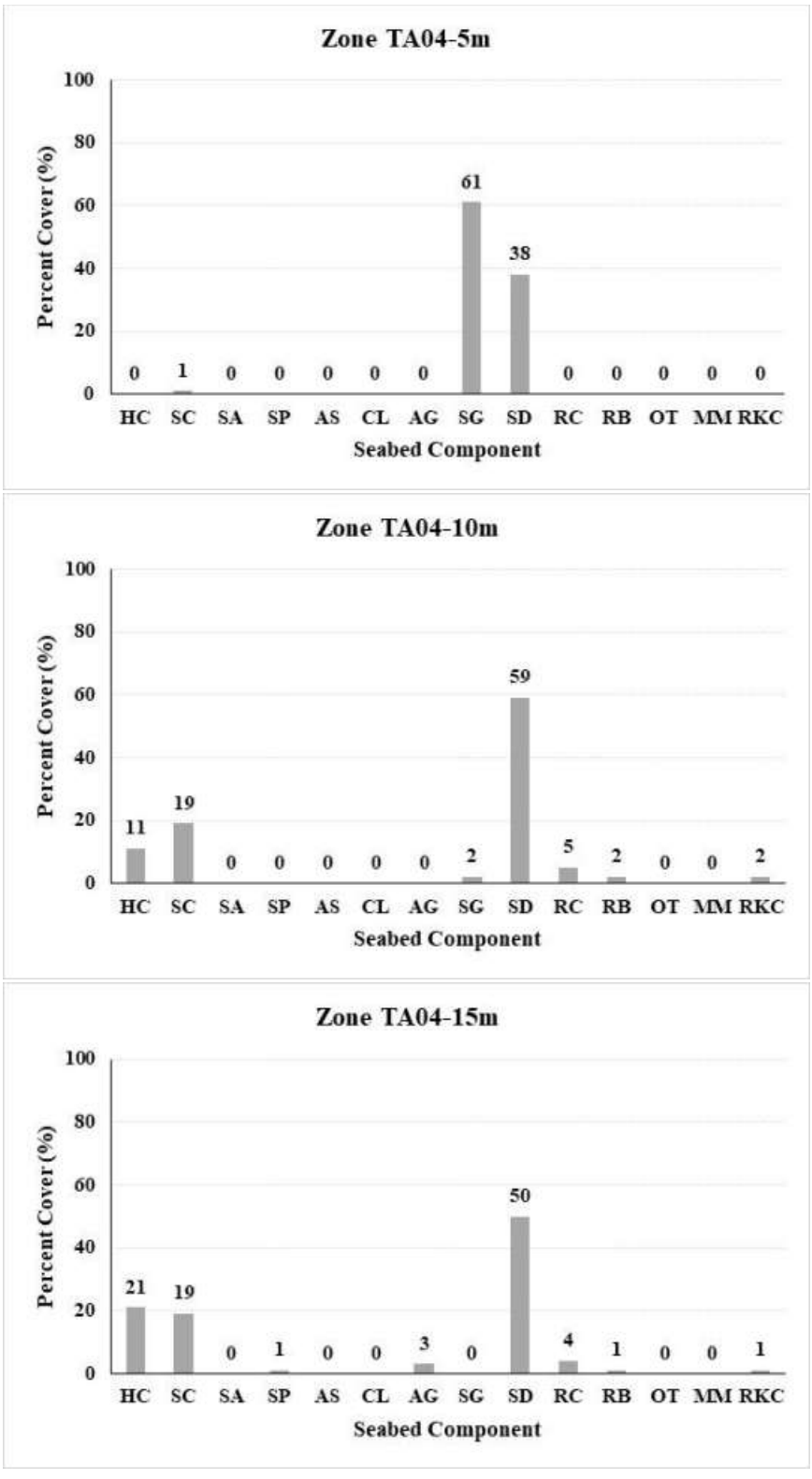


Figure 3 10: Cover percentages of the seabed habitat components at 5m (top), 10m (middle), and 15m (bottom) (Station TA04).

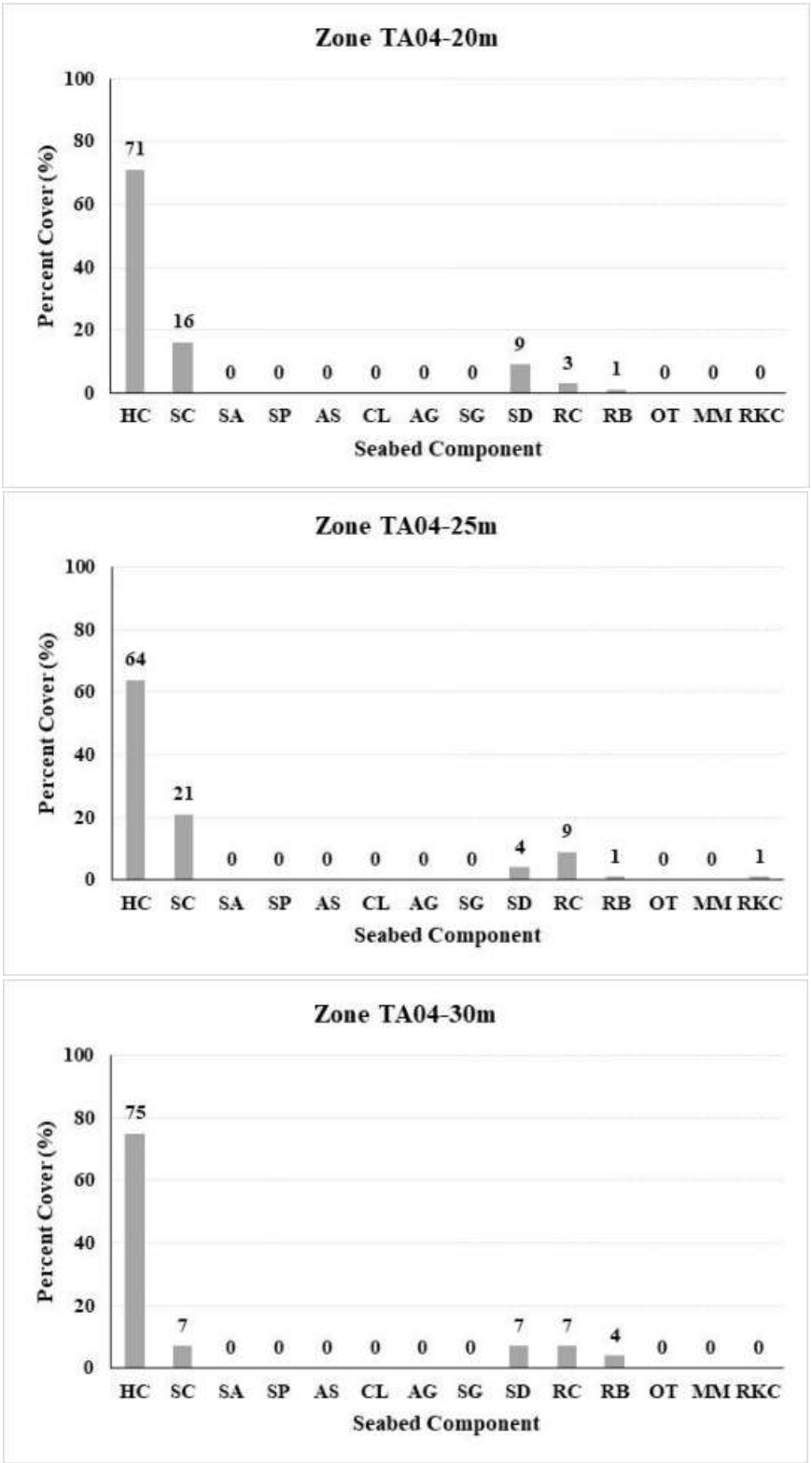


Figure 3 11: Cover percentages of the seabed habitat components at 20m (top), 25m (middle), and 30m (bottom) (Station TA04).

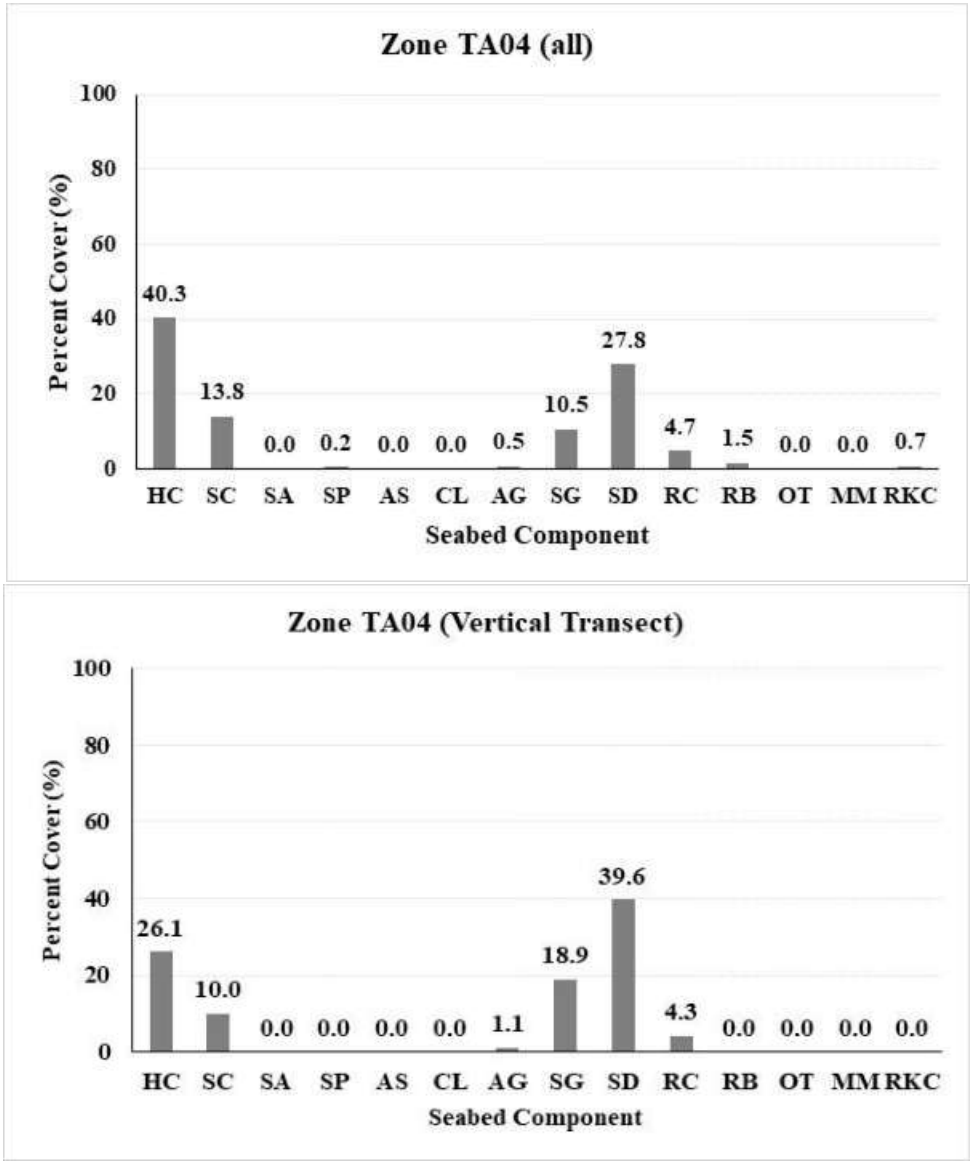


Figure 3 12: Cover percentages of the seabed habitat components at 5m (top), 10m (middle), and 15m (bottom) (Station TA04).

3.1.5. Station TA05

In station TA05, the 5m depth contour is characterized by having very high percent cover of seagrass meadows (Fig. 13). The hard corals covered very low percentage (3%) of the bottom surface at this depth. Starting from 10m depth and going down to

the 30m depth contours, the hard corals increased their cover percentages from 21% at 10m depth and reached 84% at the 30m depth (Fig. 14).

Overall, the hard corals covered about 46% of the bottom surface at this station (Fig. 15). The vertical transect showed that the seagrass meadows are very important component of the bottom habitat at this station, where they occupied about 19% of the bottom surface (Fig. 15).

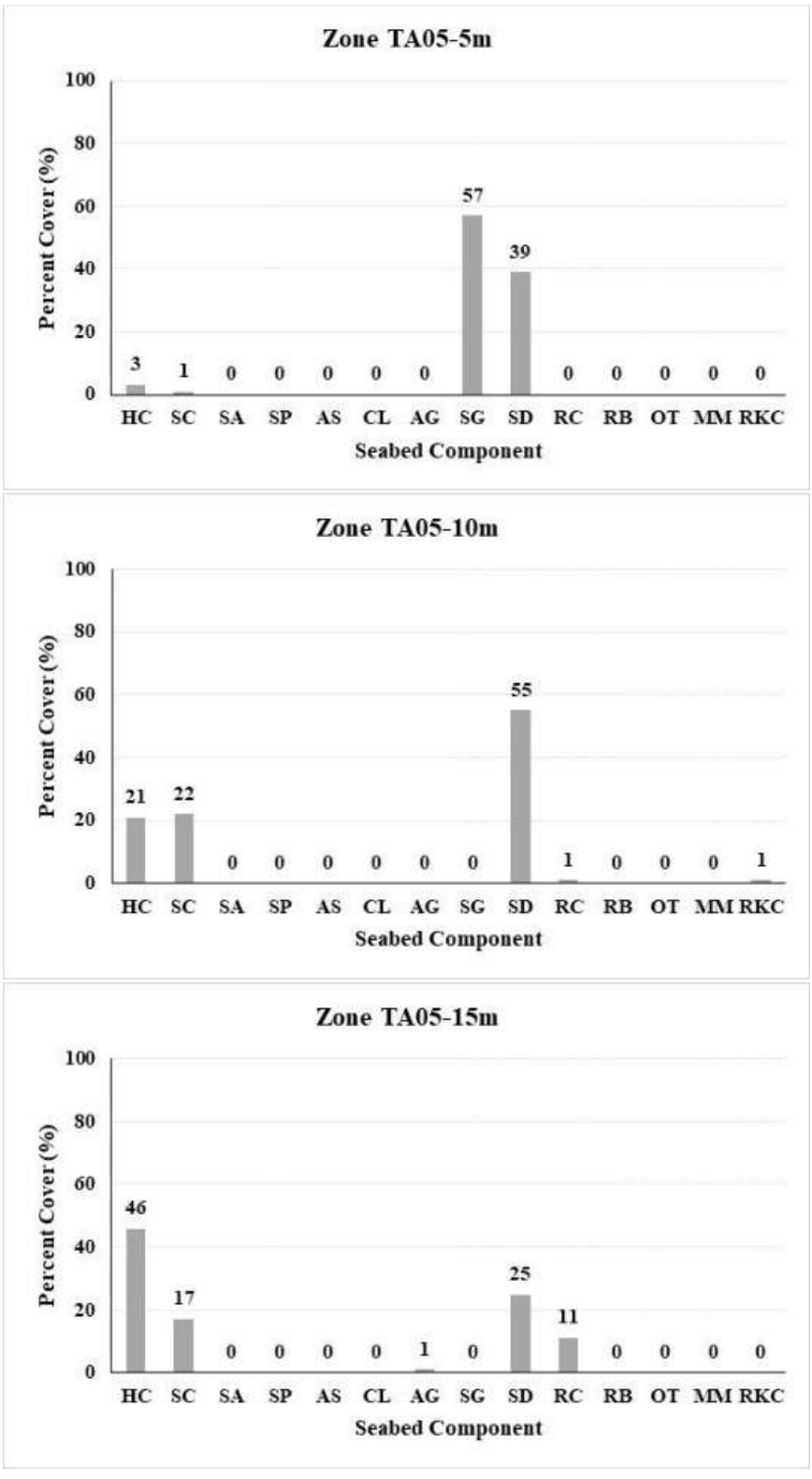


Figure 3 13: Cover percentages of the seabed habitat components at 5m (top), 10m (middle), and 15m (bottom) (Station TA05).

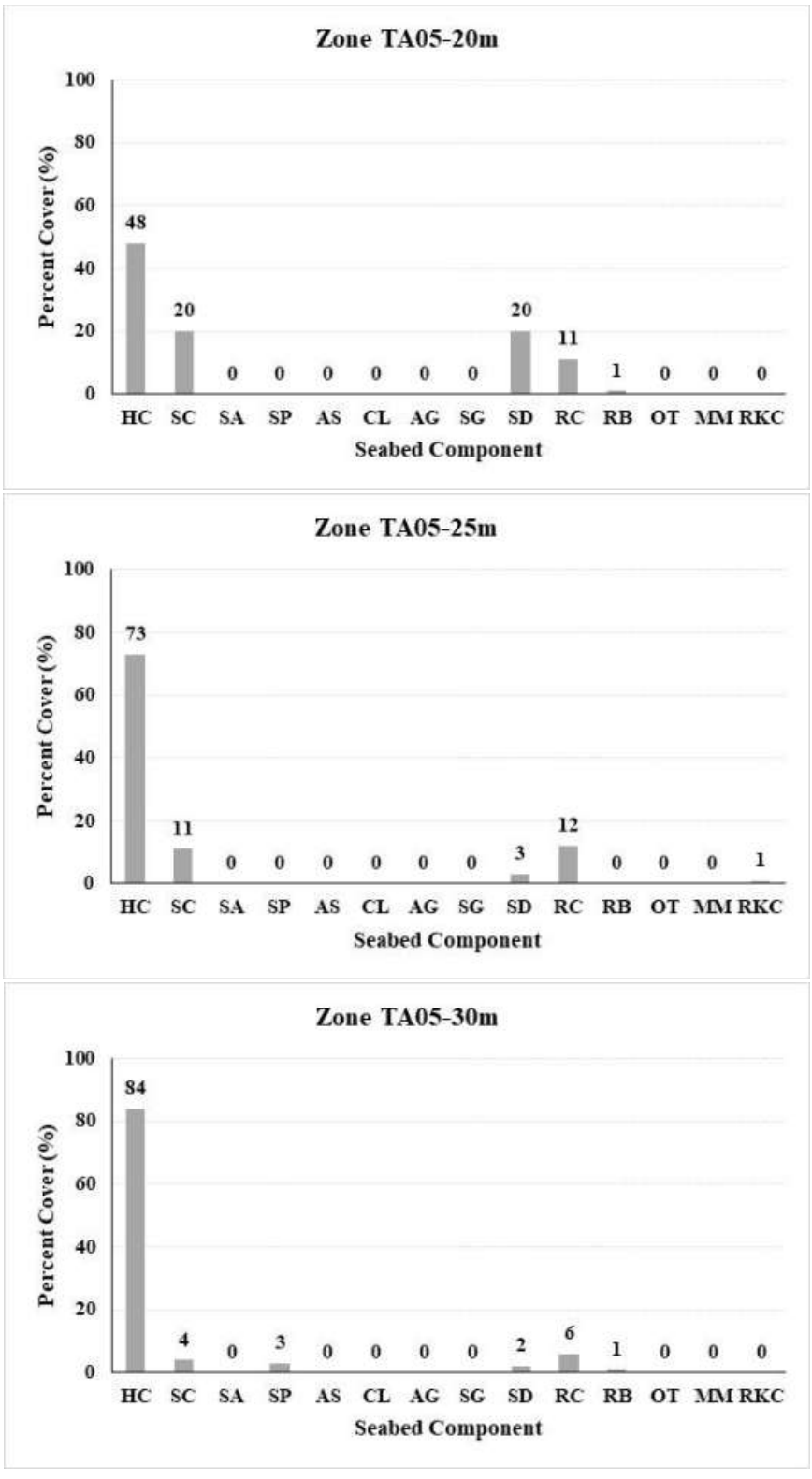


Figure 3 14: Cover percentages of the seabed habitat components at 20m (top), 25m (middle), and 30m (bottom) (Station TA05).

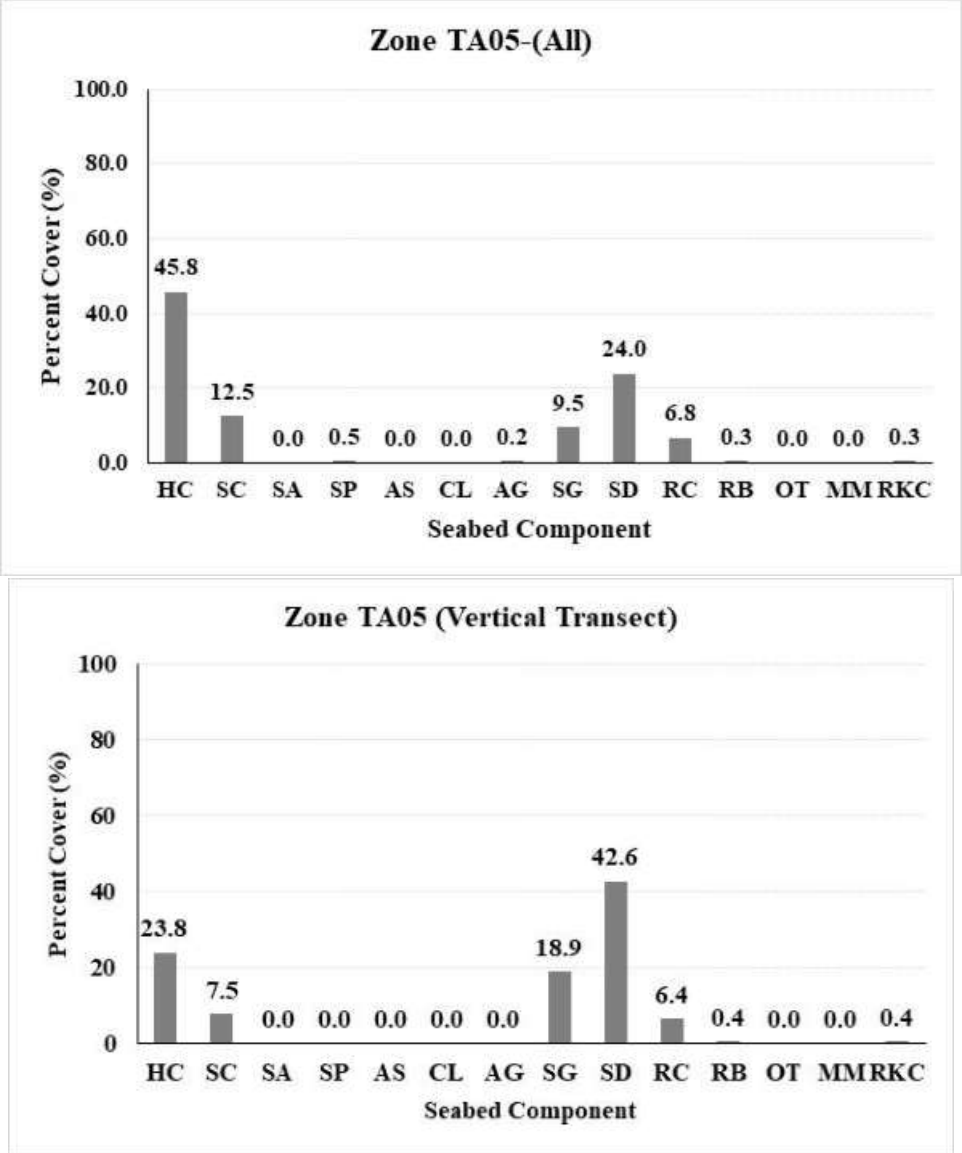


Figure 3 15: Cover percentages of the seabed habitat components at 5m (top), 10m (middle), and 15m (bottom) (Station TA05).

3.1.6. Station TA06

Like the situation observed in TA05, the shallow depths at TA06 station (the 5 and 10m depths), are mostly seagrass meadows, with very little percent cover of the corals (Fig. 16). Starting from 15m depth, the seagrass meadows were nor recorded, while the hard corals had 29% cover. The other depth contours (20-30m), had more coral cover

with 22%, 30%, and 36%, respectively (Fig. 17). At 25m, the rock component covered about 50% of the bottom surface, indicating that the corals in this area have been destroyed in the past (Fig. 17).
Overall average showed about 22% cover of healthy corals, and about 14% seagrass meadows (Fig. 18). In the vertical transect, the corals had about 10% cover, which means that the sections between the transects is not full of corals, rather the sand and rock components combined, occupied about 66% of the bottom surface (Fig. 18).

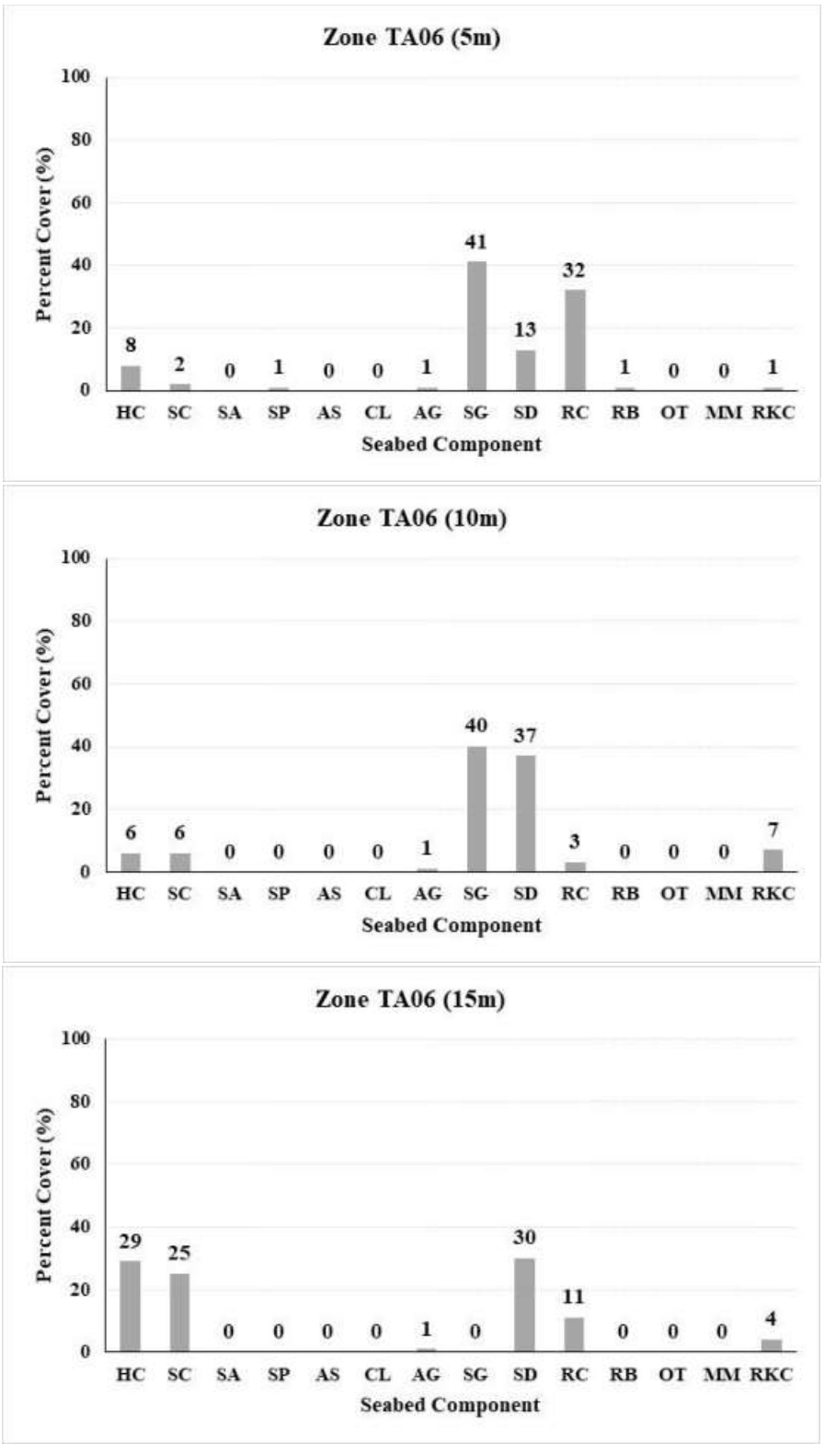


Figure 3 16: Cover percentages of the seabed habitat components at 5m (top), 10m (middle), and 15m (bottom) (Station TA06).

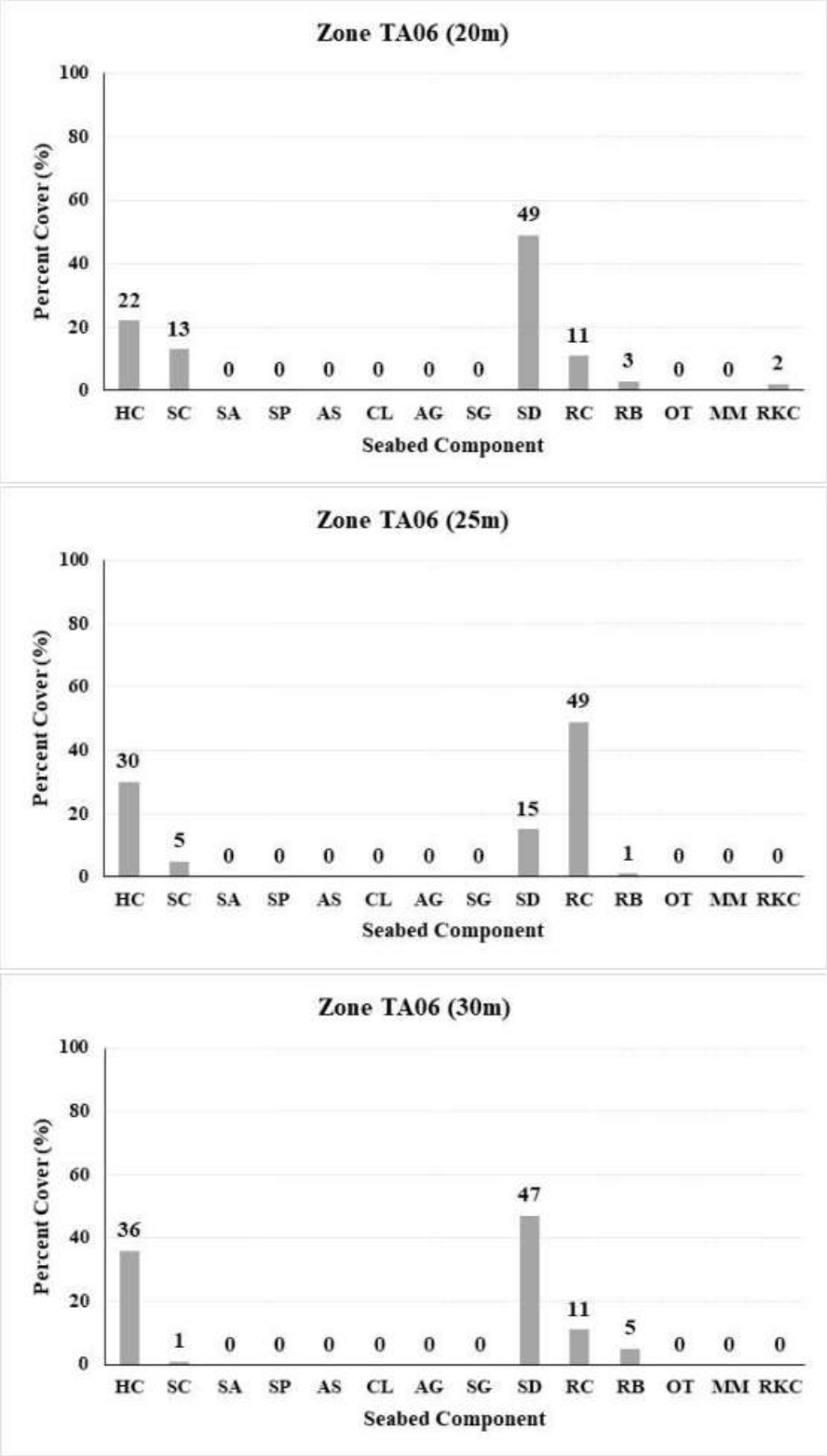


Figure 3 17: Cover percentages of the seabed habitat components at 20m (top), 25m (middle), and 30m (bottom) (Station TA06).

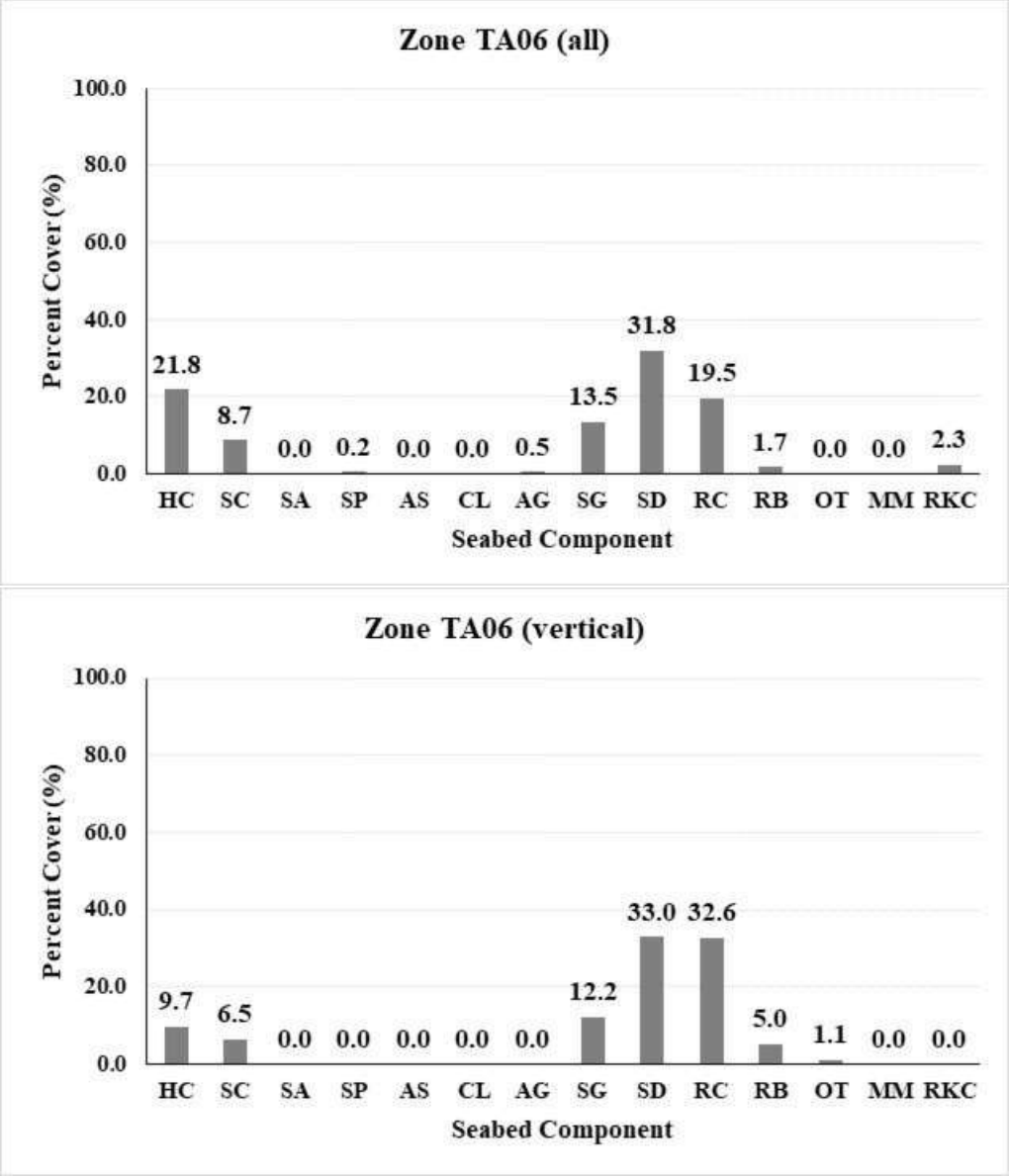


Figure 3 18: Cover percentages of the seabed habitat components at 5m (top), 10m (middle), and 15m (bottom) (Station TA06).

3.1.7. Station TA07

At TA07, the hard coral cover was low in all depths, except for the 15m and 30m depths (Fig. 19). The 5m depth transect was mostly seagrass meadows, while the sand component dominated the 10m depth. It was noticed that this station had very high coral damage,

which seems to have happened in the past years. The percent cover of the rock component was 40%, 57%, 72%, and 53% at 15m, 20m, 25m, and 30m depths, respectively (Fig. 20). The average coral cover was about 12%, while the rock was about 40% (Fig. 21). The vertical transects showed similar results like the overall average of the station (Fig. 21).

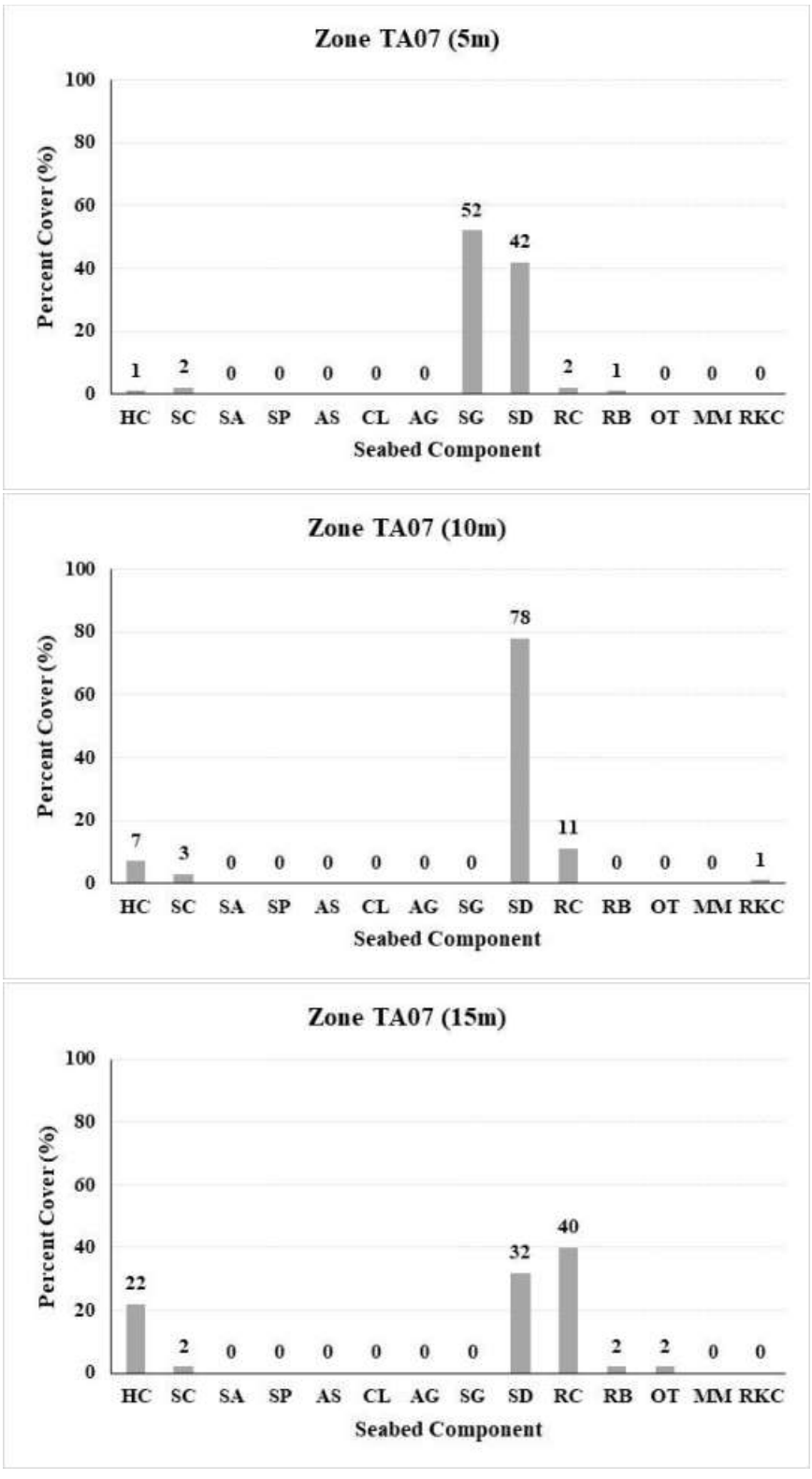


Figure 3 19: Cover percentages of the seabed habitat components at 5m (top), 10m (middle), and 15m (bottom) (Station TA07).

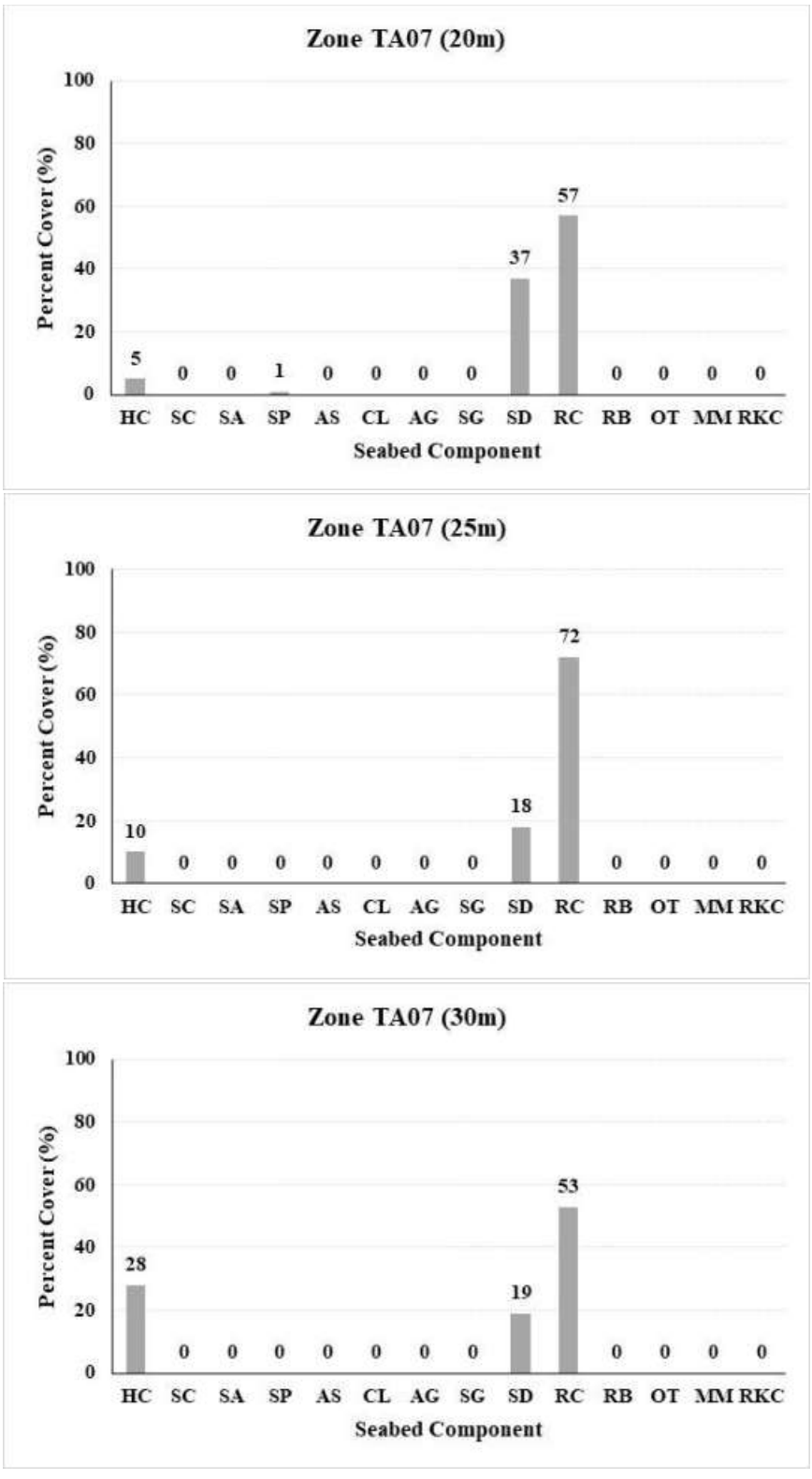


Figure 3 20: Cover percentages of the seabed habitat components at 20m (top), 25m (middle), and 30m (bottom) (Station TA07).

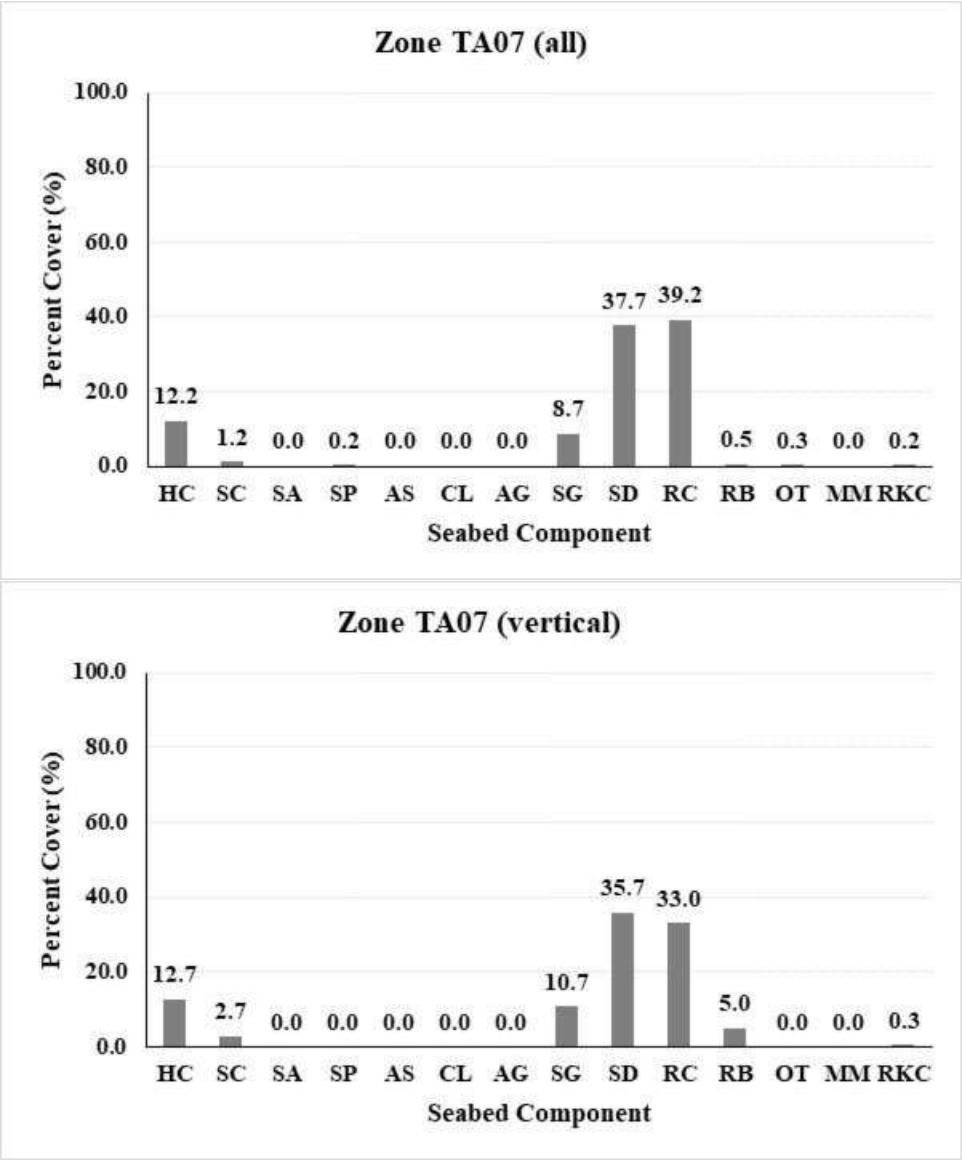


Figure 3 21: Cover percentages of the seabed habitat components at 5m (top), 10m (middle), and 15m (bottom) (Station TA07).

3.1.8. Station TA08

In station TA08, most of the bottom surface at the shallow depths (5-20m) was covered by seagrass meadows, with about 60% cover. The coral cover was very low at these depths. At the 25m and 30m depths, the coral covered increased to 20% and 33%

at the two depths, respectively (Fig. 22 and 23). The overall average and the vertical transect reflected this situation (Fig. 24).

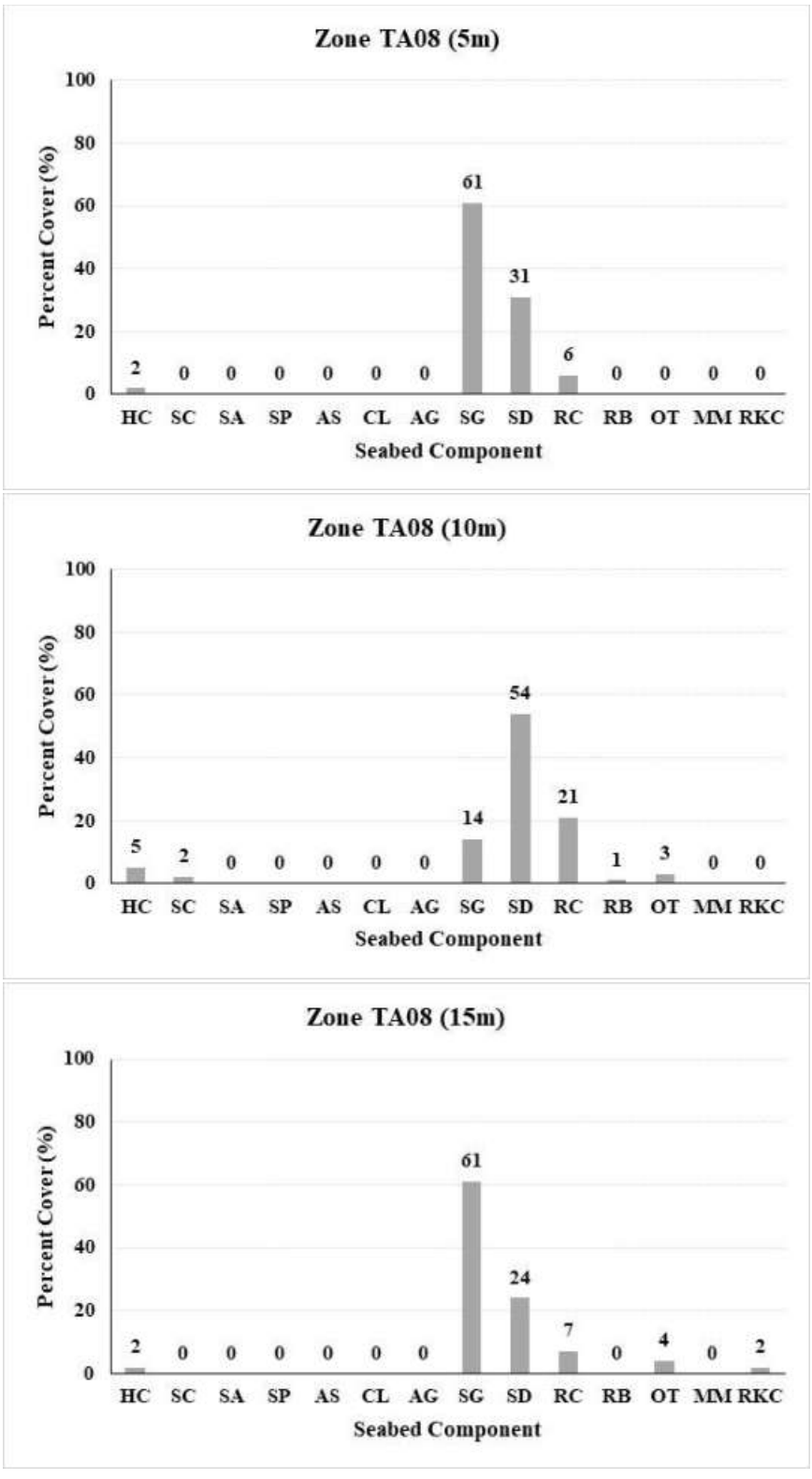


Figure 3 22: Cover percentages of the seabed habitat components at 5m (top), 10m (middle), and 15m (bottom) (Station TA08).

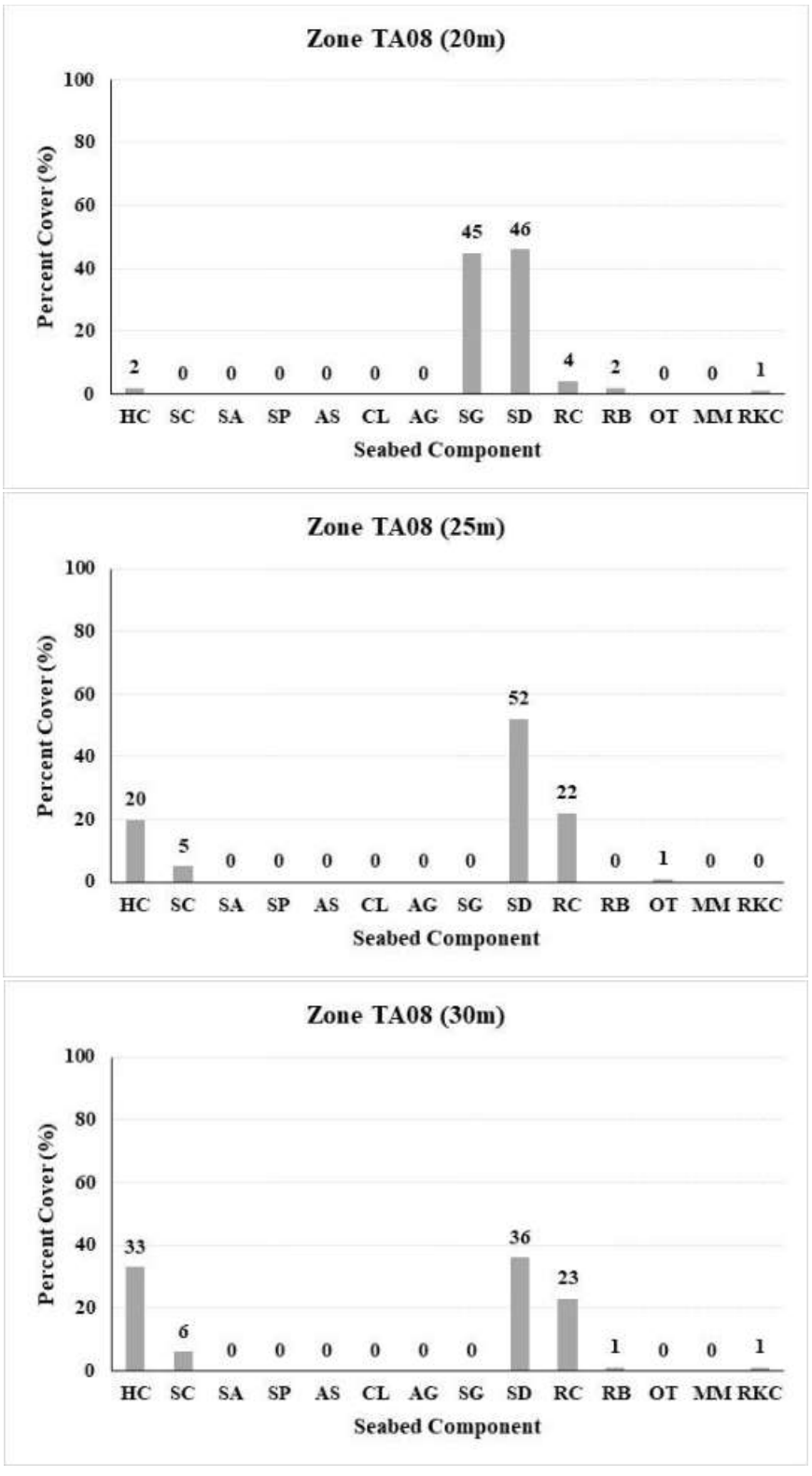


Figure 3 23: Cover percentages of the seabed habitat components at 20m (top), 25m (middle), and 30m (bottom) (Station TA08).

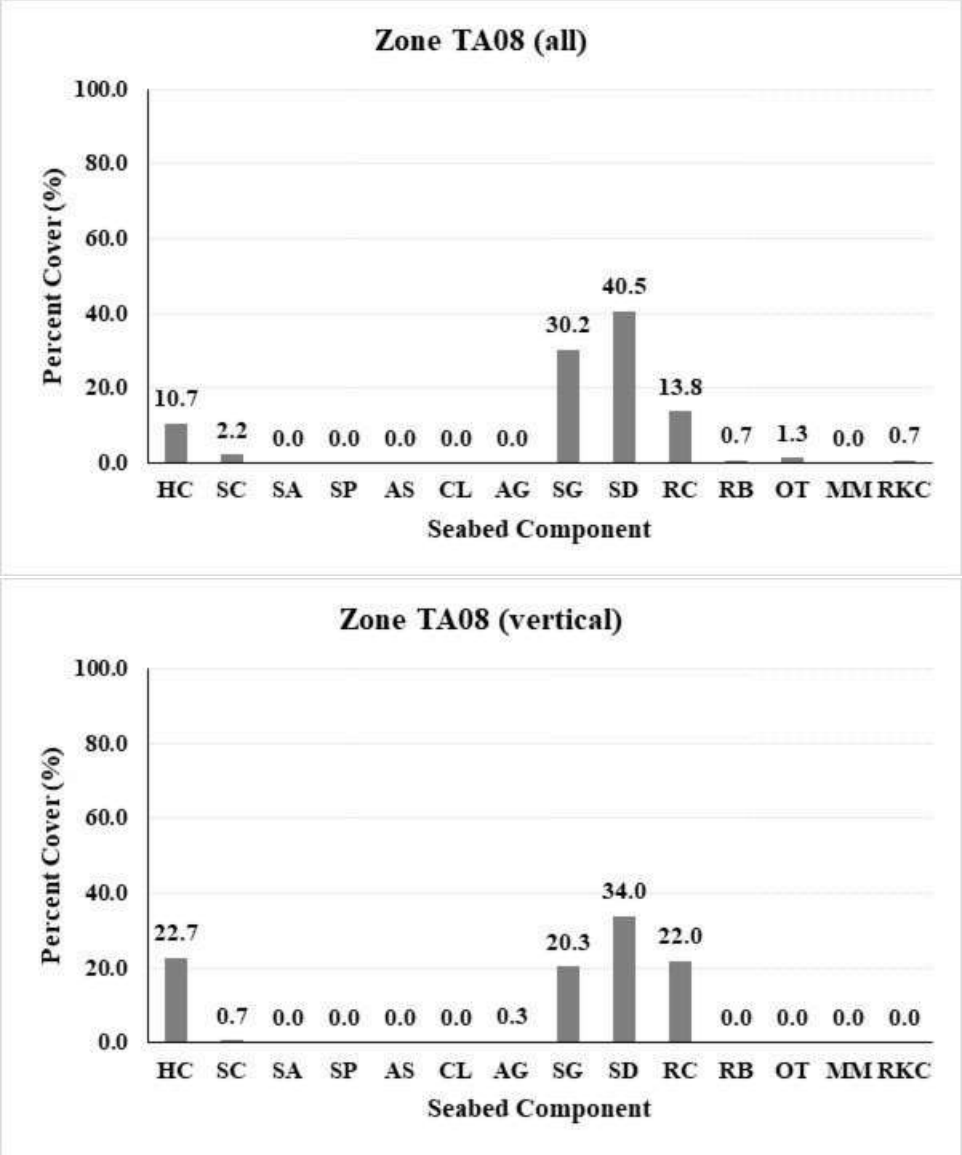


Figure 3 24: Cover percentages of the seabed habitat components at 5m (top), 10m (middle), and 15m (bottom) (Station TA08).

3.1.9. Station TB01

At TB01 station, the 5 to 15m depths was mainly sandy bottoms and to a less extent rocks (Fig. 3.25). The hard coral component became increasingly high starting at 20m depth (19%) and continuing to the 25m and 30m depths (29% and 44%, respectively) (Fig. 3.26).

On average, the hard corals covered 22% of the bottom surface, the sand covered 53%,

and the rocks covered 20% of the bottom surface (Fig. 3.27). In the vertical transect, the sand component dominated the bottom surface with about 73% coverage, while hard corals covered 15% of the bottom surface (Fig. 3.27).

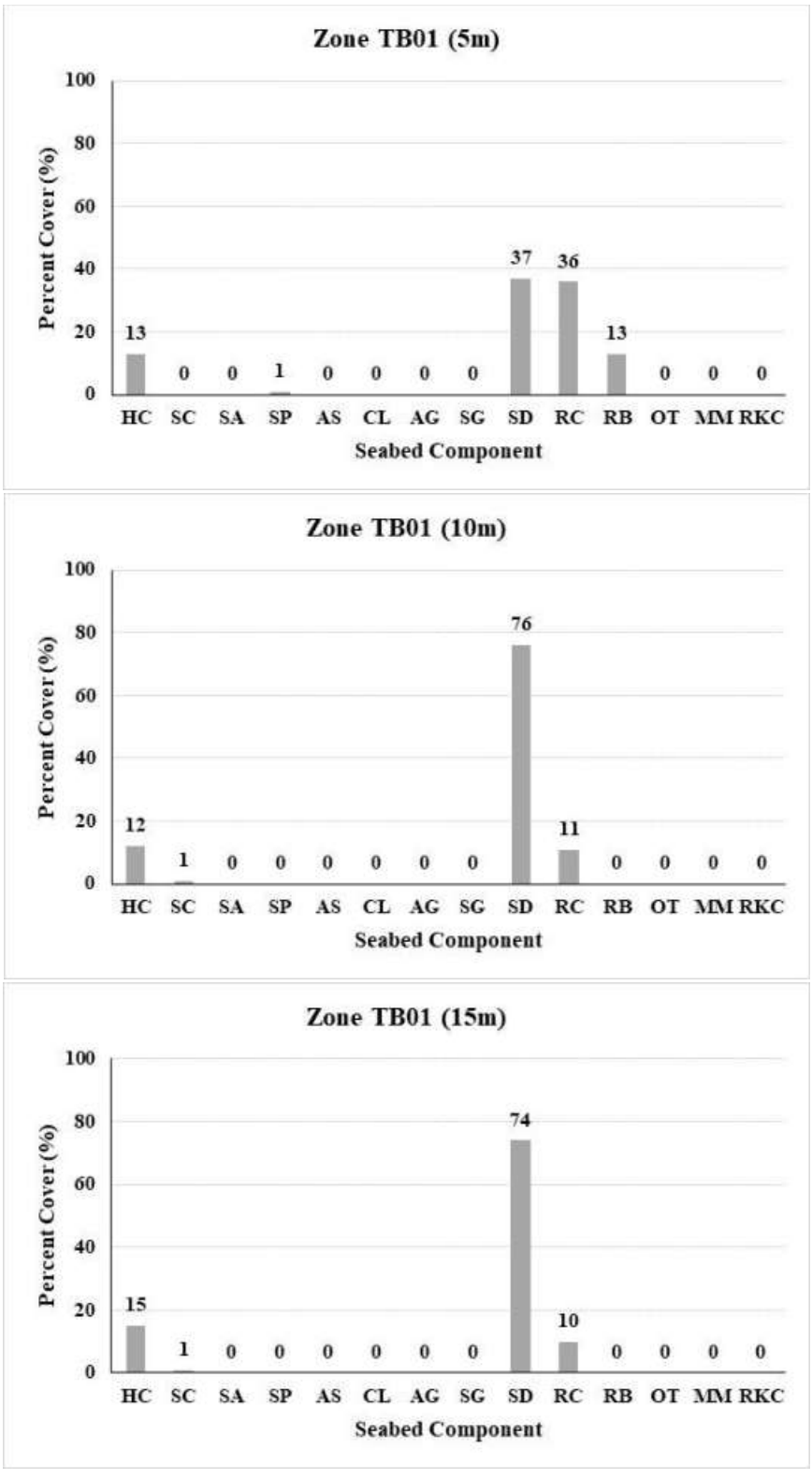


Figure 3 25: Cover percentages of the seabed habitat components at 5m (top), 10m (middle), and 15m (bottom) (Station TB01).

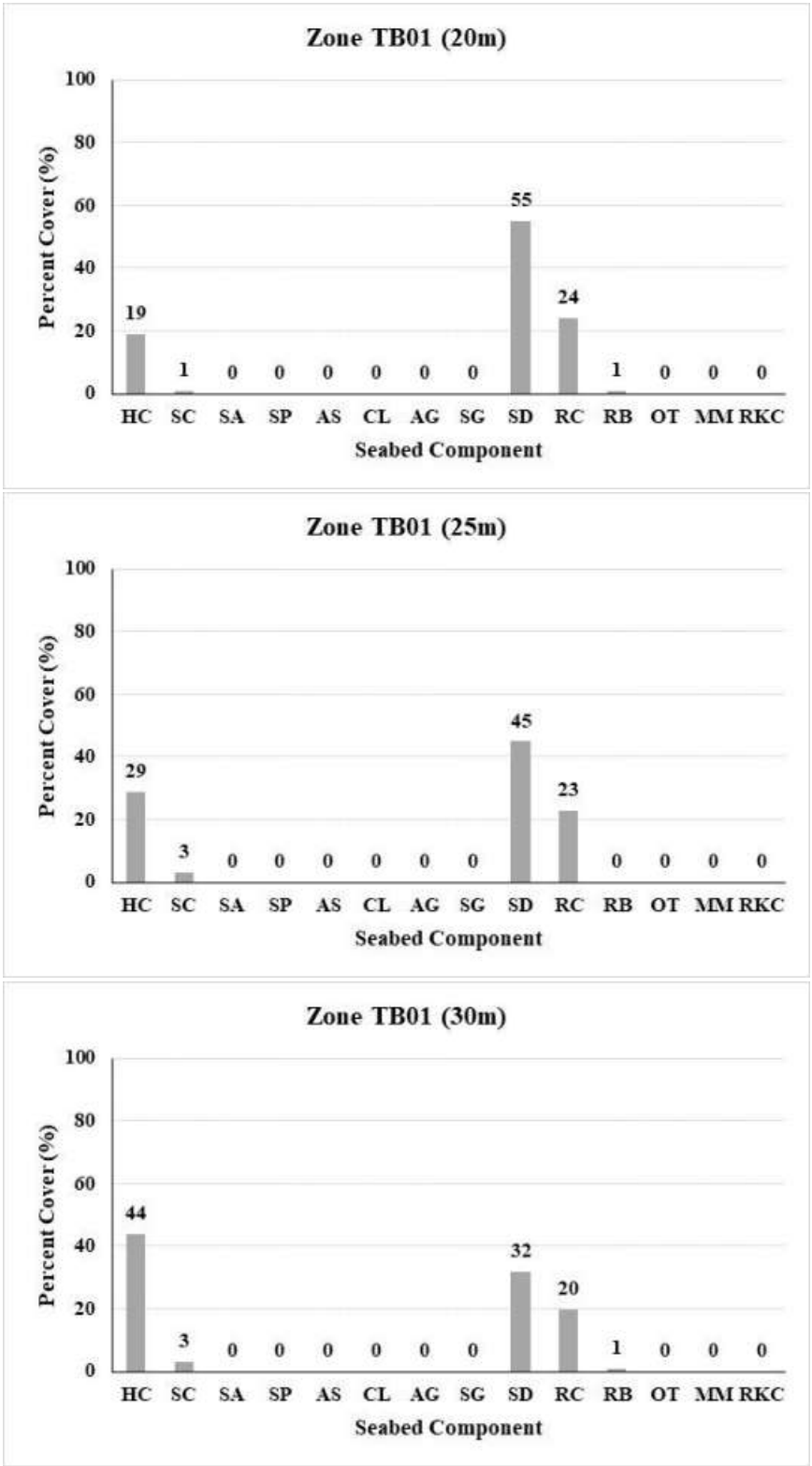


Figure 3 26: Cover percentages of the seabed habitat components at 20m (top), 25m (middle), and 30m (bottom) (Station TB01).

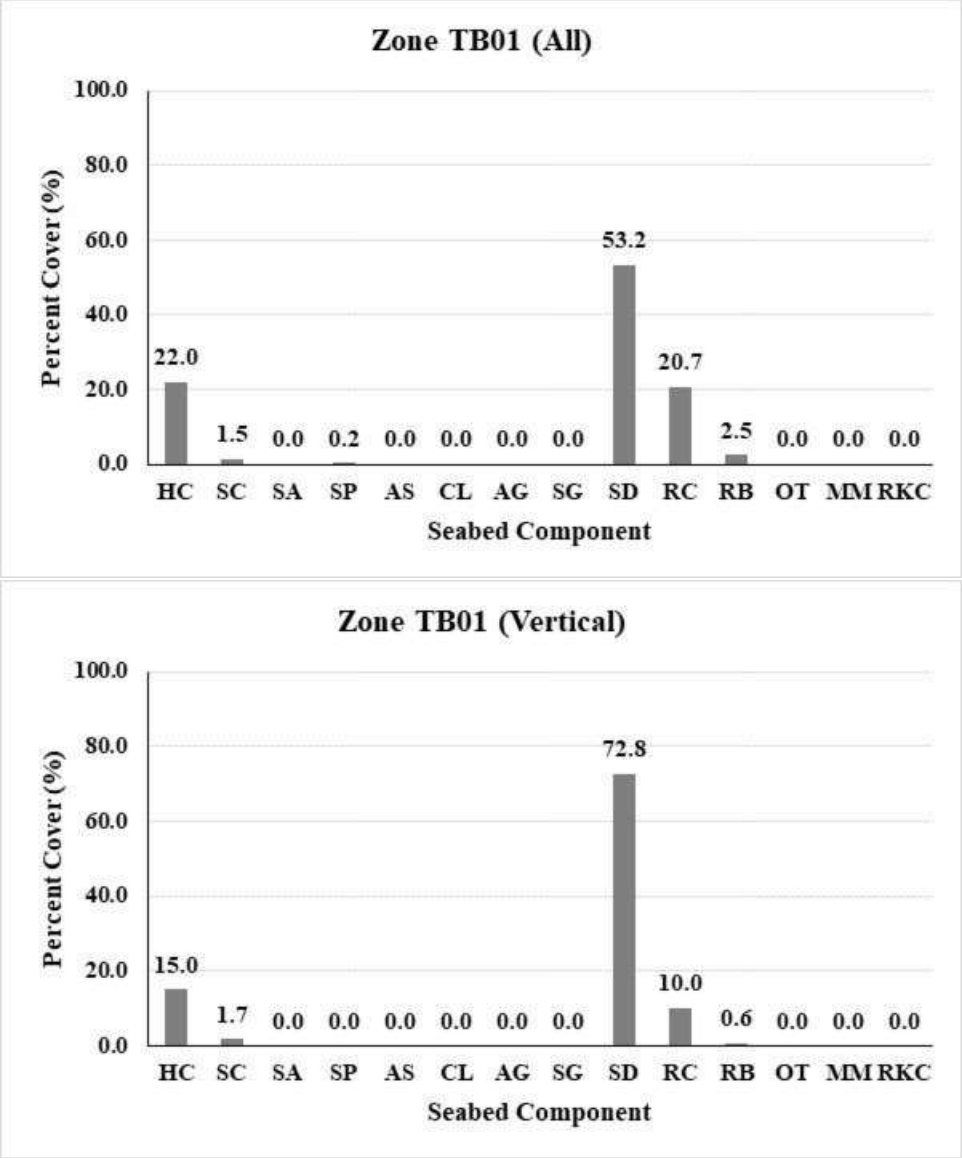


Figure 3 27: Cover percentages of the seabed habitat components at 5m (top), 10m (middle), and 15m (bottom) (Station TA08).

3.2. Coral Taxonomy

3.2.1. Station TA01

The coral identification results obtained from station TA01 have shown that there were 1862 individual corals, representing 14 coral families and 41 genera (Table 3.1). The highest number of coral colonies was observed at depths between 10m and 25m. Although the coral diversity was high, but the total number of individual colonies was relatively small.

Table 3 4: Coral genera, families, and the number of individual colonies for each genus at varying depths in station TA01.

Station No. TA-01								
Family	**Genus**	**5m**	**10m**	**15m**	**20m**	**25m**	**30m**	**Total No. Individuals/Genus**
Dendrophylliidae	*Turbinaria*	2	19	3	3	7	2	36
Poritidae	*Goniopora*		1	9	6	1	7	24
	Porites	4	3	9	12	20	7	55
Agariciidae	*Leptoseris*		1	2	2	15	4	24
	Pavona	3	2	6	9	17	6	43
Acroporidae	*Acropora*	8	23	35	28	39	6	139
	Alveopora			1	2	1		4
	Astreopora	2	19	9	10	14	3	57
	Montipora	8	16		28	40	13	105
Euphylliidae	*Galaxea*	2		2	1	1	1	7
Siderastreidae	*Siderastrea*		1	1		2	1	5
Coscinaraeidae	*Craterastrea*					1		1
Fungiidae	*Fungia*		1	1	1		1	4
	Herpolitha		2	3				5
	Podabacia					3	1	4
	Danafungia			2	1	2		5
Plesiastreidae	*Plesiastrea*		1	2			1	4
Lobophylliidae	*Lobophyllia*		21	13	6	15	4	59
	Echinophyllia	2		2	2	6	5	17
	Oxypora			4	2	1		7
	Acanthastrea	1	1	3	3	3	4	15
Mirulinidae	*Caulastraea*	1	1	2				4
	Cyphastrea	1	9	11	5	15	7	48
	Dipsastrea	13	40	38	38	44	16	189
	Echinopora	2	8	13	5	9	4	41
	Erythrastrea		4	1	2	1		8
	Favites	1	9	4	13	24	6	57
	Paragoniastrea	1		1	1	4	1	8
	Goniastrea	47	32	25	21	27	8	160

	Hydnophora	**10**	**1**	**1**				**12**
	Mycedium		**21**	**6**	**1**	**6**	**5**	**39**
	Paramontastrea	**1**	**20**	**16**	**31**	**24**	**17**	**109**
	Platygyra	**15**	**93**	**54**	**12**	**10**	**7**	**191**
Pocilloporidae	*Pocillopora*	**25**	**6**	**10**	**5**	**1**		**47**
	Seriatopora	**2**		**4**	**1**	**1**	**3**	**11**
	Stylophora	**77**	**39**	**41**	**29**	**31**	**6**	**223**
	Stylocoeniella	**1**	**1**	**3**	**3**	**2**	**1**	**11**
Psammocoridae	*Psammocora*	**1**	**1**	**5**	**9**	**17**	**11**	**44**
Incertae Sedis	*Pachyseris*						**5**	**5**
	Leptastrea			**7**	**6**	**1**	**2**	**16**
	Plerogyra		**2**	**2**	**5**	**7**	**3**	**19**
Total No. of individuals/depth		**230**	**398**	**351**	**303**	**412**	**168**	
Total No. of individuals/Station		**1862**						

3.2.2. Station TA02

Station TA02 had 2478 coral individuals, representing 13 families and 42 coral genera (Table 3.2). With respect to depth contour, the highest number of individuals was seen at 10m, with a total number of 755 individual colonies.

Table 3 5: Coral genera, families, and the number of individual colonies for each genus at varying depths in station TA02.

Station No. TA-02								
Family	**Genus**	**5m**	**10m**	**15m**	**20m**	**25m**	**30m**	**Total No. Individuals/Genus**
Dendrophylliidae	*Turbinaria*	7	7	11	2	3	0	30
Poritidae	*Goniopora*	7	4	2	0	1	3	17
	Porites	4	10	11	27	14	29	95
Agariciidae	*Gardineroseris*	1	3	0	0	0	0	4
	Leptoseris	0	1	0	0	5	12	18
	Pavona	11	33	4	9	18	31	106
Acroporidae	*Acropora*	29	31	11	43	12	25	151
	Astreopora	1	2	2	1	0	1	7
	Montipora	9	25	17	37	39	50	177
Euphylliidae	*Galaxea*	3	4	1	1	1	0	10
Coscinaraeidae	*Coscinaraea*	2	8	0	7	6	6	29
Fungiidae	*Fungia*	0	1	0	1	0	4	6
	Herpolitha	0	3	0	0	0	0	3
	Podabacia	0	0	0	0	0	2	2
Plesiastreidae	*Plesiastrea*	0	0	0	1	0	0	1
Lobophylliidae	*Lobophyllia*	4	27	18	13	2	6	70
	Echinophyllia	8	12	0	3	2	10	35

	Oxypora	0	4	0	2	3	0	9
	Acanthastrea	0	5	0	3	0	0	8
Mirulinidae	*Cyphastrea*	3	4	11	14	5	4	41
	Dipsastrea	17	62	30	40	9	12	170
	Echinopora	4	83	24	15	8	10	144
	Favites	1	5	5	1	1	11	24
	Paragoniastrea	0	1	5	3	0	2	11
	Goniastrea	57	90	42	64	25	20	298
	Hydnophora	5	3	1	0	0	0	9
	Merulina	0	5	6	8	7	10	36
	Mycedium	0	11	14	7	11	9	52
	Paramontastrea	4	39	15	27	9	20	114
	Platygyra	28	84	39	6	3	3	163
	Leptoria	2	1	2	0	0	0	5
	Oulophyllia	0	1	5	4	0	2	12
Pocilloporidae	*Pocillopora*	12	7	8	1	0	0	28
	Seriatopora	2	1	7	0	0	0	10
	Stylophora	136	135	31	29	26	21	378
	Stylocoeniella	1	3	2	0	2	1	9
Psammocoridae	*Psammocora*	0	4	3	9	7	12	35
Incertae Sedis	*Pachyseris*	0	0	0	2	4	16	22
	Leptastrea	14	34	11	12	15	16	102
	Blastomussa	0	0	0	1	0	2	3
	Plerogyra	1	1	5	3	4	1	15
Milleporidae	*Millepora*	6	1	0	9	3	0	19
Total No. of individuals/depth		**379**	**755**	**343**	**405**	**245**	**351**	
Total No. of individuals/Station		**2478**						

3.2.3. Station TA03

In station TA03, the number of coral colonies encountered in the belt was very high with about 4000 colonies, representing 14 families and 43 coral genera (Table 3.3). The highest number of coral colonies was found at 10-20m depth contours. This reflects the high density of coral cover in those depths.

Table 3 6: Coral genera, families, and the number of individual colonies for each genus at varying depths in station TA03.

Station No. TA-03								
Family	**Genus**	**5m**	**10m**	**15m**	**20m**	**25m**	**30m**	**Total No. Individuals/Genus**
Dendrophylliidae	*Turbinaria*	2	14	3	2	4	1	**26**
Poritidae	*Goniopora*	16	10	2	2	1	0	**31**
	Porites	24	12	17	48	55	86	**242**
Agariciidae	*Leptoseris*	0	1	0	0	0	8	**9**
	Pavona	40	21	15	15	27	51	**169**
Acroporidae	*Acropora*	20	40	58	46	56	59	**279**
	Alveopora	0	0	0	0	2	0	**2**
	Astreopora	4	2	1	4	2	1	**14**
	Montipora	18	20	45	66	64	75	**288**
Euphylliidae	*Galaxea*	4	3	6	2	0	0	**15**
	Gyrosmilia	0	0	1	0	0	0	**1**
Coscinaraeidae	*Coscinaraea*	2	4	0	10	1	10	**27**
Fungiidae	*Fungia*	0	0	6	1	0	2	**9**
	Ctenactis	0	1	0	0	0	0	**1**
	Herpolitha	0	2	0	0	0	0	**2**
	Podabacia	0	0	0	0	0	4	**4**
Plesiastreidae	*Plesiastrea*	0	1	0	0	0	0	**1**
Lobophylliidae	*Lobophyllia*	9	23	49	26	11	11	**129**
	Echinophyllia	6	10	8	6	3	7	**40**
	Oxypora	0	2	0	1	2	4	**9**
	Acanthastrea	0	6	7	7	0	0	**20**
Mirulinidae	*Cyphastrea*	14	22	7	7	3	5	**58**
	Dipsastrea	44	75	85	76	37	17	**334**
	Echinopora	14	47	60	32	12	22	**187**
	Erythrastrea	0	0	2	4	1	1	**8**
	Favites	4	7	7	4	3	1	**26**
	Paragoniastrea	0	1	1	0	0	0	**2**
	Goniastrea	54	101	210	114	33	34	**546**
	Hydnophora	17	4	0	0	0	0	**21**
	Merulina	0	6	16	42	19	25	**108**
	Mycedium	0	25	26	10	18	12	**91**
	Paramontastrea	6	48	51	53	26	17	**201**
	Platygyra	38	67	90	26	6	2	**229**
	Leptoria	0	1	0	0	0	0	**1**
	Oulophyllia	0	0	4	0	2	1	**7**
Pocilloporidae	*Pocillopora*	63	15	11	5	4	1	**99**
	Seriatopora	1	0	0	0	0	1	**2**
	Stylophora	128	159	84	53	45	39	**508**
	Stylocoeniella	0	3	1	1	0	0	**5**
Psammocoridae	*Psammocora*	2	0	1	3	9	18	**33**
Incertae Sedis	*Pachyseris*	0	0	0	1	6	20	**27**
	Leptastrea	21	31	35	45	25	19	**176**
	Plerogyra	0	3	5	17	12	3	**40**
Milleporidae	*Millepora*	3	5	6	7	0	2	**23**
Total No. of individuals/depth		**554**	**792**	**920**	**736**	**489**	**559**	
Total No. of individuals/Station		**4050**						

3.2.4. Station TA04

The number of individuals found at station TA04 was also high with about 4600 colonies seen the six belts surveyed. This total number of colonies represented 14 coral families and 42 coral genera (Table 3.4). The highest number of individual colonies was seen at 15m and 20m depths. This result also reflects high densities of coral at those two depths.

Table 3 7: Coral genera, families, and the number of individual colonies for each genus at varying depths in station TA04.

Station No. TA-04								
Family	**Genus**	**5m**	**10m**	**15m**	**20m**	**25m**	**30m**	**Total No. Individuals/Genus**
Dendrophylliidae	*Turbinaria*	4	7	7	9	7	2	36
Poritidae	*Goniopora*	1	13	9	6	1	2	32
	Porites	2	5	9	31	64	114	225
Agariciidae	*Gardineroseris*		1	0	0	0	1	2
	Leptoseris		4	0	1	3	14	22
	Pavona	5	27	4	29	29	123	217
Acroporidae	*Acropora*		23	46	50	51	33	203
	Astreopora	3		11	21	2	4	41
	Montipora	3	19	35	31	54	56	198
Euphylliidae	*Galaxea*		1	5	4	1	1	12
	Gyrosmilia			0	0	1	1	2
Coscinaraeidae	*Coscinaraea*		1	1	0	0	5	7
Fungiidae	*Fungia*			0	4	7	2	13
	Ctenactis			0	2	1	1	4
	Herpolitha			0	1	0	0	1
	Podabacia			0	0	1	0	1
Plesiastreidae	*Plesiastrea*			0	1	0	0	1
Lobophylliidae	*Lobophyllia*	4	26	45	64	31	14	184
	Echinophyllia	3	6	11	22	17	12	71
	Oxypora		1	2	38	20	7	68
	Acanthastrea		4	14	15	1	4	38
Mirulinidae	*Cyphastrea*	2	3	9	12	1	7	34
	Dipsastrea		81	138	57	31	9	316
	Echinopora	2	87	126	150	49	27	441
	Favites		14	8	17	5	1	45
	Paragoniastrea			9	2	0	1	12
	Goniastrea	28	102	161	189	132	38	650
	Hydnophora	7	15	10	12	0	0	44

	Merulina		11	11	18	20	30	90
	Mycedium			11	57	77	68	213
	Paramontastrea	4	33	93	75	45	37	287
	Platygyra	23	84	93	77	33	9	319
	Oulophyllia			0	9	0	0	9
Pocilloporidae	*Pocillopora*		2	2	7	0	0	11
	Seriatopora	5	5	0	1	0	0	11
	Stylophora	30	137	91	67	47	65	437
	Stylocoeniella			1	2	0	3	6
Psammocoridae	*Psammocora*	1	2	5	4	2	5	19
Incertae Sedis	*Pachyseris*			2	1	6	20	29
	Leptastrea	6	31	40	32	6	4	119
	Blastomussa			0	0	1	0	1
	Plerogyra		12	6	41	16	11	86
Milleporidae	*Millepora*	2		6	2	1	1	12
Total No. of individuals/depth		**135**	**757**	**1021**	**1161**	**763**	**732**	
Total No. of individuals/Station		**4569**						

3.2.5. Station TA05

Station TA05 had the highest number of coral individuals among all the stations surveyed, with a total of 5735 coral colonies, representing 15 coral families and 46 coral genera (Table 3.5). All depths, except for the 5m depth, had very high number of coral colonies encountered in the belts surveyed. These results indicate that the deeper depths are more significant in terms of coral diversities and coral densities.

Table 3 8: Coral genera, families, and the number of individual colonies for each genus at varying depths in station TA05.

Station No. TA-05								
Family	**Genus**	**5m**	**10m**	**15m**	**20m**	**25m**	**30m**	**Total No. Individuals/Genus**
Dendrophylliidae	*Turbinaria*	5	22	12	8	6	1	**54**
Poritidae	*Goniopora*	3	10	9	6	7	4	**39**
	Porites	3	20	30	72	88	108	**321**
Agariciidae	*Gardineroseris*		5	4	0	0	0	**9**
	Leptoseris			7	1	10	8	**26**
	Pavona	1	14	15	26	62	107	**225**
Acroporidae	*Acropora*	23	71	39	58	29	36	**256**
	Alveopora				1	0	0	**1**
	Astreopora	5	36	26	6	2	3	**78**
	Montipora	8	40	77	60	51	109	**345**

Euphylliidae	*Galaxea*	2	3	4	1	5	2	**17**
	Gyrosmilia		2	1	0	0	0	**3**
Siderastreidae	*Siderastrea*		16	19	0	0	0	**35**
Coscinaraeidae	*Coscinaraea*				1	1	3	**5**
Fungiidae	*Fungia*		2	1	3	7	4	**17**
	Ctenactis				0	0	1	**1**
	Herpolitha		1		0	1	0	**2**
	Podabacia		1	1	0	1	3	**6**
Plesiastreidae	*Plesiastrea*		2		0	0	0	**2**
Lobophylliidae	*Lobophyllia*		57	36	34	41	18	**186**
	Echinophyllia	4	15	18	48	23	17	**125**
	Oxypora		4	13	10	17	7	**51**
	Acanthastrea	2	20	12	8	4	3	**49**
Mirulinidae	*Cyphastrea*		13	39	21	22	2	**97**
	Dipsastrea	16	181	115	98	42	19	**471**
	Echinopora	2	87	68	81	82	55	**375**
	Erythrastrea		12	10	0	0	0	**22**
	Favites		97	43	21	10	4	**175**
	Paragoniastrea		8	9	5	3	0	**25**
	Goniastrea	14	94	108	159	144	64	**583**
	Hydnophora	6	18	4	4	5	2	**39**
	Merulina			1	82	75	65	**223**
	Mycedium		9	40	64	159	135	**407**
	Paramontastrea	5	45	47	107	66	66	**336**
	Platygyra	19	94	58	55	67	19	**312**
	Oulophyllia		50		5	3	0	**58**
Pocilloporidae	*Pocillopora*	7	14	4	1	1	1	**28**
	Seriatopora	1	1		0	0	0	**2**
	Stylophora	39	91	63	47	87	85	**412**
	Stylocoeniella	4	17	5	4	3	7	**40**
Psammocoridae	*Psammocora*		5	22	6	3	7	**43**
Incertae Sedis	*Pachyseris*				2	6	27	**35**
	Leptastrea	4	22	7	26	7	19	**85**
	Blastomussa				1	0	0	**1**
	Plerogyra		15	17	20	29	20	**101**
Milleporidae	*Millepora*	1		1	4	5	1	**12**
Total No. of individuals/depth		**174**	**1214**	**985**	**1156**	**1174**	**1032**	
Total No. of individuals/Station		**5735**						

3.2.6. Station TA06

In station TA06, there were about 3300 coral individuals, representing 15 families and 46 coral genera, which similar to the diversity seen at station TA05 (Table 3.6). The highest number of colonies was seen at 15m depth, and to a less extent at 10m depth.

Table 3 9: Coral genera, families, and the number of individual colonies for each genus at varying depths in station TA06.

Station No. TA-06								
Family	**Genus**	**5m**	**10m**	**15m**	**20m**	**25m**	**30m**	**Total No. Individuals/Genus**
Dendrophylliidae	*Turbinaria*	4	12	5	2	2	3	28
Poritidae	*Goniopora*		7	10	5			22
	Porites	96	36	61	45	32	56	326
Agariciidae	*Leptoseris*	4		5	3	22	30	64
	Pavona	19	7	49	20	12	38	145
Acroporidae	*Acropora*	49	60	95	58	33	27	322
	Alveopora	1		2	1		2	6
	Astreopora	7	23	26	22	4	3	85
	Montipora	9	22	51	30	38	37	187
Euphylliidae	*Galaxea*	1		3	1		2	7
Siderastreidae	*Siderastrea*	1		4	9			14
Coscinaraeidae	*Coscinaraea*	1					14	15
	Craterastrea						2	2
Fungiidae	*Fungia*	1	1	3		1		6
	Ctenactis	1		2				3
	Herpolitha	1	1	2	2	1		7
	Podabacia						13	13
	Danafungia		2	2		1		5
	Pleuractis			2				2
Plesiastreidae	*Plesiastrea*				4			4
Lobophylliidae	*Lobophyllia*	5	2	11	13	2	2	35
	Echinophyllia	2	6	9	2	4		23
	Oxypora	1		4	3	6	1	15
	Acanthastrea	3	12	14	4	1	1	35
Mirulinidae	*Caulastraea*	1	1	2	4			8
	Cyphastrea	5	3	41	25	8	15	97
	Dipsastrea	24	75	84	30	10	8	231
	Echinopora	16	13	41	14	1	6	91
	Erythrastrea			4	2			6
	Favites	11	40	33	27	4	7	122
	Paragoniastrea	1			1		4	6
	Goniastrea	17	73	110	55	24	19	298
	Hydnophora	5	14	18	5	3		45
	Merulina			1				1
	Mycedium			1	10	8	16	35
	Paramontastrea	4	4	4	14	8		34
	Platygyra	40	81	63	51	5		240
Pocilloporidae	*Pocillopora*	22	22	3	4	2	2	55
	Seriatopora	16	104	65	3	2		190
	Stylophora	76	100	50	29	21	10	286

	Stylocoeniella		10	10	1	1		22
Psammocoridae	*Psammocora*			7	16	10	5	38
Incertae Sedis	*Pachyseris*					7	16	23
	Leptastrea	3		6	7	3	1	20
	Plerogyra		5	12	1	1	2	21
Milleporidae	*Millepora*	37	5					42
Total No. of individuals/depth		**484**	**741**	**915**	**523**	**277**	**342**	
Total No. of individuals/Station		**3282**						

3.2.7. Station TA07

Station TA07 was relatively poor with respect to the number of individual coral colonies (1150 colonies), which reflects the status of coral reefs at this station, where much of the area has damaged coral reefs. The number of coral families 15, and the number of coral genera was 44, which indicates high diversities, but with low densities of corals at this station (Table 3.7). The depth contours have very low number of individual colonies at the deep sections of this station (i.e. 25m and 30m depths). This might be due to the damage caused by previous construction works in this area, and the continued existence of the liquid gas ship, which parks in that area for very long periods. The shade of the ship prevents light penetration to the water body, and therefore leads to eventual coral death.

Table 3 10: Coral genera, families, and the number of individual colonies for each genus at varying depths in station TA07.

Station No. TA-07								
Family	**Genus**	**5m**	**10m**	**15m**	**20m**	**25m**	**30m**	**Total No. Individuals/Genus**
Dendrophylliidae	*Turbinaria*	3	9	3	2		1	18
Poritidae	*Goniopora*		3	6				9
	Porites	2	14	13	4		2	35
Agariciidae	*Leptoseris*			6	3		14	23
	Pavona	2	16	18	1	1	5	43
Acroporidae	*Acropora*	6	26	10	4			46
	Alveopora		4	1				5
	Astreopora		7	15	3			25
	Montipora		15	10	8	1	9	43

Euphylliidae	*Galaxea*		3	1				4
	Gyrosmilia				1			1
Siderastreidae	*Siderastrea*		7	4	1		1	13
Fungiidae	*Cycloseris*		1					1
	Cantharellus			1				1
	Fungia		1		2			3
	Ctenactis							0
	Herpolitha			3				3
Plesiastreidae	*Plesiastrea*				3			3
Lobophylliidae	*Lobophyllia*		2	19	6			27
	Echinophyllia		6	7	3		6	22
	Oxypora			2	3		7	12
	Acanthastrea	1	7	4	2		1	15
Mirulinidae	*Cyphastrea*		2	18	5		2	27
	Dipsastrea	11	66	28	12		10	127
	Echinopora	7	18	10	4		1	40
	Erythrastrea			2			1	3
	Favites	9	48	23	4		2	86
	Paragoniastrea		1	1	2		1	5
	Goniastrea		14	9	6		1	30
	Hydnophora	4	5	1				10
	Merulina		1					1
	Mycedium			13	7	1	12	33
	Paramontastrea		17	23	4			44
	Platygyra	10	58	18	5	1	5	97
Pocilloporidae	*Pocillopora*	13	18	4	2			37
	Seriatopora	1						1
	Stylophora	70	125	22	2		3	222
	Madracis				1			1
Psammocoridae	*Psammocora*		1	1			1	3
Incertae Sedis	*Pachyseris*			1	3		7	11
	Leptastrea				2			2
	Plerogyra		6	5			3	14
Milleporidae	*Millepora*		3					3
Tubiporidae	*Tubipora*		1					1
Total No. of individuals/depth		**139**	**505**	**302**	**105**	**4**	**95**	
Total No. of individuals/Station		**1150**						

3.2.8. Station TA08

Similar situation to that seen at station TA07 was also observed at station TA08, where there were only 1424 coral colonies observed (Table 3.8). The number of families represented in this station was 14 families, while there were 42 coral genera. This reflects a high coral diversity, while the density is remains low.

Table 3 11: Coral genera, families, and the number of individual colonies for each genus at varying depths in station TA08.

Station No. TA-08								
Family	**Genus**	**5m**	**10m**	**15m**	**20m**	**25m**	**30m**	**Total No. Individuals/Genus**
Dendrophylliidae	*Turbinaria*	1	2	2	2	1		8
Poritidae	*Goniopora*	4	9	1		1	1	16
	Porites	21	25		6	29	22	103
Agariciidae	*Leptoseris*					8	8	8
	Pavona		2	2	3	14	27	48
Acroporidae	*Acropora*	1	44	20	18	30	55	168
	Alveopora	1						1
	Astreopora	1	9	3	2	6	7	28
	Montipora	14		7	9	9	39	39
Euphylliidae	*Galaxea*					2		2
	Gyrosmilia			1	2		3	3
Siderastreidae	*Siderastrea*			1	5	7	13	13
Coscinaraeidae	*Coscinaraea*	6			4	2	12	12
Fungiidae	*Fungia*					2	1	3
	Danafungia				1	1	2	2
	Pleuractis		1					1
Lobophylliidae	*Lobophyllia*		2	2	2	8	14	14
	Echinophyllia	1		1	4	4	10	10
	Oxypora					4	3	7
	Acanthastrea	2	1	9	2	4	18	18
Mirulinidae	*Caulastraea*				1		1	1
	Cyphastrea	4		1	2	1	8	8
	Dipsastrea	2	31	16	29	20	36	134
	Echinopora	2	5	2	4	9	22	22
	Erythrastrea				3		3	3
	Favites	2	25	3	13	32	20	95
	Paragoniastrea					1	1	1
	Goniastrea	3	18	2	5	16	15	59
	Hydnophora	1			2	3	6	6
	Merulina						2	2
	Mycedium					3	3	3
	Paramontastrea				4	4	8	8
	Platygyra	5	11	3	17	12	12	60
Pocilloporidae	*Pocillopora*	5		15	4	15		39
	Seriatopora	27	44	14	4			89
	Stylophora	12	159	68	71	38	28	376
Psammocoridae	*Psammocora*			1			1	1
Incertae Sedis	*Pachyseris*				1	4	5	5
	Leptastrea				1		1	1

	Blastomussa				2		2	2
	Plerogyra					1	1	2
Milleporidae	*Millepora*	1	2					3
Total No. of individuals/depth		**86**	**412**	**157**	**199**	**272**	**298**	
Total No. of individuals/Station		**1424**						

3.2.9. Station TB01

In station TB01, the total number of families was 15, represented by 49 coral genera, which is the highest in terms of diversity. Though, the number of individual coral colonies was very low (1500 colonies), similar to the situation seen at stations TA07 and TA08 (Table 3.9).

Table 3 12: Coral genera, families, and the number of individual colonies for each genus at varying depths in station TA08.

Station No. TB-01								
Family	**Genus**	**5m**	**10m**	**15m**	**20m**	**25m**	**30m**	**Total No. Individuals/Genus**
Dendrophylliidae	*Tubastrea*						1	1
	Turbinaria	1	1	1	4		4	11
Poritidae	*Goniopora*				1	2	5	8
	Porites		1	2	8	22	44	77
Agariciidae	*Gardineroseris*			1	1	2		4
	Leptoseris					4	12	16
	Pavona	1		2	1	2	16	22
Acroporidae	*Acropora*	5	12	16	17	16	29	95
	Alveopora			1				1
	Astreopora	1	2	2	4	6	8	23
	Montipora	2	3	12	20	20	39	96
Euphylliidae	*Galaxea*					3		3
	Gyrosmilia							0
Siderastreidae	*Siderastrea*		1	3	1	3	5	13
Coscinaraeidae	*Coscinaraea*					1	5	6
Fungiidae	*Cycloseris*						1	1
	Fungia			1		1	1	3
	Ctenactis	1						1
	Herpolitha						1	1
	Podabacia						2	2
	Danafungia		1		1			2
Lobophylliidae	*Lobophyllia*			1	6	2	9	18

	Echinophyllia	4	4	4	2	9	10	33
	Oxypora			1	2	4	14	21
	Acanthastrea		2	3	4	8	3	20
Mirulinidae	*Caulastraea*					3	5	8
	Cyphastrea			4	6	17	21	48
	Dipsastrea	4	24	20	42	54	47	191
	Echinopora	1		1	2	4		8
	Erythrastrea				2		3	5
	Favites	1	1	4	6	17	30	59
	Paragoniastrea					7	9	16
	Goniastrea	6	8	11	4	32	33	94
	Hydnophora			2	1			3
	Mycedium					5	50	55
	Paramontastrea		1	10	10	20	33	74
	Platygyra		1	1	8	6	8	24
	Oulophyllia	1	5	4	13	13	11	47
Pocilloporidae	*Pocillopora*	20	13	3	3	1		40
	Seriatopora		2	9	6	9	1	27
	Stylophora	25	58	57	27	20	15	202
	Madracis		6			2		8
	Stylocoeniella	1	4	2	1			8
Psammocoridae	*Psammocora*				4	11	27	42
Incertae Sedis	*Pachyseris*						5	5
	Leptastrea					2	8	10
	Plerogyra	1		1		4	8	14
Milleporidae	*Millepora*	30	3					33
Tubiporidae	*Tubipora*						1	1
Total No. of individuals/depth		**105**	**153**	**179**	**207**	**332**	**524**	
Total No. of individuals/Station		**1500**						

3.2.10. Overview of the Coral Taxonomy

The overall situation in the study site in terms of coral diversity in the nine stations surveyed revealed that there are more than 26000 coral individuals encountered in all stations and all depths studied (Table 3.10). This reflects a high density of corals, although variations among the different stations was also observed. The highest number of coral genera was recorded at station TB01, while the highest number of coral families was reported was nearly similar among the stations. In terms of depth, the 5m depth had the lowest number of total coral colonies, while the highest number of colonies was recorded at 10m and 15m, and to a lower extent at 20m. This reflects the general distribution of coral reefs in the study area, which shows the highest densities at those depths, relative to the shallow and deepest depths studied.

Table 3 13: Summary results of all nine stations surveyed in the study area.

Station	families	Genera	5m	10m	15m	20m	25m	30m	Total
TA01	14	41	230	398	351	303	412	168	1862
TA02	13	42	379	755	343	405	245	351	2478
TA03	14	43	554	792	920	736	489	559	4050
TA04	14	42	757	135	1021	1161	763	732	4569
TA05	15	46	174	1214	985	1156	1174	1032	5735
TA006	15	46	484	741	915	523	277	342	3282
TA07	15	44	139	505	302	105	4	95	1150
TA08	14	42	86	412	157	199	272	298	1424
TB01	15	49	105	153	179	207	332	524	1500
			2908	**5105**	**5173**	**4795**	**3968**	**4101**	**26050**

3.3. Planktons Survey

3.3.1. Taxonomic Overview

Across the 14 stations analyzed, the assemblage comprised a mixture of holoplankton (notably calanoid and cyclopoid copepods and chaetognaths), nematodes, and meroplanktonic larvae (gastropods, decapods, fish), with occasional planktonic foraminifera. Copepods were ubiquitous: *Paracalanus parvus* and *Oithona nana* occurred at most stations and often ranked among the top contributors to abundance, while *Clausocalanus furcatus* was consistently present at lower to moderate levels. The chaetognath *Sagitta enflata* occurred broadly but with highest prominence at the most even, lower-abundance stations. Nematodes (*Oncholaimus campylocercoides*, *Chromadora nudicapitata*, *Desmodora communis*) were common but rarely dominant. Meroplankton, especially gastropod larvae, drove large swings in total abundance at several stations. Composition and relative abundance of zooplankton taxa collected from all sampling sites (S1–S18). For each sampling site, the taxonomic composition (family, genus, and species), number of individuals, and relative abundance (%) recorded are presented in their respective tables (Tables 3.14-3.27).

Table 3 14: Composition and relative abundance of zooplankton taxa collected from S1 station.

Family	Genus	Species	Individuals	Relative Abundance (%)
Oncholaimidae	Oncholaimus	*O. campylocercoides*	2	13.33
Chromadoridae	Chromadora	*C. nudicapitata*	1	6.67
Desmodoridae	Desmodora	*D. communis*	1	6.67
Paracalanidae	Paracalanus	*P. parvus*	2	13.33
Oithonidae	Oithona	*O. nana*	2	13.33
Sagittidae	Sagitta	*S. enflata*	3	20.00
Decapod larvae	—	—	1	6.67
Fish larvae	—	—	0	0.00
Gastropod larvae	—	—	3	20.00

According to Table 3.14, a total of 15 individuals were recorded at Sampling Site S1, representing 8 species distributed among 8 families. The zooplankton community displays moderate diversity, reflecting a balanced interaction between benthic and pelagic organisms. The highest abundances were observed for *Sagitta enflata* and gastropod larvae (20% each), indicating active predation and molluscan reproduction. Copepods such as *Paracalanus parvus* and *Oithona nana* (13.33% each) illustrate efficient energy transfer within the pelagic food web. The nematodes *Oncholaimus campylocercoides*, *Chromadora nudicapitata*, and *Desmodora communis* collectively account for over a quarter of total individuals, suggesting sediment resuspension and benthic-pelagic coupling. Decapod larvae contribute additional diversity, while the absence of fish larvae may reflect temporal variability in spawning. Overall, the composition at Site S1 indicates a stable and ecologically productive nearshore environment within the Gulf's oligotrophic waters.

Table 3 15: Composition and relative abundance of zooplankton taxa collected from S2.

Family	**Genus**	**Species**	**Individuals**	**Relative Abundance (%)**
Oncholaimidae	Oncholaimus	*O. campylocercoides*	3	17.65
Chromadoridae	Chromadora	*C. nudicapitata*	2	11.76
Desmodoridae	Desmodora	*D. communis*	1	5.88
Paracalanidae	Paracalanus	*P. parvus*	1	5.88
Oithonidae	Oithona	*O. nana*	1	5.88
Sagittidae	Sagitta	*S. enflata*	2	11.76
Decapod larvae	—	—	1	5.88
Fish larvae	—	—	3	17.65
Gastropod larvae	—	—	3	17.65

As shown in Table 3.15, 17 individuals were identified at Site S2, encompassing 8 species from 8 families. The assemblage reflects dynamic interactions between benthic and pelagic taxa. The most abundant organisms—*Oncholaimus campylocercoides*, fish larvae, and gastropod larvae (each 17.65%)—indicate concurrent reproductive and trophic activity. Nematodes such as *Oncholaimus*, *Chromadora*, and *Desmodora* highlight benthic influence, whereas copepods (*Paracalanus parvus* and *Oithona nana*, each 5.88%) emphasize pelagic grazing and nutrient cycling. *Sagitta enflata* (11.76%) and decapod larvae (5.88%) contribute to the community's predatory and developmental dynamics. The coexistence of vertebrate and invertebrate larvae signifies favorable hydrodynamic and feeding conditions. Overall, Site S2 represents a transitional ecological zone characterized by balanced diversity and effective trophic connectivity within the Gulf of Aqaba.

Table 3 16: Composition and relative abundance of zooplankton taxa collected from S3.

Family	Genus	Species	Individuals	Relative Abundance (%)
Oncholaimidae	Oncholaimus	*O. campylocercoides*	3	11.54
Chromadoridae	Chromadora	*C. nudicapitata*	2	7.69
Desmodoridae	Desmodora	*D. communis*	2	7.69
Paracalanidae	Paracalanus	*P. parvus*	4	15.38
Oithonidae	Oithona	*O. nana*	4	15.38
Clausocalanidae	Clausocalanus	*C. furcatus*	2	7.69
Sagittidae	Sagitta	*S. enflata*	1	3.85
Decapod larvae	—	—	1	3.85
Fish larvae	—	—	2	7.69
Gastropod larvae	—	—	5	19.23

Table 3.16 indicates that 26 individuals were recorded at Sampling Site S3, belonging to 10 species across 10 families. The site supports a well-structured zooplankton community influenced by both pelagic and benthic processes. Gastropod larvae dominated the assemblage (19.23%), followed by copepods from the families Paracalanidae and Oithonidae (each 15.38%), reflecting strong pelagic productivity. Nematodes (*Oncholaimus*, *Chromadora*, *Desmodora*) contributed approximately 27% of the total individuals, indicating benthic resuspension and nutrient exchange near the seabed. The occurrence of *Sagitta enflata* and decapod larvae (3.85% each) suggests ongoing predation and recruitment activity, while fish larvae (7.69%) represent

higher trophic interactions. In summary, Site S3 exemplifies a balanced and productive nearshore ecosystem with efficient benthic-pelagic coupling and sustained zooplankton diversity.

Table 3 17: Composition and relative abundance of zooplankton taxa collected from S5.

Family	Genus	Species	Individuals	Relative Abundance (%)
Oncholaimidae	Oncholaimus	*O. campylocercoides*	3	10.34
Chromadoridae	Chromadora	*C. nudicapitata*	2	6.90
Desmodoridae	Desmodora	*D. communis*	1	3.45
Paracalanidae	Paracalanus	*P. parvus*	6	20.69
Oithonidae	Oithona	*O. nana*	4	13.79
Clausocalanidae	Clausocalanus	*C. furcatus*	3	10.34
Sagittidae	Sagitta	*S. enflata*	1	3.45
Decapod larvae	—	—	2	6.90
Fish larvae	—	—	2	6.90
Gastropod larvae	—	—	5	17.24
Foraminiferida	Globigerina	*G. bulloides*	1	3.45

As presented in Table 3.17, 29 individuals were observed at Site S5, encompassing 11 species representing 11 families. The zooplankton assemblage exhibits high taxonomic diversity that includes nematodes, copepods, chaetognaths, larval forms, and foraminiferans. The dominance of *Paracalanus parvus* (20.69%) and gastropod larvae (17.24%) reflects active pelagic reproduction and nutrient-enriched conditions favorable for secondary productivity. *Oithona nana* (13.79%) and *Oncholaimus campylocercoides* (10.34%) further emphasize the functional role of copepods and nematodes. *Clausocalanus furcatus* (10.34%) points to mid-water stability, while the presence of *Globigerina bulloides* and decapod larvae indicates benthic-pelagic interaction. Moderate numbers of fish and decapod larvae (6.9% each) confirm suitable nursery conditions. Collectively, Site S5 represents a stable and diverse ecosystem supporting active trophic exchange in the coastal Gulf region.

Table 3 18: Composition and relative abundance of zooplankton taxa collected from S6.

Family	Genus	Species	Individuals	Relative Abundance (%)
Oncholaimidae	Oncholaimus	*O. campylocercoides*	2	5.13
Chromadoridae	Chromadora	*C. nudicapitata*	2	5.13
Desmodoridae	Desmodora	*D. communis*	1	2.56
Paracalanidae	Paracalanus	*P. parvus*	7	17.95
Oithonidae	Oithona	*O. nana*	6	15.38
Clausocalanidae	Clausocalanus	*C. furcatus*	3	7.69
Centropagidae	Centropages	*C. furcatus*	2	5.13
Sagittidae	Sagitta	*S. enflata*	1	2.56
Decapod larvae	—	—	2	5.13
Fish larvae	—	—	0	0.00
Gastropod larvae	—	—	12	30.77
Foraminiferida	Globigerina	*G. bulloides*	1	2.56

According to Table 3.18, 39 individuals were counted at Sampling Site S6, representing 12 species from 12 families. The zooplankton community is dominated by gastropod larvae (30.77%), followed by *Paracalanus parvus* (17.95%) and *Oithona nana* (15.38%), emphasizing the ecological importance of larval and copepod stages. The high number of molluscan larvae suggests strong reproductive output, supported by favorable nutrient availability. The coexistence of multiple copepod families, including Paracalanidae, Oithonidae, Clausocalanidae, and Centropagidae, demonstrates a well-stratified and diverse pelagic structure. Nematodes and foraminiferans (*Globigerina bulloides*) appear in smaller proportions, while the absence of fish larvae suggests seasonal variability in spawning. Overall, Site S6 reflects a pelagic-dominated system sustained by copepods and molluscan larvae, maintaining the Gulf's trophic equilibrium.

Table 3 19: Composition and relative abundance of zooplankton taxa collected from S8.

Family	Genus	Species	Individuals	Relative Abundance (%)
Oncholaimidae	Oncholaimus	*O. campylocercoides*	3	10.34
Chromadoridae	Chromadora	*C. nudicapitata*	2	6.90
Desmodoridae	Desmodora	*D. communis*	2	6.90
Paracalanidae	Paracalanus	*P. parvus*	6	20.69
Oithonidae	Oithona	*O. nana*	5	17.24
Clausocalanidae	Clausocalanus	*C. furcatus*	2	6.90
Centropagidae	Centropages	*C. furcatus*	2	6.90
Sagittidae	Sagitta	*S. enflata*	1	3.45
Decapod larvae	—	—	2	6.90
Fish larvae	—	—	0	0.00
Gastropod larvae	—	—	3	10.34
Foraminiferida	Globigerina	*G. bulloides*	1	3.45

As summarized in Table 3.19, a total of 29 individuals were recorded at Site S8, encompassing 12 species across 12 families. The community composition reveals a balanced relationship between pelagic and benthic taxa. The dominant species were *Paracalanus parvus* (20.69%) and *Oithona nana* (17.24%), indicating a productive copepod population essential for energy transfer within the food web. Gastropod larvae (10.34%) signify ongoing reproductive activity in benthic habitats, while nematodes and *Clausocalanus furcatus* (each 6.9%) highlight benthic and mid-water interactions. Additional contributors such as *Centropages furcatus*, *Sagitta enflata*, and *Globigerina bulloides* enhance overall diversity. The absence of fish larvae likely reflects spatial heterogeneity in spawning zones. Altogether, Site S8 represents an ecologically stable environment dominated by copepod-driven productivity and moderate benthic influence, typical of the Gulf's coastal waters.

Table 3 20: Composition and relative abundance of zooplankton taxa collected from S9.

Family	Genus	Species	Individuals	Relative Abundance (%)
Oncholaimidae	Oncholaimus	*O. campylocercoides*	5	13.16
Chromadoridae	Chromadora	*C. nudicapitata*	2	5.26
Desmodoridae	Desmodora	*D. communis*	2	5.26
Paracalanidae	Paracalanus	*P. parvus*	5	13.16
Oithonidae	Oithona	*O. nana*	4	10.53
Clausocalanidae	Clausocalanus	*C. furcatus*	3	7.89
Centropagidae	Centropages	*C. furcatus*	1	2.63
Sagittidae	Sagitta	*S. enflata*	1	2.63
Decapod larvae	—	—	2	5.26
Fish larvae	—	—	2	5.26
Gastropod larvae	—	—	10	26.32
Foraminiferida	Globigerina	*G. bulloides*	1	2.63

According to Table 3.20, 38 individuals were recorded at Sampling Site S9, comprising 12 species distributed across 12 families. The community is dominated by gastropod larvae (26.32%), followed by *Oncholaimus campylocercoides* and *Paracalanus parvus* (each 13.16%), highlighting a strong interaction between benthic and pelagic assemblages. Copepods such as *Oithona nana*, *Clausocalanus furcatus*, and *Centropages furcatus* further contribute to the site's functional diversity, emphasizing their key role in nutrient transfer and energy flow. The presence of fish and decapod larvae (5.26% each) reflects ongoing reproductive and developmental processes within the ecosystem. The detection of *Globigerina bulloides* and several nematode taxa also points to

active sediment-water interface exchanges. Overall, Site S9 represents a biologically rich and transitional habitat that supports both benthic and pelagic productivity in the Gulf of Aqaba.

Table 3 21: Composition and relative abundance of zooplankton taxa collected from S10.

Family	Genus	Species	Individuals	Relative Abundance (%)
Oncholaimidae	Oncholaimus	*O. campylocercoides*	2	6.90
Chromadoridae	Chromadora	*C. nudicapitata*	1	3.45
Desmodoridae	Desmodora	*D. communis*	1	3.45
Paracalanidae	Paracalanus	*P. parvus*	6	20.69
Oithonidae	Oithona	*O. nana*	5	17.24
Clausocalanidae	Clausocalanus	*C. furcatus*	3	10.34
Centropagidae	Centropages	*C. furcatus*	2	6.90
Sagittidae	Sagitta	*S. enflata*	1	3.45
Decapod larvae	—	—	1	3.45
Fish larvae	—	—	1	3.45
Gastropod larvae	—	—	5	17.24
Foraminiferida	Globigerina	*G. bulloides*	1	3.45

As shown in Table 3.21, 29 individuals were documented at Sampling Site S10, corresponding to 12 species from 12 families. The zooplankton community is mainly composed of copepods and gastropod larvae, with *Paracalanus parvus* (20.69%) and *Oithona nana* (17.24%) as the most dominant taxa. Gastropod larvae contribute an equal share (17.24%), reflecting simultaneous pelagic and benthic reproductive activity. Secondary contributors such as *Clausocalanus furcatus* (10.34%) and *Centropages furcatus* (6.9%) indicate stable mid-water conditions favorable for copepod proliferation. Minor components including *Sagitta enflata*, fish larvae, and decapod larvae (3.45% each) add to trophic complexity. The reduced presence of nematodes and foraminiferans suggests weaker benthic influence compared with other sites. Altogether, Site S10 demonstrates a pelagic-dominated ecosystem characterized by efficient energy transfer and moderate species diversity.

Table 3 22: Composition and relative abundance of zooplankton taxa collected from S11.

Family	Genus	Species	Individuals	Relative Abundance (%)
Oncholaimidae	Oncholaimus	*O. campylocercoides*	3	11.54
Chromadoridae	Chromadora	*C. nudicapitata*	2	7.69
Desmodoridae	Desmodora	*D. communis*	1	3.85
Paracalanidae	Paracalanus	*P. parvus*	4	15.38
Oithonidae	Oithona	*O. nana*	4	15.38
Clausocalanidae	Clausocalanus	*C. furcatus*	2	7.69
Centropagidae	Centropages	*C. furcatus*	1	3.85
Sagittidae	Sagitta	*S. enflata*	1	3.85
Decapod larvae	—	—	1	3.85
Fish larvae	—	—	4	15.38
Gastropod larvae	—	—	2	7.69

Foraminiferida	Globigerina	*G. bulloides*	1	3.85

Based on Table 3.22, 26 individuals were observed at Sampling Site S11, representing 12 species from 12 families. The assemblage is characterized by a balance between copepod and fish larvae populations, with *Paracalanus parvus* and *Oithona nana* (each 15.38%) co-dominating alongside fish larvae (15.38%). This composition reflects active trophic linkage between primary grazers and secondary consumers. Moderate abundances of nematodes and *Clausocalanus furcatus* (each 7–11%) indicate both benthic influence and mid-water diversity. *Sagitta enflata*, *Globigerina bulloides*, and decapod larvae each contribute smaller proportions, enriching the taxonomic structure. The coexistence of multiple larval and copepod groups underscores a stable environment supporting reproductive success and efficient energy flow. Overall, Site S11 exemplifies a productive nearshore ecosystem where pelagic activity sustains higher trophic levels.

Table 3 23: Composition and relative abundance of zooplankton taxa collected from S12.

Family	Genus	Species	Individuals	Relative Abundance (%)
Paracalanidae	Paracalanus	*P. parvus*	4	28.57
Oithonidae	Oithona	*O. nana*	3	21.43
Clausocalanidae	Clausocalanus	*C. furcatus*	2	14.29
Centropagidae	Centropages	*C. furcatus*	1	7.14
Foraminiferida	Globigerina	*G. bulloides*	1	7.14
Decapod larvae	—	—	1	7.14
Fish larvae	—	—	0	0.00
Gastropod larvae	—	—	2	14.29

As detailed in Table 3.23, 14 individuals were recorded at Sampling Site S12, encompassing 8 species distributed across 8 families. The zooplankton community is dominated by copepods, particularly *Paracalanus parvus* (28.57%) and *Oithona nana* (21.43%), which together account for half of the total abundance. The presence of *Clausocalanus furcatus* (14.29%) and *Centropages furcatus* (7.14%) further highlights the significance of copepod diversity in maintaining pelagic productivity. Gastropod larvae (14.29%) indicate moderate benthic recruitment, while *Globigerina bulloides* and decapod larvae (7.14% each) contribute to structural variety. The absence of nematodes and fish larvae suggests limited benthic influence and possible offshore sampling conditions. Collectively, Site S12 represents a copepod-driven system typical of mid-shelf regions where pelagic processes dominate energy transfer and food web stability.

Table 3 24: Composition and relative abundance of zooplankton taxa collected from S15.

Family	Genus	Species	Individuals	Relative Abundance (%)
Oncholaimidae	Oncholaimus	*O. campylocercoides*	4	8.33
Chromadoridae	Chromadora	*C. nudicapitata*	2	4.17
Desmodoridae	Desmodora	*D. communis*	1	2.08
Paracalanidae	Paracalanus	*P. parvus*	6	12.50
Oithonidae	Oithona	*O. nana*	5	10.42
Clausocalanidae	Clausocalanus	*C. furcatus*	3	6.25
Centropagidae	Centropages	*C. furcatus*	3	6.25
Sagittidae	Sagitta	*S. enflata*	1	2.08
Decapod larvae	—	—	2	4.17
Fish larvae	—	—	4	8.33
Gastropod larvae	—	—	16	33.33
Foraminiferida	Globigerina	*G. bulloides*	1	2.08

According to Table 3.24, 48 individuals were identified at Sampling Site S15, distributed among 12 species and 12 families. Gastropod larvae were the dominant group (33.33%), reflecting intense molluscan reproduction and larval dispersal. Copepods such as *Paracalanus parvus* and *Oithona nana* contributed substantially (12.5% and 10.42%, respectively), underscoring their ecological importance as grazers and energy mediators. The moderate presence of nematodes, *Clausocalanus furcatus*, and *Centropages furcatus* reflects diverse feeding niches and benthic influence. Fish larvae (8.33%) and decapod larvae (4.17%) indicate active recruitment and trophic linkages to higher consumers. Together, the assemblage at Site S15 demonstrates high biological productivity and a well-integrated benthic-pelagic dynamic characteristic of coastal Gulf waters.

Table 3 25: Composition and relative abundance of zooplankton taxa collected from S16.

Family	Genus	Species	Individuals	Relative Abundance (%)
Oncholaimidae	Oncholaimus	*O. campylocercoides*	4	9.76
Chromadoridae	Chromadora	*C. nudicapitata*	2	4.88
Desmodoridae	Desmodora	*D. communis*	1	2.44
Paracalanidae	Paracalanus	*P. parvus*	5	12.20
Oithonidae	Oithona	*O. nana*	4	9.76
Clausocalanidae	Clausocalanus	*C. furcatus*	2	4.88
Centropagidae	Centropages	*C. furcatus*	2	4.88
Sagittidae	Sagitta	*S. enflata*	1	2.44
Decapod larvae	—	—	1	2.44
Fish larvae	—	—	2	4.88
Gastropod larvae	—	—	15	36.59
Foraminiferida	Globigerina	*G. bulloides*	1	2.44

Table 3.25 reports 41 individuals recorded at Sampling Site S16, encompassing 12 species from 12 families. Gastropod larvae dominated the assemblage (36.59%), suggesting intensive molluscan spawning and favorable reproductive conditions. Copepods including *Paracalanus parvus* (12.20%) and *Oithona nana* (9.76%) maintain their role as key grazers within the pelagic zone. Nematodes and *Clausocalanus furcatus* contribute moderate representation, while *Centropages furcatus*, *Sagitta enflata*, and fish larvae provide additional functional diversity. Foraminiferans (*Globigerina bulloides*) and decapod larvae appear in low numbers, indicating limited benthic influence. Overall, Site S16 reflects a balanced yet larval-dominated community structure, highlighting active reproduction and trophic connectivity across multiple ecological levels.

Table 3 26: Composition and relative abundance of zooplankton taxa collected from S17.

Family	Genus	Species	Individuals	Relative Abundance (%)
Oncholaimidae	Oncholaimus	*O. campylocercoides*	6	8.70
Chromadoridae	Chromadora	*C. nudicapitata*	3	4.35
Desmodoridae	Desmodora	*D. communis*	2	2.90
Paracalanidae	Paracalanus	*P. parvus*	7	10.14
Oithonidae	Oithona	*O. nana*	6	8.70
Clausocalanidae	Clausocalanus	*C. furcatus*	3	4.35
Centropagidae	Centropages	*C. furcatus*	3	4.35
Sagittidae	Sagitta	*S. enflata*	2	2.90
Decapod larvae	—	—	2	2.90
Fish larvae	—	—	2	2.90
Gastropod larvae	—	—	32	46.38
Foraminiferida	Globigerina	*G. bulloides*	1	1.45

As indicated in Table 3.26, 69 individuals were recorded at Sampling Site S17, representing 12 species distributed among 12 families. Gastropod larvae overwhelmingly dominated the assemblage (46.38%), marking this site as a hotspot for molluscan reproduction. Copepods such as *Paracalanus parvus* (10.14%) and *Oithona nana* (8.70%) provided significant secondary abundance, supporting sustained pelagic productivity. Nematodes, *Clausocalanus furcatus*, and *Centropages furcatus* contributed to taxonomic diversity, while smaller proportions of *Sagitta enflata*, decapod larvae, and fish larvae indicate active trophic interactions. The exceptional density of gastropod larvae suggests localized spawning grounds or retention zones favorable for larval development.

Consequently, Site S17 exemplifies a biologically rich ecosystem where benthic-pelagic coupling enhances overall productivity and community stability.

Table 3 27: Composition and relative abundance of zooplankton taxa collected from S18.

Family	Genus	Species	Individuals	Relative Abundance (%)
Paracalanidae	Paracalanus	*P. parvus*	2	18.18
Oithonidae	Oithona	*O. nana*	2	18.18
Clausocalanidae	Clausocalanus	*C. furcatus*	1	9.09
Oncholaimidae	Oncholaimus	*O. campylocercoides*	1	9.09
Decapod larvae	—	—	0	0.00
Fish larvae	—	—	1	9.09
Gastropod larvae	—	—	3	27.27
Foraminiferida	Globigerina	*G. bulloides*	1	9.09

According to Table 3.27, 11 individuals were recorded at Sampling Site S18, encompassing 8 species from 8 families. The community displays moderate diversity dominated by gastropod larvae (27.27%), followed by *Paracalanus parvus* and *Oithona nana* (each 18.18%), reflecting strong pelagic productivity. Additional contributors such as *Clausocalanus furcatus*, *Oncholaimus campylocercoides*, and *Globigerina bulloides* (each 9.09%) illustrate benthic influence and trophic complexity. Fish larvae (9.09%) further indicate upward energy transfer to higher trophic levels. The absence of decapod larvae suggests temporal variation in recruitment or hydrodynamic dispersion. Altogether, Site S18 represents a transitional planktonic community where pelagic copepods and molluscan larvae dominate, maintaining ecological balance within the mid-shelf waters of the Gulf of Aqaba.

3.3.2. Abundance, Richness, Diversity, and Evenness Patterns

Total zooplankton abundance (N) ranged from 11 individuals at S18 to 69 at S17. Species richness (S) varied between 7 and 12, with the upper bound recorded at several mid-shelf stations (S9–S11, S15–S17). Stations S12 and S18 represented the low-abundance, low-richness end-members, dominated by small copepods. In contrast, sites S15–S17 exhibited high total abundance but only moderate increases in richness, reflecting dominance by a few prolific taxa such as gastropod larvae and small copepods. Shannon–Wiener diversity (H′) spanned 1.81–2.33 (natural log units), with the highest value at S11 (H′ = 2.33), where evenness (J′ = 0.94) was also high, indicating a well-balanced

assemblage without a single dominant species. Evenness remained uniformly high at low-abundance sites (S1–S3, S12, S18) but declined at the most abundant station (S17; J′ = 0.76), consistent with transient meroplankton pulses. Correspondingly, Simpson's diversity (1 − D) values were high across most stations, underscoring the generally equitable community structure and the limited effect of single-taxon dominance outside of S15–S17, (Table 3.28).

Table 3 28: Summary of zooplankton community structure indices across sampling sites (S1–S18). The table presents total abundance (N), species richness (S), Shannon–Wiener diversity index (H′, natural log base), and Pielou's evenness (J′) for each site.

Site	Total individuals (N)	Richness (S)	Shannon H' (ln)	Pielou evenness J'
S1	15	8	1.9913	0.9576
S2	17	9	2.0885	0.9505
S3	26	10	2.182	0.9476
S5	30	11	2.2314	0.9306
S6	39	11	2.0474	0.8538
S8	29	11	2.2528	0.9395
S9	38	12	2.2295	0.8972
S10	29	12	2.2324	0.8984
S11	26	12	2.3315	0.9383
S12	14	7	1.8095	0.9299
S15	48	12	2.1292	0.8569
S16	40	12	2.0563	0.8275
S17	69	12	1.8941	0.7623
S18	11	7	1.8462	0.9488

3.3.3. Composition by Station Groups

A pragmatic grouping, later supported by clustering, distinguishes three station sets: - Group A – Low N, high evenness (S1–S2): balanced contributions from small copepods, nematodes, and *S. enflata*. - Group B – Moderate N, mixed copepod–meroplankton assemblages (S3, S5–S11): *Paracalanus*/*Oithona* ubiquitous; gastropod and decapod larvae regular but not overwhelming. - Group C – High N with strong meroplankton signature (S15–S17): gastropod larvae 33–46% with sustained contributions from

Paracalanus and *Oithona*. - Edge cases (S12, S18): sparse communities dominated by small copepods and low meroplankton presence.

3.3.3.1. Community Similarity and Clustering

Merged version: Bray–Curtis dissimilarities (square-root–transformed data) grouped the stations into three coherent UPGMA clusters reflecting distinct community structures (Fig.1). Stations S12 and S18 formed a low-abundance cluster, representing small-copepod–dominated communities that were clearly distinct from all others. A tight S1–S2 subcluster showed high evenness and a pronounced Sagitta enflata signal. The remaining stations (S3, S5–S11, S15–S17) composed a broad high-to-moderate abundance cluster, internally grading from mixed small-copepod assemblages (e.g., S3/S5/S11; S10/S6/S8) toward meroplankton-loaded stations (S9/S15/S16/S17) where gastropod larvae increased total abundance and reduced evenness. Between-cluster dissimilarities were substantially higher than within-cluster values, confirming the distinctiveness of the low-abundance edge stations and the internal cohesion of the mixed copepod/meroplankton group.

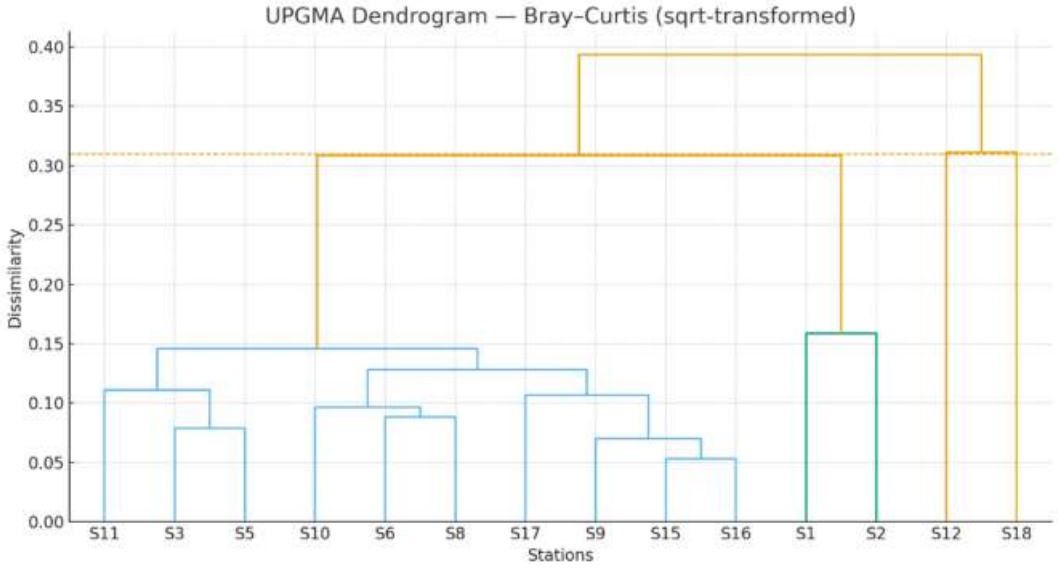


Figure 3 28: 1UPGMA dendrogram showing three station clusters: S12–S18 as low-abundance sites, S1–S2 as an even Sagitta enflata–influenced group, and S3–S11/S15–S17 as a high-to-moderate abundance cluster grading from copepod- to meroplankton-dominated communities.

3.3.4. Indicator Taxa (IndVal)

The Indicator Value (IndVal) analysis identified key taxa that characterize each station group in ecologically meaningful ways. *Sagitta enflata* showed the strongest association with Group A, marking stations with even, mid-abundance communities typical of stable or transitional environments. Group C was primarily defined by the dominance of gastropod larvae, indicating meroplankton-rich, high-abundance conditions. Within this group, *Clausocalanus furcatus* and *Centropages furcatus* also served as co-indicators, reflecting the contribution of small to medium copepods to the assemblage. The sparse edge stations (S12–S18) were characterized by *Globigerina bulloides*, which, despite its low abundance, consistently distinguished this low-density, oceanic-type community from the others. Additionally, small copepods such as *Paracalanus* and *Oithona* appeared as secondary indicators for Group B and the marginal stations, underscoring their broad ecological tolerance and presence across more variable environments. Overall, the IndVal results delineate a clear ecological gradient from chaetognath-dominated assemblages through larval-rich communities to sparse oceanic microplankton assemblages.

3.3.5. Overall Status of Plankton Communities

The patterns observed across stations reveal the strong influence of hydrographic variability, shoreline configuration, and benthic reproductive timing in structuring coastal plankton assemblages. These findings align closely with established ecological expectations for dynamic coastal systems where hydrodynamic retention and localized spawning events drive short-term shifts in community composition.

3.3.6. Meroplankton Pulses and Community Dynamics

Stations S15–S17 displayed the highest total abundances, primarily due to surges of gastropod larvae, which contributed 33–46% of total individuals. Such peaks are emblematic of episodic recruitment events resulting from synchronized spawning and subsequent larval retention in hydrodynamically quiescent zones—such as eddies, semi-enclosed bays, or reef-sheltered pockets. The pronounced reduction in evenness at these sites reflects the transient dominance of a few meroplanktonic groups, temporarily overwhelming the otherwise balanced mesozooplankton community.

In contrast, the low-abundance, high-evenness stations (S1–S2) were distinguished by the consistent presence of Sagitta enflata, a cosmopolitan chaetognath commonly associated with transitional or moderately productive waters. This pattern likely indicates stable, well-mixed conditions with moderate nutrient availability, favoring coexistence among small copepods, nematodes, and chaetognaths. Meanwhile, the low-density communities at S12 and S18, characterized by small copepods and minimal meroplankton, likely represent either more oligotrophic, flushed environments or periods of reduced productivity within the sampling window.

3.3.7. Biodiversity and Functional Structure

Alpha diversity across the study area ranged from moderate to high ($H' = 1.8–2.33$), with correspondingly elevated Simpson's diversity ($1-D$) values, underscoring the overall equitability of community structure. Station S11 exhibited both high richness and exceptional evenness ($J' = 0.94$), implying a stable, mixed assemblage with no dominant taxon—likely reflective of balanced hydrographic conditions and the absence of recent recruitment pulses.

The widespread dominance of small copepod taxa—Paracalanus parvus, Oithona nana, and Clausocalanus furcatus—is characteristic of warm, oligotrophic to mesotrophic coastal ecosystems. These species form a vital trophic link, transferring primary production from nanoplankton and microplankton to higher consumers, including larval and juvenile fish. While Clausocalanus furcatus occurred at lower densities, its consistent presence contributes to functional redundancy within the copepod guild, enhancing the stability of energy transfer pathways.

3.3.8. Community Gradients and Cluster Interpretation

Multivariate analysis using Bray–Curtis dissimilarity and UPGMA clustering delineated three ecologically coherent station groups, representing distinct assemblage states along the inshore–offshore and productivity gradients:Group A (S1–S2): Even, chaetognath-influenced communities typifying transitional or mixing zones. Group B (S3–S11): Moderate-abundance, mixed copepod–meroplankton assemblages reflecting stable, mesotrophic mid-shelf environments.

Group C (S15–S17): High-abundance, meroplankton-dominated assemblages linked to localized larval retention and benthic reproductive activity.

Peripheral stations S12 and S18 formed a distinct low-abundance subcluster dominated by small copepods and occasional Globigerina bulloides, suggesting periodic intrusion of offshore or oceanic water masses. The progression from Sagitta enflata-dominated to gastropod-rich communities reflects a clear ecological continuum governed by productivity, retention, and life-cycle dynamics.

3.4. Infauna Survey

3.4.1. Results Overview

Alpha diversity parameters across the 18 benthic grab stations, providing insight into within-station species richness, abundance, and evenness. The total number of individuals (N) ranges widely from 13 (G03, G16) to 99 (G08), indicating considerable heterogeneity in faunal density along the sampled transect. Species richness (S) similarly varies from 3 to 12, with the highest taxonomic diversity observed at G08 (S = 12) and the lowest at G03 and G18 (S = 3). These spatial differences suggest microhabitat variability and potential environmental gradients affecting colonization and resource availability.

The Shannon–Wiener diversity index (H′) ranges from 0.559 (G18) to 2.061 (G08), reflecting a marked contrast between stations dominated by a few taxa and those with a more balanced taxonomic distribution. Simpson's diversity (1−D) values support this pattern, with high diversity at G08 (0.83) and low diversity at G18 (0.295), implying that certain stations may experience ecological dominance by a single or few opportunistic species. Pielou's evenness (J), which normalizes diversity to species richness, is highest at G06 (0.928), indicating equitable distribution among species, and lowest at G07 (0.499), where high total abundance (N = 98) is driven by dominance of one or two taxa.

Overall, the alpha diversity metrics highlight spatial structuring of benthic assemblages across the survey area. Stations such as G08, G02, and G10 exhibit mature, balanced communities typical of stable substrates, whereas G07 and G18 show low evenness suggestive of localized dominance or environmental stress.

3.4.2. Alpha diversity by station

Table 3 29: Alpha diversity metrics per station (S, N, Shannon H′, Simpson 1−D, Pielou J).

Station	N	S	Shannon_H	Simpson_1D	Pielou_J
G01	54.0	9.0	1.799	0.775	0.819
G02	41.0	10.0	1.948	0.825	0.846
G03	13.0	3.0	0.984	0.592	0.896
G04	75.0	9.0	1.795	0.801	0.817
G05	62.0	8.0	1.867	0.811	0.898
G06	21.0	6.0	1.662	0.794	0.928
G07	98.0	8.0	1.039	0.446	0.499
G08	99.0	12.0	2.061	0.83	0.829
G09	23.0	9.0	1.934	0.828	0.88
G10	44.0	9.0	1.876	0.805	0.854
G11	46.0	7.0	1.717	0.784	0.883
G12	27.0	8.0	1.358	0.582	0.653
G13	25.0	7.0	1.546	0.736	0.794
G14	26.0	8.0	1.678	0.737	0.807
G15	26.0	7.0	1.67	0.769	0.858
G16	13.0	7.0	1.733	0.781	0.89
G17	22.0	5.0	1.112	0.554	0.691
G18	41.0	3.0	0.559	0.295	0.509

3.4.3. Large benthic foraminifera (LBF) by station

Table 3.30 delineates the distribution of Large Benthic Foraminifera (LBF) across the 18 surveyed stations, providing critical insight into the photic-zone carbonate-producing component of the benthic community. LBF were detected at seven stations (G01, G03–G05, G07–G10), with abundances ranging from 11 to 83 individuals and relative contributions (LBF%) between 59.6% and 89.3%. The highest proportional dominance occurs at G04 (89.3%) and G07 (84.7%), both of which also exhibit substantial total faunal densities, indicative of healthy, light-saturated substrates conducive to symbiont-bearing foraminiferal growth.

The complete absence of LBF at 11 stations (G02, G06, G09–G18) is ecologically significant and likely reflects substrate instability, reduced light penetration, or increased sedimentation—conditions known to suppress phototrophic and symbiont-dependent taxa. Species richness of LBF varies between 2 and 5, with the most diverse assemblages found

at G04, suggesting locally optimal environmental conditions such as stable hard substrate and minimal turbidity.

The distribution pattern delineates a clear ecological partitioning: LBF-present stations coincide with reefal and mixed hard-bottom habitats, whereas LBF-absent stations correspond to sandy or fine-grained sedimentary environments. This pattern underscores the potential of LBF as sensitive bioindicators for light availability, substrate type, and chronic water quality conditions. The high relative contributions (>70%) at multiple sites further confirm that carbonate productivity remains robust across portions of the survey area, a promising indicator of the ecological integrity of the benthic photic zone within the AAWDCP site.

Table 3 30: LBF abundance (LBF_N), species richness (LBF SR), and contribution (LBF %) per station.

Station	LBF_N	LBF_Species_Richness	LBF_%
G01	41	4	75.9
G02	0	0	0.0
G03	11	2	84.6
G04	67	5	89.3
G05	38	3	61.3
G06	0	0	0.0
G07	83	3	84.7
G08	59	3	59.6
G09	0	0	0.0
G10	34	4	77.3
G11	0	0	0.0
G12	0	0	0.0
G13	0	0	0.0
G14	0	0	0.0
G15	0	0	0.0
G16	0	0	0.0
G17	0	0	0.0
G18	0	0	0.0

3.4.4. Composition by higher taxonomic group

Table 3.31 presents the cumulative taxonomic composition of benthic macrofaunal and foraminiferal assemblages across all 18 stations, aggregating individuals into major higher-level taxonomic groups. The dataset reveals clear dominance by Foraminifera (45.6%) and

Gastropoda (35.6%), together accounting for over 80% of total individuals (n = 756). This taxonomic structure is characteristic of warm, oligotrophic, carbonate-rich environments such as the Gulf of Aqaba, where both groups play key roles in benthic productivity and sediment biogenesis. The prevalence of Foraminifera, particularly symbiont-bearing forms, indicates extensive hard-bottom influence and stable photic conditions favorable for calcium carbonate deposition.

The Bivalvia (12.2%) constitute the third most abundant group, reflecting a secondary assemblage associated with softer sediments and detrital substrates. Minor contributions from Ostracoda (2.2%), Crustacea (0.7%), and Scaphopoda (0.4%) suggest specialized microhabitats or low-density opportunistic colonization. The presence of Polychaeta (Serpulidae) and a single echinoderm record highlights limited but detectable faunal complexity, typical of coarse carbonate sands and reefal interfaces.

In ecological terms, the proportional dominance of Foraminifera over metazoan invertebrates reinforces the high water clarity and oligotrophic character of the region. Gastropods' strong representation, particularly from families like Cerithiidae and Rissoidae, aligns with detritus-rich microhabitats adjacent to reef structures. Overall, the composition by major taxonomic group provides a coherent ecological signature of mixed carbonate-siliciclastic substrates under low nutrient regimes, confirming a benthic community structured by photic depth, substrate texture, and hydrodynamic stability.

Table 3 31: Overall composition by higher taxonomic group.

HighGroup	Total_Abundance	Species_Richness	Percent_of_Total_%
Foraminifera	345	9	45.6
Gastropoda	269	24	35.6
Bivalvia	92	17	12.2
Other/Indet.	22	6	2.9
Ostracoda	17	3	2.2
Crustacea (Cirripedia)	5	1	0.7
Scaphopoda	3	1	0.4
Polychaeta (Serpulidae)	2	1	0.3
Echinodermata	1	1	0.1

Table 3.32 details the percentage composition of major taxonomic groups at each station, offering a spatially resolved view of community structure and substrate association. The

data highlight two contrasting assemblage regimes across the survey area: LBF-dominated stations (e.g., G01, G03, G04, G05, G07, G08, G10) and metazoan-dominated stations (e.g., G11–G18).

Stations G04 and G07 exhibit exceptionally high Foraminifera percentages (89.3% and 84.7%, respectively), consistent with illuminated, stable substrates typical of shallow reefal environments. Similarly, G03 (84.6%) and G10 (77.3%) display strong foraminiferal dominance, reinforcing their identification as carbonate-producing zones with low turbidity and robust benthic light fields. Conversely, G11–G16 show complete absence of Foraminifera and are dominated by Gastropoda and Bivalvia, taxa associated with sandy or mixed sediment habitats. The pronounced bivalve dominance at G17 (77.3%) suggests a fine-grained, possibly depositional environment with lower energy conditions, while G18's unique crustacean peak (12.2%) indicates localized hard-substrate microenvironments or fouling assemblages.

Ostracods, polychaetes, and other minor groups appear sporadically, contributing less than 10% per station, though their occurrence (e.g., Ostracoda at G04, Polychaeta at G08) marks sites of enhanced microhabitat diversity. The overall spatial heterogeneity underscores strong habitat partitioning within the survey area—ranging from photic, reef-proximal habitats rich in LBF to deeper or sandier stations characterized by molluscan macrofauna. This compositional gradient mirrors sediment type and hydrodynamic regime, making Table 5 a key dataset for interpreting benthic zonation, trophic structure, and substrate-specific biodiversity in the AAWDCP survey area

Table 3 32: Composition by higher taxonomic group per station (%).

Station	Bivalvia	Crustacea (Cirripedia)	Echinodermata	Foraminifera	Gastropoda	Ostracoda	Other/Indet.	Polychaeta (Serpulidae)	Scaphopoda
G01	11.1	0.0	0.0	75.9	11.1	1.9	0.0	0.0	0.0
G02	19.5	0.0	0.0	0.0	75.6	0.0	2.4	2.4	0.0
G03	0.0	0.0	0.0	84.6	15.4	0.0	0.0	0.0	0.0
G04	1.3	0.0	0.0	89.3	2.7	6.7	0.0	0.0	0.0
G05	12.9	0.0	0.0	75.8	6.5	4.8	0.0	0.0	0.0
G06	19.0	0.0	0.0	0.0	47.6	0.0	33.3	0.0	0.0
G07	2.0	0.0	0.0	84.7	11.2	0.0	2.0	0.0	0.0
G08	5.1	0.0	0.0	62.6	18.2	4.0	7.1	1.0	2.0
G09	17.4	0.0	0.0	0.0	73.9	0.0	8.7	0.0	0.0
G10	4.5	0.0	0.0	77.3	13.6	0.0	4.5	0.0	0.0

G11	21.7	0.0	0.0	0.0	69.6	8.7	0.0	0.0	0.0
G12	11.1	0.0	0.0	0.0	85.2	0.0	3.7	0.0	0.0
G13	24.0	0.0	0.0	0.0	76.0	0.0	0.0	0.0	0.0
G14	26.9	0.0	0.0	0.0	73.1	0.0	0.0	0.0	0.0
G15	19.2	0.0	3.8	0.0	76.9	0.0	0.0	0.0	0.0
G16	30.8	0.0	0.0	0.0	69.2	0.0	0.0	0.0	0.0
G17	77.3	0.0	0.0	0.0	18.2	0.0	0.0	0.0	4.5
G18	0.0	12.2	0.0	0.0	87.8	0.0	0.0	0.0	0.0

3.4.5. Family and species-level summaries

Table 3.33 presents the dominant benthic families identified across all sampling stations, integrating abundance, species richness, and frequency of occurrence to reveal the structural backbone of the community. The data indicate that benthic assemblages in the AAWDCP survey area are heavily influenced by foraminiferal and gastropod families, with Amphisteginidae (11.9%), Soritidae (11.1%), and Nummulitidae (11.1%) jointly accounting for over one-third of total individuals. These families comprise symbiont-bearing large benthic foraminifera (LBF), key bioindicators of photic-zone carbonate productivity and water clarity. Their co-dominance across multiple stations underscores the prevalence of stable, well-lit substrates that support photosymbiotic assemblages.

Among metazoans, the Cerithiidae (10.4%) and Rissoidae (6.5%) emerge as principal gastropod contributors, each exhibiting high station frequency (15 and 11 stations, respectively). These taxa typically occupy sandy to rubble habitats adjacent to coral frameworks, feeding on detritus and microalgae—indicators of moderate organic flux without eutrophication. Tellinidae (5.2%) and Phasianellidae (4.6%) further reflect mixed-sediment habitats, suggesting the coexistence of soft- and hard-bottom fauna.

Notably, families such as Peneroplidae, Miliolidae, and Turbinidae reinforce the dual nature of the benthic assemblage—one photic and carbonate-based, the other detrital and molluscan. The recurrence of families like Neritidae and Cytheridae in low abundances broadens the ecological profile, denoting transitional habitats. Overall, Table 6 reveals a balanced taxonomic composition structured by light availability and substrate

heterogeneity, aligning with the biogeographic expectations for the oligotrophic northern Gulf of Aqaba.

Table 3 33: Top families by total abundance, with species richness and station frequency.

Family	Total_Abundance	Species_Richness	Station_Frequency	Percent_of_Total_%
Amphisteginidae	90	1	7	11.9
Soritidae	84	1	5	11.1
Nummulitidae	84	1	2	11.1
Cerithiidae	79	3	15	10.4
Rissoidae	49	2	11	6.5
Tellinidae	39	2	11	5.2
Peneroplidae	38	1	5	5.0
Miliolidae	37	2	5	4.9
Phasianellidae	35	1	2	4.6
Turbinidae	24	1	2	3.2
Turbinidae (Trochoidea)	17	1	1	2.2
Colloniidae	14	1	1	1.9
Semelidae	14	1	1	1.9
Neritidae	13	3	3	1.7
Cytheridae (Ostracoda)	13	2	4	1.7

Table 3.34 refines the faunal analysis to the species level, identifying the 20 most abundant and widely distributed taxa across the AAWDCP survey. The dominant species, *Amphistegina lobifera* (n = 90), *Sorites orbiculus* (n = 84), and *Operculina ammonoides* (n = 84), collectively represent the core of the symbiont-bearing LBF assemblage characteristic of photic, low-nutrient carbonate environments. Their high relative abundances and presence in multiple stations (FO% = 27.8–38.9) corroborate the optical clarity and stable substrate conditions prevailing in the reef-associated sampling zones.

Among metazoans, *Cerithium caeruleum* (n = 50, FO% = 66.7) stands out as the most ubiquitous species, found at 12 of 18 stations. This detritivorous gastropod thrives on sandy–rubble substrates under moderate organic enrichment, suggesting healthy benthic productivity without excessive nutrient loading. *Tellina flacca* (bivalve, FO% = 55.6) and *Alvania dorbignyi* (gastropod, FO% = 44.4) show broad distributions, indicating their ecological generalism across mixed sediment habitats.

Other recurrent species such as *Peneroplis planatus, Tricolia indica*, and *Turbo radiatus* are typical of coral rubble and seagrass interfaces, further reinforcing the habitat diversity captured by the survey. The lower-frequency taxa (e.g., *Ctena divergens, Rissoina ambigua*) represent specialized guilds associated with microhabitat niches.

Overall, this species-level inventory emphasizes the dual dominance of LBF and gastropods, reflecting both photic carbonate platform processes and benthic detrital productivity. The high frequency of taxa shared between stations confirms a cohesive regional fauna structured primarily by substrate stability and light availability.

Table 3 34: Top 20 species by total abundance and frequency of occurrence.

	Total_Abundance	Station_Frequency	FO_%	Mean_per_station
Amphistegina lobifera	90	7	38.9	5.0
Sorites orbiculus	84	5	27.8	4.67
Operculina ammonoides	84	2	11.1	4.67
Cerithium caeruleum	50	12	66.7	2.78
Alvania dorbignyi	38	8	44.4	2.11
Peneroplis planatus	38	5	27.8	2.11
Tellina flacca	36	10	55.6	2.0
Tricolia indica	35	2	11.1	1.94
Turbo radiatus	24	2	11.1	1.33
Triloculina seminula	19	3	16.7	1.06
Quinqueloculina seminula	18	2	11.1	1.0
Bittium sp. (= *Cerithium caeruleum*)	17	2	11.1	0.94
Rochia (= *Tectus) erythraea*	17	1	5.6	0.94
Abra aegyptiaca	14	1	5.6	0.78
Homalopoma sanguineum	14	1	5.6	0.78
Cerithidium sp. (= *Cerithium caeruleum*)	12	1	5.6	0.67
Rissoina ambigua	11	3	16.7	0.61
Seila adamsii	10	2	11.1	0.56
Nerita orbignyana	10	1	5.6	0.56
Ctena divergens	8	4	22.2	0.44

3.4.6. Indicator taxa (LBF-present vs. LBF-absent)

Table 3.35 summarizes the results of Indicator Value (IndVal) analysis, distinguishing taxa significantly associated with stations containing Large Benthic Foraminifera (LBF) versus those where LBF were absent. This table provides a quantitative assessment of habitat specificity and fidelity, enabling ecological interpretation of assemblage partitioning across substrate and light regimes.

For LBF-present stations, indicator taxa include *Amphistegina lobifera* (IndVal = 100%), *Peneroplis planatus* and *Sorites orbiculus* (71.4%), and *Operculina ammonoides* (28.6%)—all symbiont-bearing foraminifera highly dependent on clear, oligotrophic waters. Their perfect specificity and high fidelity reflect stable carbonate substrates and sustained photic energy. Secondary indicators such as *Triloculina seminula*, *Quinqueloculina seminula*, and *Cytheropteron excisum* extend this assemblage to finer sediment interfaces, representing transitional microhabitats along the reef–sediment gradient.

In contrast, LBF-absent stations are characterized by metazoan macrofauna such as *Naticarius onca*, *Ctena divergens*, and *Cerithium caeruleum*, all exhibiting high specificity (1.0) but moderate fidelity (0.36–0.46). These taxa typify sandy and mixed sediment substrates with higher particulate load, reduced light, and occasional organic enrichment. The recurrence of *Tellina flacca* and *Alvania dorbignyi* in both groups suggests ecological overlap between hard-bottom margins and soft sediments, possibly reflecting transitional environmental conditions.

Overall, the IndVal analysis provides strong statistical evidence for ecological bifurcation within the survey area—symbiont-bearing foraminiferal assemblages vs. detritivorous molluscan assemblages—driven primarily by substrate stability and photic regime. This delineation supports using LBF presence as a bioindicator of environmental quality and carbonate-production potential within the Gulf of Aqaba.

Table 3 35: Indicator values (IndVal %) for the top taxa associated with LBF-present and LBF-absent stations.

Species	Group	IndVal %	Specificity	Fidelity	N_group
Naticarius onca	LBF_absent	45.455	1.0	0.455	7
Ctena divergens	LBF_absent	36.364	1.0	0.364	8
Cerithium caeruleum	LBF_absent	33.818	0.62	0.545	31
Drupella cornus	LBF_absent	27.273	1.0	0.273	6
Fragum sueziense	LBF_absent	27.273	1.0	0.273	5
Tellina flacca	LBF_absent	21.465	0.472	0.455	17
Alvania dorbignyi	LBF_absent	19.139	0.526	0.364	20
Donax faba	LBF_absent	18.182	1.0	0.182	4
Laevichlamys andamanica	LBF_absent	18.182	1.0	0.182	2
Seila adamsii	LBF_absent	18.182	1.0	0.182	10
Turbo radiatus	LBF_absent	18.182	1.0	0.182	24
Turritella terebra	LBF_absent	14.545	0.8	0.182	4
Amphistegina lobifera	LBF_present	100.0	1.0	1.0	90
Peneroplis planatus	LBF_present	71.429	1.0	0.714	38
Sorites orbiculus	LBF_present	71.429	1.0	0.714	84
Triloculina seminula	LBF_present	42.857	1.0	0.429	19
Tellina flacca	LBF_present	37.698	0.528	0.714	19
Cerithium caeruleum	LBF_present	32.571	0.38	0.857	19
Cytheropteron excisum	LBF_present	28.571	1.0	0.286	6
Operculina ammonoides	LBF_present	28.571	1.0	0.286	84
Paracytheridea aqabaensis	LBF_present	28.571	1.0	0.286	7
Quinqueloculina seminula	LBF_present	28.571	1.0	0.286	18
Alvania dorbignyi	LBF_present	27.068	0.474	0.571	18
Ammonia tepida	LBF_present	14.286	1.0	0.143	4

3.4.7. Dissimilarity matrix (Bray–Curtis)

Table 3.36 presents the Bray–Curtis dissimilarity matrix, a quantitative measure of community compositional differences between stations based on species abundance data. Values range from 0 (identical assemblages) to 1 (completely dissimilar). The dataset reveals pronounced beta diversity across the 18 stations, confirming spatial heterogeneity in benthic community structure within the AAWDCP survey area.

Low dissimilarity values occur among stations sharing dominant Large Benthic Foraminifera (LBF) taxa—for example, G01–G04 (0.426) and G04–G08 (0.414)—indicating strong similarity among photic, reef-associated assemblages dominated by *Amphistegina lobifera*, *Sorites orbiculus*, and *Peneroplis planatus*. These pairings reflect consistent environmental conditions such as stable carbonate substrates and high light penetration. Conversely, high dissimilarities (≥0.9) between stations like G02–G03 (1.0), G06–G04 (0.958), and G07–G11 (1.0) suggest clear ecological segregation, likely driven by substrate texture, depth, and organic flux differences.

Intermediate values (0.6–0.8) between certain LBF-dominated and molluscan-dominated stations (e.g., G05–G10 = 0.604) imply transitional habitats with partial taxonomic overlap. The overall pattern delineates two distinct assemblage clusters—LBF-rich versus LBF-absent—consistent with the indicator species results and hierarchical clustering analyses described in Section 3.6.

Ecologically, the Bray–Curtis matrix reinforces the strong spatial partitioning between carbonate-producing and detritus-based communities. It confirms that substrate heterogeneity, water clarity, and hydrodynamic regime are primary structuring forces for benthic assemblages in the Gulf of Aqaba. This quantitative differentiation provides a robust baseline for monitoring future ecological shifts or anthropogenic impacts within the AAWDCP footprint.

Table 3 36: Pairwise Bray–Curtis dissimilarities among stations (0 = identical; 1 = completely dissimilar).

Station	G01	G02	G03	G04	G05	G06	G07	G08	G09	G10
G01	0.0									
G02	0.937	0.0								
G03	0.851	1.0	0.0							
G04	0.426	0.983	0.818	0.0						
G05	0.655	0.922	0.653	0.504	0.0					
G06	0.84	0.839	0.882	0.958	0.831	0.0				
G07	0.921	1.0	0.874	0.734	0.9	0.95	0.0			
G08	0.503	0.929	0.839	0.414	0.453	0.85	0.888	0.0		
G09	0.766	0.812	0.889	0.939	0.812	0.591	1.0	0.754	0.0	
G10	0.592	0.953	0.614	0.647	0.604	0.785	0.887	0.664	0.761	0.0

3.4.8. Overall Status of Benthic Communities

Our station-by-species analysis of 18 grab samples revealed two principal assemblage types: (i) stations dominated by large benthic foraminifera (LBF; e.g., *Amphisteginidae*, *Soritidae*, *Nummulitidae*, *Miliolidae*), with high proportional contributions (60–90% of individuals) at G04, G07, and G10, and (ii) stations dominated by gastropods and bivalves (e.g., *Cerithiidae*, *Rissoidae*, *Veneridae*), notably G11–G15 and G18. Alpha diversity was highest at G08 ($S = 12$, $H' = 2.061$), and evenness peaked at G06 ($J = 0.928$). These patterns are consistent with the depth-related habitat mosaic identified in the Marine Habitat Screening (shallow mixed sediment and patch reef → mid-depth rugose reef → deeper, sedimented reef slope).

The dominance of LBF at several stations is ecologically meaningful. Symbiont-bearing LBF are confined to the photic zone and thrive under clear, oligotrophic conditions conducive to carbonate production; their assemblages respond predictably to water-quality degradation (e.g., nutrient enrichment or turbidity). This concept underpins the FORAM Index (FI), which classifies functional groups of foraminifera to infer whether environmental conditions support calcifying photosymbioses and reef accretion (Hallock et al., 2003; Hallock, 2012). Empirical studies from the Indo-Pacific and Caribbean demonstrate that shifts toward small, opportunistic heterotrophs and away from symbiont-bearing taxa are indicative of nutrification and increased turbidity (Uthicke & Nobes, 2008). In our dataset, the high proportions of LBF at G04, G07, and G10 are therefore consistent with local hard-bottom influence, good light penetration, and limited chronic eutrophication.

Recent research in the Red Sea further supports the utility of LBF in the northern Gulf of Aqaba. The relative abundance of *Amphisteginidae*, particularly *Amphistegina lobifera*, closely tracks thermal stress at regional scales, providing a complementary bioindicator to coral cover (Humphreys et al., 2022). Experimental studies have also shown that LBF sensitivity varies with temperature, nutrient levels, and light availability, with elevated temperature and nitrate concentrations reducing survivorship and fecundity (Prazeres et al., 2017). Collectively, these findings indicate that the observed contrast between LBF and

metazoan macrofauna provides an informative proxy for habitat type, light regime, and chronic water-quality or thermal context.

The screening survey documented a transition from shallow mixed-sediment and patch-reef habitats to mid-depth rugose reefs and deeper, sedimented reef slopes. Across reef systems, decreasing light with depth drives shifts in coral photophysiology and morphology, including an increased prevalence of flattened or plating growth forms that enhance light capture under low irradiance (Lesser et al., 2021; Morgan et al., 2020). In the Gulf of Aqaba, corals exhibit exceptional thermal tolerance, and light regime often explains depth-related community changes more effectively than depth alone (Kochman-Gino & Fine, 2023). The co-occurrence of high LBF contributions with stations associated with harder, better-lit substrates is therefore expected, whereas gastropod- and bivalve-dominated stations likely correspond to sandier or mixed sediments characterized by greater sediment mobility and light attenuation.

Our Bray–Curtis/UPGMA analysis identified two major clusters reflecting the LBF versus metazoan macrofauna dichotomy. The Bray–Curtis index is widely recommended for community data because it is sensitive to shared abundances yet robust to joint absences; it underpins analytical methods such as SIMPER and PERMANOVA that are routinely applied in marine ecology (Clarke & Warwick, 2001; Clarke et al., 2006). Indicator Value (IndVal) analysis formalizes the association of taxa with specific assemblages through measures of specificity and fidelity, making it suitable for detecting such contrasts (Dufrêne & Legendre, 1997). In this study, LBF-present stations were characterized by *Amphistegina*, *Sorites*, and *Peneroplis*, while LBF-absent stations were dominated by taxa such as *Cerithium*, *Tellina*, and *Naticarius*, consistent with harder versus softer substrate types, respectively.

Multiple studies identify the northern Red Sea and Gulf of Aqaba as a relative thermal refuge, where corals withstand anomalously high temperatures without experiencing mass bleaching. This resilience has been documented through both field observations and experimental research (Kochman-Gino & Fine, 2023, and references therein). Within this context, LBF-based metrics, including FI scoring and *Amphistegina* abundance, offer cost-effective and minimally intrusive proxies for assessing environmental conditions relevant

to coral recruitment and hard-bottom influence (Hallock et al., 2003; Hallock, 2012; Humphreys et al., 2022). We therefore recommend monitoring LBF proportional abundance and FI in parallel with macrofaunal metrics during future baseline surveys and construction-phase monitoring programs.

3.4.9. Summary of infauna Genera and Families

Table 3.37 provides a comprehensive inventory of all species identified across the 18 sampling stations, totaling 63 taxa distributed among 44 families. This dataset forms the core biodiversity reference for the AAWDCP Marine Baseline and highlights both dominant and rare components of the benthic assemblage. The upper tier of abundance is dominated by symbiont-bearing foraminifera, including *Amphistegina lobifera* (n = 90), *Sorites orbiculus* (n = 84), and *Operculina ammonoides* (n = 84), followed by the detritivorous gastropods *Cerithium caeruleum* and *Alvania dorbignyi*. The co-occurrence of these taxa confirms the coexistence of photic carbonate and detrital sediment assemblages within the same regional context.

The middle abundance tier features mollusks such as *Tellina flacca*, *Tricolia indica*, and *Turbo radiatus*, typical of sandy–rubble habitats with moderate energy and organic inputs. The lower abundance and single-station records—e.g., *Donax faba*, *Diadema setosum*, *Oliva oliva*, *Trachycardium lacunosum*—represent rare, habitat-restricted, or transient species, reflecting localized microhabitat heterogeneity.

The wide frequency range (FO% = 5.6–66.7) underscores spatial variability and ecological specialization. Species with high FO%, such as *Cerithium caeruleum* and *Tellina flacca*, are broadly tolerant and characterize mixed sediment habitats, while foraminiferal taxa display narrower but ecologically meaningful distributions linked to photic hard-bottom environments.

In total, the table encapsulates the full taxonomic breadth of the benthic community, reinforcing that the Gulf of Aqaba supports a structurally diverse assemblage driven by substrate stability, light regime, and microhabitat diversity—a robust baseline for long-term environmental monitoring.

Table 3 37: Full species list with total abundance, station frequency (FO%) and mean per station.

Species	Total_Abundance	Station_Frequency	FO_%	Mean_per_station
Amphistegina lobifera	90	7	38.9	5.0
Sorites orbiculus	84	5	27.8	4.67
Operculina ammonoides	84	2	11.1	4.67
Cerithium caeruleum	50	12	66.7	2.78
Alvania dorbignyi	38	8	44.4	2.11
Peneroplis planatus	38	5	27.8	2.11
Tellina flacca	36	10	55.6	2.0
Tricolia indica	35	2	11.1	1.94
Turbo radiatus	24	2	11.1	1.33
Triloculina seminula	19	3	16.7	1.06
Quinqueloculina seminula	18	2	11.1	1.0
Bittium sp. (= *Cerithium caeruleum*)	17	2	11.1	0.94
Rochia (= *Tectus) erythraea*	17	1	5.6	0.94
Abra aegyptiaca	14	1	5.6	0.78
Homalopoma sanguineum	14	1	5.6	0.78
Cerithidium sp. (= *Cerithium caeruleum*)	12	1	5.6	0.67
Rissoina ambigua	11	3	16.7	0.61
Seila adamsii	10	2	11.1	0.56
Nerita orbignyana	10	1	5.6	0.56
Ctena divergens	8	4	22.2	0.44
Naticarius onca	7	5	27.8	0.39
Paracytheridea aqabaensis	7	2	11.1	0.39
Drupella cornus	6	3	16.7	0.33
Cytheropteron excisum	6	2	11.1	0.33
Fragum sueziense	5	3	16.7	0.28
Turritella terebra	5	3	16.7	0.28
Amphibalanus amphitrite	5	1	5.6	0.28
Elphidium crispum	5	1	5.6	0.28
Donax faba	4	2	11.1	0.22
Pitar hebraeus	4	2	11.1	0.22
Turbonilla sp.	4	2	11.1	0.22
Ammonia tepida	4	1	5.6	0.22
Loxoconchella scottoi	4	1	5.6	0.22
Paratapes textilis	4	1	5.6	0.22

Pegophysema kora	4	1	5.6	0.22
Dentalium reevei	3	2	11.1	0.17
Cerastoderma glaucum	3	1	5.6	0.17
Eulimella sp.	3	1	5.6	0.17
Gafrarium pectinatum	3	1	5.6	0.17
Lyrocardium anaxium	3	1	5.6	0.17
Miniacina miniacea	3	1	5.6	0.17
Pecten erythraeensis	3	1	5.6	0.17
Tellina adenensis	3	1	5.6	0.17
Laevichlamys andamanica	2	2	11.1	0.11
Spirobranchus cf. tetraceros	2	2	11.1	0.11
Anomia achaeus	2	1	5.6	0.11
Cyclostrema gyalum	2	1	5.6	0.11
Mimachlamys sanguinea	2	1	5.6	0.11
Neritina pulligera	2	1	5.6	0.11
Odostomia sp.	2	1	5.6	0.11
Triphora cf. perversa	2	1	5.6	0.11
juvenile fragments	2	1	5.6	0.11
Cellana rota	1	1	5.6	0.06
Clithon cf. corona	1	1	5.6	0.06
Diadema setosum	1	1	5.6	0.06
Mirapecten yaroni	1	1	5.6	0.06
Mitrella menkeana	1	1	5.6	0.06
Oliva oliva	1	1	5.6	0.06
Oliva oliva (= mis-ID Olivellidae)	1	1	5.6	0.06
Patelloida rolani	1	1	5.6	0.06
Polinices mammilla	1	1	5.6	0.06
Terebra sp.	1	1	5.6	0.06
Trachycardium lacunosum	1	1	5.6	0.06

Table 3.38 compiles all recorded benthic families from the AAWDCP Marine Baseline survey, offering an intermediate taxonomic overview that bridges species-level detail with higher-group compositional patterns. Forty-four families were identified, with abundances and frequencies confirming two dominant ecological guilds: carbonate-platform foraminifera and molluscan macrofauna.

The highest-ranking families—*Amphisteginidae* (11.9%), *Soritidae* (11.1%), and *Nummulitidae* (11.1%)—comprise the Large Benthic Foraminifera (LBF), emblematic of oligotrophic, photic reef environments with stable carbonate substrates. Their cumulative dominance (>34% of individuals) demonstrates a system still strongly influenced by symbiont-bearing biocalcifiers, consistent with high water transparency and minimal chronic nutrient loading.

Among metazoan families, *Cerithiidae* (10.4%), *Rissoidae* (6.5%), and *Tellinidae* (5.2%) exhibit the widest distribution and substantial contributions, indicating ecologically productive soft and mixed-sediment zones adjacent to reefal habitats. The presence of *Peneroplidae* and *Miliolidae* links these molluscan-rich areas to transitional environments supporting smaller benthic foraminifera tolerant of variable sedimentation.

Lower-frequency families such as *Lucinidae*, *Cardiidae*, *Veneridae*, and *Naticidae* signal localized patches of fine sediment and organic matter enrichment, while rare taxa like *Serpulidae*, *Terebridae*, and *Patellidae* reveal habitat complexity and microtopographic diversity. The overall evenness among multiple low-abundance families highlights the ecological mosaic within the Gulf of Aqaba's nearshore benthos.

Thus, Table 3.38 confirms that while foraminiferal families dominate total abundance, the broader benthic fauna encompasses a balanced spectrum of trophic and habitat types, underscoring the region's high ecological resilience and heterogeneity under oligotrophic conditions.

Table 3 38: All families with total abundance, species richness, station frequency and percent of total.

Family	Total_Abundance	Species_Richness	Station_Frequency	Percent_of_Total_%
Amphisteginidae	90	1	7	11.9
Soritidae	84	1	5	11.1
Nummulitidae	84	1	2	11.1
Cerithiidae	79	3	15	10.4
Rissoidae	49	2	11	6.5
Tellinidae	39	2	11	5.2
Peneroplidae	38	1	5	5.0
Miliolidae	37	2	5	4.9

Phasianellidae	35	1	2	4.6
Turbinidae	24	1	2	3.2
Turbinidae (Trochoidea)	17	1	1	2.2
Colloniidae	14	1	1	1.9
Semelidae	14	1	1	1.9
Neritidae	13	3	3	1.7
Cytheridae (Ostracoda)	13	2	4	1.7
Lucinidae	12	2	5	1.6
Cardiidae	12	4	6	1.6
Veneridae	11	3	4	1.5
Cerithiopsidae	10	1	2	1.3
Pyramidellidae	9	3	4	1.2
Pectinidae	8	4	5	1.1
Naticidae	8	2	6	1.1
Turritellidae	5	1	3	0.7
Balanidae	5	1	1	0.7
Elphidiidae	5	1	1	0.7
Rotaliidae	4	1	1	0.5
Donacidae	4	1	2	0.5
Gastropoda – indet.	4	1	1	0.5
Loxoconchidae (Ostracoda)	4	1	1	0.5
Homotrematidae	3	1	1	0.4
Dentaliidae	3	1	2	0.4
Serpulidae	2	1	2	0.3
Anomiidae	2	1	1	0.3
Muricidae	2	1	2	0.3
Tornidae	2	1	1	0.3
Triphoridae	2	1	1	0.3
Bivalvia (indet.)	2	1	1	0.3
Patellidae	1	1	1	0.1
Olividae	1	1	1	0.1
Olivellidae	1	1	1	0.1
Echinoidea	1	1	1	0.1
Columbellidae	1	1	1	0.1
Terebridae	1	1	1	0.1
Lottiidae	1	1	1	0.1

Table 3.39 provides a station-wise breakdown of benthic community composition across major taxonomic groups, offering a spatial perspective on habitat zonation and substrate influence within the AAWDCP survey area. The data reveal a pronounced dichotomy between foraminiferal-dominated and molluscan-dominated stations, mirroring the ecological gradient from shallow, well-lit reefal habitats to deeper or sandier depositional zones.

Stations G01, G03, G04, G05, G07, G08, and G10 show strong dominance of Foraminifera (ranging from 62.6% to 89.3%), indicative of clear-water, photic substrates where symbiont-bearing taxa such as *Amphistegina lobifera*, *Sorites orbiculus*, and *Operculina ammonoides* thrive. These stations correspond to hard or mixed carbonate surfaces, suggesting optimal conditions for photosymbiotic calcifiers. In contrast, G11–G16 exhibit complete absence of foraminifera and are dominated by Gastropoda and Bivalvia, implying sandy, mobile sediments with limited light penetration and greater organic flux.

Station G17 is distinctive, showing extreme Bivalvia dominance (77.3%)—a hallmark of fine-grained, low-energy sediment environments—while G18 displays unique crustacean representation (12.2%), possibly linked to fouling or epibenthic assemblages on scattered hard substrates. Minor groups such as Ostracoda, Polychaeta, and Scaphopoda appear sporadically, yet their occurrence adds to microhabitat diversity.

Overall, the spatial variation in Table 3.39 underscores the benthic habitat heterogeneity of the Gulf of Aqaba's coastal shelf, governed primarily by substrate type, hydrodynamic exposure, and photic regime. This distribution forms an essential ecological baseline for detecting future habitat shifts due to construction or environmental change.

Table 3 39: Percentage composition by large taxonomic group for all stations.

Station	Bivalvia	Crustacea (Cirripedia)	Echinodermata	Foraminifera	Gastropoda	Ostracoda	Other/ Indet.	Polychaeta (Serpulidae)	Scaphopoda
G01	11.1	0.0	0.0	75.9	11.1	1.9	0.0	0.0	0.0
G02	19.5	0.0	0.0	0.0	75.6	0.0	2.4	2.4	0.0
G03	0.0	0.0	0.0	84.6	15.4	0.0	0.0	0.0	0.0
G04	1.3	0.0	0.0	89.3	2.7	6.7	0.0	0.0	0.0
G05	12.9	0.0	0.0	75.8	6.5	4.8	0.0	0.0	0.0
G06	19.0	0.0	0.0	0.0	47.6	0.0	33.3	0.0	0.0
G07	2.0	0.0	0.0	84.7	11.2	0.0	2.0	0.0	0.0
G08	5.1	0.0	0.0	62.6	18.2	4.0	7.1	1.0	2.0
G09	17.4	0.0	0.0	0.0	73.9	0.0	8.7	0.0	0.0
G10	4.5	0.0	0.0	77.3	13.6	0.0	4.5	0.0	0.0
G11	21.7	0.0	0.0	0.0	69.6	8.7	0.0	0.0	0.0
G12	11.1	0.0	0.0	0.0	85.2	0.0	3.7	0.0	0.0
G13	24.0	0.0	0.0	0.0	76.0	0.0	0.0	0.0	0.0
G14	26.9	0.0	0.0	0.0	73.1	0.0	0.0	0.0	0.0
G15	19.2	0.0	3.8	0.0	76.9	0.0	0.0	0.0	0.0
G16	30.8	0.0	0.0	0.0	69.2	0.0	0.0	0.0	0.0
G17	77.3	0.0	0.0	0.0	18.2	0.0	0.0	0.0	4.5
G18	0.0	12.2	0.0	0.0	87.8	0.0	0.0	0.0	0.0

Appendix 3.40 presents a concise quantitative summary of biodiversity metrics—total families, total species, and total individuals—for each of the 18 benthic sampling stations. This dataset integrates the taxonomic and abundance data into a clear spatial profile of benthic community structure, highlighting local variations in ecological richness and faunal density.

The total number of families ranges from 3 (G03, G18) to 12 (G08), paralleling species richness patterns that similarly span 3–12 species per station. The highest diversity occurs at G08, consistent with its elevated Shannon diversity ($H' = 2.061$) reported in Table 2, confirming this station as a local biodiversity hotspot—likely representing a stable, heterogeneous substrate within the photic zone. Conversely, stations G03, G17, and G18 exhibit minimal taxonomic representation, indicative of environmentally constrained habitats such as mobile sandy bottoms or turbid depositional zones.

Total individual counts vary markedly, from 13 individuals (G03, G16) to 99 individuals (G08), underscoring significant differences in faunal productivity and habitat carrying capacity. The close correspondence between individual abundance and species richness across stations suggests that structural habitat complexity, rather than stochastic recruitment, governs local biodiversity levels.

Overall, Appendix E reinforces patterns of spatially structured benthic diversity within the AAWDCP project area. The data demonstrate that nearshore carbonate-rich substrates (e.g., G04–G10) sustain higher diversity and abundance, while peripheral sandy or fine-sediment zones support depauperate but specialized assemblages—key information for environmental baseline mapping and impact monitoring.

Table 3 40: Biodiversity metrics by station (G01–G18), showing the number of unique families and species, and the total individuals (n) recorded in the survey.

station	total families	total species	total individuals
G01	9	9	54
G02	10	10	41
G03	3	3	13
G04	9	9	75
G05	8	8	62
G06	6	6	21
G07	8	8	98

G08	12	12	99
G09	9	9	23
G10	9	9	44
G11	7	7	46
G12	8	8	27
G13	7	7	25
G14	8	8	26
G15	7	7	26
G16	7	7	13
G17	5	5	22
G18	3	3	41

3.5. Sediment physicochemical analysis

3.5.1. Sediment Particle Size Analysis (PSA)

The results of the particle size analysis (PSA) of the sediment samples from the study area are summarized in Table 3.41 and are represented in Figure 3.29.

Table 3 41: Particle size distribution (PSA) for sediments collected from eighteen stations (G01-G18) within the study area.

Site/ Mesh size (mm)	Percentage passing (%)					
	2 mm	1 mm	0.5 mm	0.25 mm	0.18 mm	<0.063 mm
G01	100	98.16	84.29	74.73	50.70	27.60
G02	100	97.76	79.84	69.26	48.93	26.62
G03	100	97.14	94.00	88.69	49.48	19.39
G04	100	95.24	71.00	51.45	20.91	6.80
G05	100	96.45	72.24	54.93	21.28	8.93
G06	100	97.72	79.81	67.45	33.54	11.03
G07	100	95.54	55.03	39.53	17.74	5.88
G08	100	97.29	75.15	55.35	21.16	7.01
G09	100	98.57	88.49	78.8	56.19	34.96
G10	100	95.90	71.73	53.54	32.53	14.22
G11	100	97.94	70.03	52.93	22.55	8.41
G12	100	97.88	88.08	72.39	34.36	17.25
G13	100	95.73	77.96	60.19	25.64	6.42
G14	100	96.37	82.40	67.05	31.84	12.59
G15	100	95.18	82.58	73.3	54.72	34.01

G16	100	95.20	72.66	58.61	25.28	10.10
G17	100	97.09	77.57	60.85	26.73	9.93
G18	100	97.86	70.55	53.70	21.54	7.54
Maximum	**100**	**98.57**	**94**	**88.69**	**56.19**	**34.96**
Minimum	**100**	**95.18**	**55.03**	**39.53**	**17.74**	**5.88**
Average	**100**	**96.83**	**77.41**	**62.93**	**33.06**	**14.92**

Based on this data, sediments from the study area showed different sediment textures (Table 3.42, Figure 3.29). All sites don't contain gravel sized sediments (>2mm) and the grain sizes fall within the sand-silt size particles, the highest retention occurred between 1 mm and 0.50 mm sieves (96.83% to 77.41, respectively).

The mud content (<0.063 mm, representing silt and clay) from all sites ranged between 5.88-34.96% (average 14.92%) with highest values (>25%) recorded at G01, G02, G09, and G15 (Table 3.43) reflecting poorly sorted sediments associated with low-energy environments. However, the lowest mud values (<7%) were recorded at G04, G07, and G13 indicating well to moderately sorted sediments associated with high-energy marine settings.

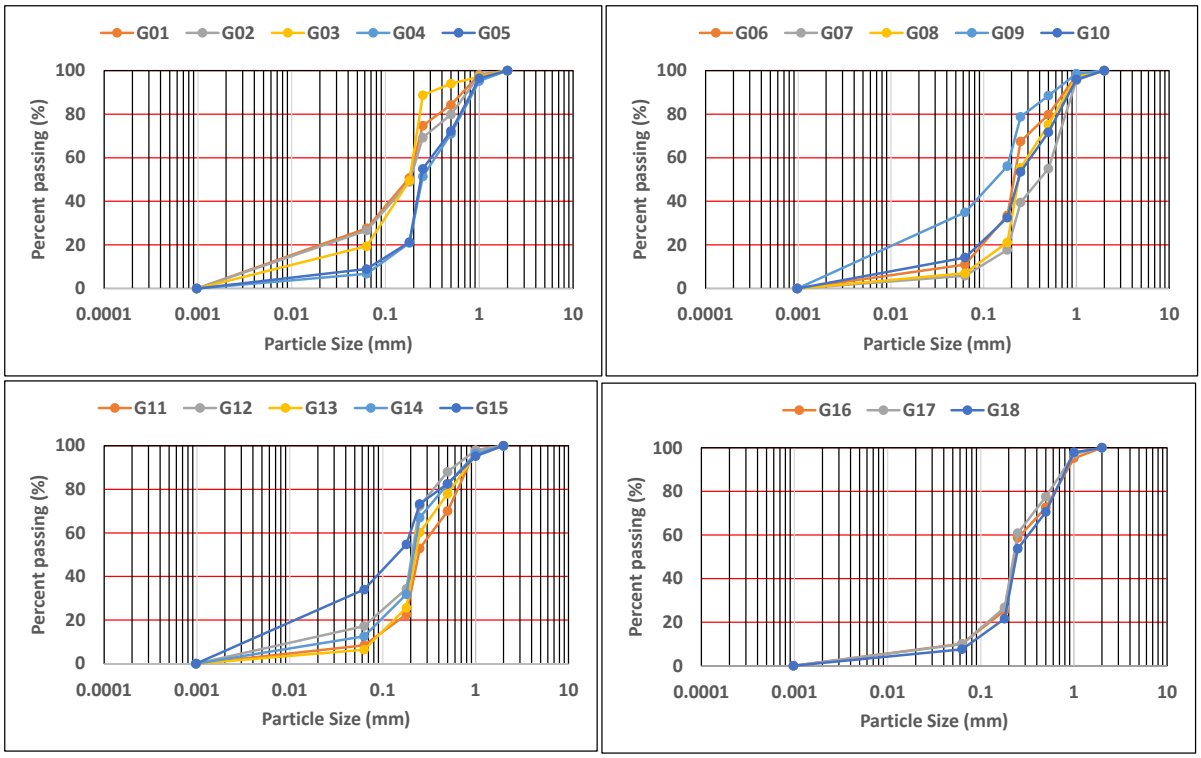


Figure 3 29: Cumulative particle size distribution (PSA) curves for sediments collected from eighteen stations (G01-G18) within the study area.

3.5.2. Chemical properties of sediments

3.5.2.1. Organic pollutants

The results of the organic compound analysis of the sediment samples are summarized in Tables 3.42 and 3.43 and represented in Figure 3.30

Table 3 42: Concentrations of TOC (g/kg), IOL (g/kg), Organotin (µg/kg), Hydrocarbons (mg/kg), and Polychlorinated Biphenyls (PCPs, mg/kg) compounds for marine sediments collected from eighteen stations (G01-G18) within the study area.

Station/Compound	Organic content (g/kg)		Organotin (µg/kg)		Hydrocarbons (mg/kg)	Polychlorinated Biphenyls (PCPs), (mg/kg)		
	TOC	IOL	Tributyl Tin (TBT)	Dibutyl Tin (DBT)	Mineral Oil	Aroclor 1260	Aroclor 1242	Aroclor 1254
G01	1.08	44.2	<5.0	<5.0	<0.5	<0.1	<0.1	<0.1
G02	0.39	42.5	<5.0	<5.0	<0.5	<0.1	<0.1	<0.1
G03	0.3	24.9	<5.0	<5.0	<0.5	<0.1	<0.1	<0.1
G04	0.6	35.6	<5.0	<5.0	<0.5	<0.1	<0.1	<0.1
G05	0.9	93.4	<5.0	<5.0	<0.5	<0.1	<0.1	<0.1
G06	0.96	38.9	<5.0	<5.0	<0.5	<0.1	<0.1	<0.1
G07	0.6	42.9	<5.0	<5.0	<0.5	<0.1	<0.1	<0.1
G08	0.84	43.4	<5.0	<5.0	<0.5	<0.1	<0.1	<0.1
G09	0.51	52.7	<5.0	<5.0	<0.5	<0.1	<0.1	<0.1
G10	0.15	33.7	<5.0	<5.0	<0.5	<0.1	<0.1	<0.1
G11	0.3	39.2	<5.0	<5.0	<0.5	<0.1	<0.1	<0.1
G12	0.06	33.4	<5.0	<5.0	<0.5	<0.1	<0.1	<0.1
G13	0.48	51.3	<5.0	<5.0	<0.5	<0.1	<0.1	<0.1
G14	0.72	42.2	<5.0	<5.0	<0.5	<0.1	<0.1	<0.1
G15	0.6	36.5	<5.0	<5.0	<0.5	<0.1	<0.1	<0.1
G16	0.3	48.7	<5.0	<5.0	<0.5	<0.1	<0.1	<0.1
G17	0.75	39.5	<5.0	<5.0	<0.5	<0.1	<0.1	<0.1
G18	0.21	32.7	<5.0	<5.0	<0.5	<0.1	<0.1	<0.1
Maximum	**1.08**	**93.4**	**<5.0**	**<5.0**	**<0.5**	**<0.1**	**<0.1**	**<0.1**
Minimum	**0.06**	**24.9**	**<5.0**	**<5.0**	**<0.5**	**<0.1**	**<0.1**	**<0.1**
Average	**0.54**	**43.09**	**<5.0**	**<5.0**	**<0.5**	**<0.1**	**<0.1**	**<0.1**

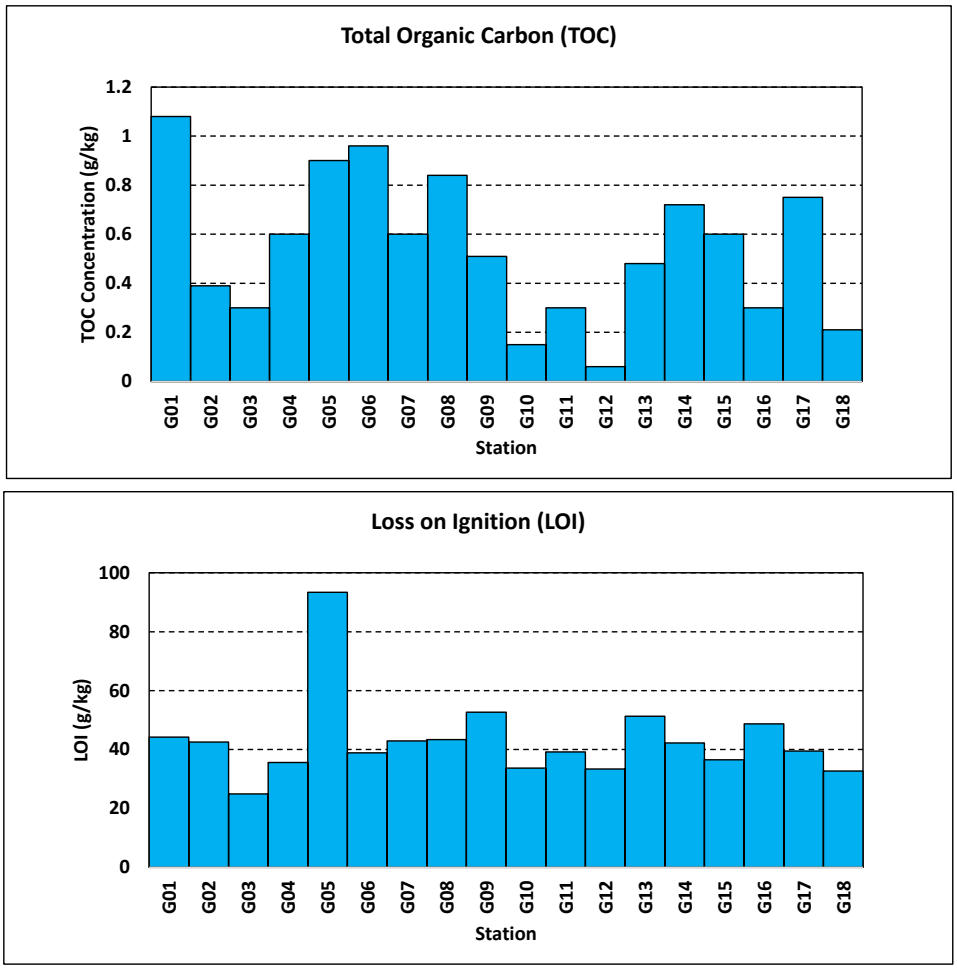


Figure 3 30: Contents of TOC (g/kg) and LOI (g/kg) for sediments collected from eighteen stations (G01-G18) within the study area.

The TOC values from the study area are low and range between 0.06-1.08 g/kg with highest values (>0.8 g/kg) recorded at G01, G05, G06, and G08 that could be due to localized conditions as these sites are located close to the port zones. However, low TOC values (<0.2 g/kg) at G10 and G12, both sites are located very close to each other.

The IOL range between 24.9-93.4 g/kg with highest values (>50 g/kg) recorded at G05, G9, and G13 and lowest values (<35 g/kg) were recorded at G03, G10, G12, and G18. Generally, TOC and LOI showed moderate correlation; stations with higher TOC generally had higher LOI (with exceptions, G05). The IOL values are much higher

than TOC indicating that sediments from the study area are mainly carbonate, and supports the interpretation that the study area is largely influenced by coral reef ecosystems, which are known to produce high levels of biogenic carbonate sediments.

Organotin compounds, Tributyl Tin (TBT) and Dibutyl Tin (DBT), were below detection limits (<5 µg/kg) in all sediment samples (Table 3.42), suggesting the absence of contamination from industrial PCB-based sources. Similarly, hydrocarbon concentrations (reported as mineral oil) were below 0.5 mg/kg, and fall within typical natural background levels, reflecting minimal input from oil pollution and/or petroleum activities.

Polychlorinated Biphenyls (PCBs), represented by Aroclor 1260, Aroclor 1242, and Aroclor 1254, were also below detection limits (<0.1 mg/kg) across all stations (Table 3.42). This indicates no detectable PCBs contamination in the study area.

The concentrations of Polyaromatic Hydrocarbons (PAHs) in the marine sediment samples (G01–G18) are shown in Table 4.33. The data shows considerable spatial variation across the study sites. In general, many of the lighter PAHs (e.g., Acenaphthylene, Acenaphthene, Fluorene, Naphthalene) were below the detection limit (< 5 µg/kg) in all stations. On the other hand, several high molecular weight (HMW) PAHs, such as Fluoranthene, Pyrene, Chrysene, Benzo(pyrene), and Indeno(1,2,3-cd)pyrene, were detected at measurable to elevated levels.

The highest PAH concentrations were observed at sites G04 and G08, which showed markedly elevated values for several compounds. For example, Fluoranthene, Pyrene, and Benzo(b)fluoranthene reached concentrations of 141 µg/kg, 119 µg/kg, and 79.8 µg/kg at G04, respectively. Similarly, G08 recorded the highest concentrations of Phenanthrene (102.7 µg/kg), Fluoranthene (178 µg/kg), Pyrene (131.7 µg/kg), and Indeno(1,2,3-cd)pyrene (86.5 µg/kg). These elevated concentrations at stations G04 and G08 indicate possible proximity to pollution sources, as both sites located near the gas tanker shipping port. The lowest PAH

levels were recorded at sites G02, G03, G06, G09, and G12, where most compounds were close to or below detection limits (Table 4.33).

Table 3 43: Concentrations of Polyaromatic Hydrocarbons (PAHs) in µg/kg in marine sediments collected from eighteen stations (G01-G18) within the study area.

Station	Polyaromatic Hydrocarbons (PAHs) Concentration (µg/kg)															
	Benzo (a) pyrene	Acenaphthylene	Phenanthrene	Fluoranthene	Dibenzo (a,h) anthracene	Benzo (b) fluoranthene	Chrysene	Pyrene	Naphthalene	Acenaphthene	Benzo (g,h,i) perylene	Benzo (k) fluoranthene	Indeno (1,2,3-cd) pyrene	Anthracene	Benzo (a) anthracene	Fluorene
G01	10.2	<5.0	32	35.2	9.4	17.8	13.2	27.5	<5.0	<5.0	9.9	9.6	16.9	<5.0	6.9	<5.0
G02	<5.0	<5.0	17.3	6.2	7.1	6.7	<5.0	5.8	<5.0	<5.0	<5.0	<5.0	9.6	<5.0	<5.0	<5.0
G03	<5.0	<5.0	12.6	5.2	6.1	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	7.3	<5.0	<5.0	<5.0
G04	66.8	<5.0	46	141	54.4	79.8	77.8	119	<5.0	<5.0	52.4	65.2	108.4	<5.0	59.6	<5.0
G05	<5.0	<5.0	17.7	14.1	7.1	8.4	5.3	13.2	<5.0	<5.0	<5.0	<5.0	10.2	<5.0	<5.0	<5.0
G06	<5.0	<5.0	15.8	7.3	6.3	5.2	<5.0	6.2	<5.0	<5.0	<5.0	<5.0	8	<5.0	<5.0	<5.0
G07	6.1	<5.0	9.2	13.2	7.7	11.2	5.5	11.7	<5.0	<5.0	5.6	5.2	11.7	<5.0	<5.0	<5.0
G08	56.4	<5.0	102.7	178	23.4	70.9	77.1	131.7	<5.0	<5.0	30.7	51.2	86.5	13	66.1	<5.0
G09	<5.0	<5.0	11.3	7.6	7.2	8.8	<5.0	7.1	<5.0	<5.0	<5.0	<5.0	10.4	<5.0	<5.0	<5.0
G10	14.1	<5.0	7.5	16.2	10.7	25.9	15.3	16.3	<5.0	<5.0	10.7	13.2	19.4	<5.0	12.1	<5.0
G11	6.3	<5.0	12.9	14.3	7.8	12.1	5.4	12.4	<5.0	<5.0	5.7	5.6	12.1	<5.0	<5.0	<5.0
G12	<5.0	<5.0	11.3	6.8	<5.0	<5.0	<5.0	5.5	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0
G13	5.4	<5.0	12.3	12.3	7.5	10.2	<5.0	10.6	<5.0	<5.0	5.3	<5.0	11.3	<5.0	<5.0	<5.0
G14	12.4	<5.0	21.7	37.4	11.2	26	14.4	32	<5.0	<5.0	12.4	14.4	21.7	<5.0	10.4	<5.0
G15	10.7	<5.0	18.8	25	10.8	23	13.5	22.1	<5.0	<5.0	11.5	12.5	20.4	<5.0	8.7	<5.0
G16	8.1	<5.0	7.4	12.4	8.7	14	6.9	12	<5.0	<5.0	6.9	6.9	14.7	<5.0	5.4	<5.0
G17	14.9	<5.0	9	23.8	12.3	27.7	12.5	22	<5.0	<5.0	12.9	15.6	24.4	<5.0	10.4	<5.0
G18	9.8	<5.0	11.7	24.5	9.3	19.6	8.9	22.4	<5.0	<5.0	8.2	9.9	16.8	<5.0	6.3	<5.0
Max.	**66.8**	**<5.0**	**102.7**	**178**	**54.4**	**79.8**	**77.8**	**131.7**	**<5.0**	**<5.0**	**52.4**	**65.2**	**108.4**	**13**	**66.1**	**<5.0**
Min.	**5.4**	**<5.0**	**7.4**	**5.2**	**<5.0**	**<5.0**	**<5.0**	**<5.0**	**<5.0**	**<5.0**	**<5.0**	**<5.0**	**<5.0**	**<5.0**	**<5.0**	**<5.0**
Avg.	**18.43**	**<5.0**	**20.96**	**32.25**	**12.18**	**22.96**	**21.32**	**28.09**	**<5.0**	**<5.0**	**14.35**	**19.03**	**24.11**	**13.00**	**20.66**	**<5.0**

3.5.2.2. Metals

The results of the chemical analysis of metals in the sediment from the study area are summarized in Table (3.44) and represented in Figure (3.31).

Table 3 44: Concentrations of some metals (Pb, Ni, Cu, Cr, Cd, Zn, As, Hg, and Sn) in mg/kg for marine sediments collected from eighteen stations (G01-G18) within the study area.

Station	Metal Concentration (mg/kg)								
	Pb	Ni	Cu	Cr	Cd	Zn	As	Hg	Sn
G01	0.61	2.44	0.54	6.03	<0.1	2.79	0.64	<0.1	<5.0
G02	0.69	2.49	0.56	7.31	<0.1	6.24	0.99	<0.1	<5.0
G03	4.24	17.31	1.03	32.64	<0.1	9.33	0.79	<0.1	<5.0
G04	0.93	4.53	1.49	9.37	<0.1	9.27	1.29	<0.1	<5.0
G05	0.83	5.8	1.27	11.61	<0.1	8.41	0.63	<0.1	<5.0
G06	1.04	7.64	1.1	18.09	<0.1	9.41	1.1	<0.1	<5.0
G07	1.61	8.55	2.26	17	<0.1	18.63	1.1	<0.1	<5.0
G08	0.77	4.49	1.36	9.07	<0.1	8.3	0.77	<0.1	<5.0
G09	0.55	2.78	1.11	6.26	<0.1	3.84	0.64	<0.1	<5.0
G10	1.87	11.56	1.92	26.35	<0.1	16.27	1.2	<0.1	<5.0
G11	0.99	5.54	2.02	7.38	<0.1	9.98	0.67	<0.1	<5.0
G12	1.76	21.38	1.76	49.74	<0.1	12.71	0.84	<0.1	<5.0
G13	1.04	6.37	1.76	13.31	<0.1	9.45	1.19	<0.1	<5.0
G14	1.03	10.13	1.75	19.66	<0.1	8.55	1.18	<0.1	<5.0
G15	0.59	4.43	2.83	9.59	<0.1	4.01	0.79	<0.1	<5.0
G16	0.89	7.06	1.58	15.36	<0.1	8.44	1.28	<0.1	<5.0
G17	1.03	6.75	1.69	13.91	<0.1	9.01	1.19	<0.1	<5.0
G18	0.93	9.34	1.74	19.68	<0.1	8.77	1.21	<0.1	<5.0
Maximum	**4.24**	**21.38**	**2.83**	**49.74**	**<0.1**	**18.63**	**1.29**	**<0.1**	**<5.0**
Minimum	**0.55**	**2.44**	**0.54**	**6.03**	**<0.1**	**2.79**	**0.63**	**<0.1**	**<5.0**
Average	**1.19**	**7.70**	**1.54**	**16.24**	**<0.1**	**9.08**	**0.97**	**<0.1**	**<5.0**

The concentrations of the metals in the marine sediment samples (G01–G18) from the study area show clear spatial variation among the different sampling stations. Generally, most metals occur at relatively low levels, while a few elements display some high values (Table 3.44, Figure 3.31).

Pb concentrations range from 0.55 to 4.24 mg/kg, with the highest value recorded at site G03 as this site is very close to port and industrial discharge. Nickle (Ni) exhibits wider variability (2.44 to 21.38 mg/kg), with G03 and G12 showing the highest levels highlighting potential sources such as cooling water discharges.

Cu levels are generally low at all stations (0.54–2.83 mg/kg), while Cr shows more pronounced variation (6.03–49.74 mg/kg), with G03, G10, and G12 displaying elevated concentrations due to the proximity of these stations to port activities and cooling water discharges. Zn concentrations range from 2.79 to 18.63 mg/kg, with sites G07, G10, G12 showing the highest levels possibly for the same reasons (Table 3.44, Figure 3.31).

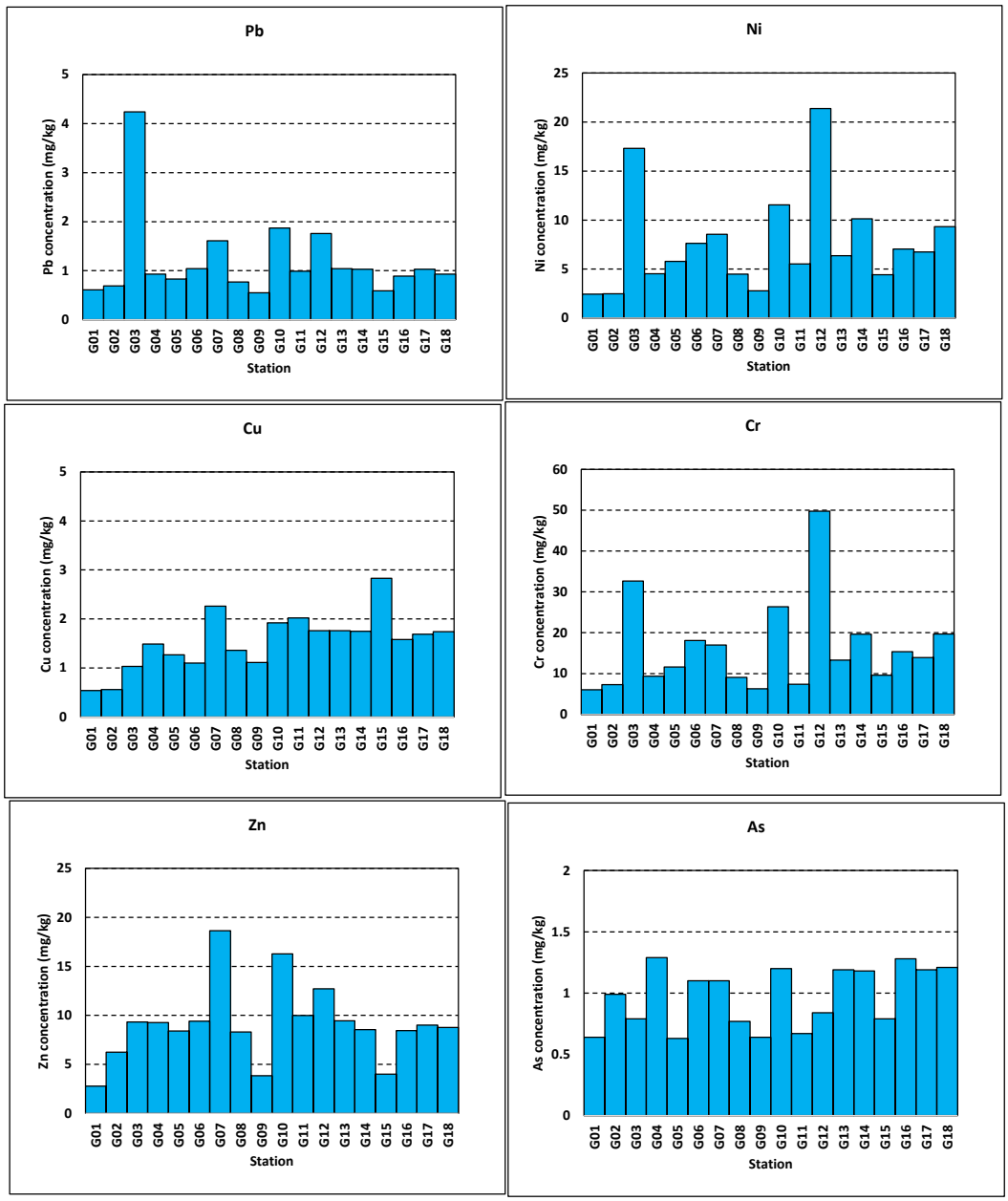


Figure 3 31: Concentrations of some metals (Pb, Ni, Cu, Cr, Cd, Zn, As, Hg, and Sn) in mg/kg for marine sediments collected from eighteen stations (G01-G18) within the study area.

Arsenic (As) concentrations remain within a narrow range (0.63–1.29 mg/kg), that may indicate uniform background levels across all sites. Cd and Hg concentrations were below detection limits in all samples. Similarly, Tin (Sn) levels were consistently < 5 mg/kg from all sites suggesting its presence only in trace amounts (Table 3.44, Figure 3.31).

Generally, the spatial patterns of metals suggest that while the study area is largely uncontaminated, certain hotspots (notably G03, G10, and G12) may be influenced by localized anthropogenic pollution sources.

3.5.3. Comparison with quality guidelines

Sediment quality guidelines are helpful to screen sediment contamination. They compare contaminant concentrations in sediment to set standards, helping to identify harmful pollutants, prioritize problem areas, and indicate contamination levels. The measured concentrations of organic compounds and heavy metals from the study sites were compared with the **Provincial Sediment Quality Guidelines (PSQGs) of Ontario** (Fletcher et al., 2008; Persaud et al., 1993). These guidelines are used to assess whether the concentrations of certain contaminants in sediments from the study area are acceptable or whether they might pose risks to aquatic life, ecosystems, or human health (Tables 3.45-3.37). These guidelines establish three levels of effect:

1. **The No Effect Level:** The No Effect Level (NEL) indicates a concentration of a chemical in the sediment that does not affect fish or sediment-dwelling organisms. At this level negligible transfer of chemicals through the food chain and no effect on water quality is expected. Sediment meeting the NEL are considered clean.
2. **The Lowest Effect Level:** The Lowest Effect Level (LEL) indicates a level of contamination that can be tolerated by the majority of sediment-dwelling organisms. Sediments meeting the LEL are considered clean to marginally polluted.
3. **The Severe Effect Level:** The Severe Effect Level (SEL) indicates a level of contamination that is expected to be detrimental to the majority of sediment-dwelling organisms. Sediments exceeding the SEL are considered heavily contaminated.

Table 3 45: Comparison of measured metal concentrations in marine sediments from the study sites (G01-G18) with the Provincial Sediment Quality Guidelines (PSQGs) of Ontario (all concentrations are in mg/kg).

Metals	Lowest Effect Level (PSQGs)	Severe Effect Level (PSQGs)	Concentration ranges from the studied sites
Pb	31	250	**0.55-4.24**
Sn	-	-	**<5.0**
Ni	16	75	**2.44-21.38**
Zn	120	820	**2.79-18.63**
As	6	33	**0.63-1.29**
Cd	0.6	10	**<0.1**
Cr	26	110	**6.03-49.74**
Cu	16	110	**0.54-2.83**
Hg	0.2	2	**<0.1**

All metal concentrations from the study area except Ni and Cr are well below the lowest effect level (LEL), indicating no significant contamination in all sites. Ni and Cr show some exceedances of lowest effect level (LEL) but remain far below the Severe Effect Level (SEL), suggesting minor to moderate enrichment. Generally, sediments from all stations (G01–G18) appear to be unpolluted to slightly polluted, with Cr and Ni being the only elements warranting further monitoring.

The concentrations of the total organic carbon (TOC) observed at the studied sites are all within the natural range of marine sediments and below the lowest and severe effect level (1-10 %), indicating minimal risk from TOC levels (Table 3.46).

Table 3 46: Comparison of some organic compounds' concentration in marine sediments within the study area (G01-G18) with the Provincial Sediment Quality Guidelines (PSQGs) of Ontario.

Organic Compound	Unit	Lowest Effect Level (PSQGs)	Severe Effect Level (PSQGs)	Concentration ranges from the studied sites
TOC	g/kg	10	100	**0.54-1.08**
Tributyl Tin (TBT)	µg/kg	--	--	**<5.0**
Dibutyl Tin (DBT)	µg/kg	--	--	**<5.0**

Mineral oil	mg/kg	--	--	**<0.5**
aroclor 1260	mg/kg	0.005	24	**<0.1**
aroclor 1242	mg/kg	--	--	**<0.1**
aroclor1254	mg/kg	0.006	34	**<0.1**

Regarding the organotin compounds (TBT, DBT) and mineral oil were all below detection limits, suggesting no measurable contamination. PCBs (Aroclors 1260, 1242, and 1254) were detected at very low levels (<0.1 mg/kg), which are far below the Severe Effect Levels (SELs; Table 3.46).

The concentrations of polycyclic aromatic hydrocarbons (PAHs) in sediments from the study area (G01–G18) generally exceed the Lowest Effect Levels (LELs) of the Ontario Provincial Sediment Quality Guidelines (PSQGs) but remain below the Severe Effect Levels (SELs) as shown in Table (3.47). This indicates a moderate ecological risk. Fluoranthene and Pyrene exhibited the highest concentrations, while Dibenzo(a,h)anthracene and Benzo(a)pyrene also exceeded LELs at some sites, suggesting localized contamination.

Several compounds, including Acenaphthylene, Naphthalene, and Acenaphthene, were mostly below detection limits (<5 µg/kg), indicating minimal contribution to overall PAH levels (Table 3.47).

Table 3 47: Comparison of Polyaromatic Hydrocarbons (PAHs) compounds concentrations in marine sediments within the study area (G01-G18) with the Provincial Sediment Quality Guidelines (PSQGs) of Ontario. All values are expressed in µg/kg.

Compound	Lowest Effect Level (PSQGs)	Severe Effect Level (PSQGs)	Concentration ranges from the studied sites
Benzo (a) pyrene	0.37	1440	**5.4-66.8**
Acenaphthylene	--	--	**<5.0**
Phenanthrene	0.56	950	**7.4-102.7**
Fluoranthene	0.75	1020	**5.2-178**
Dibenzo (a,h) anthracene	0.06	130	**<5.0-54.4**
Benzo (b) fluoranthene			**<5.0-79.8**
Chrysene	0.34	460	**<5.0-77.8**
Pyrene	0.49	850	**<5.0-131.7**
Naphthalene	--	--	**<5.0**

Acenaphthene	--	--	**<5.0**
Benzo (g,h,i) perylene	0.17	320	**<5.0-52.4**
Benzo (k) fluoranthene	0.24	1340	**<5.0-65.2**
Indeno (1,2,3-cd) pyrene	0.20	320	**<5.0-108.4**
Anthracene	0.220	370	**<5.0-13**
Benzo (a) anthracene	0.320	1480	**<5.0-66.1**
Fluorene	0.19	160	**<5.0**

3.6. Seawater in situ Survey

Some physicochemical properties of seawater are summarized in Table (3.48) and illustrated in Figure (2-4).

Table 3 48: Vertical profiles of key physicochemical parameters of seawater collected from multiple stations (3 depths) within the study area.

Station	Depth (m)	Turbidity (NTU)	pH Surf / Mid / Bot	Salinity (PSU) Surf / Mid / Bot	Temp (°C) Surf / Mid / Bot	D.O (mg/L) Surf / Mid / Bot
G01	60	0.048	8.29 / 8.27 / 8.26	40.37 / 40.82 / 40.80	26.05 / 25.10 / 23.33	6.61 / 6.54 / 6.49
G02	59	0.049	8.30 / 8.28 / 8.28	40.79 / 40.85 / 40.91	26.19 / 25.84 / 25.62	6.60 / 6.57 / 6.50
G03	43	0.065	8.29 / 8.28 / 8.28	40.66 / 40.83 / 40.88	25.99 / 25.89 / 25.86	6.59 / 6.56 / 6.55
G05	70	0.054	8.29 / 8.26 / 8.27	39.35 / 40.91 / 41.19	26.09 / 25.58 / 24.35	6.60 / 6.57 / 6.54
G06	30	0.041	8.29 / - / 8.29	40.70 / 40.83 / 40.69	26.04 / 25.64 / 21.45	6.60 / - / 6.57
G08	33	0.039	8.30 / - / 8.28	40.14 / 40.38 / 40.64	25.97 / 23.80 / 21.60	6.60 / - / 6.56
G09	68	0.046	8.30 / 8.30 / 8.28	40.55 / 40.70 / 40.79	26.04 / 25.75 / 25.52	6.58 / 6.58 / 6.55
G10	100	0.060	8.30 / 8.27 / 8.25	40.79 / 40.86 / 40.89	26.12 / 25.84 / 25.75	6.60 / 6.54 / 6.51
G11	13	≤0.067	8.29 / - / -	40.95 / 40.87 / 40.90	25.95 / 25.96 / 25.86	6.60 / - / -
G12	7	0.044	8.30 / - / -	40.08 / 40.77 / 40.80	26.15 / 25.72 / 25.50	6.60 / - / -
G15	19	0.047	8.30 / - / -	40.10 / 40.88 / 40.93	26.10 / 26.00 / 25.95	6.60 / - / -
G16	40	≤0.121	8.30 / - / 8.28	40.35 / 40.58 / 40.60	26.10 / 25.98 / 25.94	6.58 / - / 6.56
G17	53	≤0.320	8.28 / - / 8.28	40.78 / 40.77 / 40.82	26.21 / 26.07 / 26.06	6.57 / - / 6.56
G18	7	≤0.320	8.29 / - / -	40.70 / 40.76 / 40.88	26.10 / 26.06 / 25.90	6.59 / - / -

Based on Table (3.48), seawater turbidity ranged between 0.039-0.320 NTU with high turbidity in shallow depths (stations G11, G12, G18. These results are consistent with typical shallow coastal marine environments, where many factors (e.g., waves, currents, and anthropogenic/ natural disturbances) resuspend sediments and increase turbidity. However, deeper stations show low turbidity values, reflecting clearer deep water due to reduced sediment disturbance (Table 3.48, Figure 3.32).

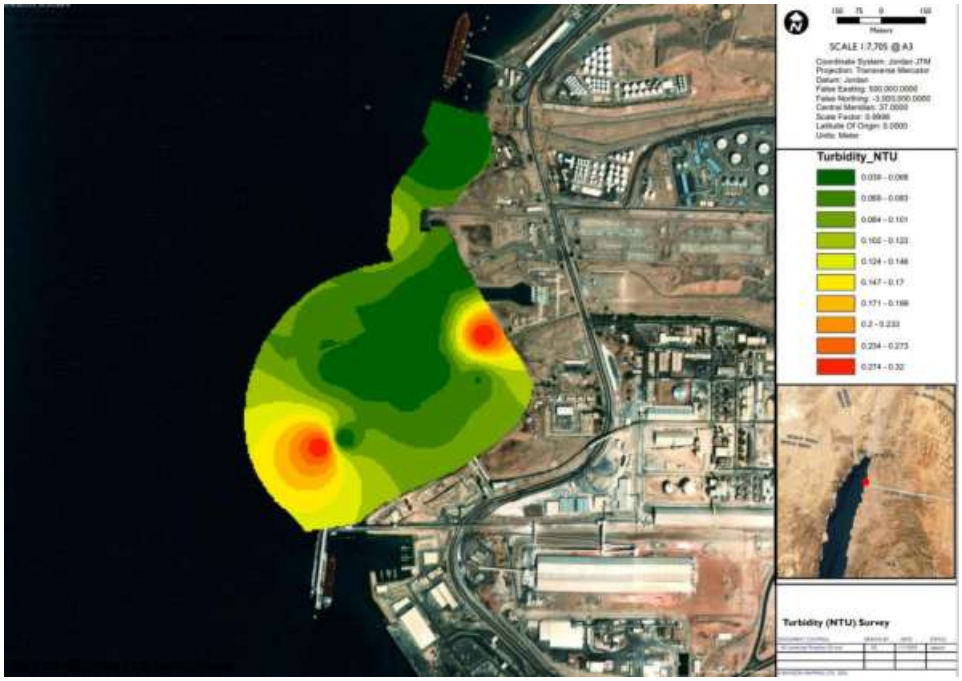


Figure 3 32: Seawater turbidity map of the study area showing salinity measurements at surface, mid-depth, and bottom layers across all sampling stations.

Slight variations of pH were recorded between stations and depth with values ranging between 8.25 to 8.30 across all layers (Table 3.48) reflecting typical oligotrophic tropical waters with minimal localized acidification effects.

Salinity increases slightly with depth at most stations (39.35-41.19 PSU) reflecting stratification patterns in such semi-enclosed basins. (Table 3.48, Figure 3.33). However, minor spatial variations indicate relatively homogeneous surface saline conditions.

In contrast, seawater temperature decreases slightly with increasing depth, ranging from 26.21°C at the surface to 23.33°C in deeper waters. Stations G06 and G08 recorded exceptionally low temperatures (21.45–21.60°C), that could be linked to cooling water discharges in both sites (Table 3.48 and Figure 3.34).

For dissolved oxygen (DO), the values range between 6.49 to 6.61 mg/L with slight decrease with depth (Table 3.48) suggesting adequate ventilation and low organic pollution, consistent with oligotrophic nature of the Gulf of Aqaba.

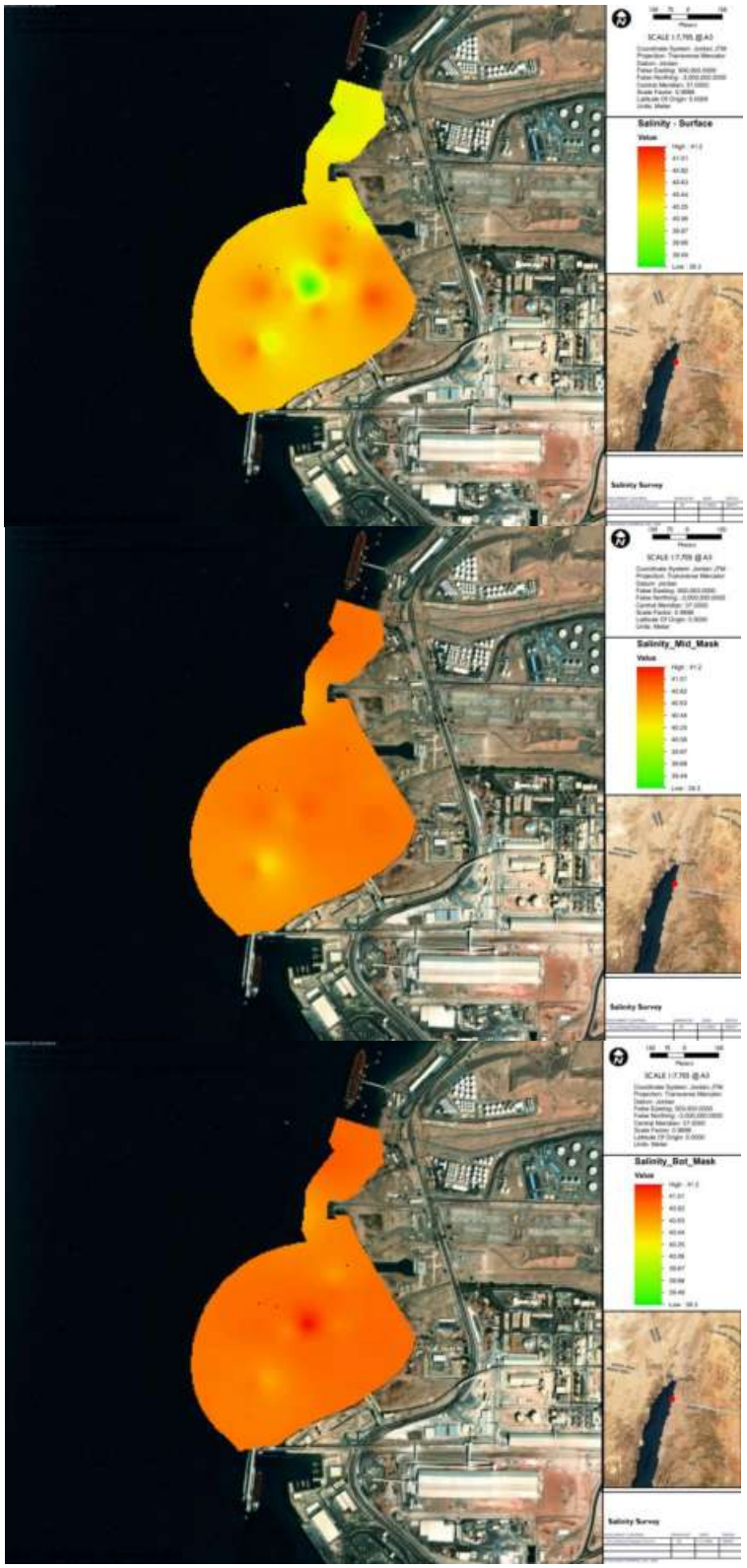


Figure 3 33: Seawater salinity maps of the study area showing salinity measurements at surface, mid-depth, and bottom layers across all sampling stations.

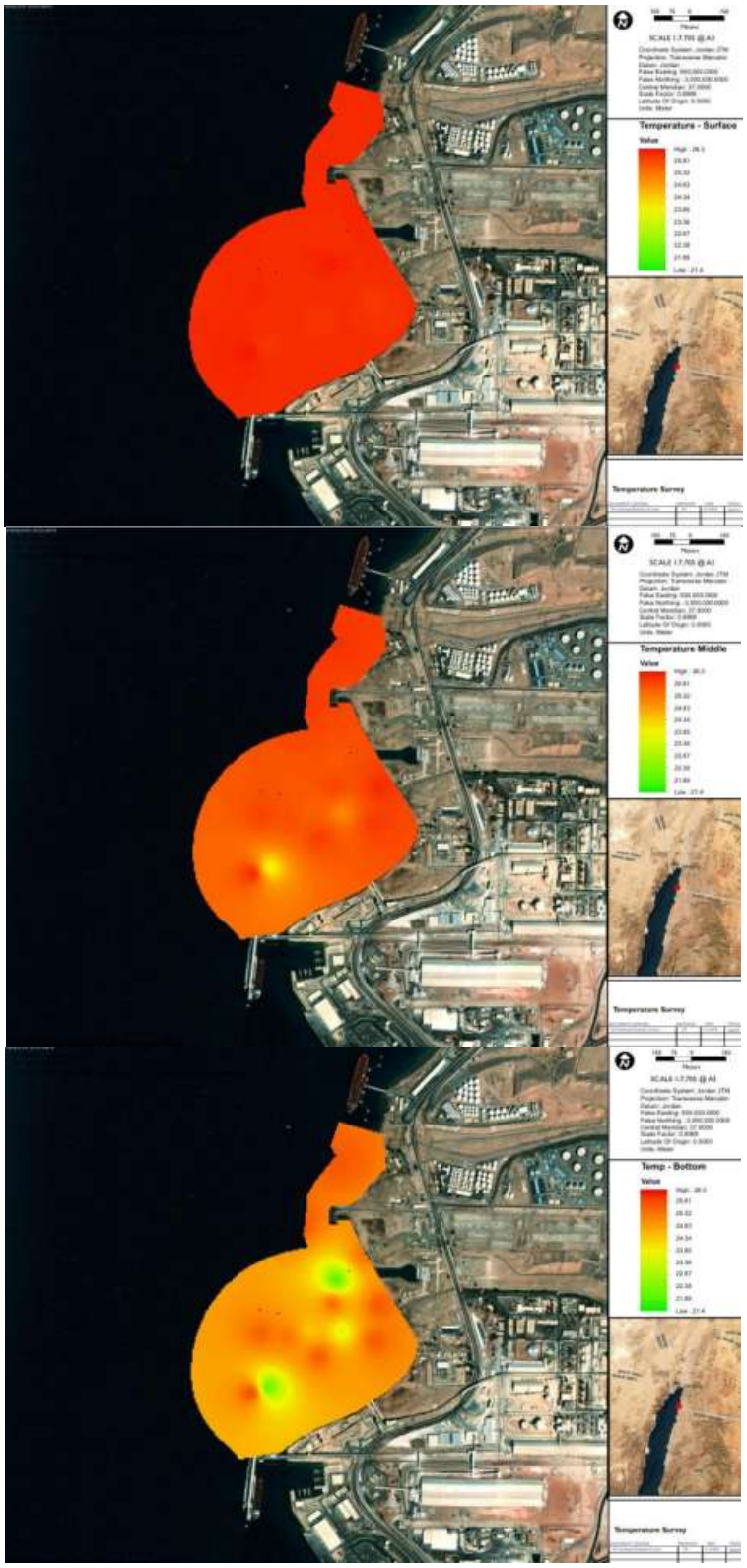


Figure 3 34: Seawater temperature maps of the study area showing salinity measurements at surface, mid-depth, and bottom layers across all sampling stations.

3.7. Solid waste

3.7.1. Integrated summaries

As shown in Table 3.49, totals rise from shallow bands to a mid-profile maximum at 15 m (68 items), before tapering toward 30 m. The increase coincides with greater category richness, consistent with hydrodynamic sorting and retention across the profile. Figure 3.35 mirrors Table 3.49, visualizing the mid-depth maximum and shallower decline. The pronounced crest near 15 m indicates an accumulation zone where buoyant plastics and heavier items co-occur, reinforcing the need to prioritize mid-profile transects for cleanup and monitoring.

Table 3 49: Depth-banded totals (5–30 m) across all stations with counts of unique standardised categories per band; bands reflect nominal survey depths.

Depth (m)	Total_Items	Unique_Categories
5.0	36.0	8.0
10.0	47.0	8.0
15.0	68.0	10.0
20.0	54.0	7.0
25.0	48.0	7.0
30.0	41.0	8.0

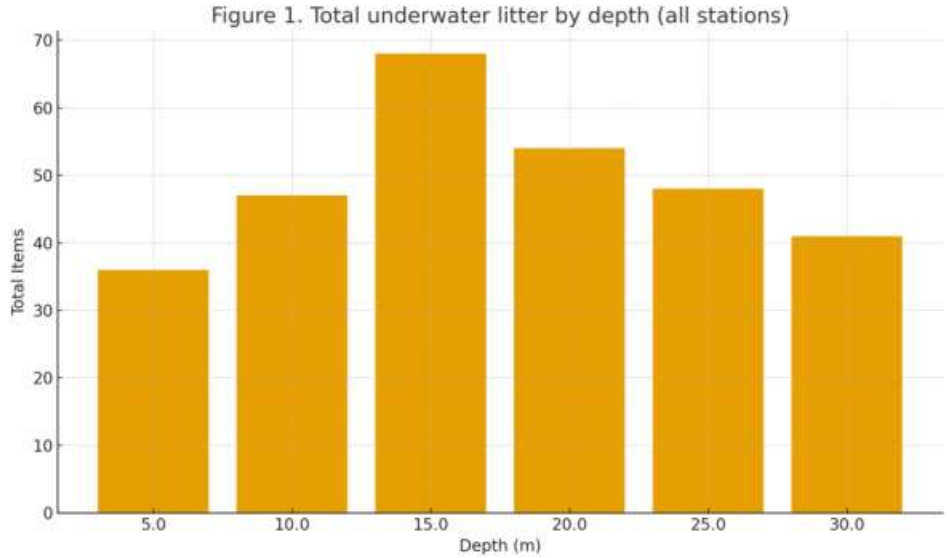


Figure 3 35: Column chart showing total items per depth band (5–30 m) aggregated over all stations, highlighting the pronounced mid-profile peak.

Table 3.50 ranks categories by frequency. The leading types are Metal fragment (77, 26.2%); Other/Unknown (59, 20.1%); Tyre (59, 20.1%), forming a steep head that captures most observations. Beyond the top ranks, counts drop quickly, indicating many rare categories that contribute marginally to totals. Figure 3.36 complements Table 2 by emphasising the rank-size structure. Dominant categories occupy a large share, while the tail compresses rapidly. This pattern suggests targeted interventions on the top few types can yield outsized reductions.

Table 3 50: Top standardised categories across all stations (top 15 by count), ordered by abundance to show the dominant head and long tail.

StdCategory	Total_Items
Metal fragment	77
Other/Unknown	59
Tyre	59
Metal rod/beam/plate	30
Metal can	24
Plastic bottle	24
Fishing gear - rope	14
Glass bottle	3
Pipe/tube (unspecified)	2
Plastic pipe/tube	2

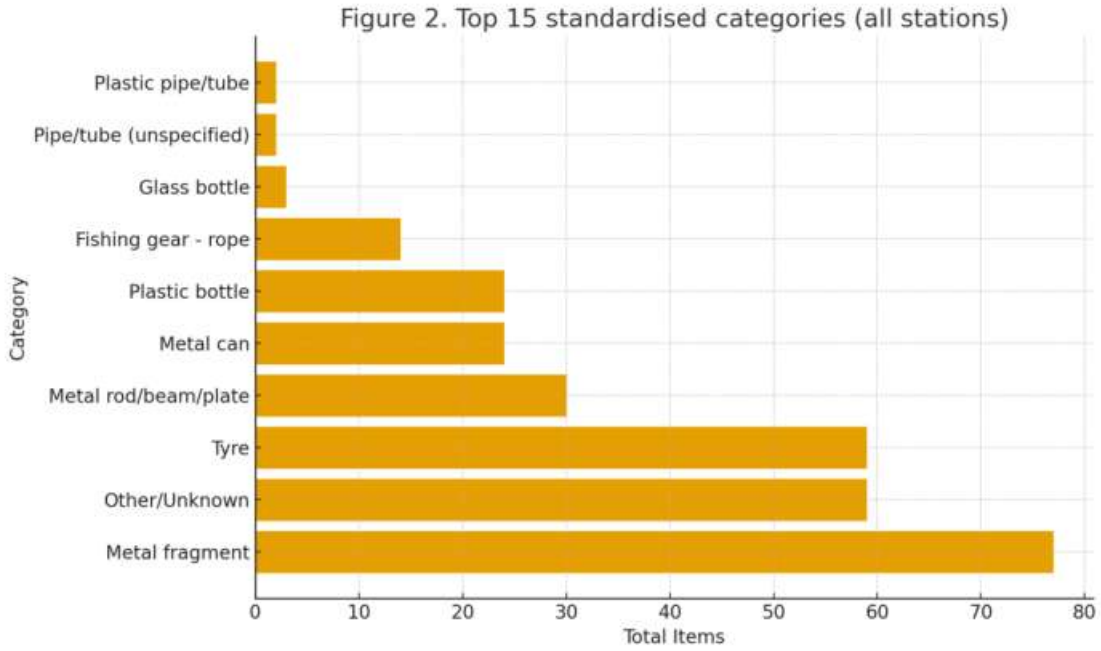


Figure 3 36: Horizontal bar chart of the top fifteen standardised categories across all stations.

Figure 3 aligns with Table 3, confirming metalwork and tyres as major contributors. The mix implies co-occurrence of legacy, heavy debris and more mobile plastics, with implications for cleanup tooling and diver safety. Table 3 shows that materials are dominated by Metal (131, 44.6%); Rubber (59, 20.1%). The composition reflects both persistent heavy items and common consumer debris, indicating multiple input pathways and variable seabed retention.

Table 3. Totals by material class aggregated across all stations.

StdMaterial	Total_Items
Metal	131
Rubber	59
Unknown	58
Plastic	43
Glass	3

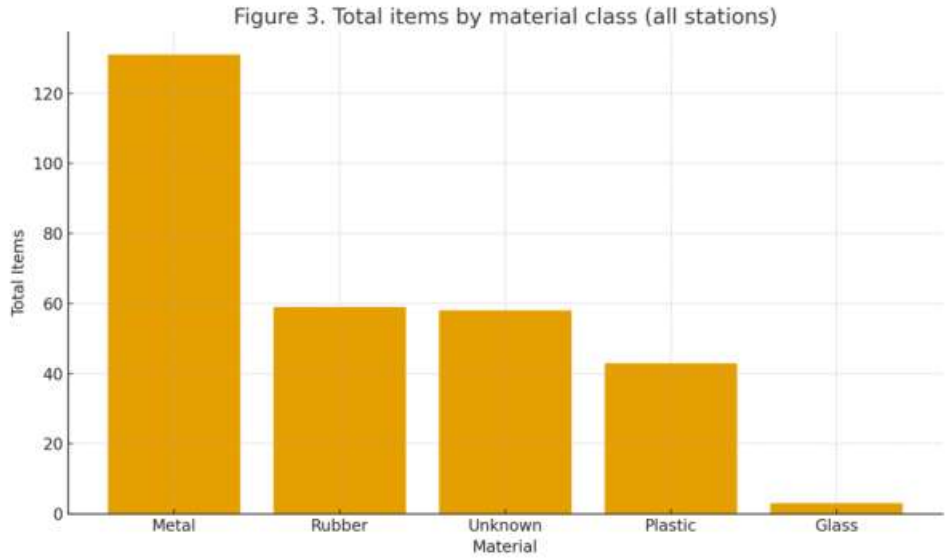


Figure 3. Column chart of total items by material class across all stations.

Table 3.51 reveals heterogeneous station loads, led by TA08 (88), TA07 (54), TB01 (52). Contrasts suggest localised inputs and retention features. Stations with high totals warrant intensified effort, while lower-load sites can serve as controls to track background conditions. Figure 3.37 reinforces Table 3.51, marking clear hotspots. Differences likely reflect proximity to access points, moorings, and micro-topography that traps debris, pointing to station-specific cleanup strategies.

Table 3 51: Station-level summary: total items and unique standardised categories.

Station	Total Items	Unique Categories
TA08	88	8
TA07	54	8
TB01	52	9
TA06	32	7
TA01	23	5
TA03	14	5
TA05	14	4
TA02	12	5
TA04	5	4

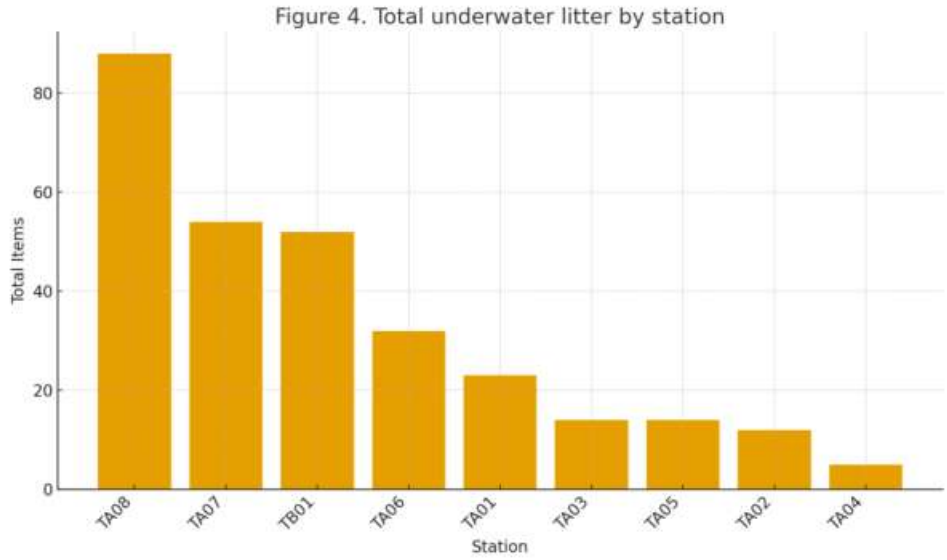


Figure 3 37: Column chart of total items by station, highlighting hotspots relative to background stations.

3.7.2. Statistical analysis

Table 5 reports LR tests indicating significant contributions from Station, Depth (categorical), Category to observed counts (α=0.05). Accounting for overdispersion improves inference compared with Poisson or OLS ANOVA and supports depth-band and station-specific planning.

Table 3 52: Negative Binomial GLM (log link): likelihood-ratio tests for main effects with overdispersion accounted ($\varphi \approx 1.34$, $\alpha \approx 0.140$).

Effect	LR statistic	df	p_value
Station	19.7443	8	0.0113
Depth (categorical)	17.6313	5	0.0034
Category	19.1865	9	0.0237

3.7.3. Station-by-station analysis

3.7.3.1. Station: TA01

Table 3.53 summarizes TA01 with 23 items overall. Counts peak at 25 m (6 items) and are dominated by Tyre (9) and Other/Unknown (7). The cross-tab clarifies which types drive the depth pattern and where targeted removal would be most efficient. Figure 5 depicts the within-band composition shifts detailed in Table 6. Bands near the peak depth include both dominant and rare categories, providing useful guidance for divers on safe handling methods and the appropriate selection of removal tools.

Table 3 53: TA01 — depth × standardized category counts (items per band).

Depth (m)	Metal fragment	Metal rod/beam/plate	Other/Unknown	Plastic bottle	Tyre
5.0	0.0	0.0	0.0	0.0	1.0
10.0	2.0	0.0	0.0	0.0	3.0
15.0	0.0	1.0	0.0	1.0	0.0
20.0	0.0	0.0	4.0	0.0	0.0
25.0	0.0	1.0	3.0	0.0	2.0
30.0	0.0	0.0	0.0	2.0	3.0

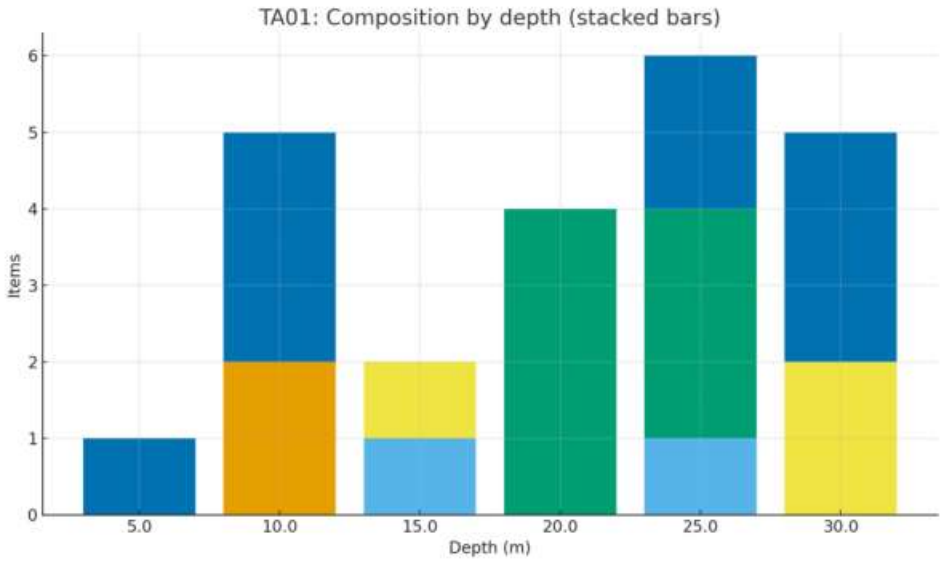


Figure 3 38: TA01, stacked-bar composition by depth showing the relative mix of dominant and rare categories at each band.

3.7.3.2. Station: TA02

Table 3.54 summarizes TA02 with 12 items overall. Counts peak at 15 m (7 items) and are dominated by Metal rod/beam/plate (4) and Tyre (3). The cross-tab clarifies which types drive the depth pattern and where targeted removal would be most efficient. Figure 6 illustrates the within-band composition shifts presented in Table 3.54. Bands near the peak depth contain both common and rare categories, offering practical insight for divers on safe handling techniques and appropriate tool selection during removals.

Table 3 54: TA02 — depth × standardised category counts (items per band).

Depth (m)	Metal fragment	Metal rod/beam/plate	Other/Unknown	Plastic bottle	Tyre
5.0	0.0	0.0	1.0	0.0	0.0
10.0	1.0	0.0	0.0	0.0	3.0
15.0	1.0	4.0	1.0	1.0	0.0

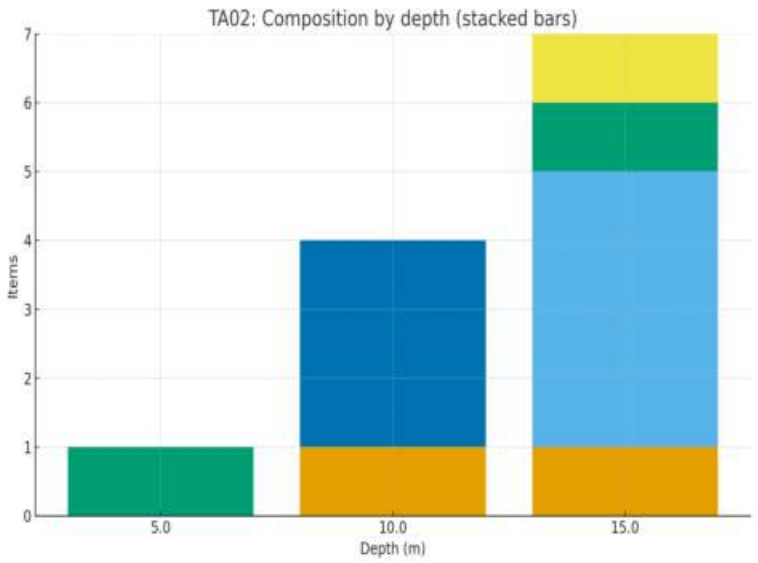


Figure 3 39: TA02 — stacked-bar composition by depth showing the relative mix of dominant and rare categories at each band.

3.7.3.3. Station: TA03

Table 3.55 summarizes TA03 with 14 items overall. Counts peak at 10 m (8 items) and are dominated by Tyre (10) and Glass bottle (1). The cross-tab clarifies which types drive the depth pattern and where targeted removal would be most efficient. Figure 3.40 complements Table 8 by showing within-band composition shifts. Bands near the peak depth host both prevalent and niche categories, guiding safe diver handling and tool choice during removals.

Table 3 55: *TA03 — depth × standardised category counts (items per band).*

Depth (m)	Glass bottle	Metal fragment	Metal rod/beam/plate	Plastic bottle	Tyre
5.0	0.0	1.0	1.0	0.0	4.0
10.0	1.0	0.0	0.0	1.0	6.0

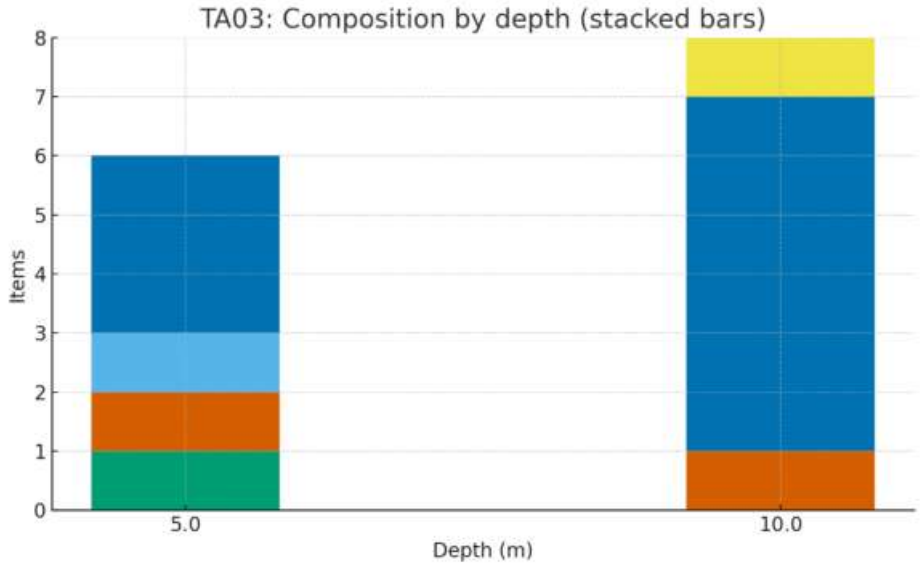


Figure 3 40: TA03 — stacked-bar composition by depth showing the relative mix of dominant and rare categories at each band.

3.7.3.4. Station: TA04

Table 3.56 summarizes TA04 with 5 items overall. Counts peak at 30 m (3 items) and are dominated by Other/Unknown (2) and Metal can (1). The cross-tab clarifies which types drive the depth pattern and where targeted removal would be most efficient. Figure 3.41 complements Table 3.56 by showing within-band composition shifts. Bands near the peak depth host both prevalent and niche categories, guiding safe diver handling and tool choice during removals.

Table 3 56: TA04 — depth × standardised category counts (items per band).

Depth (m)	Metal can	Other/Unknown	Plastic bottle	Tyre
10.0	0.0	0.0	1.0	0.0
15.0	1.0	0.0	0.0	0.0
30.0	0.0	2.0	0.0	1.0

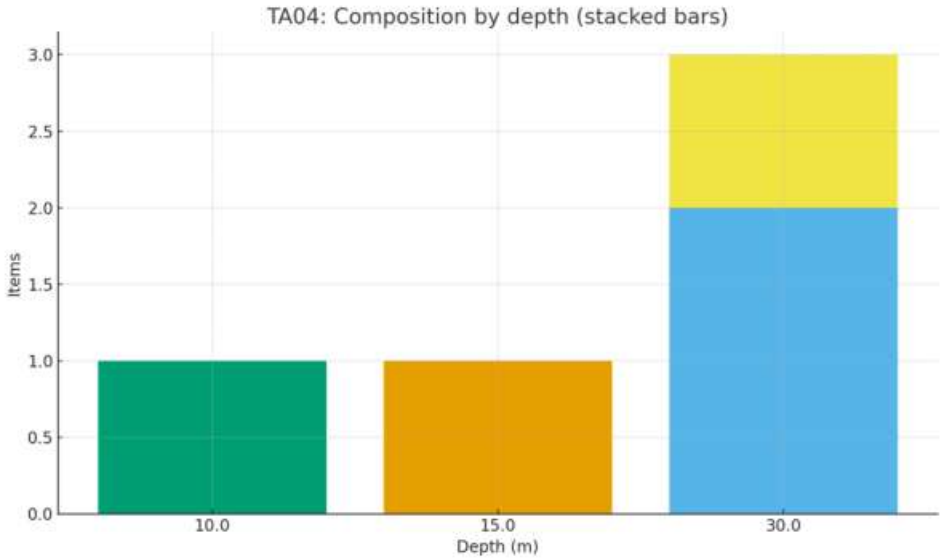


Figure 3 41: TA04 — stacked-bar composition by depth showing the relative mix of dominant and rare categories at each band.

3.7.3.5. Station: TA05

Table 3.57 summarizes TA05 with 14 items overall. Counts peak at 20 m (6 items) and are dominated by Other/Unknown (11) and Glass bottle (1). The cross-tab clarifies which types drive

the depth pattern and where targeted removal would be most efficient. Figure 3.41 complements Table 3.57 by showing within-band composition shifts. Bands near the peak depth host both prevalent and niche categories, guiding safe diver handling and tool choice during removals.

Table 3 57: TA05 — depth × standardized category counts (items per band).

Depth (m)	Glass bottle	Metal fragment	Other/Unknown	Tyre
15.0	1.0	0.0	0.0	0.0
20.0	0.0	0.0	6.0	0.0
25.0	0.0	0.0	4.0	0.0
30.0	0.0	1.0	1.0	1.0

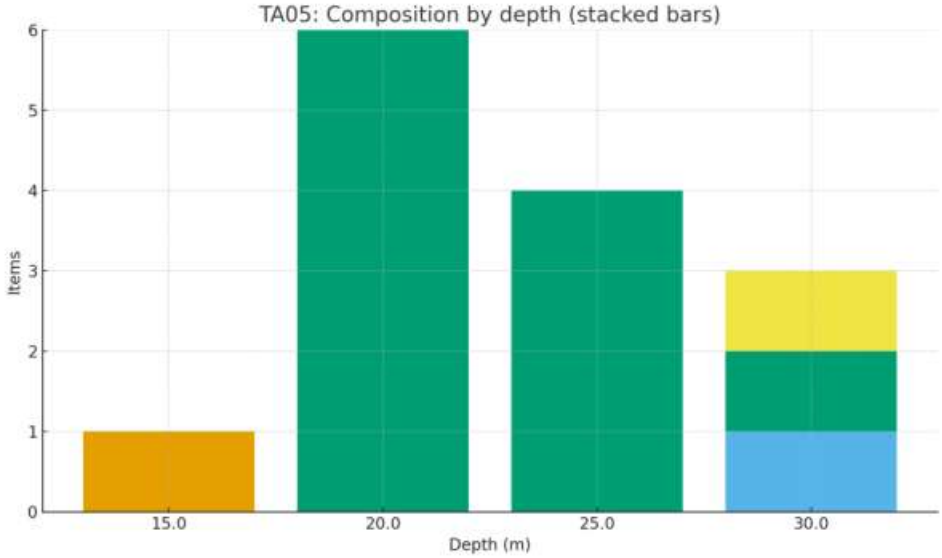


Figure 3 42: TA05 — stacked-bar composition by depth showing the relative mix of dominant and rare categories at each band.

3.7.3.6. Station: TA06

Table 3.58 summarizes TA06 with 32 items overall. Counts peak at 25 m (13 items) and are dominated by Other/Unknown (9) and Metal can (6). The cross-tab clarifies which types drive the depth pattern and where targeted removal would be most efficient. Figure 3.43 matches Table 3.58 by showing within-band composition shifts. Bands near the peak depth host both prevalent and niche categories, guiding safe diver handling and tool choice during removals.

Table 3 58: TA06 — depth × standardised category counts (items per band).

Depth (m)	Metal can	Metal fragment	Metal rod/beam/plate	Other/Unknown	Plastic bottle	Plastic pipe/tube	Tyre
5.0	0.0	2.0	0.0	0.0	0.0	1.0	0.0
10.0	3.0	0.0	0.0	0.0	1.0	0.0	1.0
15.0	0.0	2.0	0.0	0.0	0.0	0.0	1.0
20.0	0.0	0.0	4.0	0.0	0.0	0.0	0.0
25.0	2.0	1.0	0.0	9.0	0.0	0.0	1.0
30.0	1.0	1.0	0.0	0.0	1.0	0.0	1.0

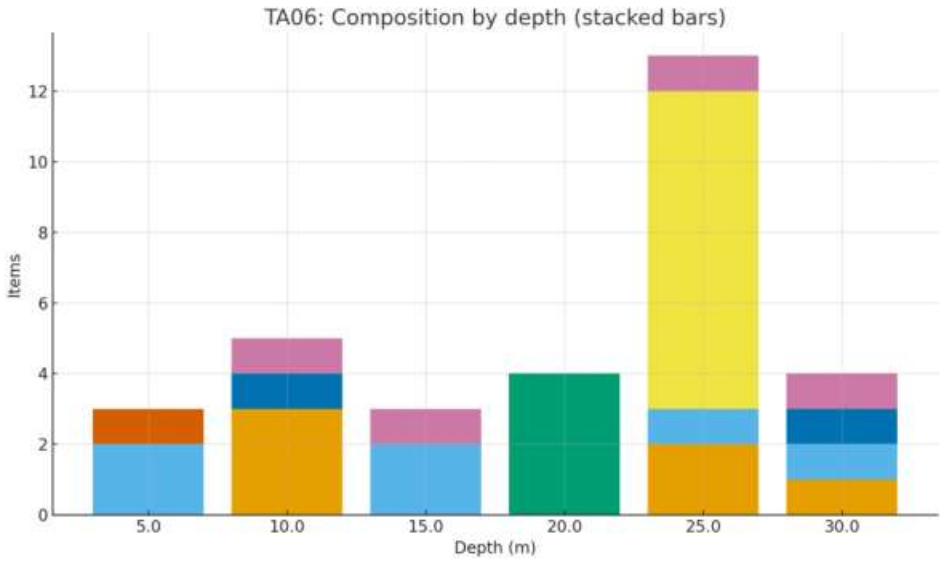


Figure 3 43: TA06 — stacked-bar composition by depth showing the relative mix of dominant and rare categories at each band.

3.7.3.7. Station: TA07

Table 12 summarizes TA07 with 54 items overall. Counts peak at 15 m (21 items) and are dominated by Metal fragment (32) and Other/Unknown (6). The cross-tab clarifies which types drive the depth pattern and where targeted removal would be most efficient. Figure 11 illustrates composition shifts within depth bands. Bands near the peak depth contain both dominant and rare categories, providing valuable guidance for divers in ensuring safe handling and selecting appropriate tools during removals.

Table 3 59: TA07 — depth × standardized category counts (items per band).

Depth (m)	Fishing gear - rope	Metal can	Metal fragment	Metal rod/beam/plate	Other/Unknown	Pipe/tube (unspecified)	Plastic bottle	Tyre
5.0	0.0	1.0	0.0	0.0	4.0	0.0	0.0	2.0
10.0	2.0	2.0	0.0	0.0	0.0	0.0	1.0	1.0
15.0	0.0	0.0	17.0	1.0	0.0	1.0	0.0	2.0
20.0	0.0	0.0	12.0	0.0	0.0	0.0	0.0	0.0
25.0	1.0	0.0	1.0	0.0	1.0	0.0	0.0	0.0
30.0	0.0	0.0	2.0	1.0	1.0	0.0	0.0	1.0

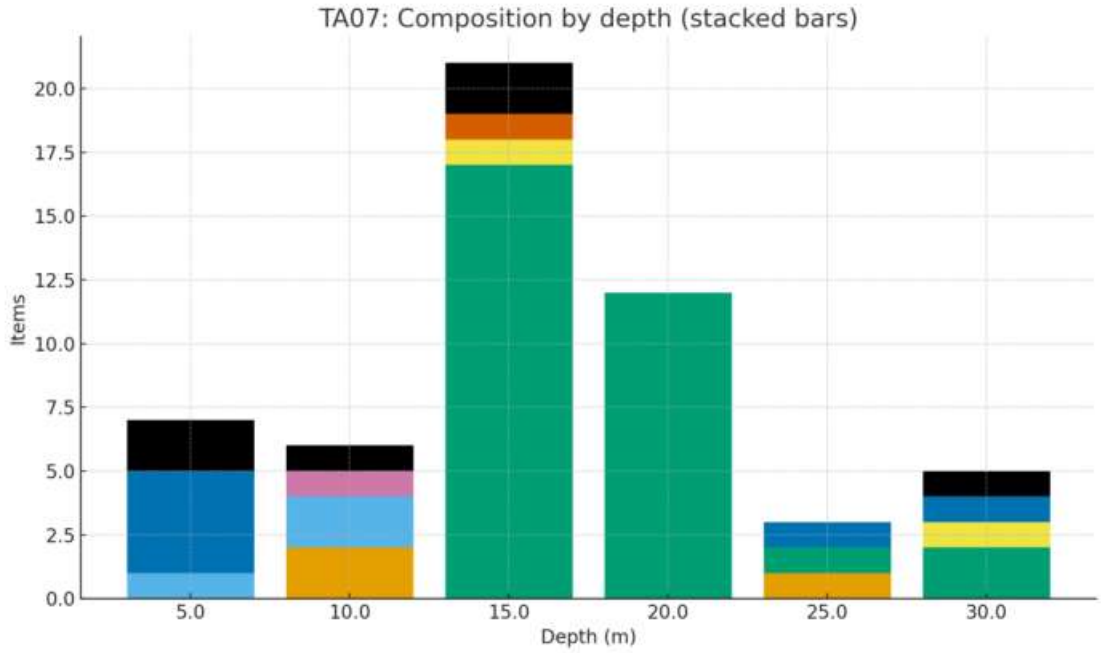


Figure 3 44: TA07 — stacked-bar composition by depth showing the relative mix of dominant and rare categories at each band.

3.7.3.8. Station: TA08

Table 3.60 summarizes TA08 with 88 items overall. Counts peak at 15 m (19 items) and are dominated by Tyre (23) and Metal fragment (21). The cross-tab clarifies which types drive the depth pattern and where targeted removal would be most efficient. Figure 3.45 builds on the data

in Table 3.60 by illustrating composition shifts within depth bands. Bands around the peak depth include both dominant and rare categories, providing practical guidance for divers when choosing suitable handling methods and removal tools.

Table 3 60*:* TA08 — depth × standardized category counts (items per band).

Depth (m)	Fishing gear - rope	Glass bottle	Metal can	Metal fragment	Metal rod/beam/plate	Other/Unknown	Plastic bottle	Tyre
5.0	1.0	0.0	1.0	6.0	1.0	2.0	1.0	0.0
10.0	0.0	0.0	1.0	0.0	0.0	2.0	2.0	11.0
15.0	0.0	1.0	7.0	3.0	0.0	0.0	0.0	8.0
20.0	0.0	0.0	2.0	6.0	5.0	0.0	0.0	4.0
25.0	0.0	0.0	0.0	5.0	0.0	2.0	6.0	0.0
30.0	0.0	0.0	1.0	1.0	0.0	9.0	0.0	0.0

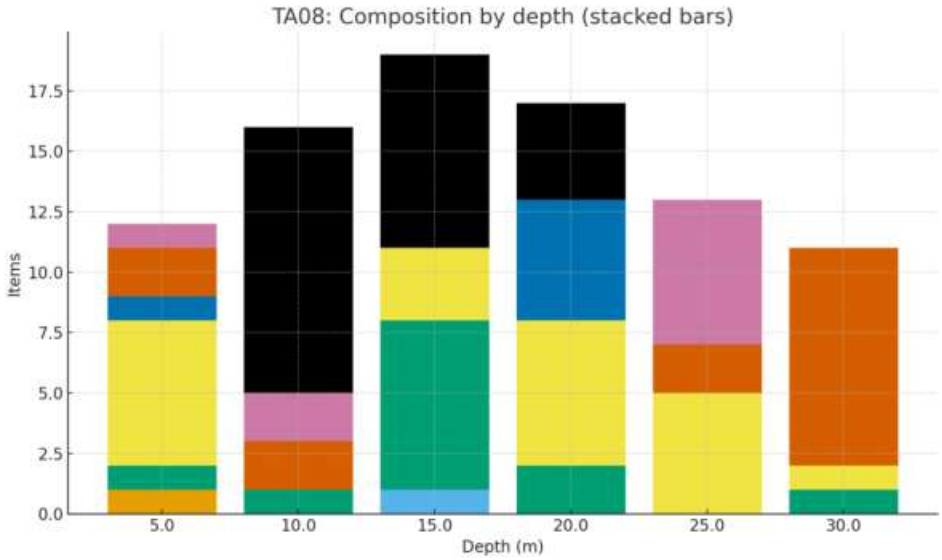


Figure 3 45: TA08 — stacked-bar composition by depth showing the relative mix of dominant and rare categories at each band.

3.7.3.9. Station: TB01

Table 3.61 summarizes TB01 with 52 items overall. Counts peak at 15 m (14 items) and are dominated by Metal fragment (12) and Metal rod/beam/plate (11). The cross-tab clarifies which types drive the depth pattern and where targeted removal would be most efficient. Figure 3.46 expands on the data in Table 3.61 by illustrating composition shifts within depth bands. Bands

near the peak depth include both common and rare categories, offering guidance for divers on safe handling practices and the selection of appropriate removal tools.

Table 3 61: TB01 — depth × standardized category counts (items per band).

Depth (m)	Fishing gear - rope	Metal can	Metal fragment	Metal rod/beam/plate	Other/Unknown	Pipe/tube (unspecified)	Plastic bottle	Plastic pipe/tube	Tyre
5.0	0.0	0.0	3.0	2.0	1.0	0.0	0.0	0.0	0.0
10.0	0.0	0.0	0.0	1.0	0.0	0.0	0.0	0.0	1.0
15.0	4.0	1.0	3.0	4.0	1.0	0.0	0.0	1.0	0.0
20.0	3.0	1.0	1.0	0.0	2.0	0.0	3.0	0.0	1.0
25.0	2.0	0.0	2.0	3.0	1.0	0.0	1.0	0.0	0.0
30.0	1.0	0.0	3.0	1.0	2.0	1.0	2.0	0.0	0.0

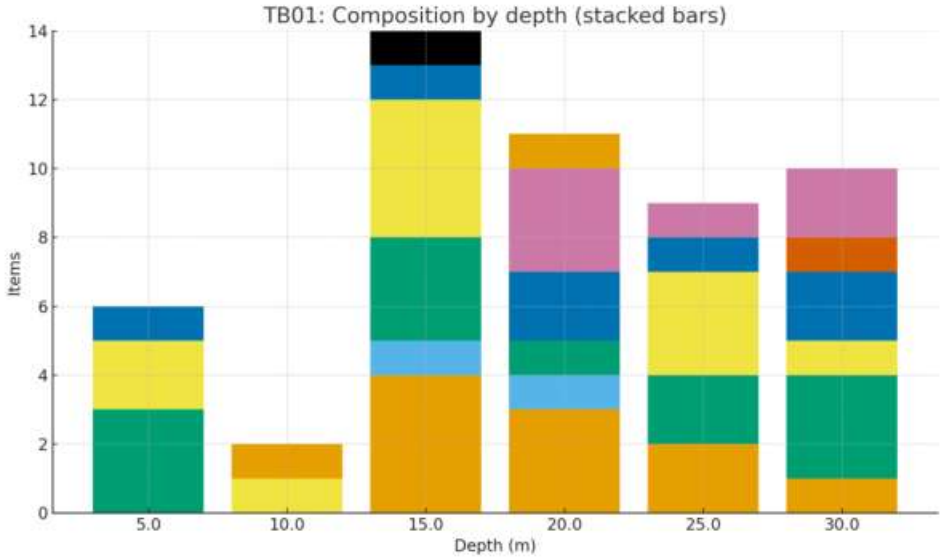


Figure 3 46: TB01 — stacked-bar composition by depth showing the relative mix of dominant and rare categories at each band.

3.7.4. Overall Status of Marine Litter Assessment

The combined dataset reveals a coherent depth structure and a strongly skewed composition that together define the character of seafloor litter in the investigated area. Totals and variety peak in the mid-profile (15–20 m), where two processes intersect: light items arriving from the shallow belt are still present, while heavier objects have settled and begin to dominate. This overlap produces both a numerical maximum and the highest diversity, as indicated by the richness and Shannon profiles. The shallow end of the profile is more selective, shaped by repeated

reworking and export of buoyant plastics until they snag; the deeper end becomes progressively simpler, retaining tyres and metalwork that are slow to move once lodged. The material balance supports this view: metal and rubber are the largest classes overall, with plastics forming a persistent but secondary signal.

Across stations, totals are unevenly distributed—few hotspots carry much of the load. Yet the differences are not only in size but also in mix. The Bray–Curtis-style contrasts embedded in the per-station tables and figures show that hotspots are compositionally distinct rather than scaled-up versions of low-load stations. In practice this means that the same depth band can look different from one station to the next: at one location tyres and rods dominate; at another, the same band contains more cans and rope. The standardised category set makes these contrasts explicit and repeatable. The rank–abundance pattern further clarifies the structure: a small head of common categories explains much of the dataset while a long tail of rare types persists across depths and stations. The Hill numbers and evenness indicators are consistent with this picture; where totals are high, dominance tends to increase and effective diversity (N2) falls, showing that a few categories account for most of the count.

The ANOVA tests align with these visual impressions. In the factorial model, the standardised category set explains the greatest share of variation, confirming the head–tail structure. Depth is also significant, reflecting the vertical sorting of items, and station differences are detectable even when depth and category are accounted for. The one-way tests reinforce this reading from a simpler angle: there are differences among stations, among depth bands, and—most strongly—among categories. Because the design is unbalanced and the response is a count, these tests are interpreted as directional evidence rather than as strict inference; nevertheless, the agreement between the statistics and the figures gives confidence in the underlying patterns. Two methodological points qualify the interpretation. First, results are presented as counts rather than densities because transect area and visibility estimates were not provided. Counts are well suited to describing structure and prioritising future observations, but they cannot be compared directly to area-based benchmarks. Second, classification inevitably involves uncertainty where descriptions are ambiguous. The standardisation used here prefers clarity over speculation by assigning such cases to an “Other/Unknown” class. The mapping table included in the appendix documents how terms were interpreted.

3.8. Benthic Habitat Mapping

The benthic habitat at the study area was mapped using data analyzed from the ROV quick survey that was conducted at 54 sampling stations and the reef check data, which quantitatively estimate various benthic habitat components as it has been explained before (section 3.2).

The analysis of the videos collected by the ROV showed that the seabed nature varies from area to area, where sometimes, the scanned location is coral reef area, while in others can be sandy area. Other types of bottom habitat were seagrass meadows or mixed coral reefs and sandy bottoms. The final habitat map is presented in figure 3.47.

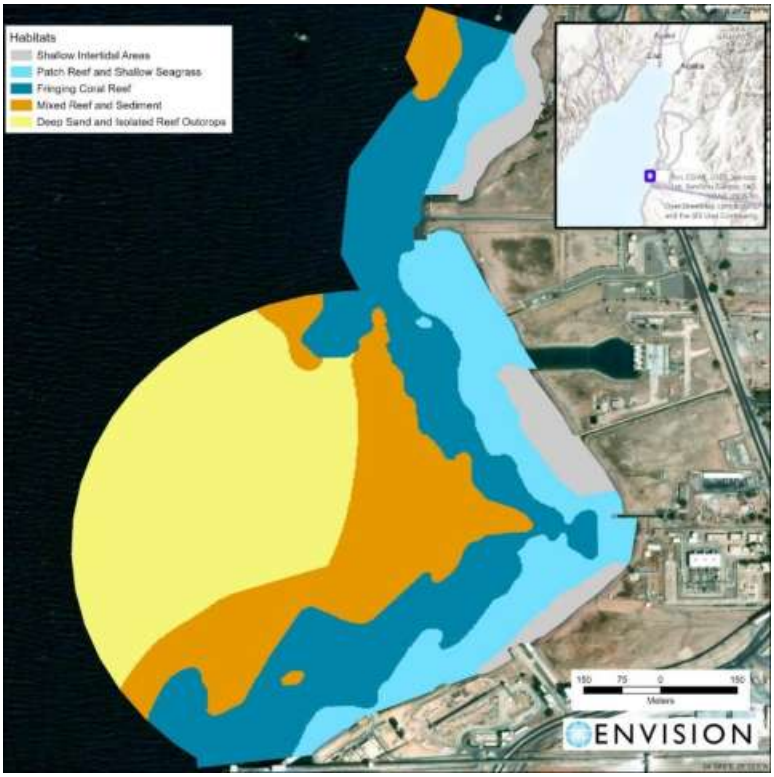


Figure 3 47: Qualitative habitat map of the seabed at the study site based on data collected by ROV.

A more detailed quantitative description of the seabed was achieved through analysis of data collected from the reef check survey, in which various seabed components were quantified as previously described (Section 3.2). The survey involved conducting point-intercept studies at nine stations, each comprising six depth levels (Fig. 3.2). The survey extended to a maximum depth of

30 m; therefore, the resulting maps represent seabed features down to this depth. The findings indicated that the shallow areas at the first three stations were predominantly sandy, whereas the next three stations were mainly covered by seagrass meadows. In contrast, the deeper sections were characterized by a higher density of coral cover, which in some locations exceeded 80% of the seabed surface (Fig. 3.48). Damaged coral reef distribution was concentrated in two main areas The first one is located close to new phosphate jetty, while the second one is located close to the gas ship (Fig. 3.49).

Seagrass meadows are more c on concentrated at the shallow depths in stations TA04-TA08 and TB01 station (Fig. 3.50). The sandy bottoms are distributed in all shallow depths in all stations with varying percentages (Fig. 3.51).

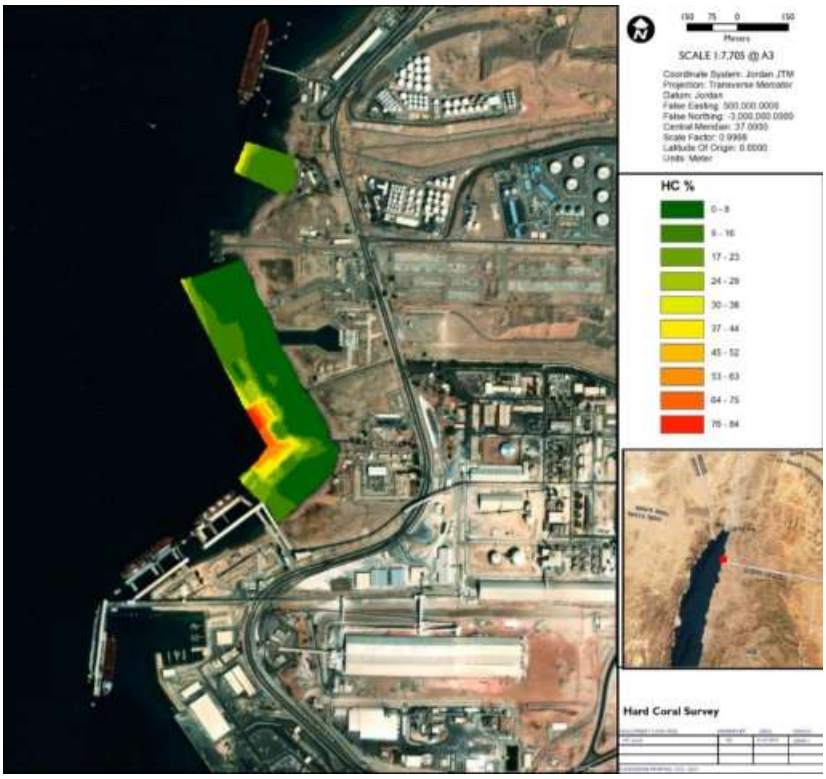


Figure 3 48: Map of hard coral distribution in the study area.

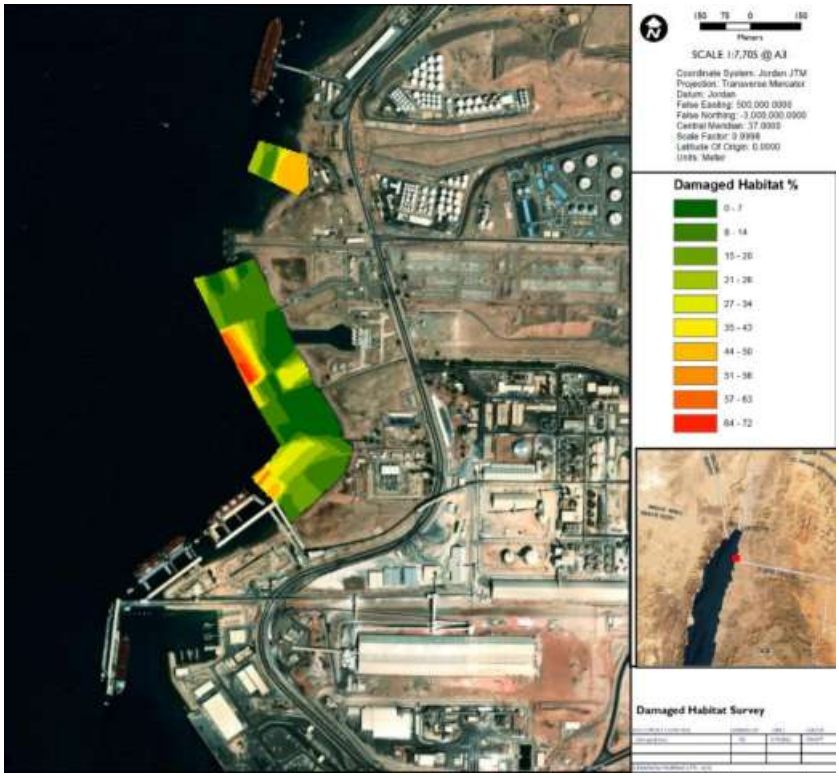


Figure 3 49: Map of damaged coral reef areas at the study area.

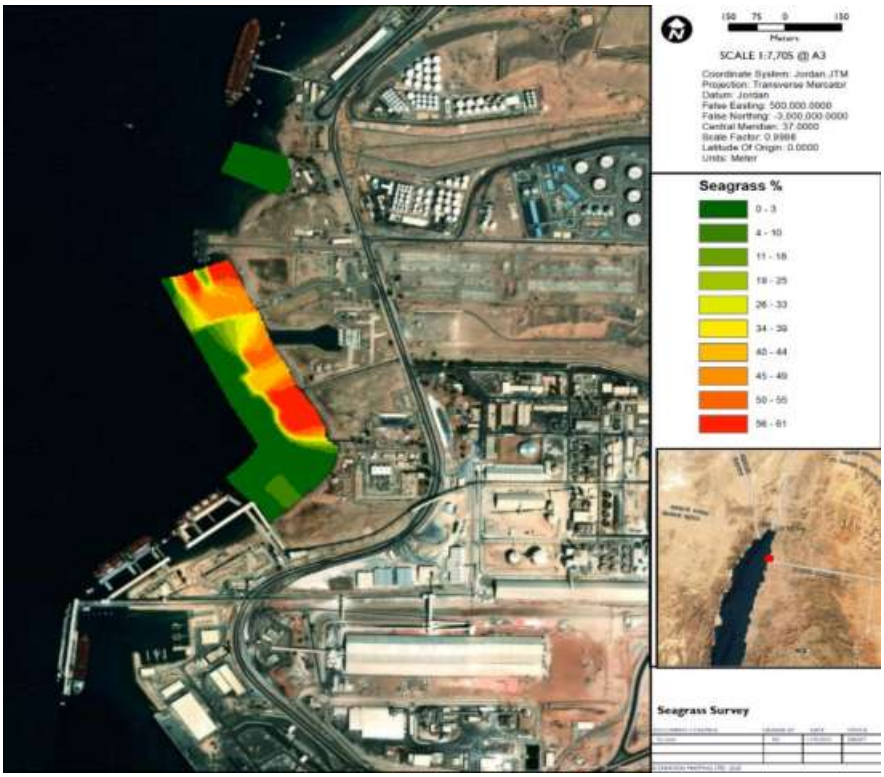


Figure 3 50: Map of seagrass distribution in the study area.

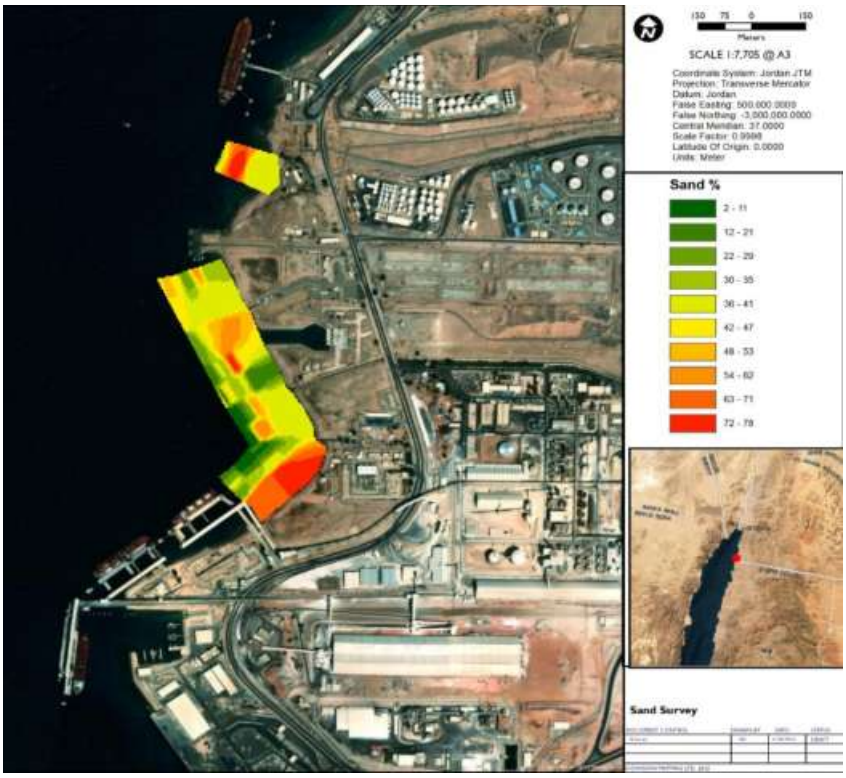


Figure 3 51: Map of sandy beds distribution in the study area.

Maps showing the distribution of the identified coral families and genera, in addition to the number of coral colonies encountered in the study area were produced to show their distribution among the different specific sites with the study area (Figures 3.52-3,54). The detailed result was presented in the coral taxonomy section above.

In addition to the coral taxa distribution, the solid wastes encountered during the benthic habitat survey was analyzed and their distribution in the study area was mapped (Figure 3.66).

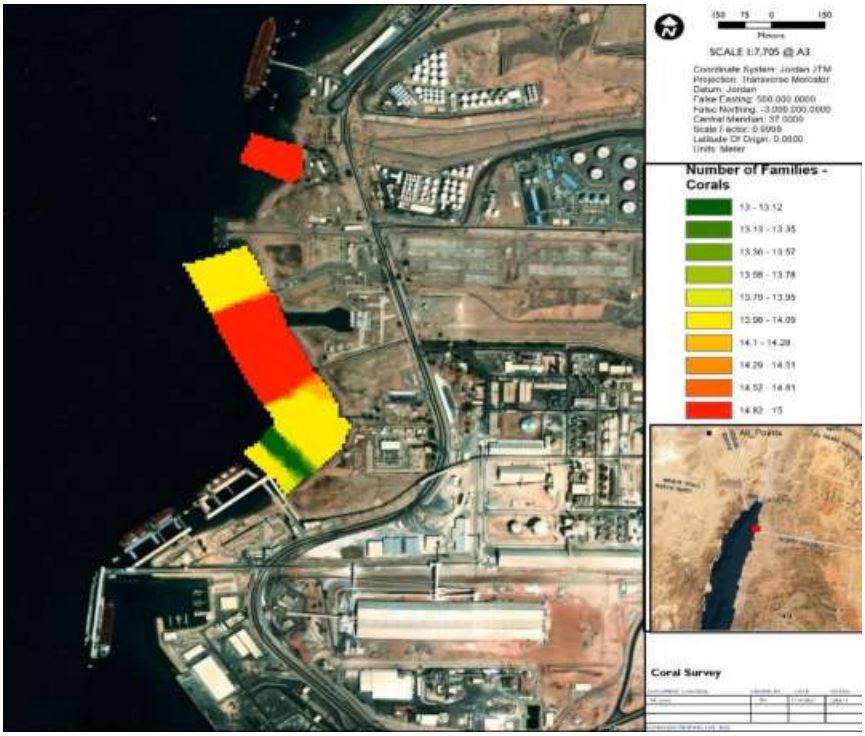


Figure 3 52: Mapping of the coral families' distribution in the study area.

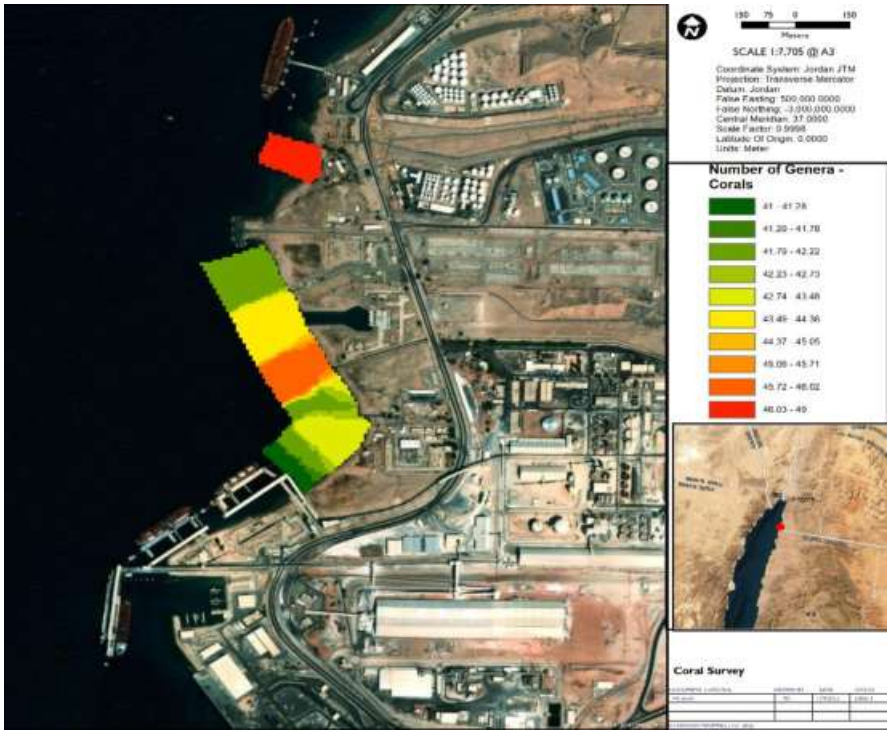


Figure 3 53: Mapping of the coral Genera distribution in the study area.

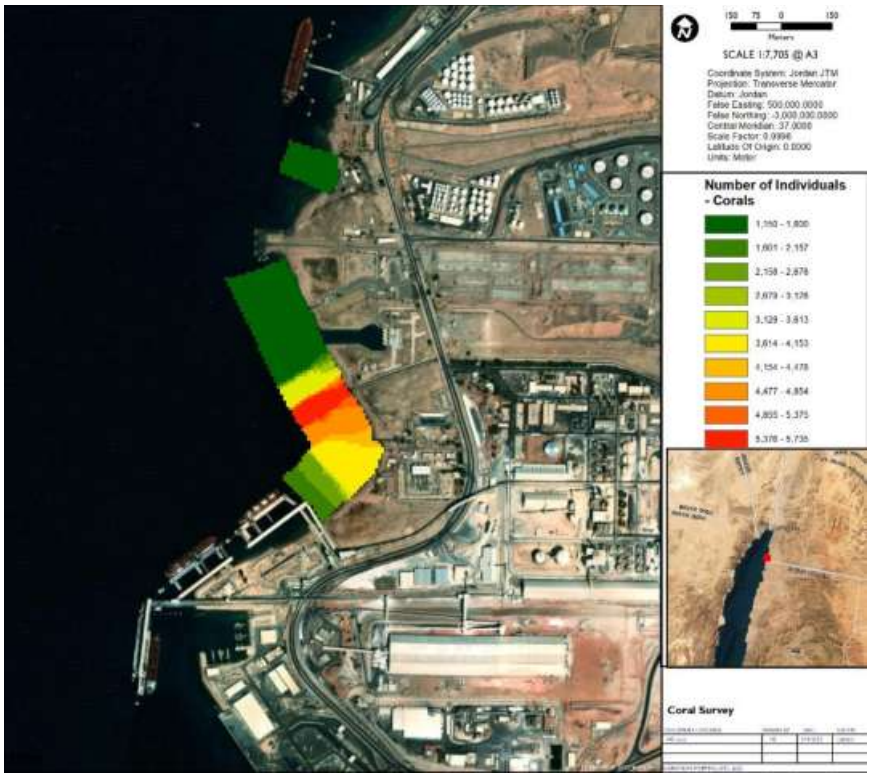


Figure 3 54: Mapping of the distribution the number of coral colonies in the study area.

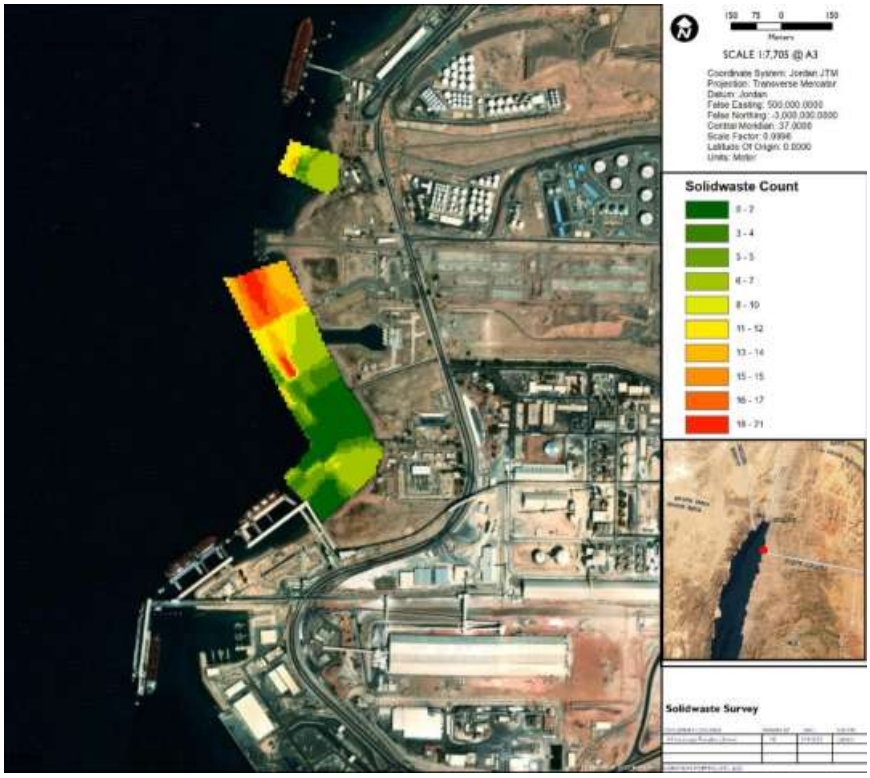


Figure 3 55: Mapping of the distribution the number of coral colonies in the study area.

4. Concluding Remarks

4.1. Plankton Survey

This study found that coastal plankton communities are shaped by local hydrography, shoreline features, and reproductive cycles. Small copepods (*Paracalanus parvus*, *Oithona nana*, *Clausocalanus furcatus*) dominated across stations, forming a stable trophic core resilient to environmental fluctuations.

Stations S15–S17 showed high abundances due to gastropod larvae, indicating spawning or larval retention zones, while S1–S2 reflected stable, mixed waters, and S12–S18 showed offshore influence with sparse communities.

Diversity was generally moderate to high, revealing three main assemblages along a gradient from chaetognath-rich transitional waters to meroplankton-dominated nearshore areas. The results demonstrate a dynamic balance between stability and variability, with copepods ensuring continuity and larval pulses driving short-term shifts. This work provides a strong baseline for future monitoring of ecological and climate-driven changes in coastal plankton dynamics.

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Marine Habitats Baseline Report

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1. Executive Summary

This report presents the results of the marine habitats baseline survey for the Aqaba–Amman Water Desalination and Conveyance (AAWDC) Project in the northern Gulf of Aqaba, Jordan. The purpose of the baseline is to characterise marine habitats and water and sediment quality within and around the proposed marine development footprint, and to provide an evidence base for the Environmental and Social Impact Assessment (ESIA), Critical Habitat Assessment (CHA) and Biodiversity Management Plan.

The Area of Survey covers the nearshore embayment and adjacent deeper waters, spanning intertidal rock platforms, shallow subtidal zones, fringing reefs, mesophotic reef slopes and deeper soft sediments. The survey programme combined diver transects, remotely operated vehicle (ROV) footage, water column profiling and sediment sampling. This mixed-method approach was designed to map the distribution and condition of key benthic habitats, quantify coral and seagrass cover across depth gradients, describe infaunal and epifaunal communities, and assess water quality and sediment characteristics relevant to the design and placement of marine infrastructure.

Results show a heterogeneous but coherent habitat mosaic. The shallow intertidal and upper subtidal zones are dominated by rocky platforms with patchy coral colonies, turf and macroalgae, and characteristic invertebrates such as urchins, giant clams and sea cucumbers. Seagrass habitat is most abundant in shallow northern parts of the bay, forming classic nearshore meadows that contribute to primary production, nursery function and water-quality regulation. With increasing depth, habitats transition through mixed reef and sediment into mesophotic coral communities on the reef slope, and finally to deep sandy seabeds with scattered reef outcrops beyond 70 metres.

Coral communities show a clear depth-related pattern. Very shallow zones support relatively low coral cover on mobile or sediment-influenced substrates. Coral cover increases to 30 metres, reaching locally high values where stable hard substrate and moderate light coincide, with a diverse assemblage of branching, massive and plating growth forms. Below about 35 metres, coral abundance declines as light levels fall, although mesophotic corals remain present into the 50-70 metre range. Seagrass cover is concentrated in shallow, sheltered areas and diminishes with depth and exposure. Overall, the distribution of coral and seagrass broadly aligns with regional patterns previously used to define Critical Habitat in the northern Gulf of Aqaba.

Water column data indicate a well-oxygenated, chemically stable system with generally low turbidity and relatively deep euphotic depths offshore, and more variable conditions in nearshore pockets influenced by local disturbance and sediment resuspension. Sediment samples show a mix of grain sizes and organic content, supporting a benthic fauna that reflects the transition from reef-influenced assemblages to more typical soft-bottom communities. Some localised anthropogenic inputs are evident, including debris such as tyres and metal objects, particularly near existing infrastructure, but there is no indication of widespread degradation, coral bleaching or disease at the time of survey.

In terms of Critical Habitat, the baseline confirms the importance of the shallow reef–seagrass mosaic at regional scale, and refines the location of features of particular concern. Very shallow zones with high densities of protected or restricted-range species (such as giant clams) should be regarded as

Critical Habitat and avoided or stringently protected. Deeper mixed reef and sediment habitats between roughly 35 and 60 metres, where mesophotic corals extend the functional reef system downslope, are also sensitive to disturbance and need to be factored into impact avoidance, infrastructure siting and mitigation design. The baseline provides the spatial detail needed to link these values explicitly to the proposed layout of intake and outfall structures and associated corridors.

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The survey provides a robust foundation for understanding marine habitats and biodiversity in the study area, while recognising some remaining limitations. Depth coverage was constrained to diver surveys to 30 metres and ROV deployment to approximately 80 metres, so deeper habitats and certain faunal groups are only partially characterised. Effort was focused inside the bay, with more limited coverage of outer reef slopes that may differ in exposure and community structure, and the work represents a single seasonal sampling event. ROV imagery also restricts taxonomic resolution for small or cryptic taxa. These factors should be considered when interpreting the baseline and can help guide priorities for any future survey, imaging and geomorphological or substrate mapping work.

2. Introduction

The Aqaba–Amman Water Desalination and Conveyance (AAWDC) Project is being developed to address Jordan's chronic water scarcity by producing around 300 million cubic metres of potable water per year from the Gulf of Aqaba and transferring it to Amman via a new transmission system. The marine components include a seawater intake, brine and other discharges, and associated pipelines and infrastructure within a small, heavily used section of Jordan's 27–30 km coastline at Aqaba. This coast is environmentally sensitive, with a very narrow shelf, fringing coral reefs, steep reef slopes dropping rapidly to deep water, and existing industrial and utility infrastructure including a gas pipeline corridor and a phosphate loading terminal.

The purpose of the marine habitats baseline survey is to establish a robust, site-specific description of the benthic habitats, water quality, and associated biological communities within and around the proposed development footprint. Specifically, the survey is designed to map the distribution of key habitat types (including coral reef, seagrass and mixed reef-sediment assemblages), quantify habitat condition and structure using standardised diver transects, characterise surficial sediments and infauna, and document the prevailing water column properties and plankton communities. The work is intended to generate georeferenced spatial products and a structured dataset, with full metadata, that can be used both for impact assessment and for future monitoring of construction and operational effects. The survey design and objectives were developed to be consistent with lender requirements and with the marine biodiversity data needs identified in the Critical Habitat Assessment (CHA).

The Area of Survey (AoS) (Figure 1) is located around a semi-enclosed bay on the Jordanian shore of the northern Gulf of Aqaba, within the broader ESIA marine Area of Influence. It encompasses the nearshore reef flat, the fringing reef slope, adjacent mixed reef–sediment zones and deeper soft-sediment areas that could reasonably be affected by construction and operational discharges. The seabed within the AoS mirrors the typical Jordanian configuration of a narrow reef-fringed shelf falling steeply from about 20–45 m into deeper water, with a gas pipeline running through a sandy valley and physically degraded reef and rubble associated with the phosphate terminal to the south.

This Marine Habitats Baseline Report forms one of the core technical inputs to the project Environmental and Social Impact Assessment (ESIA). It provides the primary description of seabed habitats and associated water and sediment quality against which the significance of project impacts on marine receptors will be evaluated. The methods and survey coverage are aligned with, and complement, other ESIA baseline chapters, including bathymetry and physical oceanography and plankton, which together provide the physical and ecological context for interpreting habitat condition, connectivity and sensitivity to changes in hydrodynamics, water quality and entrainment. This report also updates and refines information collected for the 2022 ESIA, providing higher-resolution mapping and quantitative data focused on the current project layout and the present condition of the receiving environment.

The survey and this report are closely linked to the Marine Critical Habitat Assessment (CHA). At lender level, the CHA is the mechanism through which biodiversity values that qualify as Critical Habitat or Priority Biodiversity Features are identified, using regional datasets, literature, previous surveys and consultation with a Marine Expert Group. The CHA defines Ecologically Appropriate

Areas of Analysis (EAAAs) at the scale of the Gulf of Aqaba for wide-ranging taxa and at smaller depth- and habitat-based scales for corals, seagrass and associated species. Within that hierarchy, the AoS is one of the key locations where project-specific field data are required to confirm the presence, status and spatial extent of those values. The marine baseline survey was explicitly designed in consultation with the CHA team to fill identified data gaps and to generate spatially explicit habitat and condition data that can be incorporated into subsequent iterations of the CHA. In turn, the CHA outcomes on Critical Habitat and Priority Biodiversity Features provide the framework for interpreting the baseline results in terms of sensitivity, guiding the focus of the ESIA impact assessment, application of the mitigation hierarchy and development of the Biodiversity Management Plan and any future mitigation planning.



Figure 1.
Project Area of Survey and potential development plans

3. Survey Planning and Implementation

3.1. Survey Planning

The baseline marine environmental survey followed a structured plan to characterise existing conditions across the site and establish reliable data for future comparison. The Area of Survey (AoS) was segmented into 4 zones: A; B1; B2; and C (Figure 2**Error! Reference source not found.**). Zone A is the area likely to be directly influenced by any future development, Zones B1 & B2 are peripheral zones which may be influenced by indirect impacts and zone C is deeper waters which may be affected by any discharge.

Fieldwork focused on physical, chemical and biological parameters, with a combination of remote and in-water methods used to build a detailed understanding of benthic habitats, water quality and sediment conditions.

Initially a survey programme which incorporated the collection and interpretation of multibeam bathymetry was planned. Security, customs and shipping limitations restricted the use of a multibeam system therefore this method was abandoned, and an alternative approach was implemented which relied on publicly available and historic bathymetry data being employed to structure the survey efforts. In addition, a rapid screening survey was implemented to collect data over the project area in a structured manner to provide information on the range and types of habitat present.

Drop-down video was deployed at predefined locations to obtain broadscale visual information on seabed features and habitat types. This provided efficient coverage of the area and helped identify key habitat zones, substrate characteristics and notable biological communities. Video footage was logged with position, depth and time, and later reviewed by experienced analysts. The video system available to the project was limited in the camera quality, underwater lighting and manoeuvrability. The ROV umbilical was planned to be able to survey in excess of 100m depth but equipment failure resulted in a depth of 80m being the survey limit.

To supplement the video data, trained scientific divers carried out quantitative transects in representative habitat areas at 5 metre depth intervals. Divers recorded benthic cover abundance and percentage cover along measured transects and took still photographs for coral genera identification and quantification. This provided detailed ground-truthing and helped detect subtle ecological patterns that were not always evident in remote footage.

Water samples were collected at surface, mid and maximum depths at selected stations, with surface and bottom samples, or surface only samples. Plankton samples were collected at each station. The samples were analysed for temperature, salinity, dissolved oxygen, pH, turbidity and euphotic depth plankton composition. Data were used to assess water quality and plankton communities.

Benthic sediment samples were taken using a grab sampler. Sediment was processed for grain size, contaminant concentrations and infaunal communities. These measurements are used to evaluate habitat quality and potential anthropogenic inputs and provided a baseline for monitoring future change.

All operations followed relevant Health and Safety protocols. Divers worked under a qualified dive supervisor to an approved diving project plan, and all lifting operations and vessel activities were risk assessed. Weather and sea state were monitored throughout, with work suspended when conditions became unsafe.

Security consents were sought and approved for all survey operations with some on-site restrictions in place due to position of existing infrastructure projects such as the regassification plant and vessel within the survey area. Where required, adaptation to survey plans were made by on-site surveyors to accommodate any restrictions to operations.

A daily progress report was prepared each survey day. The report summarised the activities completed, locations sampled, any deviations from planned activities, equipment performance and health and safety observations. It also outlined work planned for the following day and highlighted any issues requiring attention, ensuring clear communication and consistent delivery of the survey objectives.

There are several existing infrastructure projects which are adjacent to or within the area of survey (AoS), these are shown in Figure 2.**Error! Reference source not found.**

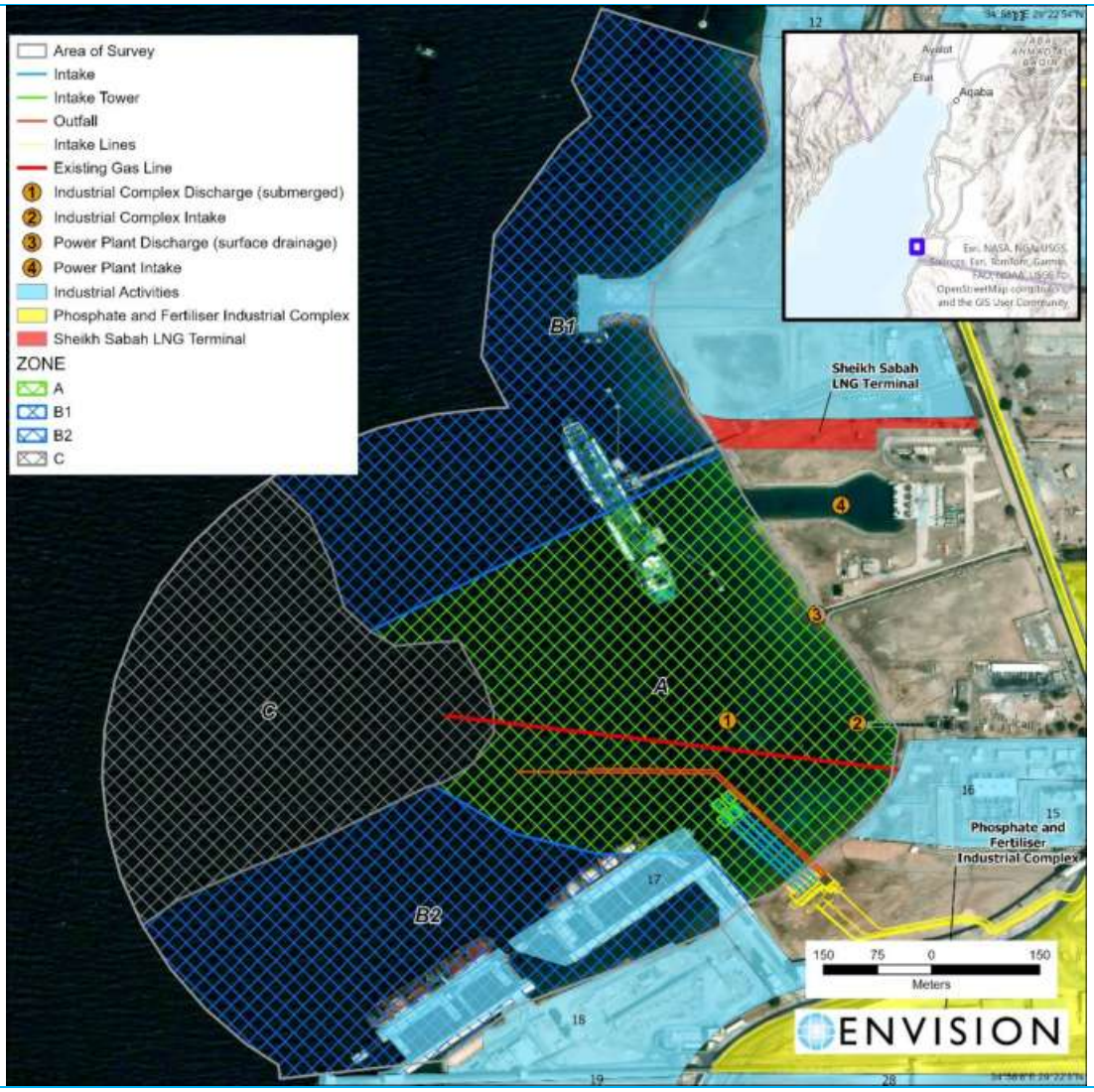


Figure 2.
Existing infrastructure projects, including the gas pipeline which transects the offshore development site

3.2. Rapid Screening Survey

A rapid screening survey of benthic habitats within the designated Area of Survey (Figure 3), using remotely operated vehicle (ROV) technology to acquire high-resolution imagery, has been undertaken (24th September – 5th October, 2025) with the primary aim of identifying and classifying major seabed types and to generate point sample habitat distribution maps to inform subsequent detailed sampling and environmental assessments. Over a five-day period, 41 ROV deployments were conducted within the survey area to provide good spatial coverage and data confidence. The survey supports planning and impact evaluation related to the proposed desalination pipeline and outfall infrastructure.

At each sample location, the survey vessel approached and positioned itself so that wind and tidal conditions caused it to drift away from the deployed camera system. This setup helped minimize interference and ensured the camera remained undisturbed during operation. Before deployment, a brief video recording—approximately five seconds long—was made of a 'Take Board', which displayed the station number or sequential take number along with the time and date of recording.

The camera system was then lowered slowly to the seafloor to reduce sediment disturbance and preserve underwater visibility. To maintain accurate spatial positioning between the vessel and the camera, the umbilical or tether length was limited to no more than twice the water depth. This constraint ensured the camera remained within a predictable spatial range relative to the vessel.

Once on the seafloor, the camera system drifted over the substrate, with its direction of travel determined by site-specific conditions such as tidal flow or wind on some occasions, and the vessel was carefully managed to prevent the umbilical from becoming fouled or entangled. During each deployment, continuous video footage was recorded for approximately five minutes to provide a clear visual record of the seabed and substrate type.

Water depth, GPS coordinates and timestamps were fixed at both the start and end of each deployment, and a continuous log of positional data was maintained throughout. After the footage was captured, the camera system was retrieved, and the procedure was repeated at subsequent sample stations.

Throughout the survey, the survey team from the Jordan Marine Science Station monitored the video feed in real time and reviewed it on-site to confirm image quality and identify any significant seabed features. The survey team also kept a detailed video log for each deployment, recording position and depth.

Review of video footage was undertaken and used to identify stations suitable for more detailed semi-quantitative analysis, with a focus on deeper water locations where continuous high resolution footage were collected.

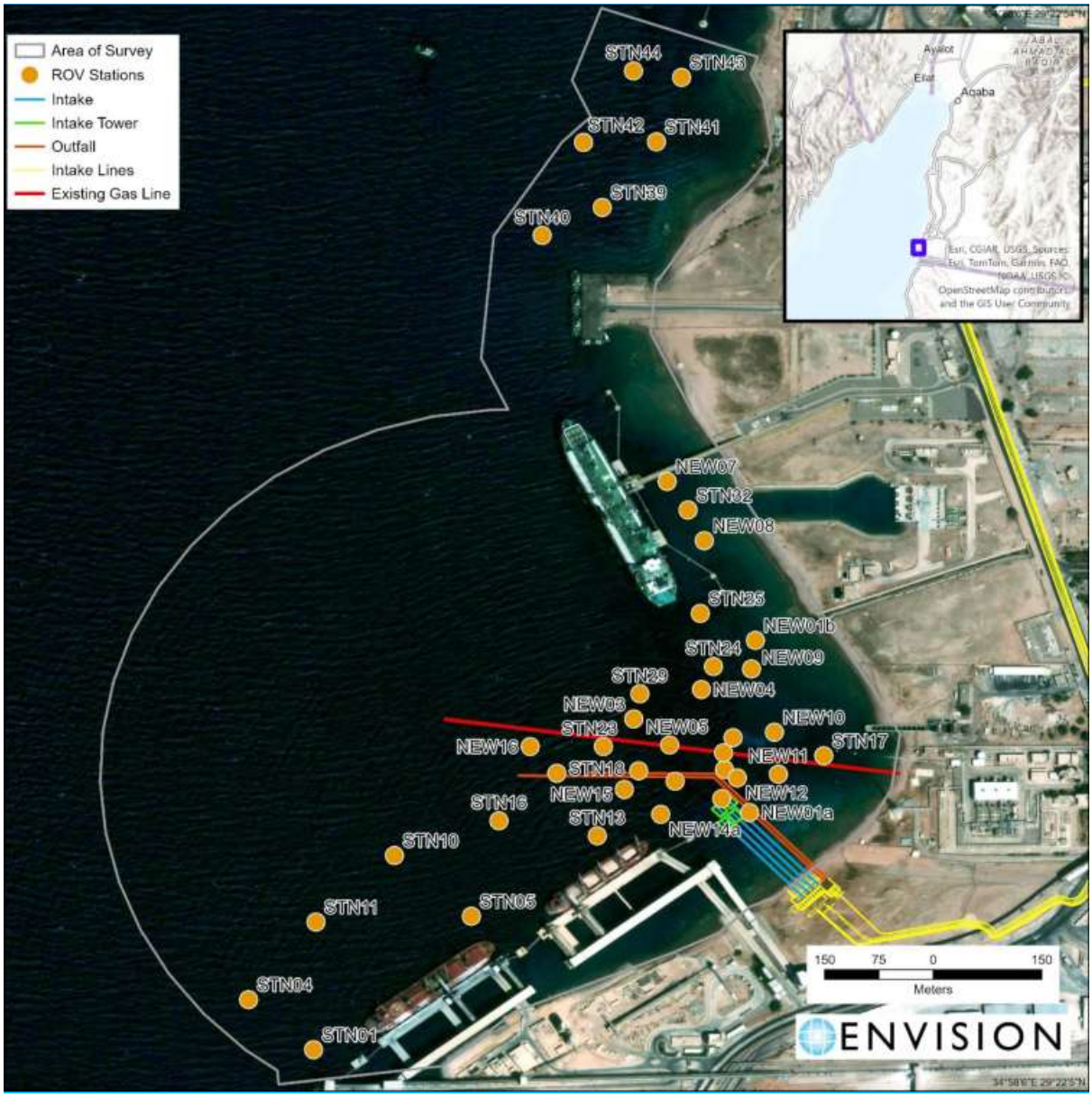


Figure 3.
Sample stations which were surveyed during the Rapid Screening Survey

3.3. Diver Survey

Coral and benthic communities were surveyed using scuba along fixed 50 m transects established at standardised depth intervals. Nine stations were surveyed (TA01-TA08 and TB01) (Figure 4). At each station, transects were placed at nominal depths of 5, 10, 15, 20, 25 and 30 m where seabed topography allowed.

Within the AoS, transects were positioned to span zone A. Start and end points of each transect were recorded with GPS at the surface and logged with depth and time. A second set of transects (TB01) was established at a reference station located to the north of the bay, following the same depth stratification and field procedures to provide a comparative baseline.

At each depth, a 50 m transect tape was laid along the seabed following the natural contour, with minimal disturbance to the substrate. After allowing any suspended sediment to settle, benthic substrate was recorded at 0.5 m intervals along the tape using a point-intercept method, giving 100 points per transect. At each point, the diver noted the primary substrate type directly beneath the tape according to a predefined classification (e.g. hard coral, soft coral, macroalgae, coralline algae, rubble, sand, rock or other). Data were recorded on underwater slates for later transcription to digital format.

In addition to the point-intercept data, a belt search was carried out along each transect to quantify coral assemblages. The survey belt extended 3 m on either side of the tape, giving a 6 m wide corridor and a sampled area of 300 m^2 per transect. Moving at a constant pace, divers recorded all coral colonies encountered within the belt. For each colony, a photographic record of was taken using an underwater digital camera, to allow later identification to genus level and abundance of each genus to be recorded. All transects were surveyed by pairs of trained scientific divers. One diver was responsible for maintaining the transect line and recording substrate points, while the second diver focused on the belt-transect coral census and photography.

These methods provided a consistent, depth-stratified dataset of benthic substrate composition, coral taxon abundance and photographic collection from both areas of potential influence and a reference station within the AoS.



Figure 4.
Proposed diver transects for the AoS

3.4. Water Sampling Survey

Water quality was assessed in accordance with the approved water sampling plan. Eighteen fixed stations were established within the AoS (Figure 5). The layout was designed to characterise conditions at the proposed outfall, within the mixing zone and mid-field, and at far-field / background locations along the shoreline.

The mixing zone is the area closest to a discharge point where effluent first enters the receiving waters and actively mixes with ambient seawater. Within this zone, the plume is most concentrated, dilution is still incomplete, and some water quality parameters may temporarily differ markedly from background conditions.

The mid-field is the area beyond the immediate mixing zone where the plume has undergone substantial dilution but remains detectable as a change from background conditions. Monitoring in this

zone assesses how quickly water quality and ecological conditions trend back towards ambient levels along the shoreline.

Far-field or background locations are shoreline areas positioned sufficiently far from the discharge and prevailing plume pathway that they are not measurably influenced by the discharge. These sites provide reference or ambient conditions against which changes in the mixing zone and mid-field can be compared.

At stations 1, 2, 3, 5, 9 and 10, full-depth vertical profiles were collected by obtaining discrete samples at surface, mid-water and near-bed depths. At stations 6, 8, 16 and 17, paired surface and bottom samples were taken to characterise stratification in the mid-field area. At nearshore stations 11, 12, 15 and 18, a single sample was collected at the surface or mid-water, depending on water depth and local mixing conditions.

Samples were collected from a survey vessel using pre-cleaned sampling equipment lowered to the target depths and transferred into pre-labelled containers. In situ measurements of basic physico-chemical parameters (for example temperature, salinity and dissolved oxygen) were made using a calibrated multi-parameter probe. Plankton samples were collected and preserved as required and transported to an laboratory for taxonomic identification.



Figure 5.
Water & plankton sample stations identified and sampled

3.5. Sediment Sampling Survey

Benthic sediment samples were collected at eighteen stations (G01–G18) to characterise surficial sediments for ecological and chemical assessment (Figure 6). Stations were selected based on review of ROV footage from the rapid screening survey, targeting clearly sedimented seabed while avoiding reef structures, large rocks and the pipeline exclusion zone. A reference station was included at distance from the proposed development area to provide comparative baseline data.

On arrival at each station, the seabed was verified from the vessel using a diver mask or glass-bottom viewer and, where available, an echosounder. If small coral patches or other unsuitable features were observed directly beneath the planned position, the station was relocated to the nearest suitable sediment patch within approximately 50 m. Once confirmed as suitable, a grab sampler was deployed to obtain surface sediment.

At each successfully sampled station, position, water depth, substrate type, date and time, and any deviations from the planned station position were recorded, and a photograph of the sediment sample was taken. Two grab samples were retained per station: one for infaunal analysis and one for chemical analysis, with preservation and handling following the receiving laboratory's standard procedures.

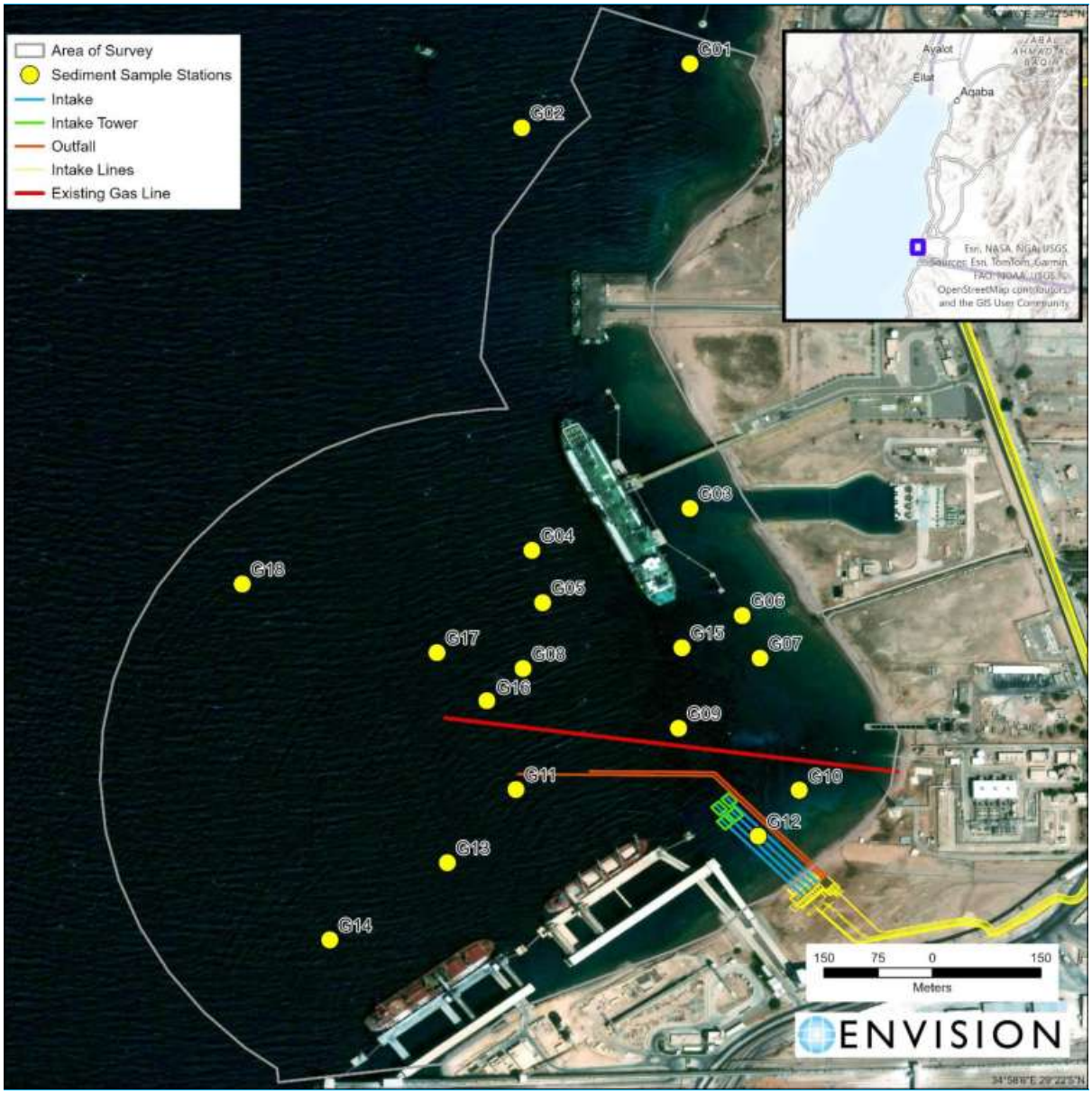


Figure 6.
Location of sediment sample stations

3.6. Intertidal Survey

A shoreline walkover survey was carried out from south to north along a 900 m coastal corridor, divided into eight stations (T1-T8). At each station, observations were made at three fixed points: about 100 m inland from the high-water line, at the high-water line itself, and at approximately 1 m water depth just offshore (Figure 7).

At every point, a standard set of parameters were recorded using visual assessment and simple classification. For the beach, width, slope, berms or erosion scars, sediment firmness, presence of vegetation or man-made structures, debris and any algae were described. Surface sediment was classified visually using a simplified Wentworth scale (sand vs gravel) and noting shells and organic content.

For the nearshore, surveyors waded or snorkelled around the ~1 m depth contour to assess reef presence and condition. At each location the following parameters were recorded; shoreline and seabed type, percent live hard coral, distance from shore and depth at which reef started, reef continuity (continuous flat vs patchy heads vs none), and simple health indicators: dead coral, bleaching, disease, dominant growth forms (massive/branching), soft corals, reef algae and key fauna such as urchins, giant clams and sea cucumbers.

GPS coordinates were logged for station starts and ends and a photographic record collected to document the conditions at each station.

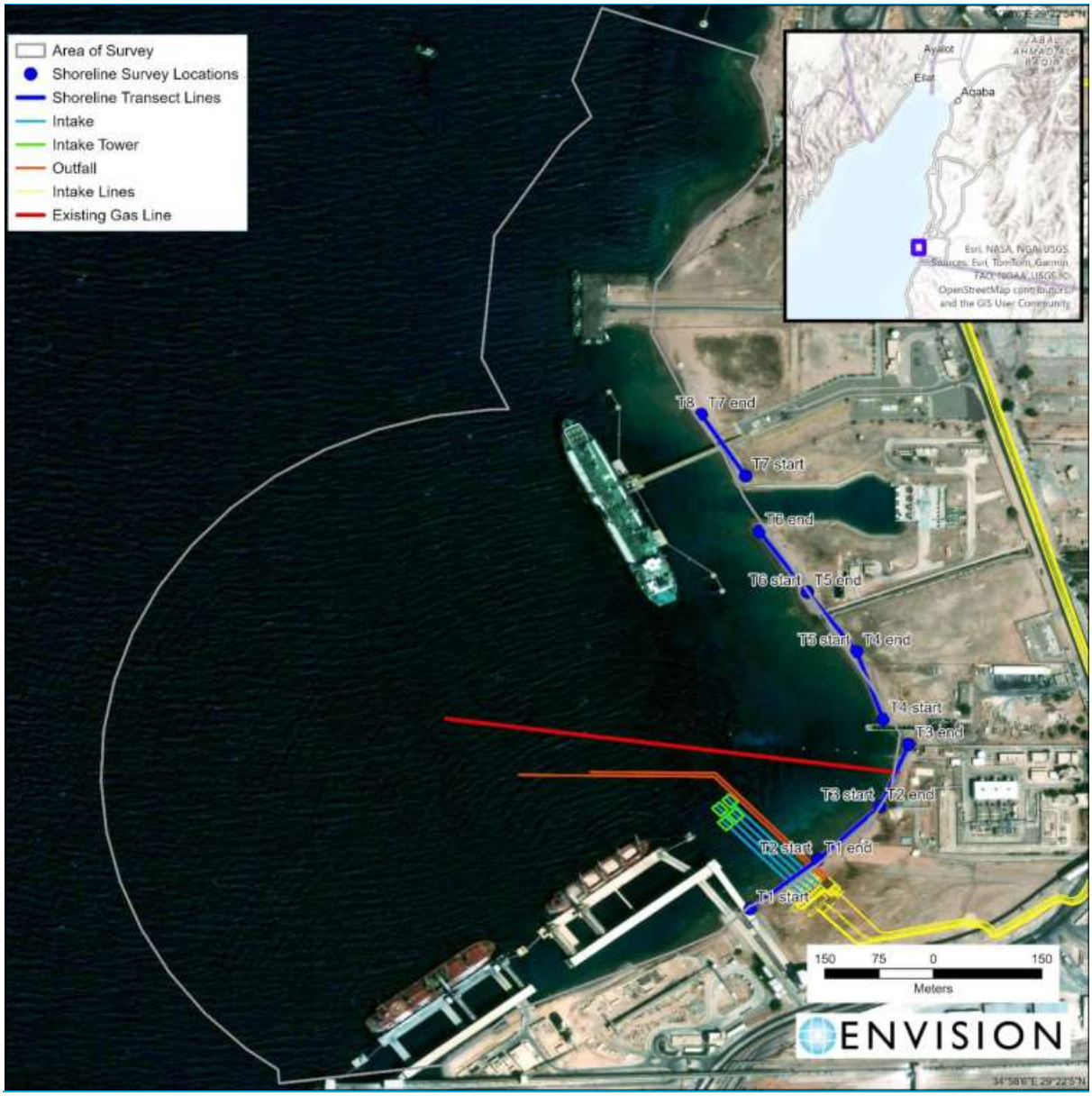


Figure 7.
Shoreline survey locations

4. Data Analysis & Interpretation

4.1. ROV Imagery Analysis

Analysts from Envision reviewed underwater video footage to characterise benthic habitats and quantify the relative cover of key biological and physical features. In the rapid screening stage, they examined all available video samples to assess overall image quality and to identify conspicuous habitat features, including coral reef, seagrass and broad-scale seabed topography. This initial analysis allowed the team to identify stations suitable for more detailed semi-quantitative analysis, focusing on deeper water locations where they had collected continuous, good quality footage.

For the selected stations, the team then carried out a structured, segment-based analysis. They divided each video into consecutive 30-second segments and reviewed the full duration of each recording. Within each segment, they visually estimated and recorded the percentage cover of hard coral, soft coral, sponges, algae, rock, sand, rubble and debris, using a consistent classification scheme. They allocated estimates so that the total cover across all categories in each segment summed to approximately 100%, representing the proportional composition of the seabed within the field of view.

To ensure data quality and consistency, the team applied an internal quality assurance process. A second analyst independently reviewed a subset of the footage and the corresponding annotations and checked the assigned habitat categories and percentage cover estimates. The analysts discussed and resolved any discrepancies and amended the dataset where necessary, resulting in a robust dataset suitable for subsequent analysis and reporting.

4.2. Benthic Interpretation

Benthic cover data were compiled from diver transects and ROV video transects. Diver data included percent cover for major benthic groups recorded at fixed depth intervals along each transect, supported by taxonomic observations. ROV stations provided percent cover estimates from annotated imagery at known coordinates and depths. Diver transect mid-points were used to assign spatial location to each depth stratum. All raw data tables were screened for formatting consistency, merged based on transect identifiers, and reshaped into sample-by-variable format prior to analysis.

Substrate classes were standardised to a common set of physical components (sand, rock and rubble), and biological components (hard coral, soft coral, sponge, algae, seagrass and other encrusting biota). Where needed, the similar fields were combined so that cover totals were directly comparable across datasets. The cover values were treated the as proportional estimates of seabed composition and were not adjusted or normalised further; comparisons therefore use the original estimated proportions rather than any re-weighted totals.

Habitat classifications were identified where a physical or biological component was clearly dominant. Coral reef habitat was identified where hard substrate was substantial (rock plus rubble at least forty

percent) and hard coral cover exceeded ten percent and was equal to or greater than soft coral and sponge cover.

This rule-based scheme ensures transparent and reproducible habitat assignment. It favours conservative thresholds for reef identification and uses clear dominance criteria to separate coral, soft coral, and sponge systems. The scheme is appropriate for semi-quantitative cover data and aligns with standard practice for field-based rapid habitat assessment in hard-bottom and mixed coastal systems.

Depth trends were assessed by calculating mean cover values by depth for diver transects and by modelling depth as a continuous variable for ROV stations. Depth ranges were then compared between habitat types to describe depth zonation. Approximate spatial patterns were reviewed by mapping sample centroids and comparing habitat distributions across the survey footprint. No smoothing or interpolation was applied.

4.2.1. Infaunal Data Analysis

Infaunal sample data were processed to produce a consistent dataset which was suitable for analysis within statistical packages. There are several species diversity indices available, of which the following were calculated:

- Number of species (S): the number of species present;
- Number of individuals (N): total number of individuals counted;
- Margalef's index (d): a measure of the number of species present for a given number of individuals. The higher the index, the greater the diversity;
- Pielou's evenness (J'): shows how equally the individuals in a population are distributed. J'=0 – 1. J' is higher, the less variation in the samples.

Multivariate analysis was used as guidance in community grouping assignment and the primary tool for the statistical analysis of the infaunal data. To obtain a measure of the degree of similarity in the faunal composition of each site, cluster analysis was carried out based on a Bray-Curtis similarity index. Statistical tests used were Hierarchical Clustering, non-metric Multidimensional Scaling (nMDS) Ordination and Species Contributions (SIMPER). The clustering technique aims to find 'natural groupings' of samples such that samples within a group are more similar to each other, generally, than samples in different groups. Hierarchical agglomerative methods are the most commonly used clustering techniques. These usually take a similarity matrix, such as Bray-Curtis, and successfully fuse the samples into groups and the groups into larger clusters. The result of the hierarchical clustering is represented by a dendrogram, with samples that are similar linking together towards the higher end of the similarity scale and those that are less similar linking towards the lower end.

4.3. Mapping

Habitat mapping was undertaken by integrating bathymetric data with benthic sample data to produce a broad-scale seabed habitat map for the AoS. Bathymetric data were collated, checked and imported into a GIS environment, transformed as required to a common horizontal and vertical reference system and resampled to coincident raster grids. Noise and artefacts were reduced using smoothing

and filtering, and a suite of secondary terrain and acoustic variables such as slope and terrain ruggedness were derived using standard topographic and image analysis tools.

Benthic sample data from the rapid screening survey were assigned to habitat classes and used as training data. For each sample, values were extracted from the bathymetric and derived layers to create a statistical signature for each habitat or substrate class. These signatures were used in supervised modelling to predict the most likely habitat classes across the AoS.

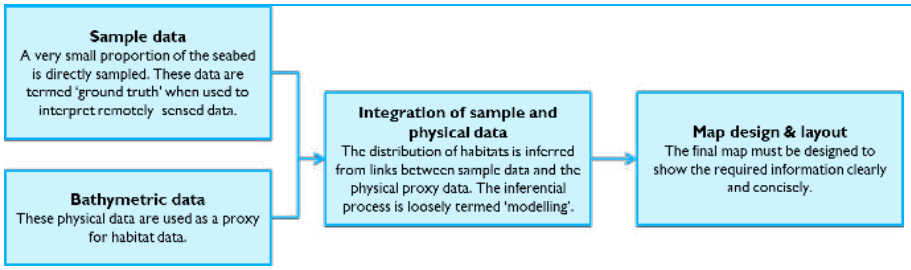


Figure 8.
A flow chart of the main stages in making a habitat map by integrating sample data and bathymetric data

Model outputs were reviewed and refined in GIS by comparing predicted habitats with source imagery and sample data, adjusting class assignments where required to ensure ecological coherence.

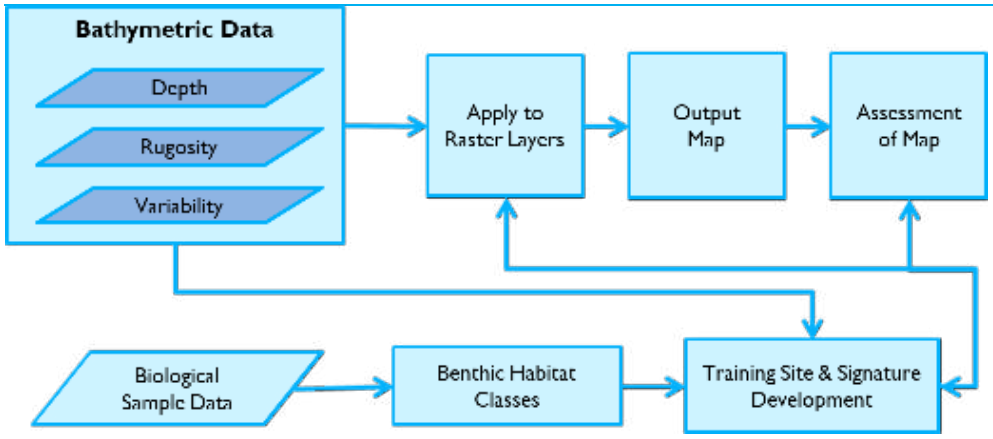


Figure 9.
Schematic diagram outlining the main stages in the production of the distributions of habitats and sediments.

5. Results and Habitat Mapping

5.1. Overview of Data Collected

The baseline survey collected several datasets, Table 1 summarises the survey types, methods, why it was employed, how and where it was applied, the key variables collected, and any notable constraints

Table 1.

Summary of data collection surveys

Survey	Purpose	Coverage	Methods	Key Data	Limitations
Rapid screening (ROV)	Locate/classify seabed habitats and guide detailed sampling	41 stations	ROV, surface GPS	Habitat class, substrate, presence/cover of corals/algae/sponges	Camera/lighting constraints; depth limited to ~80 m in practice
Diver benthic transects	Quantify benthic cover/corals by depth; coral photography & identification	9 x Depth-stratified transects at 5m intervals 5-30m (50 m length)	Point-intercept, belt census, photography, surface GPS	% cover by group; coral colonies (genus), growth forms; photo vouchers	Topography constraints; diver depth limit ~30 m
ROV Sampling	Semi-quantitative analysis, of deeper water locations with continuous, good quality footage	14 stations | ROV, surface GPS | Habitat class, substrate, presence/cover of corals/algae/sponges | Camera/lighting constraints; depth limited to ~80 m in practice			
Water sampling	Characterise water quality & plankton	14 water sample stations (profiles/surface-bottom as applicable)	Discrete sampling; calibrated multiparameter probe	Temperature, salinity, DO, pH, turbidity, euphotic depth, plankton	Nearshore turbidity pockets; offshore stratification
Sediment sampling (grabs)	Describe sediments, contaminants, infauna	18 grab sample stations	Grab sampling; photography, Surface GPS	Grain size, chemistry, infaunal taxa/abundance; position/depth/notes	Soft-sediment focus
Intertidal / very shallow walkover	Shoreline condition; shallow reef presence/health	8 shoreline transects (T1–T8)	Visual assessment; snorkel/wading; GPS & photographs	Beach form; debris; seabed type; live hard coral in shallows; shallow intertidal reef	Qualitative reconnaissance

5.2. Marine Habitat Distribution and Diversity

Benthic surveys conducted within the AoS using diver transects and ROV video show a fringing-reef system with clear spatial and depth-related structure. Habitat diversity is high for a relatively compact coastal system. A complete sequence of coastal marine habitats is present, ranging from seagrass meadows and patchy coral in shallow water, to well-developed coral reef on the mid-slope, and mixed coral-sediment habitat transitioning to sandy seabed at depth. Collectively, the data provide a coherent picture of a functioning Red Sea coastal reef system with local variation linked to exposure, sedimentation and depth.

The presence of both shallow seagrass and deep coral communities is particularly important because it allows the movement of species across depth gradients and provides resilience against localised impacts. Transitions between habitats appear to be driven primarily by natural environmental gradients such as light availability, substrate type and hydrodynamic regime, rather than by human disturbance.

The combination of habitats observed would be expected to support a broad range of fish and invertebrate assemblages. Seagrass zones offer juvenile refuge habitat, patch reefs provide feeding corridors and stepping stone habitats, mid slope reefs deliver high complexity and shelter, and deep mixed zones contribute additional ecological depth and connectivity. This range enhances the ecological value of the embayment and reinforces the importance of maintaining both shallow and deeper habitats in good condition.

5.2.1. Habitats Identified

5.2.1.1. Shallow Intertidal Habitat

Across the AoS, the shallow intertidal habitats are rocky platforms with a mixed coral/rock/sand seabed (Figure 10). Live hard coral cover is relatively high in the south (35–45%), forming a continuous shallow reef flat at T2 and a well-developed mixed coral–rock habitat at T1. No bleaching or disease was recorded, and soft corals are present in low percentages along with invertebrate fauna such as urchins, giant clams and sea cucumbers.

At the lower intertidal to ~1 m depth, habitats range from bare rock at T3 to mixed sand/rock with only isolated massive coral colonies at T4, through to coral–rock assemblages at T5-T6. Coral cover is low at T3 (~8%) and T4 (<3%), moderate at T5 (~18%), and again relatively high at T6 (~35%) where a continuous reef flat reappears, though with moderate algal growth on the reef surface. Giant clams and other macro-invertebrates are present, but there is still no evidence of coral bleaching or disease.

In the northern section (T7-T8), at T7, the shallow subtidal around 1 m depth is a mix of rock, sand and scattered coral patches, with low live cover (~8%) arranged as patchy massive colonies. By T8, the seabed at equivalent depth is simply rock and sand with no live coral reef present, and no reef-building or soft corals recorded.

In summary, the intertidal environment transitions from relatively natural, wide sandy beaches with healthy, continuous shallow coral reef in the south, through a constrained, gravel and rock-dominated, industrially bordered shoreline with fragmented coral habitats in the centre, to more degraded, gravel/rock shores with very limited or absent coral in the north.

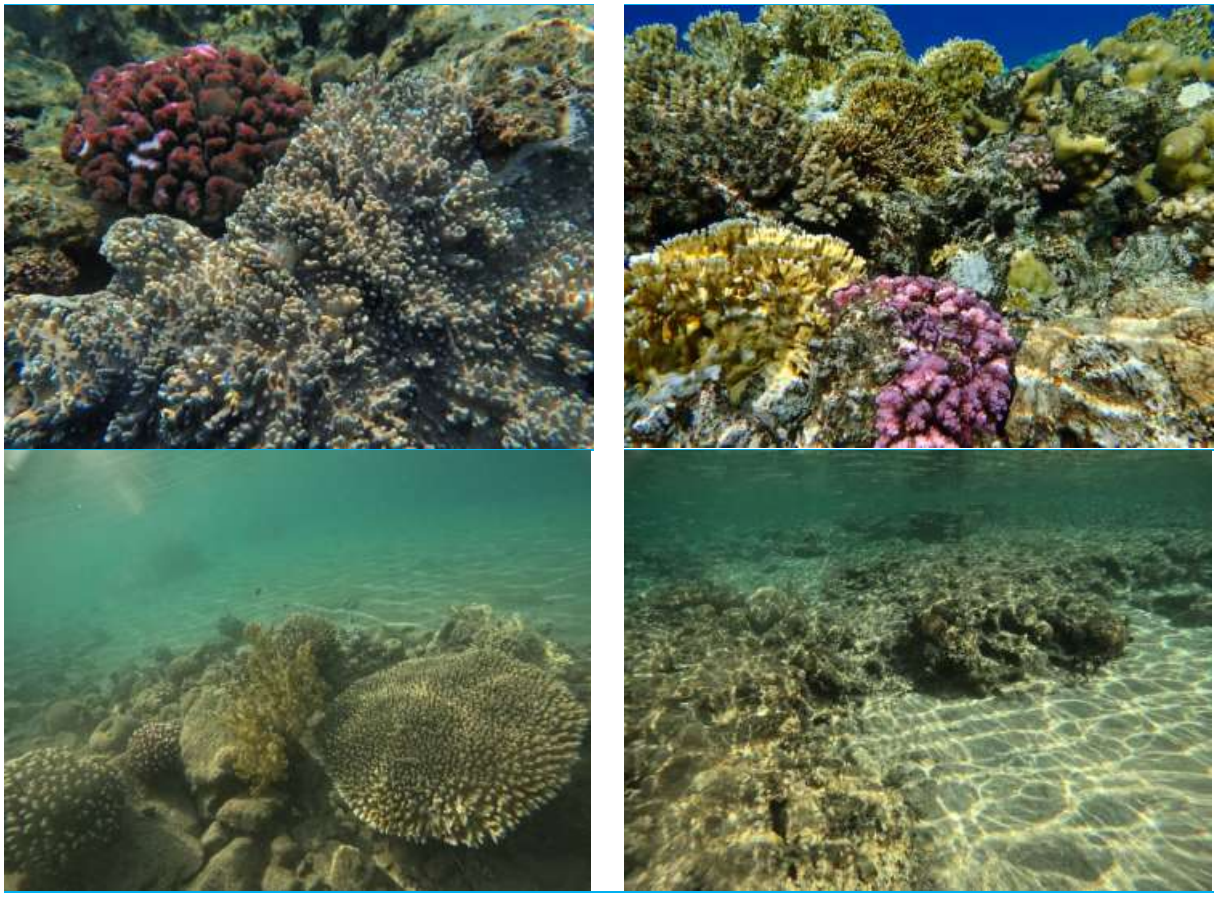


Figure 10.
Shallow intertidal habitats found to occur within the AoS.

5.2.1.2. Patch Reef and Shallow Seagrass (5-15 m)

Shallow areas support seagrass beds interspersed with sandy areas and patches of coral with low relief on rubble patches (Figure 11). The corals are relatively fast growing and typical of shallow, high light environments. The sediment between the patches of coral and seagrass is often burrowed indicating active infaunal communities. Several sites show a transitional zone where seagrass declines, and coral begins to dominate. Coral colonies here are scattered and mixed with sediment pockets, creating a patchwork mosaic on the inner reef flat. Coral cover increases up to 40% by 15 m. Coral lifeforms include massive Scleractinia colonies in both massive and branching forms along with branching fire coral. Some areas (adjacent to phosphate loading port) contain rubble and intermittent hard substrate, suggesting storm or physical disturbance in the past.

Notable ecological features

- Nursery habitat potential for juvenile fish and invertebrates
- Presence of burrowing fauna indicative of good sediment oxygenation
- Seagrass meadows provide shoreline stabilisation and carbon storage
- Pioneer coral species and small framework builders

Sensitivity

Seagrass is sensitive to increases in sediment load, water quality decline, physical disturbance and anchoring. Transitional habitats can be vulnerable to both seagrass disturbance and coral stress from poor water clarity or sedimentation.

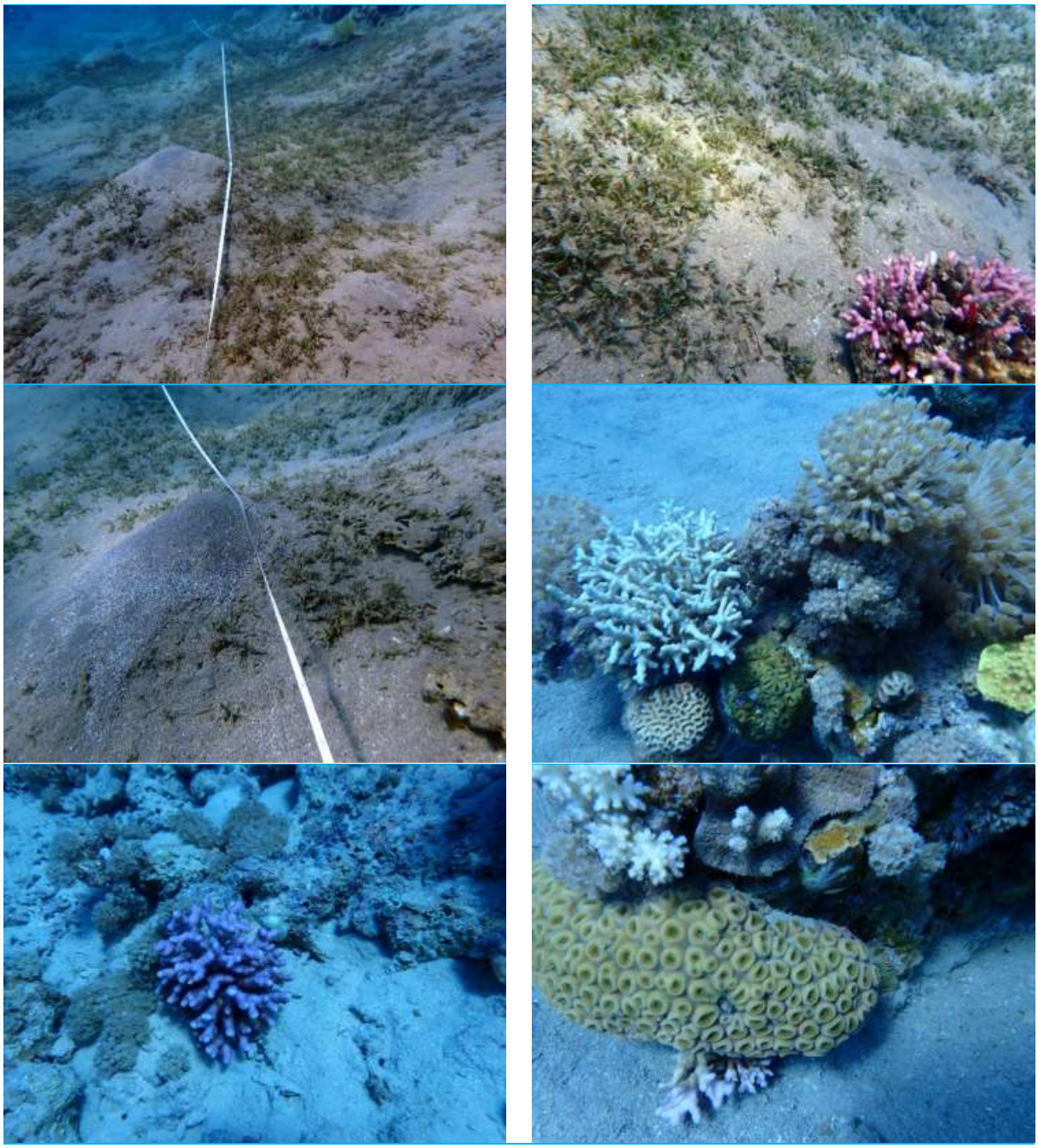


Figure 11.
Shallow subtidal habitats found to occur within the AoS.

5.2.1.3. Fringing Coral Reef (15-35 m)

The fringing reef is characterised by consolidated substrate and strong stony coral cover (Figure 12). Percentage coral cover and diversity increases from 10 m through to 30 m depth.

Relief/rugosity is higher in this habitat, and coral colonies form continuous patches or ledges. This habitat class represent the core coral reef habitat in the bay. The diver dataset shows peak coral cover at 30m, particularly at central transects (TA04 and TA05). Morphologies include massive, plating, branching and encrusting corals, with soft corals and sponges also being present.

Notable ecological features

- Structurally complex reef with high rugosity
- Presence of plating species associated with deeper light environments
- Soft corals, cup sponges and occasional gorgonians

Sensitivity

- Framework-building corals critical for long-term reef accretion
- Mesophotic-associated coral forms at deeper limits



Figure 12.
Fringing coral reef habitats found to occur within the AoS.

5.2.1.4. Mixed Reef and Sediment (35-60 m)

ROV footage shows patchy coral with sediment channels and outcrops (Figure 13). Coral cover varies widely (10-70%), depending on substrate availability. This zone likely represents a transition from mesophotic reef to deeper sand plain, with some ROV stations showing plating corals at >50 m.

Notable ecological features

- Continued coral presence into the mesophotic zone
- Sand channels used by mobile fauna
- Occasional debris (tyres, metal objects) indicating some anthropogenic input

Sensitivity

Mesophotic corals may be sensitive to light reduction, turbidity and sedimentation. Debris suggests vulnerability to coastal activity or construction.



Figure 13.
Mixed reef and sediment habitats found to occur within the AoS.

5.2.1.5. Deep Sediment and Isolated Reef Outcrops (>60 m)

Stations at 60-77 m show predominantly sandy seabed with scattered coral at the base of the reef slope (Figure 14). Coral cover drops to near zero at the deepest points. Relief is low and the habitat grades into soft-bottom deep shelf conditions.

Notable ecological features

- Sparse but diverse benthic microhabitats
- Potential habitat for mobile demersal species

Sensitivity

Primarily sensitive to sediment disturbance, organic input and physical impacts from infrastructure placement.

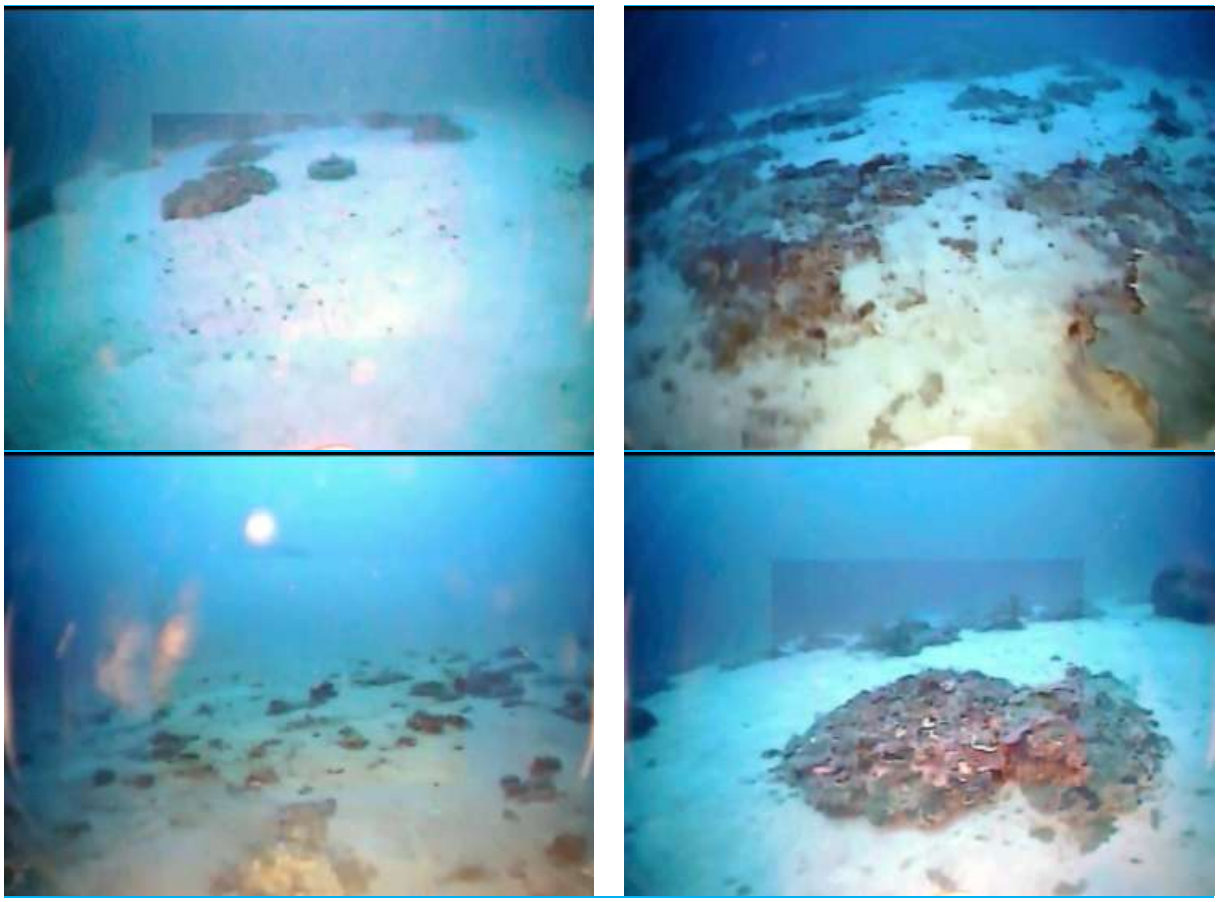


Figure 14.
Deep Sediment and Isolated Reef Outcrops habitats found to occur within the AoS. (images take from ROV looking towards deep habitats)

5.2.2. Habitat Map

Results from the habitat mapping process (Figure 15) show the area to have a fringing area of intertidal habitats and seagrass beds with patch reefs occuring in the shallow sub-tidal environment. As the seabed deepens coral levels increase and fringing coral reef is present across the length of the AoS. Mixed reef and sediment habitats become more dominated as light levels decrease with sediment and scattered reef areas becoming prevalent in deeper waters.

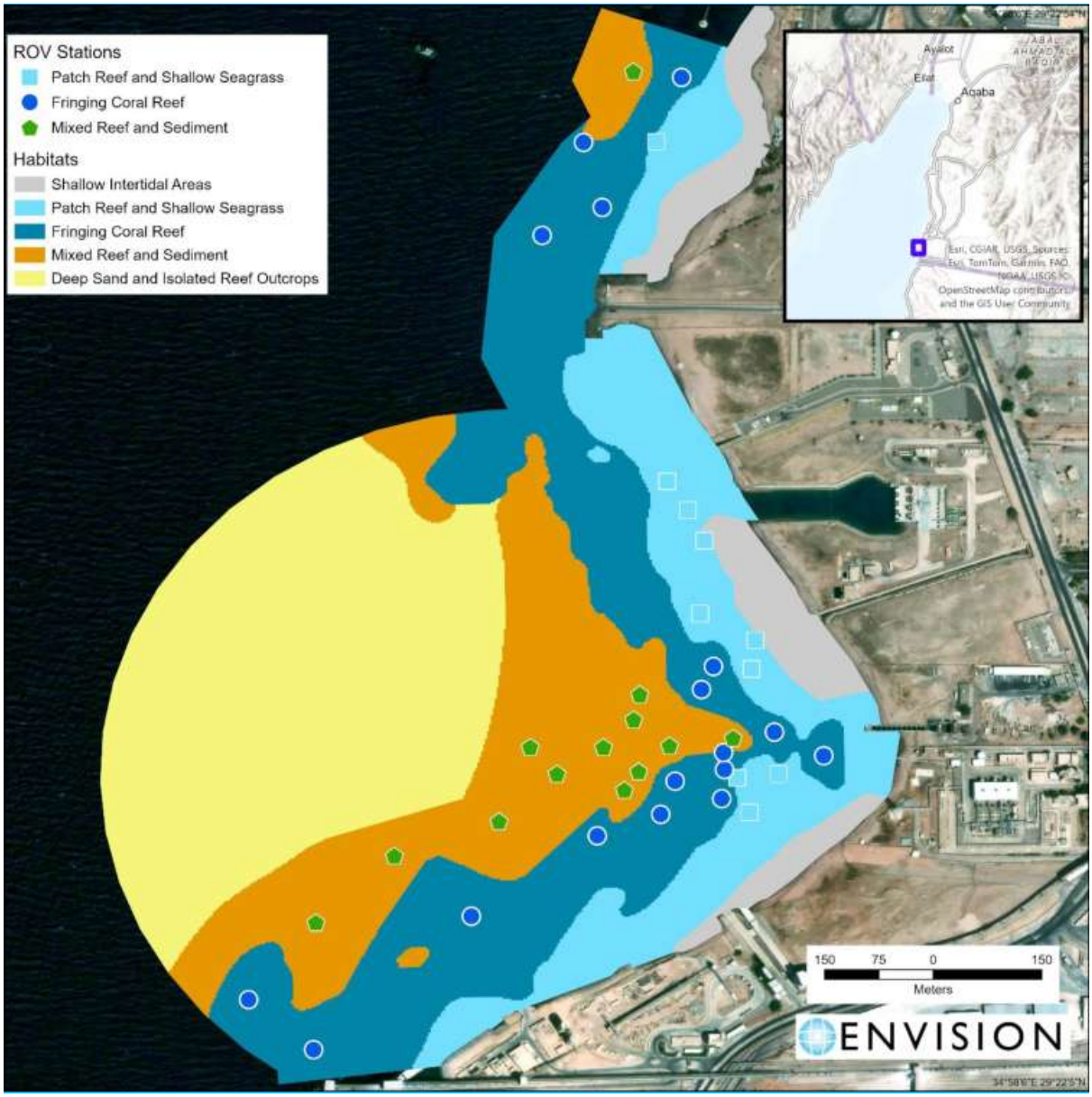


Figure 15.
Distribution of Marine habitats within the AoS

5.2.3. Depth Trends

Changes in percentage cover of coral and seagrass with depth, based on diver surveys in shallow water (5–30 m) and ROV surveys in deeper water (35–75 m+) are shown in the chart below (Figure 16).

In the shallow zone, coral cover recorded by divers starts low at about 5 % at 5 m, then increases steadily with depth to around 25–30 % by 15–20 m and peaks at just under 50 % at 30 m. Seagrass is most abundant at 5 m, with roughly 35 % cover, but drops sharply with depth and is below 10 % by 15 m, disappearing from deeper depths.

From 35 m onwards, only ROV coral data are shown. Coral cover here is approximately 35–37 %, then declines gradually with depth, falling to around 15–20 % by 50–60 m and under 10 % by 75 m+.

Overall, coral cover increases from shallow to mid-depths then tails off in deeper water, while seagrass is confined to very shallow depths and quickly diminishes with depth.

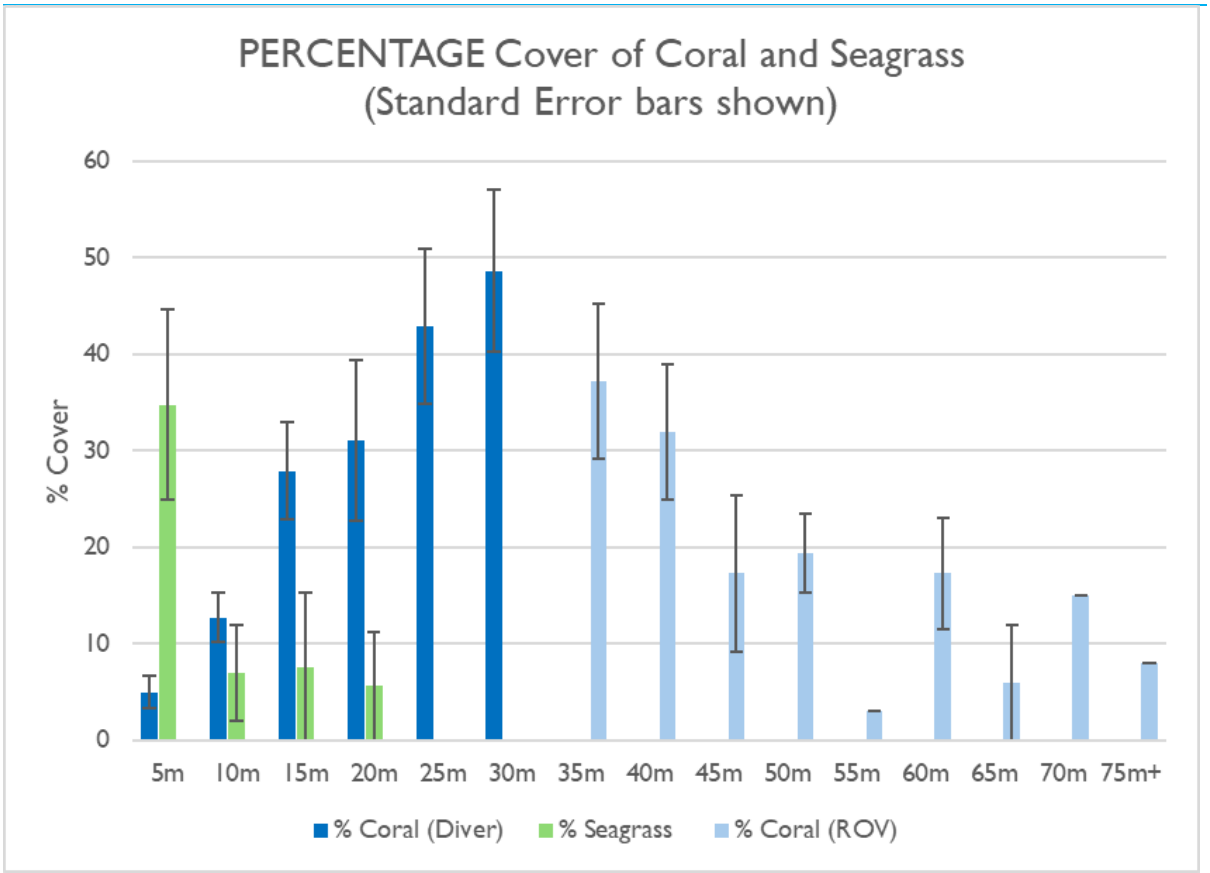


Figure 16.
Average percent cover of coral and seagrass within the AoS

Coral abundance and composition in the survey area show a clear, depth-related progression that reflects light availability, sediment influence, and substrate stability. Across both diver and ROV datasets, there is a strong gradient from low coral cover in the shallow, sandy zone to peak abundance and diversity along the mid-depth reef slope, followed by a gradual decline into deeper mixed and sandy habitats.

In the shallow zone (5 m), coral cover is generally low and patchy, typically below ten percent. The seabed here is dominated by sand and seagrass, and most coral colonies are small and isolated. *Stylophora* is the dominant genus (27% of all coral colonies recorded). Also common are *Goniastrea (11%)*, *Platygyra* (9%) *Porites (8%), Pocillopora (7%)* and *Acropora (7%)*. Growth forms are largely branching or massive colonies that can withstand sediment deposition and slight movement of the substrate.

At 10m coral cover increases to over 10% (varying between 5-21%) as substrate becomes more stable and light levels remain high. *Stylophora* is still the dominant genus, (18% of all colonies present). At this depth sub-massive forms of *Dipsastraea, Platygyra* and *Goniastrea* all contributed over 10% to the genus composition. Colonies are present in small patch reefs surrounded by sand and seagrass, and species richness rises substantially compared to the shallows.

Coral cover continues to increase at 15m to an average of nearly 30% over all transects surveyed within the AoS. The dominant genera at this depth include *Goniastrea* (14%), *Dipsastraea* (11%), *Stylophora* (10%) and *Platygyra* (9%). *Acropora* and *Echinopora* each contribute 7% to the total number of corals recorded.

At 20m coral cover averages over 30%, reaching 71% at one transect (TA04). *Goniastrea* is the dominant genus (14%) and *Stylophora* presence has dropped below 10%. *Dipsastraea, Paramontastrea, Echinopora* and *Acropora* are all present representing between 7- 9% of colonies recorded.

Coral cover reaches 43% at 25m depth, having peaked at 73% in transect TA05. *Goniastrea* is still the dominant genus (12%). *Porites* and *Montipora* colony numbers have both increased at this depth (9%), alongside *Mycedium* (8%). *Acropora* remain at 7%, however with depth increases growth forms tend towards table rather than branching colonies. *Leptoseris* colonies (2%) appear at this depth.

At 30m depth percentage coral cover reaches its maximum of 49% with 84% being recorded in TA05. The community is taxonomically diverse, dominated by *Porites (12%), Montipora* (11%), *Pavona* (11%), Mycedium (8%) and *Acropora (7%). Goniastrea* is at its least common (6%) at this depth, alongside *Platygyra* (2%). *Dipsastraea* (4%*), Leptoseris* (3%) *and Pachyseris* (3%) colonies *also are present at this depth.*

Below 35 m, coral abundance declines steadily as light levels drop and sediment cover increases. The community shifts toward massive and plating species, including *Porites*, *Montipora*, and, in the deepest records, thin-plating *Leptoseris* and *Pavona*. Branching corals disappear almost entirely, replaced by compact, sediment-tolerant morphologies. Colonies are scattered across mixed sand and rubble, and overall coral cover typically falls below 20% by 50–60 m.

In summary, coral communities transition from sparse, sediment-tolerant massive forms in the shallows, to diverse and abundant branching and massive assemblages on the mid-depth reef, and finally to low-diversity, low-relief massive and plating corals in deeper, low-light environments. This progression mirrors the physical structure of the reef, with coral abundance and diversity peaking where stable hard substrate and moderate light coincide (Figure 17).

Figure 18 shows a heatmap of coral genera across the depth bands surveyed and is summarised in the text above. It shows the relative importance of each genus to the composition of corals present at each depth.

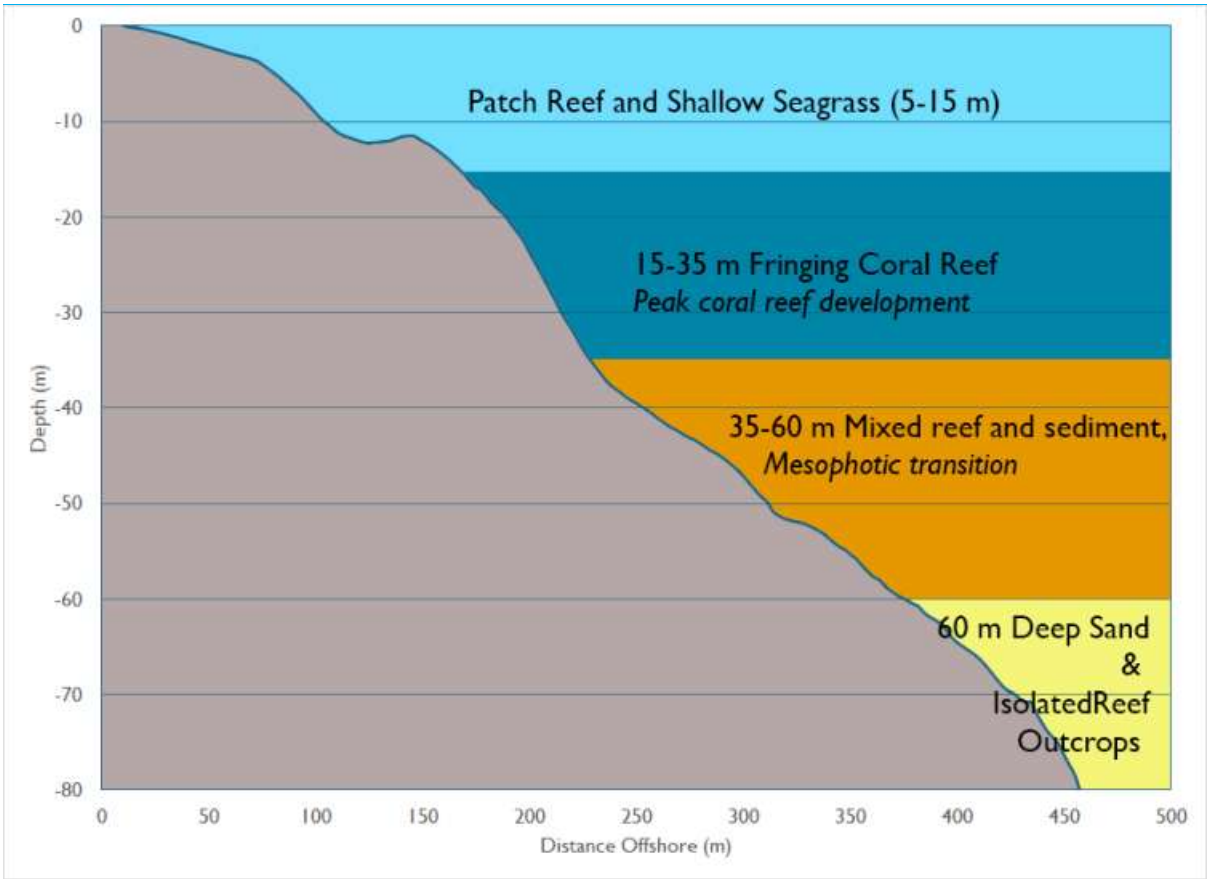


Figure 17.
Depth profile through the project area with marine habitat shown

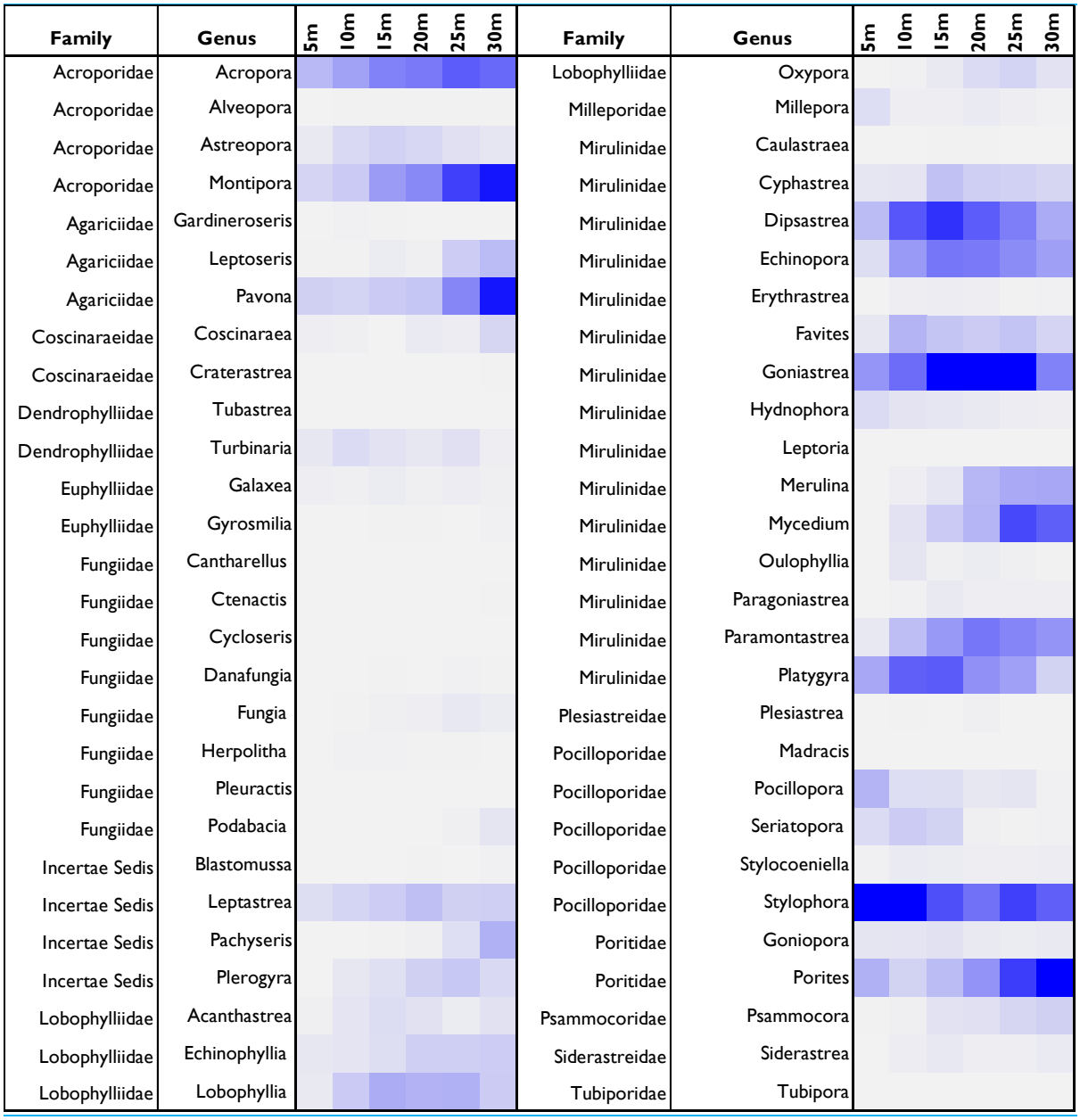


Figure 18.
Heatmap of coral genera across the depth bands surveyed. Grey – low abundance; Blue – high abundance

5.2.4. Spatial trends

5.2.4.1. Seagrass

Seagrass distribution shows a clear north–south gradient across the survey area (see Figure 19 below). In the northern section, seagrass beds are broader and more continuous, occupying the shallow sandy platform between about 5 and 10 metres. Here, the seabed is gently sloping and dominated by fine sand with scattered patches seagrass with small coral colonies. Moving southward, the shallow zone narrows and transitions into a patchier mosaic of sand, rubble, and isolated seagrass clumps. Seagrass cover becomes progressively more fragmented, giving way to increasing coral and hard substrate exposure along the mid-reef margin. By the southern transects, dense seagrass meadows are largely absent, replaced by mixed sand–rock or coral-dominated reef habitats. This pattern suggests a gradual

shift from sediment accumulation and stable seagrass beds in the north towards a steeper, more wave-exposed reef slope in the south.

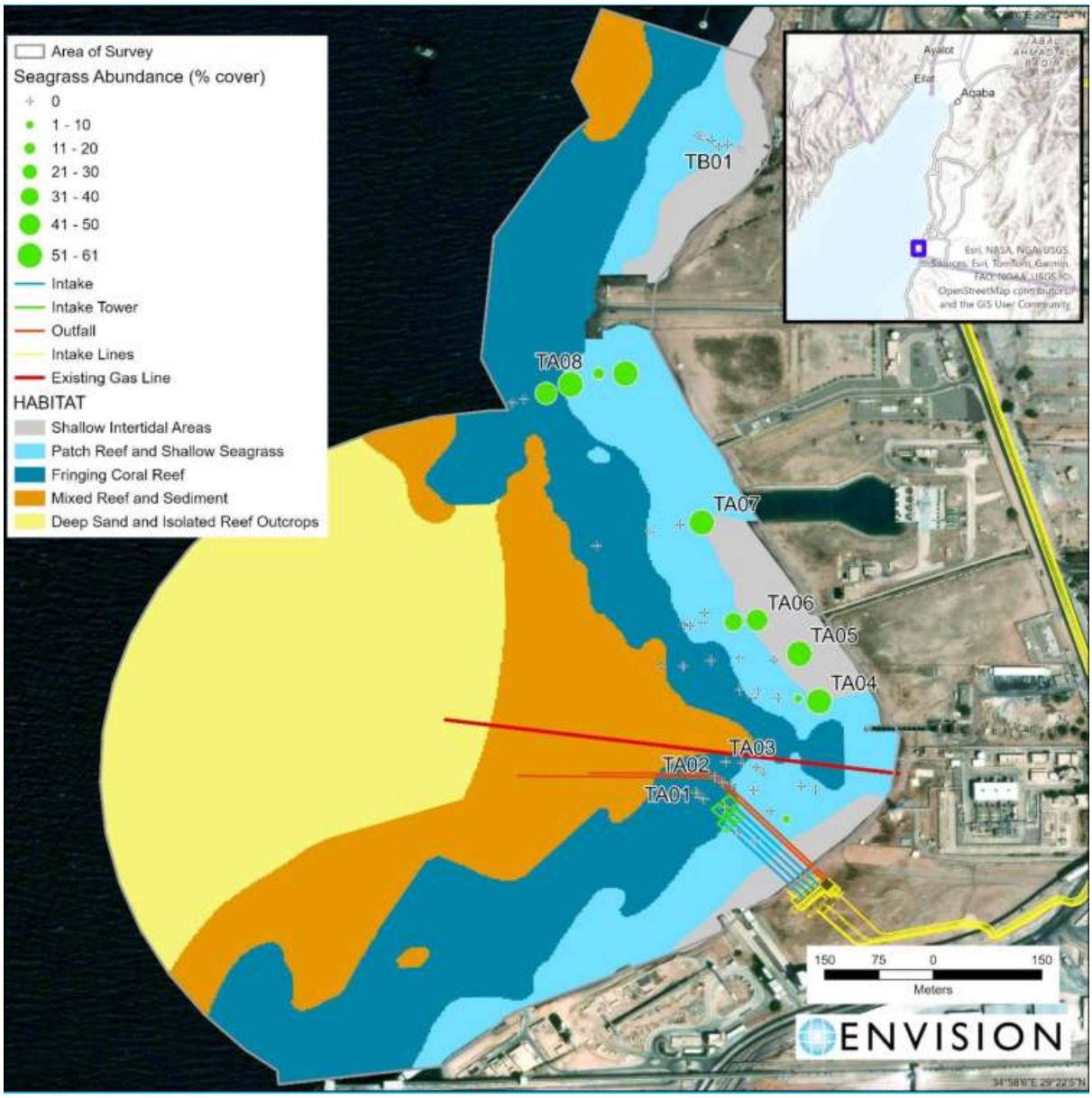


Figure 19.
Marine habitat with percentage cover of seagrass at diver transect stations

5.2.4.2. Coral

Coral cover and community structure also show a trend across the survey area (see Figure 21 below). In the northern transects, coral occurs mainly as small, scattered colonies embedded within sandy and seagrass-dominated habitats. Hard coral cover here is low, progressing towards the central area of the bay, coral becomes more abundant and structurally complex. The central portion of the area marks the development of a continuous fringing reef edge (TA04 & TA05), where hard substrate is extensive and branching, massive and plating corals form dense coral assemblages with relative high diversity. In the southernmost transects, the reef slope is steeper and transitions into reef and sediment habitats, where coral cover remains moderate but shifts toward massive and plating forms.

Overall, coral communities change from sparse, low-relief colonies in the north to well-developed, framework-building reefs in the central area, then to deeper, sediment-influenced assemblages to the south.

Inshore to offshore shows the distribution of habitats reflecting the depth of the seabed which is typical for a red sea fringing reef profile.

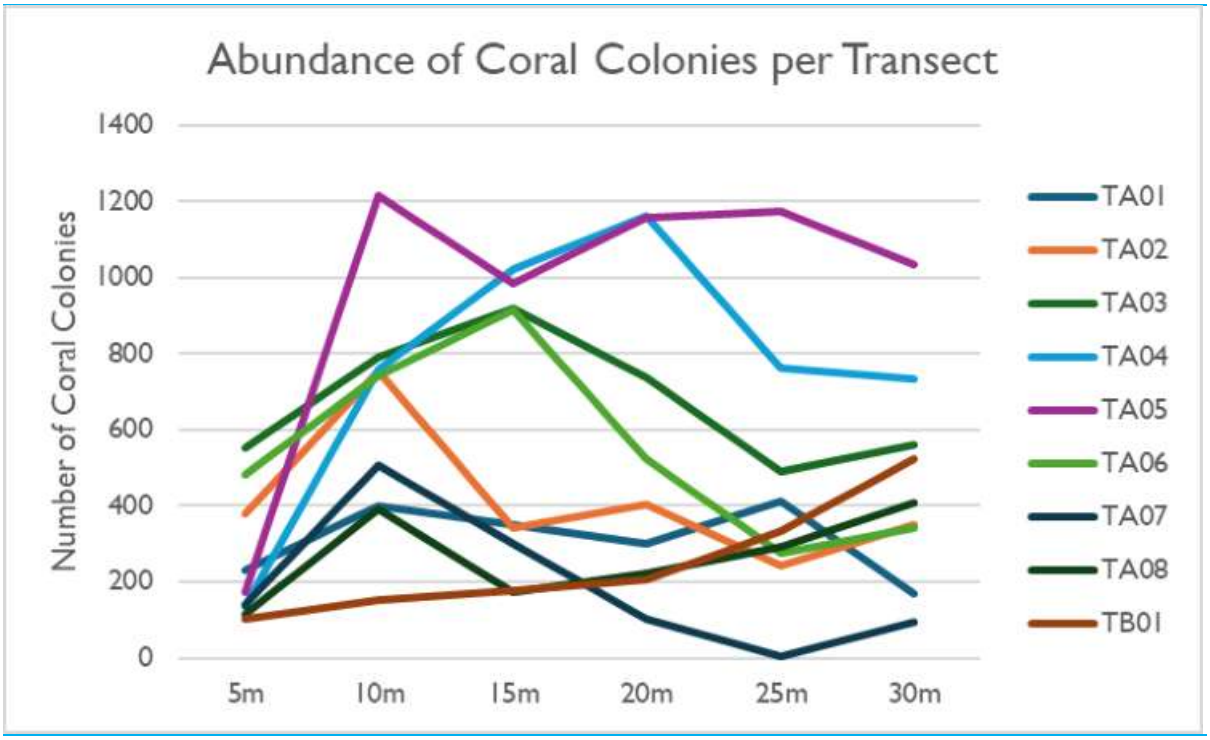


Figure 20.
Number of coral colonies at each depth surveyed by divers along all transects

The chart above (Figure 20) shows the number of coral colonies recorded along transects (TA01-TA07 and TB01) at distances from 5 m to 30 m. Transects at TA05 and TA04 have the highest abundance of coral colonies overall, while TA03 and TA06 have lower abundance. TA01, TA02 and TB01 have much lower colony numbers throughout, with TB01 (control site) consistently the lowest.

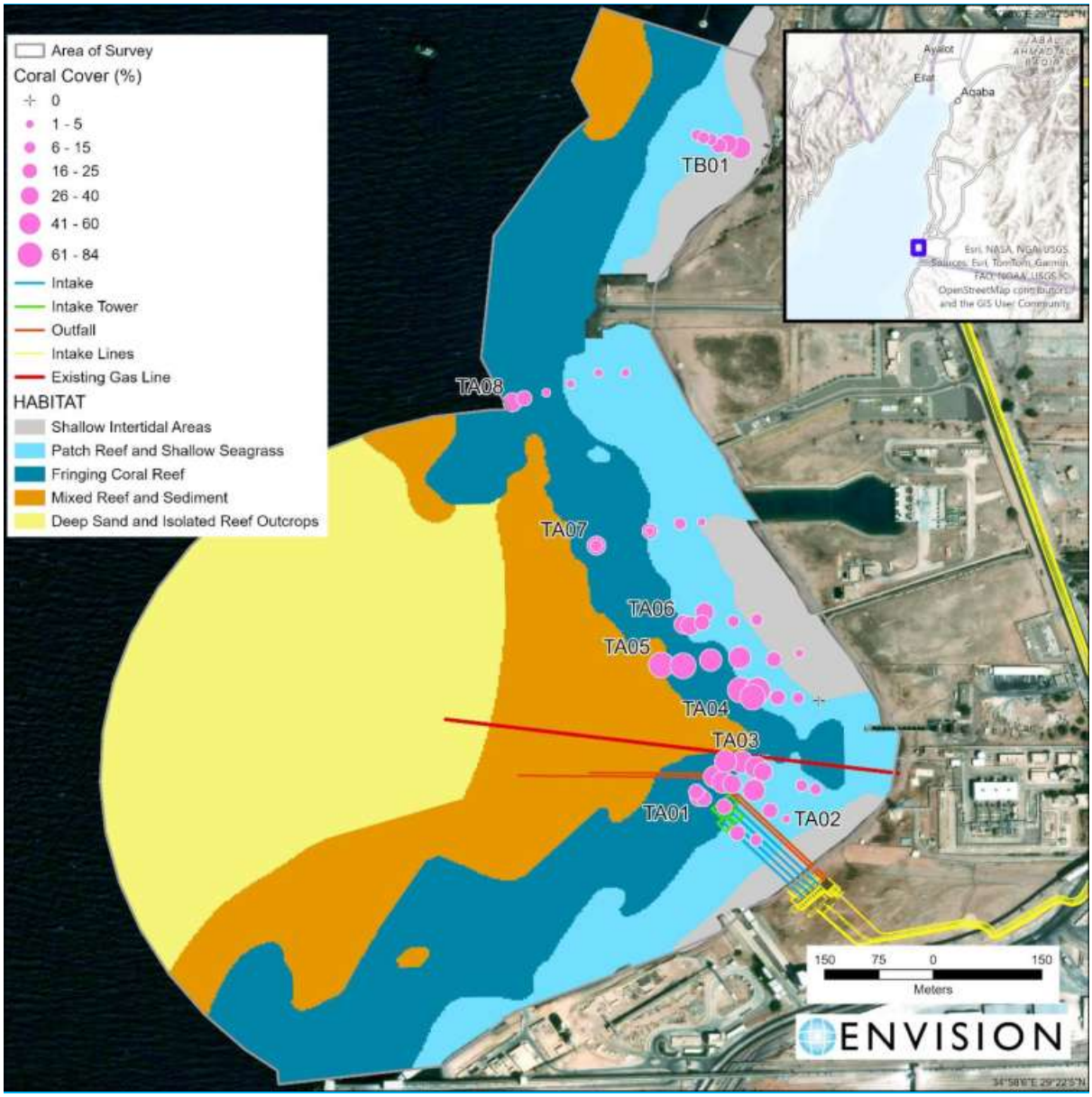


Figure 21.
Marine habitat with percentage cover of coral at diver transect stations

5.3. Habitat Quality

The AoS supports a generally high-quality benthic environment, although the condition varies between habitat zones. The mid slope reef between approximately 15 and 35 metres is clearly the healthiest and most structurally developed habitat. Coral cover in this depth band commonly exceeds 40% and reaches more than 80% in some areas. Colonies appear well established, with a mix of massive, plating and encrusting growth forms that contribute to structural complexity and long-term reef stability. The presence of sponges, soft corals and occasional gorgonians indicates a maturing and biologically rich reef community rather than a recently colonised substrate. There is little visible algal dominance in this zone and sediment accumulation appears limited, suggesting good water clarity and favourable hydrodynamic conditions.

Coral quality remains moderate to good into the deeper slope, although reef patches become more isolated and are separated by sandy channels. Coral cover between 35 and 60 metres varies from roughly 10 to 70 percent depending on the availability of hard substrate. The persistence of plating and massive corals into this depth range is a positive indication of environmental stability. However, the increasing patchiness reflects both natural zonation and higher sensitivity to sediment transport. Areas where corals are set in a largely sedimented matrix may be more vulnerable to turbidity or episodic sediment movement.

The shallow habitats display a more mixed condition. Shallow seagrass meadows are well developed in parts of the northern bay and appear healthy and persistent. These meadows are interspersed with sandy patches, burrows and small corals, creating a dynamic shallow ecosystem. However, some shallow areas include rubble, isolated debris and localised signs of disturbance which may reflect historical wave damage, vessel activity or human presence near shoreline infrastructure. These features do not dominate the system but do suggest that shallow zones are more sensitive to physical impacts than the deeper reef slope.

Beyond approximately 60 metres the habitat is predominantly sediment and habitat quality is naturally lower in structural terms. This zone is ecologically important for mobile fauna and benthic invertebrates rather than coral growth. Occasional pipelines and artificial items were noted in ROV footage. While these do not appear to have caused widespread environmental harm, they indicated that anthropogenic influence is present and should be considered in future management.

Overall, the AoS supports a generally high-quality benthic environment with strong ecological function. The most sensitive and highest quality zones are the mid slope coral reefs and the shallow seagrass meadows, both of which would benefit from protection from sedimentation, physical disturbance and degradation of water quality.

5.4. Sediment

5.4.1. Physical & Chemical Properties

5.4.1.1. Organotins & PCB

Organotins (tributyl tin (TBT) and dibutyl tin (DBT)) were not found above detectable levels in any samples. Polychlorinated biphenyls (PCBs), similarly, were not found at detectable levels throughout the AoS.

5.4.1.2. Heavy Metals

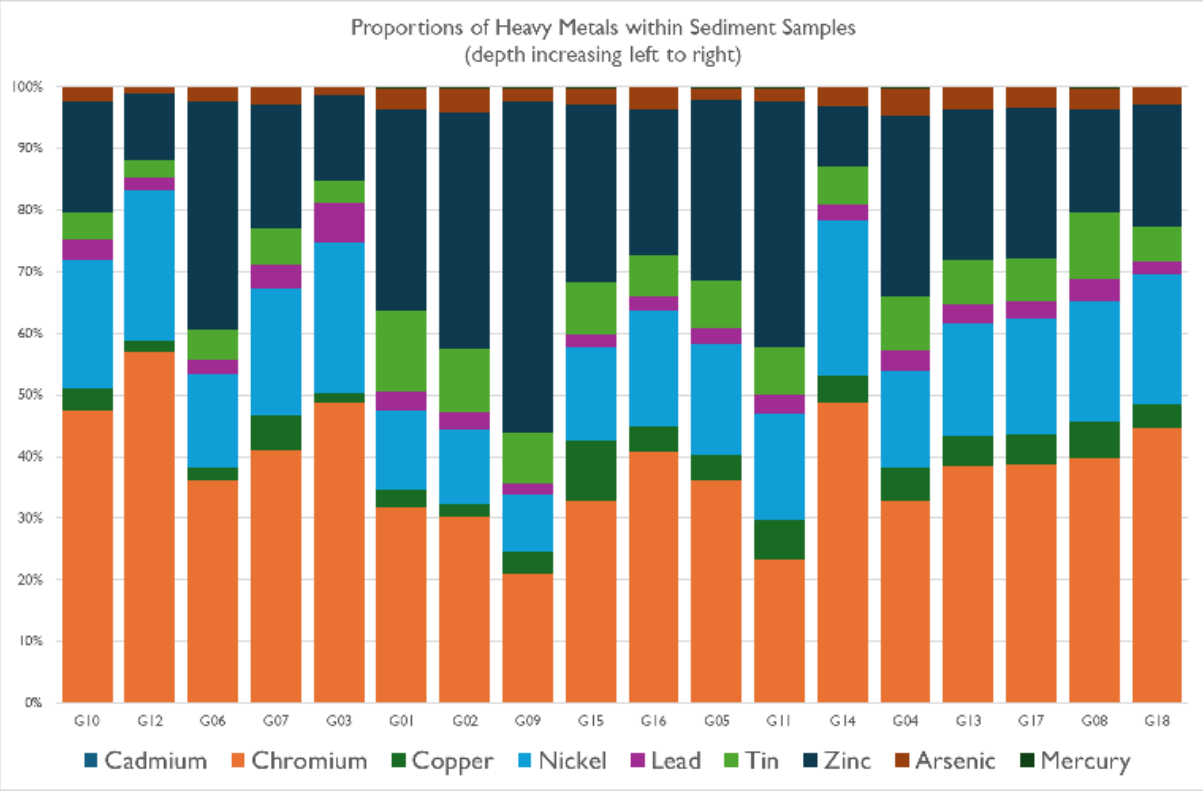


Figure 22.
Proportions of heavy metals within marine sediments within the AoS.

Heavy metals were measured in all samples, with 100% detection for arsenic, chromium, copper, lead, nickel and zinc. Cadmium and mercury levels were at the level of detection thresholds for all samples and showed no variation.

Median concentrations (mg/kg dry weight) were low to moderate across the dataset, with indicative values of arsenic ~1.05 (max 1.29), chromium ~13.6 (max 49.7), copper ~1.64 (max 2.83), lead ~0.96 (max 4.24), nickel ~6.55 (max 21.37) and zinc ~8.89 (max 18.63).

Within this baseline, chromium and nickel showed the widest ranges, while copper and lead were comparatively uniform. Figure 22 shows the proportions of each heavy metal within samples, with the graph ordered from shallow to deep, left to right, to illustrate any trends with depth of which there is no indication, suggesting that metal distributions are broadly consistent across the sampled depth range.

5.4.1.3. Hydrocarbons (PAHs)

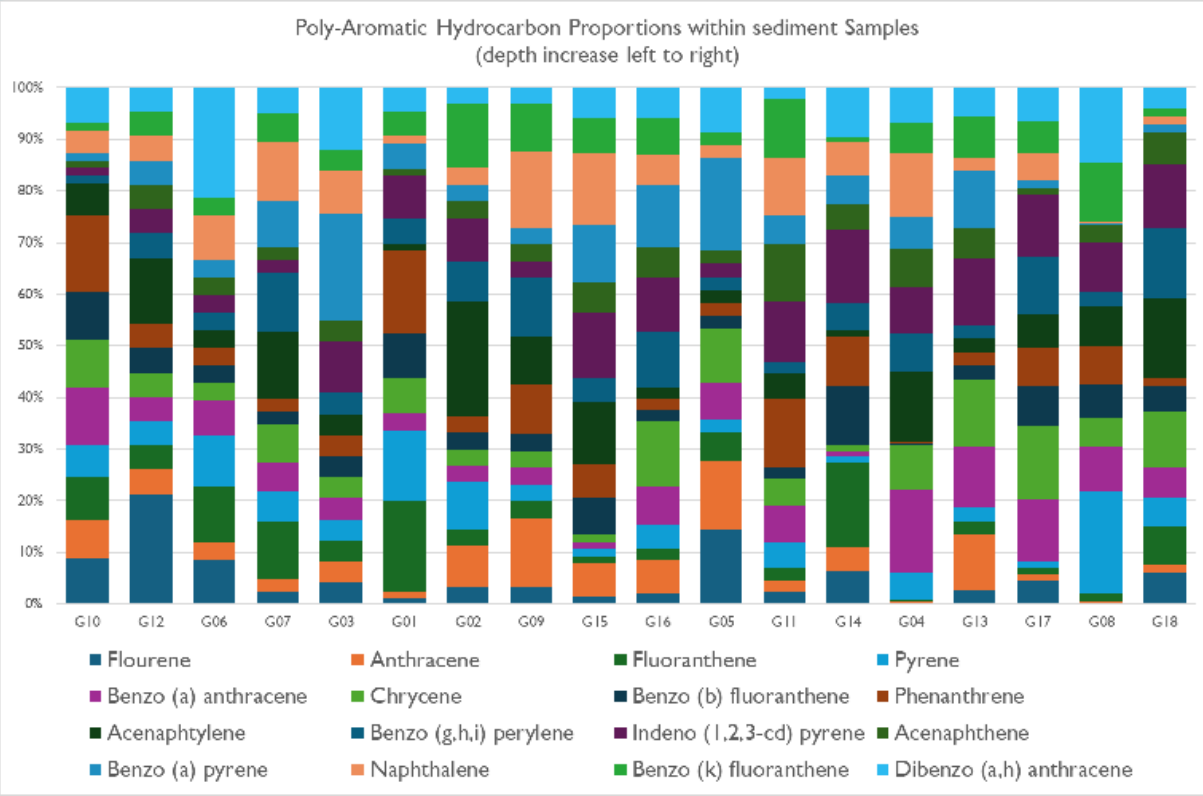


Figure 23.
Proportions of poly-aromatic hydrocarbons within marine sediments within the AoS.

Polycyclic aromatic hydrocarbons (PAHs) were detected in all samples for the suite or compounds measured. In some cases, some compounds were found at lowest detectable levels but others were elevated. Figure 23 shows the proportions of each compound within each sediment sample and these are displayed in depth order (shallow to deep – left to right). Figure 24 shows the values for each compound at each station displayed in a heatmap to highlight where compounds occur at the highest levels within the AoS. It should be noted that G04 and G08 are in close proximity to the regasification terminal which is a potential source of hydrocarbon pollution.

µg/kg	G10	G12	G06	G07	G03	G01	G02	G09	G15	G16	G05	G11	G14	G04	G13	G17	G08	G18
Flourene	15.3	11.3	6.2	2.5	2.5	2.5	2.5	2.5	2.5	2.5	14.1	2.5	14.4	2.5	2.5	9.0	2.5	9.8
Anthracene	13.2	2.5	2.5	2.5	2.5	2.5	6.2	10.4	11.8	7.4	13.2	2.5	10.4	2.5	10.2	2.5	2.5	2.5
Fluoranthene	14.1	2.5	8.0	11.2	2.5	35.2	2.5	2.5	2.5	2.5	5.3	2.5	37.4	2.5	2.5	2.5	13.0	11.7
Pyrene	10.7	2.5	7.3	6.1	2.5	27.5	7.1	2.5	2.5	5.4	2.5	5.6	2.5	46.0	2.5	2.5	178.0	8.9
Benzo (a) anthracene	19.4	2.5	5.2	5.6	2.5	6.9	2.5	2.5	2.5	8.7	7.1	7.8	2.5	141.0	11.3	23.8	77.1	9.3
Chrycene	16.2	2.5	2.5	7.7	2.5	13.2	2.5	2.5	2.5	14.7	10.2	5.7	2.5	77.8	12.3	27.7	51.2	16.8
Benzo (b) fluoranthene	16.3	2.5	2.5	2.5	2.5	17.8	2.5	2.5	13.5	2.5	2.5	2.5	26.0	2.5	2.5	15.6	56.4	8.2
Phenanthrene	25.9	2.5	2.5	2.5	2.5	32.0	2.5	7.6	11.5	2.5	2.5	14.3	21.7	2.5	2.5	14.9	66.1	2.5
Acenaphtylene	10.7	6.8	2.5	13.2	2.5	2.5	17.3	7.1	22.1	2.5	2.5	5.4	2.5	119.0	2.5	12.3	70.9	24.5
Benzo (g,h,i) perylene	2.5	2.5	2.5	11.7	2.5	9.9	5.8	8.8	8.7	12.4	2.5	2.5	12.4	65.2	2.5	22.0	23.4	21.4
Indeno (1,2,3-cd) pyrene	2.5	2.5	2.5	2.5	6.1	16.9	6.7	2.5	23.0	12.0	2.5	12.9	32.0	79.8	12.3	24.4	86.5	19.6
Acenaphthene	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	10.7	6.9	2.5	12.1	11.2	66.8	5.4	2.5	30.7	9.9
Benzo (a) pyrene	2.5	2.5	2.5	9.2	12.6	10.2	2.5	2.5	20.4	14.0	17.7	6.3	12.4	54.5	10.6	2.5	2.5	2.5
Naphthalene	7.5	2.5	6.3	11.7	5.2	2.5	2.5	11.3	25.0	6.9	2.5	12.1	14.4	108.4	2.5	10.4	2.5	2.5
Benzo (k) fluoranthene	2.5	2.5	2.5	5.5	2.5	9.6	9.6	7.2	12.5	8.1	2.5	12.4	2.5	52.4	7.5	12.5	102.7	2.5
Dibenzo (a,h) anthracene	12.1	2.5	15.8	5.2	7.3	9.4	2.5	2.5	10.8	6.9	8.4	2.5	21.7	59.6	5.3	12.9	131.7	6.3

Figure 24.
Heat map for poly-aromatic hydrocarbons within marine sediments within the AoS.

Several compounds show a positive relationship with depth with strongest correlations for several higher-molecular-weight PAHs: indeno(1,2,3-cd)pyrene, acenaphthene, benzo[g,h,i]perylene and benzo[a]anthracene.

This pattern is consistent with enrichment of PAHs in finer, deeper sediments or where conditions favour preservation.

5.4.2. Benthic Sediment Communities

The results from infaunal community analysis show three community groupings to occur at 5% similarity, which indicates there is little difference between the samples. These are shown as a dendrogram in Figure 25 and as a non-dimensional MDS plot in Figure 26. These show most samples grouped together as a single group 'A' with two samples G02 and G11 forming a separate group 'B' and a single sample G18 being an outlying group 'C'.

Examining the species compositions across the dataset there are a mix of deposit feeders, grazers, suspension feeders and a smaller number of predators. This suggests a structurally mixed benthic system with both sediment-associated and hard-substrate components.

From the multivariate analysis there are three community types in the area (Figure 27).

A. Grazer and deposit-feeder assemblage - This is the dominant community across the AoS. It is a mix of deposit feeders, small gastropod grazers and occasional suspension feeders.
B. Algal-foraminiferan assemblage - This group reflects well-lit, stable seabed conditions with symbiont-bearing foraminifera and small grazers. It suggests good water clarity, relatively low sediment stress, and some hard or coarse substrate.
C. Low-diversity assemblage - represented in only a single offshore sample with small gastropods.

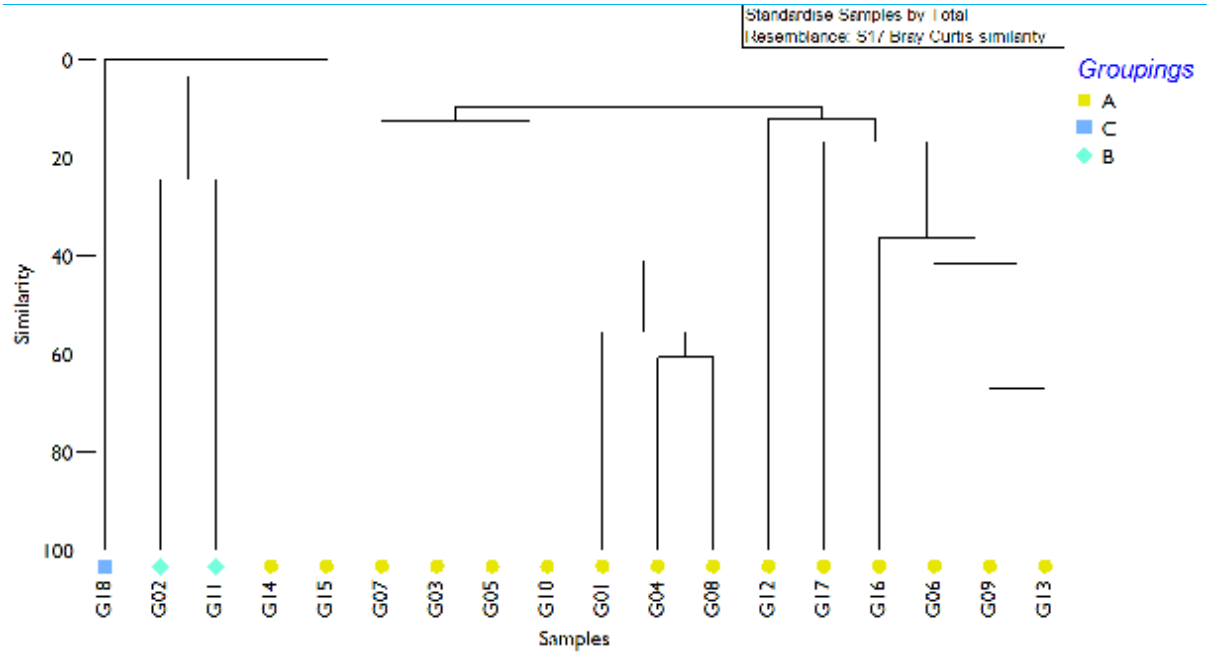


Figure 25.
Dendrogram showing similarity of samples and benthic community groupings

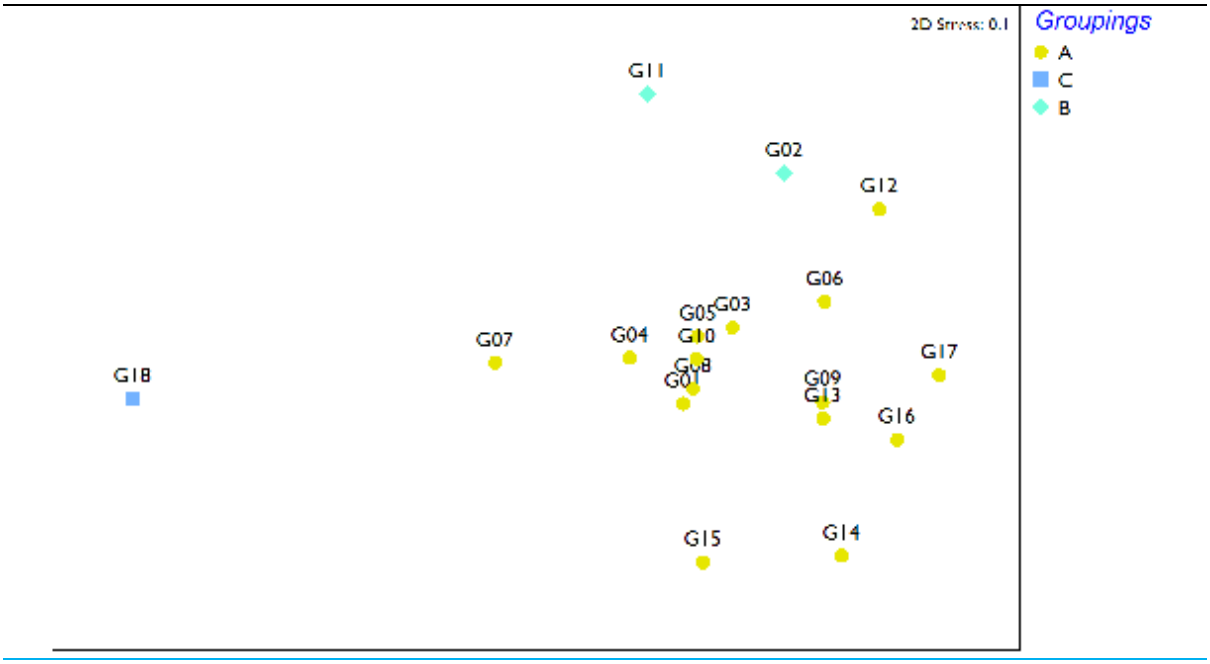


Figure 26.
Non dimensional MDS plot showing similarity of samples and benthic community groupings

Table 2.

Diversity measures of infaunal samples

Sample	Total Abundance	Richness	Shannon Diversity	Pielou Evenness
G01	54	9	1.799	0.819
G02	41	10	1.948	0.846
G03	13	3	0.984	0.896
G04	75	9	1.795	0.817
G05	62	8	1.867	0.898
G06	21	6	1.662	0.928
G07	98	8	1.039	0.499
G08	99	12	2.061	0.829
G09	23	9	1.934	0.880
G10	44	9	1.876	0.854
G11	46	7	1.717	0.883
G12	27	8	1.358	0.653
G13	25	7	1.546	0.794
G14	26	8	1.678	0.807
G15	26	7	1.670	0.858
G16	13	7	1.733	0.890
G17	22	5	1.112	0.691
G18	41	3	0.559	0.509

Univariate analysis of the samples show diversity to be relatively consistent across the samples with a noticeable low diversity in sample G18, yet species abundances do vary considerably.

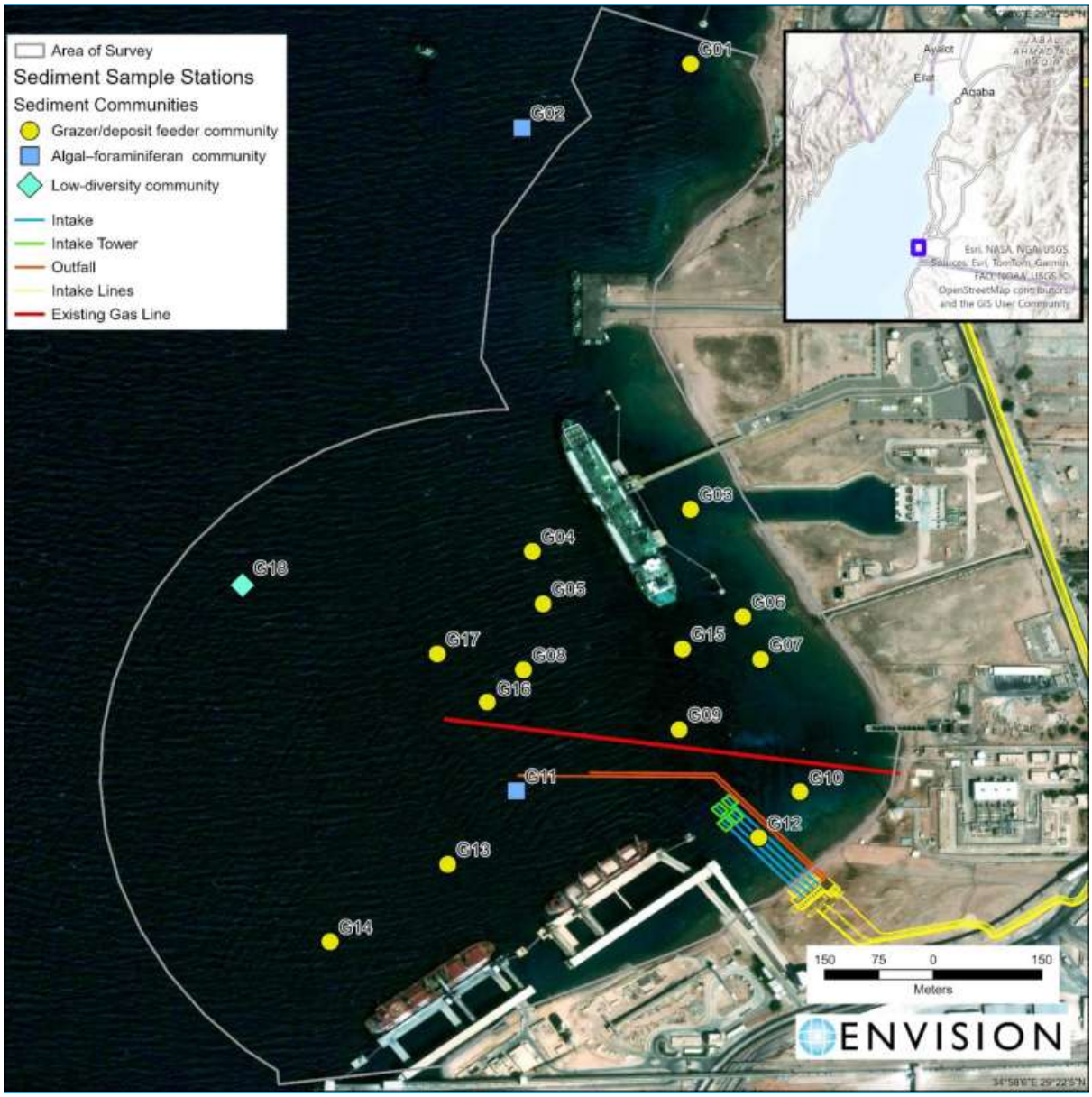


Figure 27.
Sediment communities found within the AoS

The strong abundance of large benthic foraminifera like *Amphistegina lobifera* is notable. These organisms host algal symbionts and thrive in clear, light-rich settings. Their dominance group 'B' community is consistent with well-lit, relatively stable seabed conditions, likely with some hard substrate or coarse sediment.

The presence of deposit feeders such as *Abra aegyptiaca* including *Ammonia tepida* and *Elphidium crispum* point to soft sediments with an organic content. These taxa tend to dominate productive sediments. The analysis shows that several samples with high foraminifer abundances form a coherent group, which fits with stable sedimentary habitat.

Grazers are well represented in this community with small gastropods like *Bittium*, *Cerithium* and *Clithon* indicate microalgal grazing on hard or mixed substrates. The presence of the urchin *Diadema setosum*

in low numbers supports this picture, as this species favours reefal or rocky habitat with significant algal growth.

Suspension feeders include barnacles (*Amphibalanus amphitrite*), bivalves (*Cerastoderma glaucum*, *Ctena divergens*, *Donax faba*) and the brachiopod *Anomia achaeus*. These form part of a filtering guild that relies on steady water movement and suspended particles.

Predators such as *Drupella cornus* (a coral-associated muricid) are present but not widespread. Their low abundance is not unexpected in sedimentary or mixed habitats and supports the view that hard-coral cover patchy in the area sampled. The low diversity found in a single offshore sample may be indicative of a disturbed or environmental constrained habitat.

5.4.2.1. Key ecological features

There is evidence for a mosaic benthic landscape rather than a single dominant habitat. There are:

- A stable, light-exposed assemblage rich in algal-bearing foraminifera and small grazers.
- Sedimentary patches dominated by deposit feeders and tolerant bivalves.
- Scattered reef-associated elements indicating structural complexity and some hard bottom.

This combination supports productivity through multiple pathways: microalgal grazing, filter feeding and organic particle processing. It also points to a system where habitat heterogeneity is an important driver of biodiversity.

5.4.2.2. Sensitive or informative taxa

Amphistegina lobifera is sensitive to turbidity and tends to decline with heavy sediment stress. Its presence in high numbers suggests good water clarity in parts of the study area.

Diadema setosum is typical of in proximity to reef areas and responds to changes in algal cover and reef condition. Even low counts imply connectivity to harder substrata.

The mixture of saline-tolerant species such as *Cerastoderma glaucum* with reef-linked taxa hints at environmental gradients, possibly from sheltered sediment to more exposed margins.

The presence of symbiont-bearing foraminifera support the view that at least part of this system is in fair condition. Opportunistic deposit feeders are present but not overwhelming, indicating there is some organic enrichment present.

5.5. Water Quality

The water column is well-oxygenated and chemically stable. The main signs of local influence are the elevated turbidity and reduced light penetration in the shallow nearshore/port area, together with small salinity anomalies within the port. Offshore waters remain clear and stratified, indicating limited mixing with the more turbid nearshore pockets.

5.5.1. Spatial trends

The clearest water and deepest light penetration occur away from shore. The nearshore samples show slightly higher turbidity and shallower Zeu, likely from local disturbance and sediment resuspension.

The lowest surface salinity appears offshore (Station 5), while the highest is situated at Station 11. That suggests some restricted circulation and possible evaporation influence in the bay.

Temperatures are warm and uniform at the surface everywhere. At depth, offshore stations show a stronger thermal gradient as the seabed deepens, while the shallow stations remain mixed.

Turbidity ranges from about 0.039 NTU to ≤0.32 NTU (Figure 28). The highest values occur at Stations 17 and 18 with offshore stations having lower values (0.04 to 0.06 NTU). The euphotic depth (ZEU) spans ranges between 19 to 72 metres (Figure 29) with the shallowest light penetration occurring at the same stations with higher turbidity. The lowest turbidity and deepest ZEU are offshore (~70 m at Stations 6 and 8).

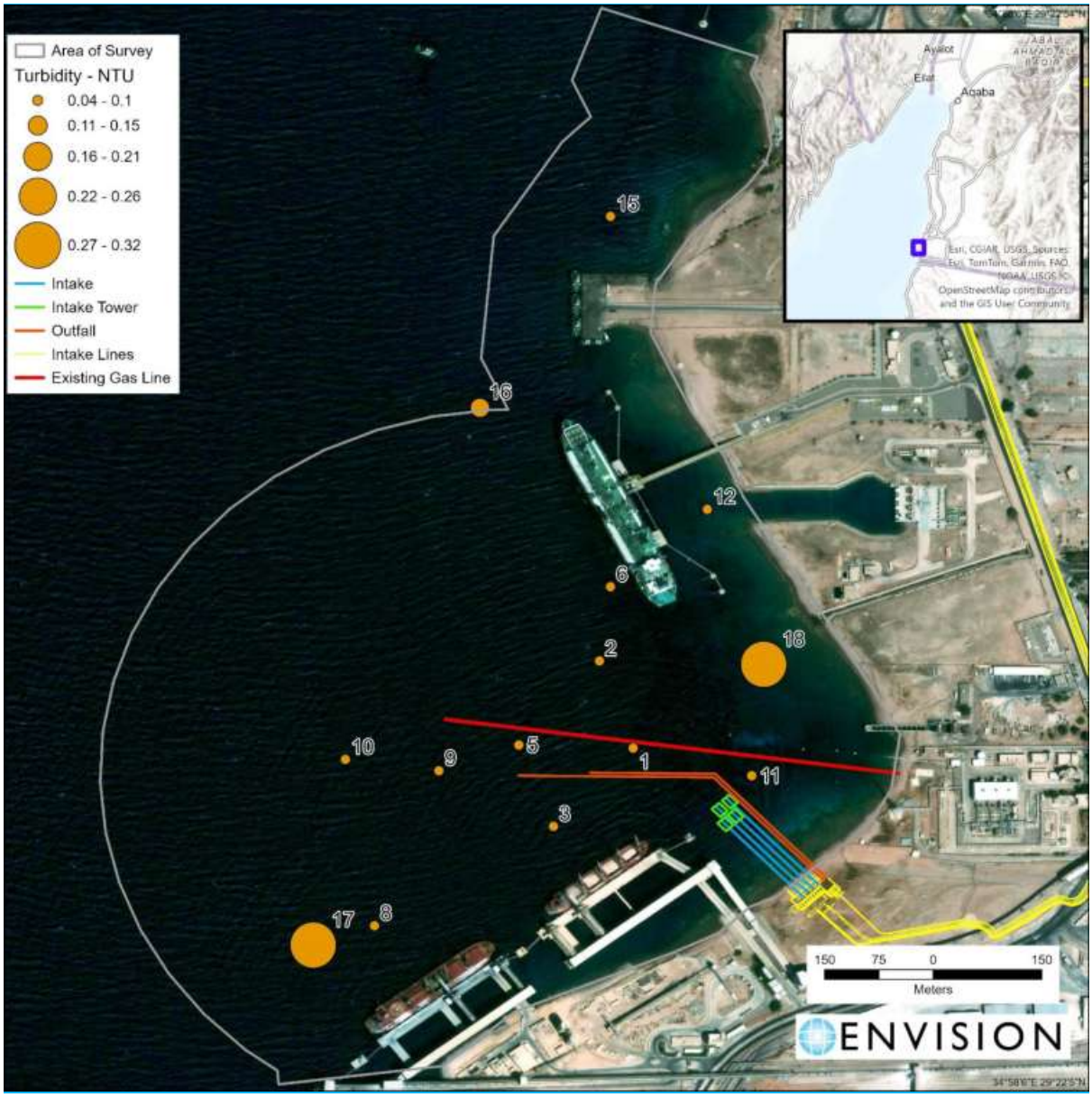


Figure 28.
Turbidity measured at each sample station within the AoS

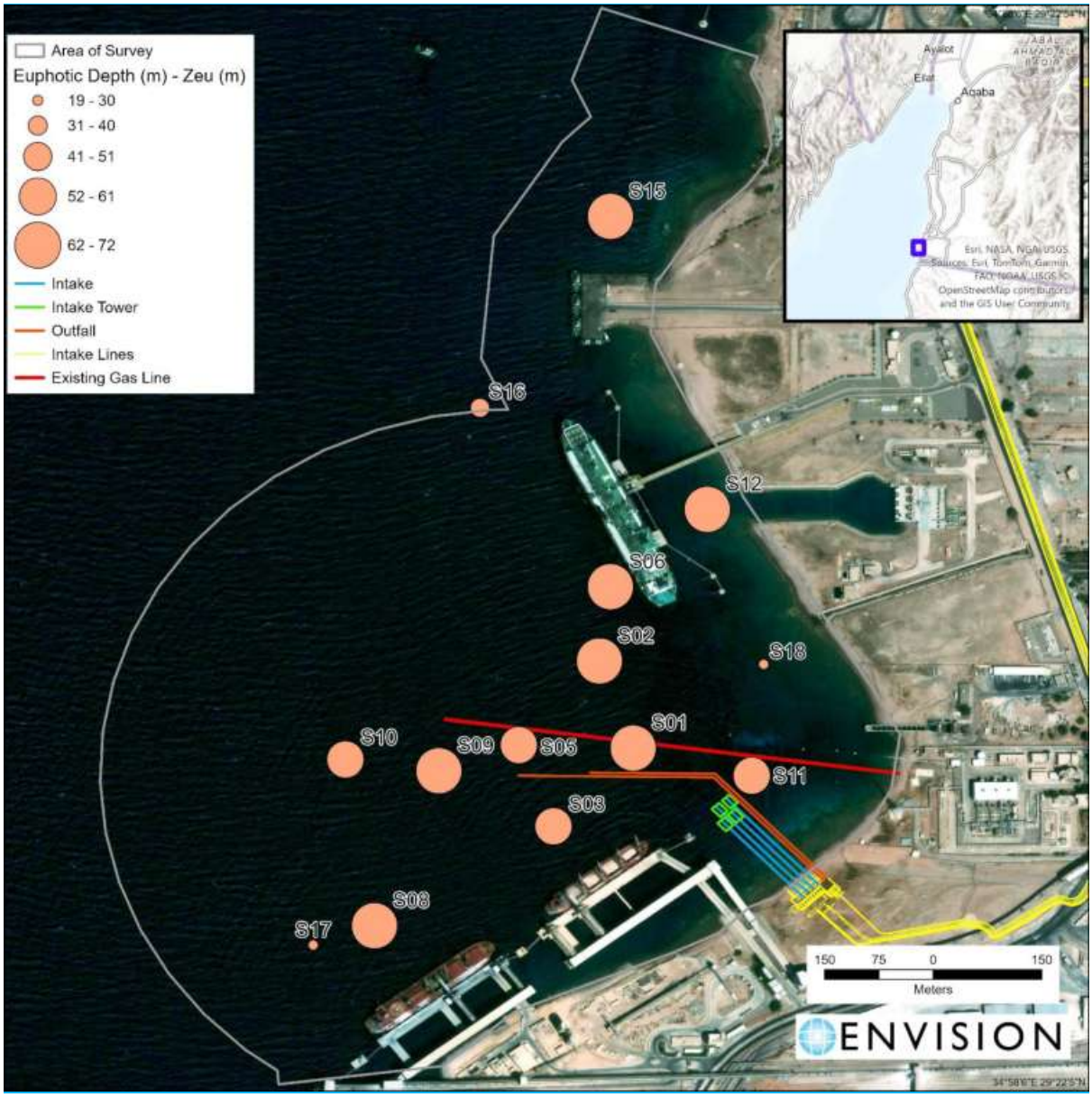


Figure 29.
Euphotic depths measured at each sample station within the AoS

5.5.2. Vertical structure

The vertical structure is consistent with a gently stratified coastal Red Sea setting. Offshore stations show a stable warm surface layer over cooler, slightly more saline water at depth. The main signals are a temperature decrease of roughly 1°C on average (up to nearly 3°C in the clearest stratified stations) and a small salinity increase of about +0.3, with oxygen and pH only showing minor variations. In contrast, the shallow and nearshore sites are well mixed, with almost no vertical gradients. This suggests wind, vessel activity, and restricted depth keep the water column homogenous, while the open water maintains a mild but persistent stratification.

Temperature

At the deeper offshore stations, surface water is between 25.9 to 26.2 °C and cools to about 23.3 to 25.9 °C at the seabed. The strongest gradient appears at Station 1 (60 m) where temperature drops from 26.05 °C at the surface to 23.33 °C at the bottom, a decline of roughly 2.7 °C. Station 5 (70 m) shows a similar pattern, falling from 26.09 °C at the surface to 24.35 °C at depth, a drop of 1.7 °C. Station 10 (100 m) cools from 26.12 °C to 25.75 °C, a smaller fall of 0.4 °C, which may reflect deeper mixing or sampling closer to a seasonal minimum gradient.

Across all deeper sites (Stations 1, 2, 3, 5, 9, 10), the average surface temperature is about 26.1 °C and the average bottom temperature is approximately 25.2 °C, giving an average decline of roughly 0.9 °C through the column. Shallower harbour-side stations show little to no thermal change with depth. For example, Station 11 (13 m) varies by only about 0.1 °C and Station 12 (7 m) by 0.65 °C, suggesting wind and vessel-induced movement keeps these pockets more mixed.

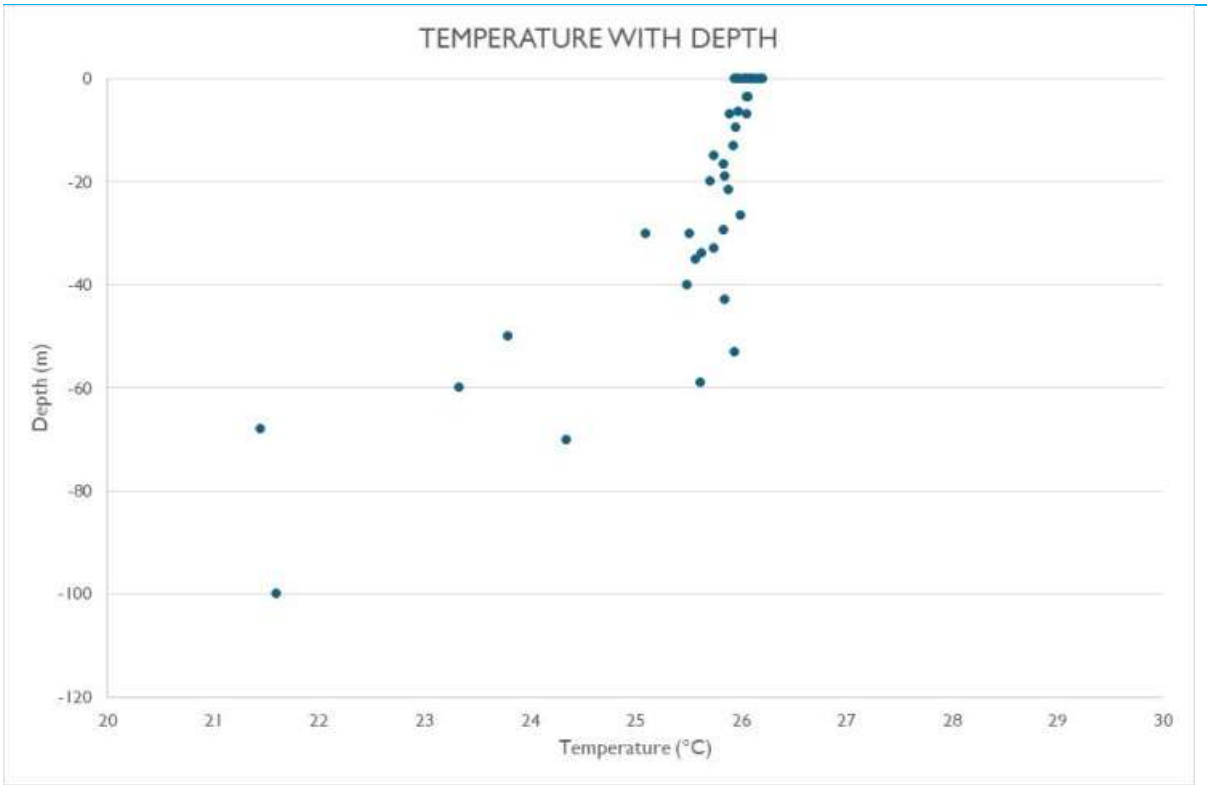


Figure 30.
Graph showing changes of temperature with depth

Salinity

Salinity increases modestly with depth at most offshore stations. At Station 1, salinity rises from 40.37 at the surface to 40.80 at the bottom (a +0.43 shift). Station 5 shows a larger step, from 39.35 (surface) to 41.19 (bottom), a difference of +1.84 that stands out as the most pronounced vertical change in the dataset.

Across the offshore group, surface salinity averages near 40.6 and bottom salinity near 40.9, so a typical increase with depth is about +0.3. In contrast, shallow stations near the port show almost no vertical difference. Station 12 shifts by only +0.72 across the short depth, but most of that occurs

between surface and mid-depth. Station 11 changes by just -0.05 from surface to bottom, indicating a nearly uniform water mass in the port corner.

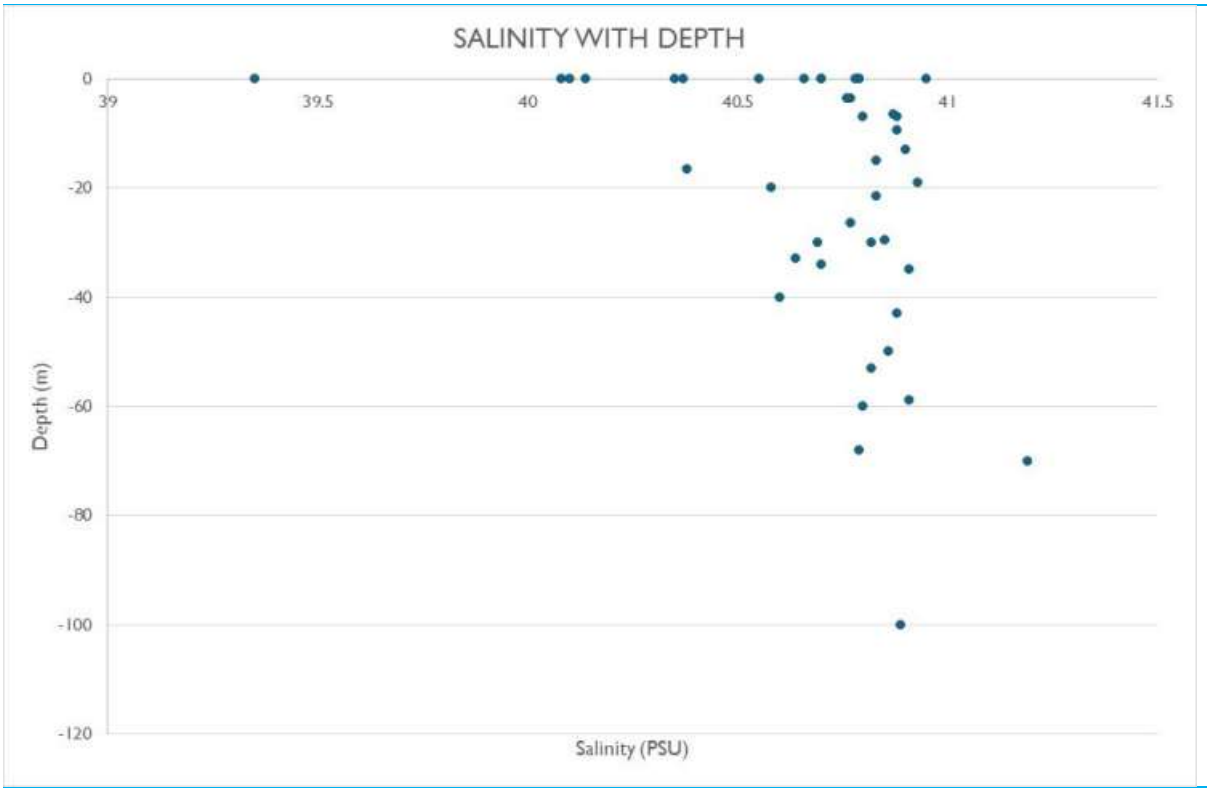


Figure 31.
Graph showing changes of salinity with depth

Dissolved oxygen

Dissolved oxygen stays high and stable from top to bottom. The offshore stations show a slight decline, usually in the range of about 0.05 to 0.12 mg L^{-1} between surface and bottom. At Station 2, oxygen falls from 6.60 mg L^{-1} to 6.50 mg L^{-1}, and at Station 10 from 6.60 to 6.51 mg L^{-1}. Averaged across deeper sites, oxygen drops from roughly 6.60 mg L^{-1} at the surface to about 6.52 mg L^{-1} at depth. This is a small decrease and suggests light respiration below the surface mixed layer but no sign of oxygen stress or stagnation.

In very shallow areas, oxygen remains almost flat. Station 12, for example, records 6.60 mg L^{-1} at the surface and does not show a mid-water or bottom reading, but values at nearby shallow stations stay close to that range.

pH

pH also shows very little vertical structure. Readings are between 8.26 and 8.30 from surface to seabed. Station 1 drops from 8.29 to 8.26 across 60 m. Station 10 from 8.30 to 8.25 across 100 m. Where data are available, the average decline through the water column is on the order of 0.02 to 0.04 pH units, which is negligible and consistent with a well-buffered marine system.

In summary, the water column is well-oxygenated and chemically stable. The main signs of local influence are the elevated turbidity and reduced light penetration in the shallow nearshore/port area, together with small salinity anomalies within the port. Offshore waters remain clear and stratified, indicating limited mixing with the more turbid nearshore pockets.

5.5.3. Plankton

Across the 14 samples, the planktonic community was consistently diverse and composed of a mixture of holoplankton (organisms that spend their whole life in the plankton) and meroplankton (larval stages of benthic or nektonic organisms). The plankton consists of gastropod larvae, decapod larvae and fish larvae, plus various holoplankton groups (copepods, nematodes, foraminifera, chaetognaths). Of note, no coral larvae were present within the samples.

A total of 12 taxa and 431 individuals were recorded. The majority of samples (9 of 14) contained 11-12 of the 12 taxa, with the lowest richness samples (S01, S01, S12, S18) still containing 7-9 taxa found in the central area of the bay. Figure 32 & Figure 33 show the distribution of species abundance and richness within the AoS. Diversity indices (Shannon's H' ≈ 1.8–2.3) indicate that no single taxon overwhelmingly dominated and that abundance was spread across multiple groups

Although samples were collected in the vicinity of coral reef habitat, no coral larvae were recorded but given the restricted temporal coverage of the sampling and the fact that the survey was not specifically targeted at coral spawning events, this absence is not indicative of low coral recruitment or reproduction rates of coral and longer term, targeted studies should be undertaken to determine levels of coral reproduction and recruitment.

Overall, the planktonic communities are characteristic of nearshore or shelf environments where resident holoplanktonic grazers (small copepods) occur alongside a varied community of other invertebrate and fish larvae, with smaller meiofaunal elements such as nematodes providing an additional link between microbial production, sediments and higher trophic levels.

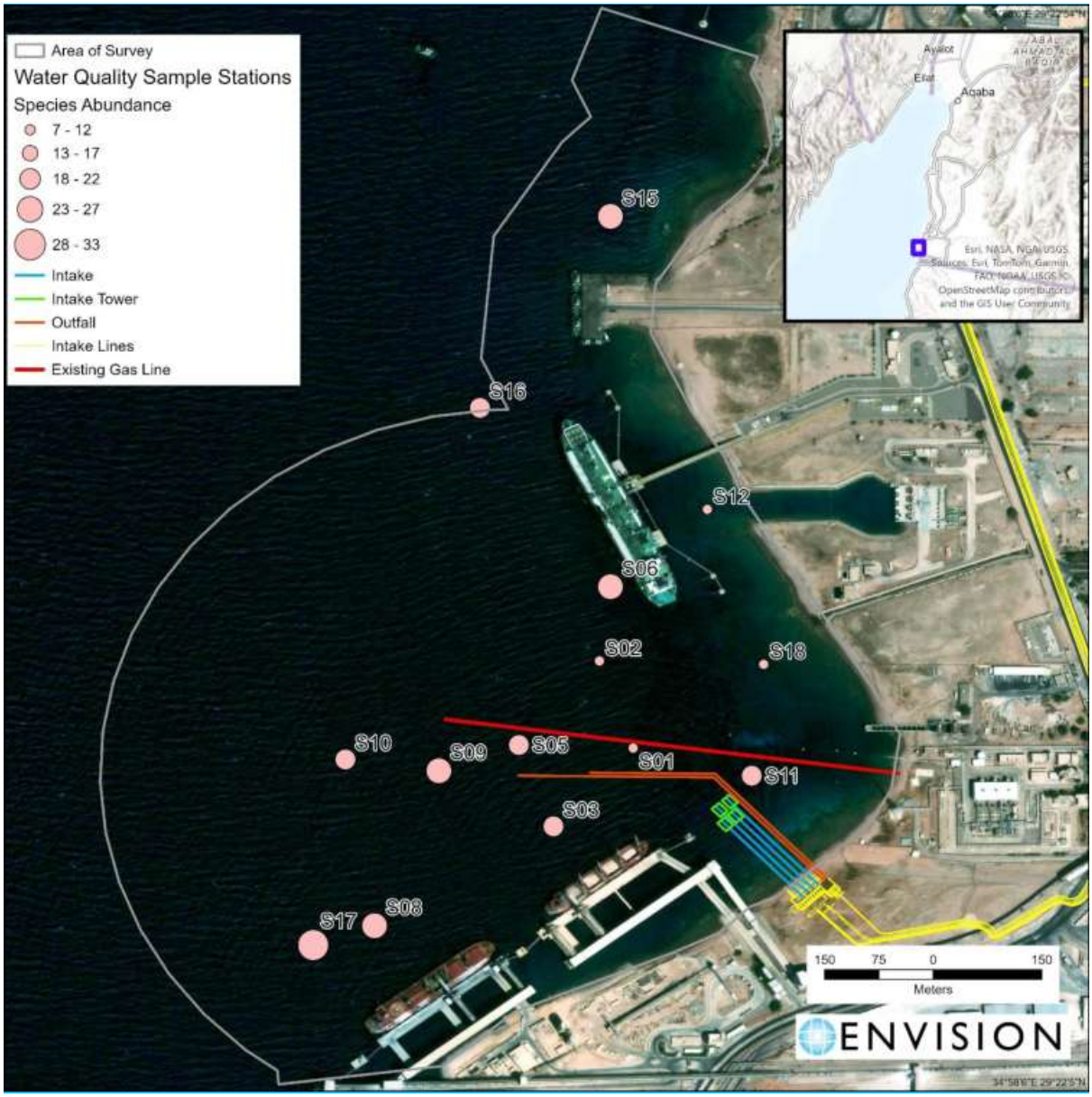


Figure 32.
Planktonic species abundance throughout the AoS

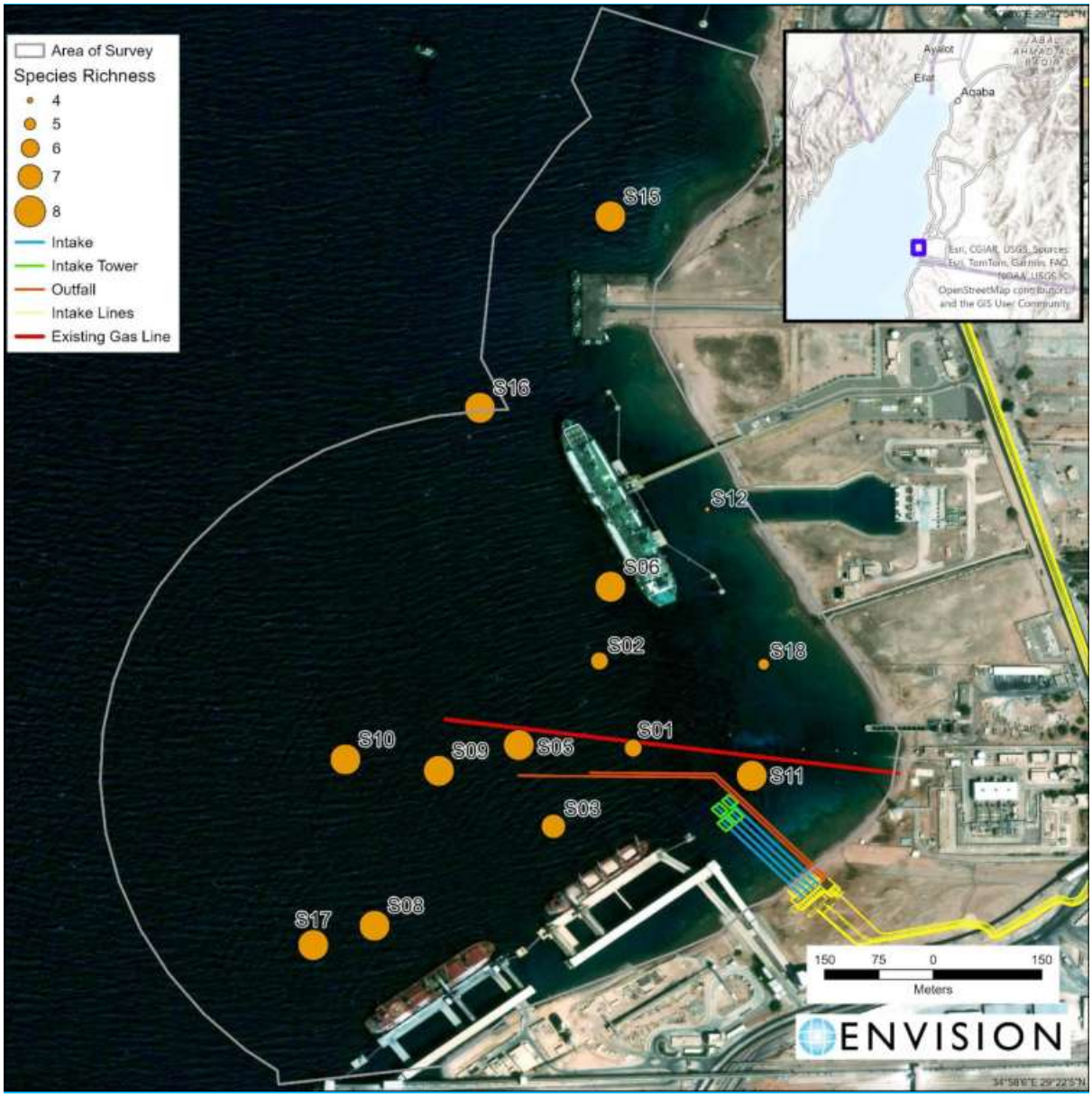


Figure 33.
Planktonic species richness throughout the AoS

5.5.3.1. Meroplanktonic component

Meroplanktonic larvae formed a major component of the community. Gastropod, decapod and fish larvae together contributed roughly 37 % of all individuals. Gastropod larvae alone accounted for about 27 % of total abundance, making them the single most abundant taxon overall.

Several samples, notably S15 and S17, were particularly rich in larval forms, where meroplankton comprised around half of all individuals. This pattern is consistent with periods of intense reproductive activity and suggests strong benthic–pelagic coupling, with benthic invertebrates and fishes contributing large numbers of offspring to the plankton for dispersal.

5.5.3.2. Copepod assemblage

Small calanoid and cyclopoid copepods formed the other dominant component of the planktonic assemblage. The copepod taxa *Centropages furcatus*, *Clausocalanus furcatus*, *Oithona nana* and *Paracalanus parvus* together contributed about 39 % of total individuals.

Within this group, *Paracalanus parvus* (~15 %) and *Oithona nana* (~13 %) were the most abundant and widespread species, while *Clausocalanus* and *Centropages* occurred at lower but consistent abundances. Several samples (e.g. S06, S08, S10, S12 and S18) were abundant with copepods, with copepods representing approximately 45-70 % of all individuals. This pattern is typical of coastal and shelf systems where small copepods form the trophic core of the zooplankton.

5.5.3.3. Nematodes and other holoplankton

Free-living nematodes (*Chromadora nudicapitata*, *Desmodora communis* and *Oncholaimus campylocercoides*) represented an important but secondary component of the community, together contributing ~19 % of total abundance. *Oncholaimus campylocercoides* was the most abundant nematode taxon. Nematodes were present in most samples and often occurred with high copepod abundances, suggesting a background meiozooplankton layer associated with the water column and possibly resuspended sediments.

5.6. Notable and Sensitive Features

5.6.1. Coral Habitat

Within the area there is a notable variation in reef quality with TA04 and TA05 having shallow communities which are relatively more abundant than the other areas and this elevated abundance continues to depth and remains comparatively rich through the upper reef slope (Figure 34). This shallow peak in abundance is indicative of strong light, good water movement, and stable substrates, which favour fast-growing massive and branching forms. It can also reflect a localised patch of reef framework with high three-dimensional complexity, which offers more settlement space and protection.

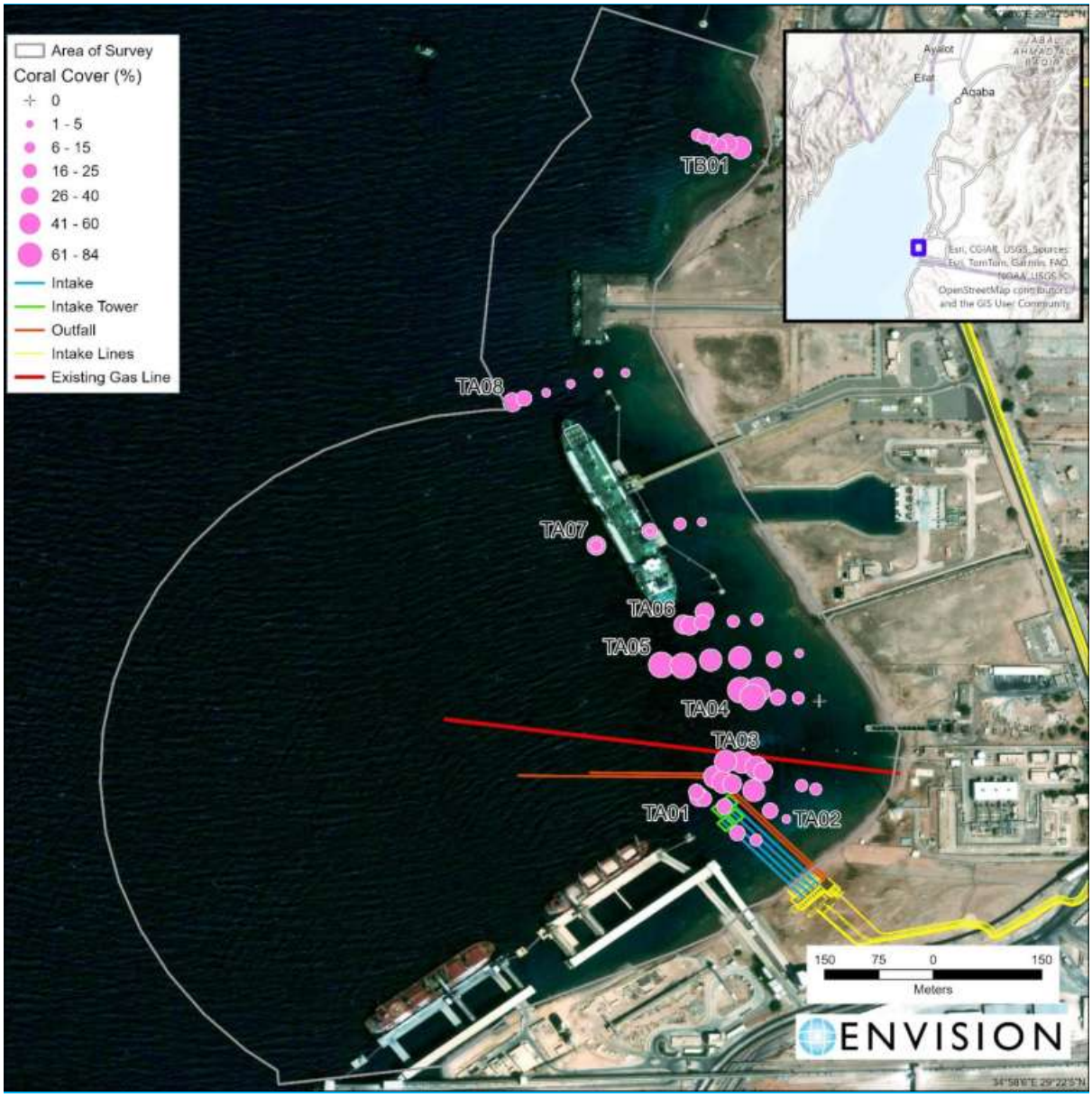


Figure 34.
Coral abundance throughout the AoS

The fact that coral abundances do not decline sharply by around 15 to 20 metres also suggests a smoother habitat transition with depth. In other areas there is a sharp decline in abundance which indicate a shift to sand, rubble, or reduced light. TA04 & TA05 appear to have a more continuous slope with suitable supporting habitat extending deeper.

In summary, the area around TA04 & TA05 likely represents a healthier or more structurally intact section of reef, with high cover in shallow areas and a gradual shift in community structure rather than an abrupt drop.

5.6.2. Seagrass Habitat

Seagrass habitat is found to be most abundant in the shallow areas in the north of the bay (Figure 35)

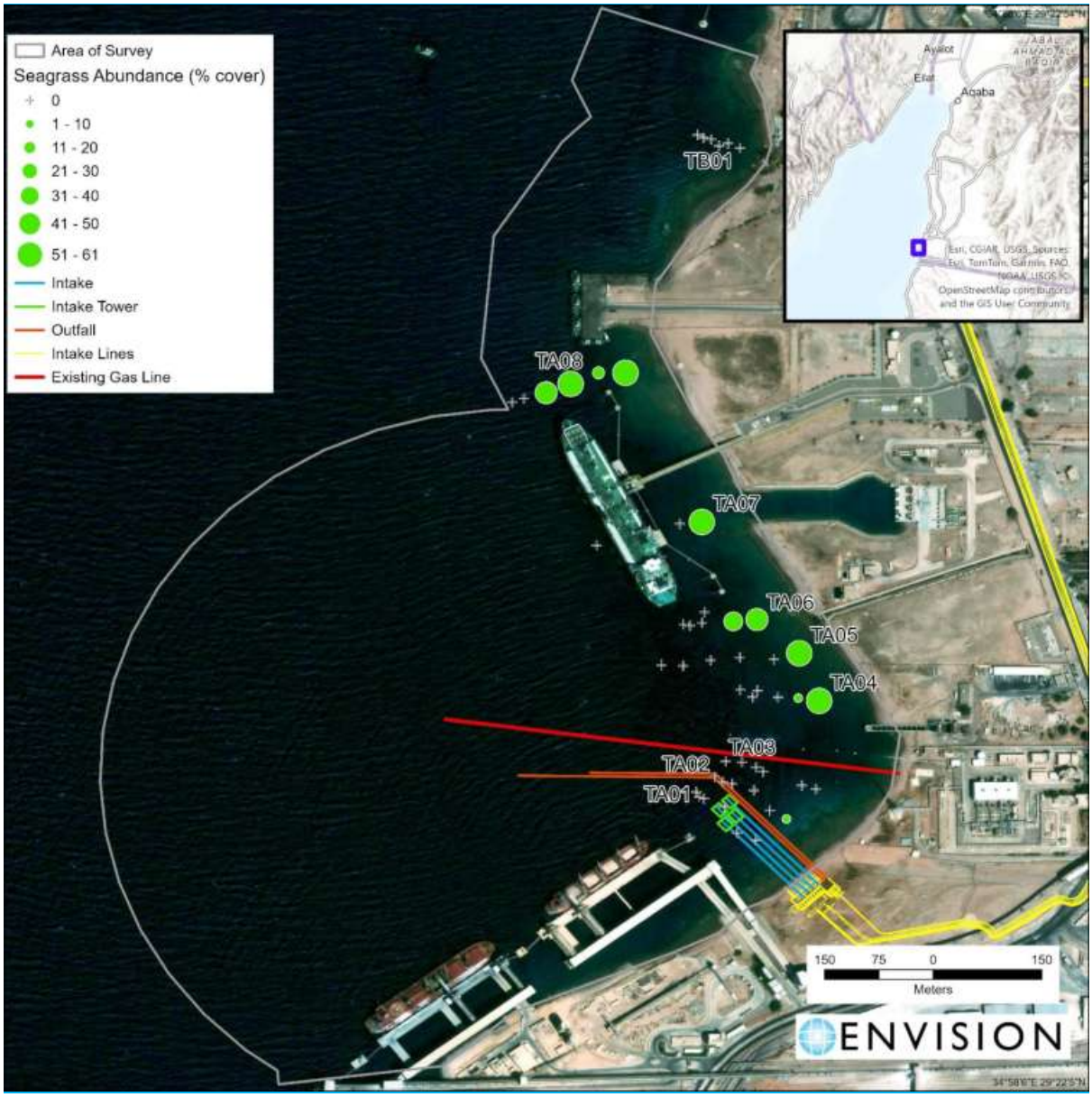


Figure 35.
Seagrass abundance throughout the AoS

Ecologically, this pattern fits a classic nearshore meadow fringe that thins with depth as light availability declines. These shallow meadows are high-value habitat. They provide nursery and foraging grounds for fish and invertebrates that also use adjacent reef and sand habitats, which boosts local biodiversity and supports fisheries productivity. The leaf canopy dampens waves and currents, with the root and rhizome system stabilising unconsolidated sediments and reduces resuspension, which helps keep nearshore water clearer for corals and other phototrophs. Seagrass meadows are also efficient blue-carbon sinks, storing organic carbon in below-ground biomass and the underlying sediments for long periods. Because they intercept and trap fine particles and nutrients, they contribute to water-quality regulation along the shallow coastal strip.

From a management perspective, the high-cover meadows at 5 m at TA04, TA05, TA07 and TA08 are priorities for anchoring controls, vessel access planning and dredging/turbidity safeguards. The lack of

seagrass at TB01 means it can serve as a useful reference for non-seagrass benthic communities but not to benchmark seagrass condition.

5.7. Limitations and recommendations

Although the survey produced a strong dataset for understanding benthic habitats inside the embayment, some limitations should be acknowledged.

5.7.1. Depth range

The diver survey extends to 30 metres and the ROV to ~80 metres, yet bathymetry indicates depths >200 metres. This means the deeper slope and basin floor remain under-sampled. These deeper zones may support mesophotic communities or sediment-dwelling fauna not captured in this assessment.

5.7.2. Spatial focus

Most effort focused inside the bay. Outer reef slope areas, more exposed ridges and deeper channels were not directly assessed. These zones may differ in coral cover, current exposure and sediment transport.

5.7.3. Seasonality

The surveys represent a snapshot in time. Seagrass condition, plankton (including coral larvae) and benthic communities, macroalgal growth and sediment movement can vary with season and weather patterns. No seasonal comparison is currently available.

5.7.4. Video-based taxonomic limitations

ROV imagery quality limits fine-scale taxonomic resolution. Some coral groups could not be identified to genus level, and cryptic or small invertebrates may have been missed.

5.7.5. Substrate and geomorphology uncertainty

While substrate type is well inferred, detailed geomorphology such as micro-relief, rugosity and sediment composition were not quantified using bathymetric or photogrammetric tools.

5.7.6. Potential disturbance context

Some debris was recorded (for example tyres and metal objects) and heavy metal and hydrocarbon contamination is moderate in some places which introduces the risk of these materials becoming more mobile and bioavailable therefore dispersing pollutants wider.

5.8. Recommendations to Address Limitations

5.8.1. Extend depth coverage

Extend ROV transects or towed benthic camera surveys down the reef slope to ~200 metres, using a high-quality camera and lighting system that supports taxonomic identification and quantitative estimates of cover. This work will close the current gap in understanding of deeper coral and soft-sediment communities that may be exposed to changes in salinity, turbidity or sediment deposition associated with the project. It will also provide more robust, spatially explicit information on seabed substrates in areas where physical disturbance or indirect effects are expected.

5.8.2. Broaden lateral coverage

Increase survey effort outside the bay entrance and along more exposed outer slopes to characterise regional variation in community structure and environmental exposure. This broader lateral coverage will help to distinguish local project-related effects from wider natural gradients and will provide a stronger reference envelope for interpreting any changes observed within the main development area and along potential plume pathways.

5.8.3. Seasonal repeat surveys

Undertake repeat surveys at least quarterly as part of a annual programme. Seasonal coverage will capture variation in seagrass condition, algal growth cycles, sediment dynamics, water temperature and coral reproductive periods. This will improve understanding of how project-related stressors may interact with natural seasonal peaks in sensitivity and will support more realistic assessment of worst-case conditions and timing for monitoring and management.

5.8.4. Higher-resolution benthic mapping

Acquire multibeam echo sounder data, including high-resolution bathymetry (and backscatter where feasible), to support detailed benthic habitat mapping and engineering design. Improved geomorphological mapping will refine estimates of habitat extent within and around the project footprint, help identify small-scale features such as patch reefs and scarps that are particularly sensitive to disturbance, and allow more precise micro-siting and routing to reduce physical impacts and optimise monitoring locations.

5.9. Monitoring Plan

5.9.1. Pre-construction baseline

- ROV survey out to 200 m contour
- High-resolution diver photogrammetry at key sites
- Seagrass condition mapping (biomass, shoot density)
- Water quality and turbidity baseline
- Benthic sediment quality sampling at planned pipeline corridor

5.9.2. Construction-phase monitoring

- Turbidity loggers positioned up-current and down-current of works
- Daily visual checks via ROV or drop camera
- Real-time sediment plume monitoring if piling or trenching occurs
- Stop-work trigger values for turbidity and sediment deposition

5.9.3. Post-construction monitoring

- Repeat ROV and diver transects at 3, 6 and 12 months, then annually
- Coral health indicators (bleaching, necrosis, sediment load)
- Seagrass recovery surveys in shallow zones
- Sediment sampling for any hydrocarbon or metal release

5.9.4. Recommendations to Limit Impact from Pipelaying or Construction

5.9.5. Avoidance and routing

- Route pipelines away from dense coral and seagrass beds
- Position landfalls and infrastructure on naturally sandy or degraded zones
- Maintain standoff distance from sensitive coral slopes

5.9.6. Sediment and turbidity control

- Use silt curtains or bubble curtains where practical in shallow works
- Time trenching to avoid peak coral stress periods (summer high temperatures)
- Select trenching or micro-tunnelling methods that minimise plume dispersion

5.9.7. Direct habitat protection

- Use pre-construction diver checks to relocate small, isolated corals where necessary
- Mark exclusion zones with buoys to prevent vessel grounding and anchor damage
- Use pre-laid concrete mattresses or float-and-sink installation to minimise seabed contact

5.9.8. Operations and maintenance

- Require high-precision positioning for anchors, ROV work and cable touchdowns
- Introduce an anchor management plan and preferably anchor-free mooring where possible

5.9.9. Community and stakeholder interaction

- Engage local marine protected area managers and research centres
- Support ongoing coral monitoring or restoration programmes if appropriate

The bay supports high-quality coral reef and seagrass habitats with natural zonation extending into deeper water. The current surveys provide a strong foundation, but extending depth and seasonal coverage will strengthen confidence and provide better resilience planning for marine construction activities. With careful routing, controlled sediment disturbance and structured monitoring, pipelaying and coastal works can be managed to minimise ecological impact.

6. Appendices

6.1. Appendix A: Station List and Coordinates

6.1.1. ROV Stations

STATION	DEPTH	LATITUDE	LONGITUDE
NEW01a	10	29.3715833	34.9640750
STN17	17.6	29.3722861	34.9649944
STN19	44	29.3725111	34.9638694
STN25	10	29.3740495	34.9634614
STN32	6.7	29.3753300	34.9633087
NEW01b	5.1	29.3737168	34.9641454
STN24	17	29.3733940	34.9636260
STN15	29	29.3719710	34.9631520
STN13	40	29.3712930	34.9621850
STN05	36	29.3702960	34.9606210
STN01	27	29.3686410	34.9586620
STN04	35	29.3692630	34.9578560
STN11	60	29.3702260	34.9586920
STN10	53	29.3710510	34.9596660
STN16	55	29.3714800	34.9609650
STN18	53	29.3720690	34.9616840
STN23	65	29.3723990	34.9622610
NEW03	64	29.3727410	34.9626360
STN29	62	29.3730530	34.9627120
NEW04	31	29.3731070	34.9634770
NEW05	53	29.3724180	34.9630820
NEW06	33	29.3721130	34.9637620
STN40	27	29.3787340	34.9615000
STN39	20	29.3790830	34.9622460
STN42	35	29.3798880	34.9620150
STN41	13	29.3798960	34.9629180
STN43	18	29.3806940	34.9632290
STN44	46	29.3807740	34.9626330
NEW07	9	29.3756861	34.9630528
NEW08	5	29.3749531	34.9635137
NEW09	5	29.3733611	34.9640972
NEW10	35	29.3725790	34.9643840
NEW11	5	29.3720580	34.9644330
NEW12	10	29.3720130	34.9639220

STATION	DEPTH	LATITUDE	LONGITUDE
NEW13	17	29.3717530	34.9637290
NEW14a	16	29.3715611	34.9629722
NEW14b	30	29.3723222	34.9637528
NEW15	51	29.3718690	34.9625200
NEW16	77	29.3724000	34.9613520
NEW17	50	29.3720980	34.9626980

6.1.2. Diver Transects

TRANSECT	DEPTH	MID_LONGITUDE	MID_LATITUDE
TA01_05	5	34.964155	29.371240
TA01_10	10	34.963921	29.371329
TA01_15	15	34.963758	29.371654
TA01_20	20	34.963509	29.371755
TA01_25	25	34.963447	29.371777
TA01_30	30	34.963412	29.371838
TA02_05	5	34.964532	29.371503
TA02_10	10	34.964329	29.371606
TA02_15	15	34.964127	29.371857
TA02_20	20	34.963858	29.371937
TA02_25	25	34.963745	29.371960
TA02_30	30	34.963643	29.372024
TA03_05	5	34.964896	29.371872
TA03_10	10	34.964722	29.371918
TA03_15	15	34.964244	29.372086
TA03_20	20	34.964156	29.372143
TA03_25	25	34.963980	29.372206
TA03_30	30	34.963777	29.372216
TA04_05	5	34.964938	29.372966
TA04_10	10	34.964679	29.373002
TA04_15	15	34.964426	29.373009
TA04_20	20	34.964173	29.373094
TA04_25	25	34.964111	29.373011
TA04_30	30	34.963960	29.373101
TA05_05	5	34.964692	29.373556
TA05_10	10	34.964376	29.373480
TA05_15	15	34.963953	29.373504
TA05_20	20	34.963590	29.373471
TA05_25	25	34.963250	29.373400
TA05_30	30	34.962980	29.373410
TA06_05	5	34.964165	29.373975
TA06_10	10	34.963875	29.373950
TA06_15	15	34.963515	29.374065
TA06_20	20	34.963485	29.373935
TA06_25	25	34.963335	29.373900
TA06_30	30	34.963255	29.373915

TRANSECT	DEPTH	MID_LONGITUDE	MID_LATITUDE
TA07_05	5	34.963480	29.375185
TA07_10	10	34.963210	29.375160
TA07_15	15	34.962835	29.375070
TA07_20	20	34.962835	29.375070
TA07_25	25	34.962175	29.374890
TA07_30	30	34.962175	29.374890
TA08_05	5	34.962535	29.377030
TA08_10	10	34.962200	29.377030
TA08_15	15	34.961855	29.376895
TA08_20	20	34.961550	29.376785
TA08_25	25	34.961275	29.376715
TA08_30	30	34.961130	29.376665
TB01_30	30	34.963430	29.379980
TB01_25	25	34.963505	29.379945
TB01_20	20	34.963600	29.379925
TB01_15	15	34.963695	29.379845
TB01_10	10	34.963805	29.379875
TB01_05	5	34.963955	29.379820

6.1.3. Sediment Samples

STATION	DEPTH	LATITUDE	LONGITUDE
G01	10	29.380860	34.963340
G02	22	29.830300	34.962340
G03	9	29.375340	34.963340
G04	50	29.374820	34.961380
G05	42	29.374170	34.961510
G06	7	29.374010	34.963990
G07	7	29.373480	34.964210
G08	70	29.373350	34.961270
G09	30	29.372610	34.963200
G10	6	29.371840	34.964700
G11	45	29.371850	34.961180
G12	6	29.371270	34.964190
G13	52	29.370940	34.960330
G14	47	29.369980	34.958870
G15	30	29.373610	34.963240
G16	40	29.372950	34.960820
G17	55	29.373550	34.960200
G18	100	29.374400	34.957780

6.1.4. Water Samples

STATION	DEPTH	LATITUDE	LONGITUDE
S01	60	29.37238	34.96263
S02	59	29.37346	34.96221
S03	43	29.37141	34.96164
S05	70	29.37242	34.96121
s09	68	29.3721	34.96022
s10	100	29.37224	34.95906
S06	30	29.37438	34.96235
S08	33	29.37018	34.95942
S16	40	29.3766	34.96073
S17	53	29.36994	34.95866
S11	13	29.37204	34.9641
S12	7	29.37534	34.96355
S15	19	29.37897	34.96235
S18	7	29.37342	34.96425

6.2. Appendix B: Laboratory Results

6.2.1. Sediment Samples - Heavy Metals

	Tributyl Tin (TBT)	Dibutyl Tin (DBT)	Cadmium	Chromium	Copper	Nickel	Lead	Tin	Zinc	Arsenic	Mercury	aroclor 1260	aroclor 1242	aroclor1254
G01	< 5.0	< 5.0	0.05	6.03	0.54	2.44	0.61	2.5	6.24	0.64	0.05	< 0.1	< 0.1	< 0.1
G02	< 5.0	< 5.0	0.05	7.31	0.56	2.94	0.69	2.5	9.33	0.99	0.05	< 0.1	< 0.1	< 0.1
G03	< 5.0	< 5.0	0.05	32.64	1.03	16.31	4.24	2.5	9.27	0.79	0.05	< 0.1	< 0.1	< 0.1
G04	< 5.0	< 5.0	0.05	9.37	1.49	4.52	0.93	2.5	8.41	1.29	0.05	< 0.1	< 0.1	< 0.1
G05	< 5.0	< 5.0	0.05	11.61	1.27	5.79	0.83	2.5	9.41	0.63	0.05	< 0.1	< 0.1	< 0.1
G06	< 5.0	< 5.0	0.05	18.09	1.1	7.63	1.04	2.5	18.63	1.1	0.05	< 0.1	< 0.1	< 0.1
G07	< 5.0	< 5.0	0.05	17	2.26	8.54	1.61	2.5	8.3	1.1	0.05	< 0.1	< 0.1	< 0.1
G08	< 5.0	< 5.0	0.05	9.07	1.36	4.48	0.77	2.5	3.84	0.77	0.05	< 0.1	< 0.1	< 0.1
G09	< 5.0	< 5.0	0.05	6.26	1.11	2.77	0.55	2.5	16.27	0.64	0.05	< 0.1	< 0.1	< 0.1
G10	< 5.0	< 5.0	0.05	26.35	1.92	11.55	1.87	2.5	9.98	1.2	0.05	< 0.1	< 0.1	< 0.1
G11	< 5.0	< 5.0	0.05	7.38	2.02	5.53	0.99	2.5	12.71	0.67	0.05	< 0.1	< 0.1	< 0.1
G12	< 5.0	< 5.0	0.05	49.74	1.76	21.37	1.76	2.5	9.45	0.84	0.05	< 0.1	< 0.1	< 0.1
G13	< 5.0	< 5.0	0.05	13.31	1.76	6.36	1.04	2.5	8.55	1.19	0.05	< 0.1	< 0.1	< 0.1
G14	< 5.0	< 5.0	0.05	19.66	1.75	10.12	1.03	2.5	4.01	1.18	0.05	< 0.1	< 0.1	< 0.1
G15	< 5.0	< 5.0	0.05	9.59	2.83	4.42	0.59	2.5	8.44	0.79	0.05	< 0.1	< 0.1	< 0.1
G16	< 5.0	< 5.0	0.05	15.36	1.58	7.05	0.89	2.5	9.01	1.28	0.05	< 0.1	< 0.1	< 0.1
G17	< 5.0	< 5.0	0.05	13.91	1.69	6.74	1.03	2.5	8.77	1.19	0.05	< 0.1	< 0.1	< 0.1
G18	< 5.0	< 5.0	0.05	19.68	1.74	9.33	0.93	2.5	8.77	1.21	0.05	< 0.1	< 0.1	< 0.1

6.2.2. Sediment Samples – Hydrocarbons (PAH)

	Mineral oil	Flourene	Anthracene	Fluoranthene	Pyrene	Benzo (a) anthracene	Chrycene	Benzo (b) fluoranthene	Phenanthrene	Acenaphtylene	Benzo (g,h,i) perylene	Indeno (1,2,3-cd) pyrene	Acenaphthene	Benzo (a) pyrene	Naphthalene	Benzo (k) fluoranthene	Dibenzo (a,h) anthracene
G01	< 0.5	2.5	2.5	35.2	27.5	6.9	13.2	17.8	32	2.5	9.9	16.9	2.5	10.2	2.5	9.6	9.4
G02	< 0.5	2.5	6.2	2.5	7.1	2.5	2.5	2.5	2.5	17.3	5.8	6.7	2.5	2.5	2.5	9.6	2.5
G03	< 0.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	6.1	2.5	12.6	5.2	2.5	7.3
G04	< 0.5	2.5	2.5	2.5	46	141	77.8	2.5	2.5	119	65.2	79.8	66.8	54.5	108.4	52.4	59.6
G05	< 0.5	14.1	13.2	5.3	2.5	7.1	10.2	2.5	2.5	2.5	2.5	2.5	2.5	17.7	2.5	2.5	8.4
G06	< 0.5	6.2	2.5	8	7.3	5.2	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	6.3	2.5	15.8
G07	< 0.5	2.5	2.5	11.2	6.1	5.6	7.7	2.5	2.5	13.2	11.7	2.5	2.5	9.2	11.7	5.5	5.2
G08	< 0.5	2.5	2.5	13	178	77.1	51.2	56.4	66.1	70.9	23.4	86.5	30.7	2.5	2.5	102.7	131.7
G09	< 0.5	2.5	10.4	2.5	2.5	2.5	2.5	2.5	7.6	7.1	8.8	2.5	2.5	2.5	11.3	7.2	2.5
G10	< 0.5	15.3	13.2	14.1	10.7	19.4	16.2	16.3	25.9	10.7	2.5	2.5	2.5	2.5	7.5	2.5	12.1
G11	< 0.5	2.5	2.5	2.5	5.6	7.8	5.7	2.5	14.3	5.4	2.5	12.9	12.1	6.3	12.1	12.4	2.5
G12	< 0.5	11.3	2.5	2.5	2.5	2.5	2.5	2.5	2.5	6.8	2.5	2.5	2.5	2.5	2.5	2.5	2.5
G13	< 0.5	2.5	10.2	2.5	2.5	11.3	12.3	2.5	2.5	2.5	2.5	12.3	5.4	10.6	2.5	7.5	5.3
G14	< 0.5	14.4	10.4	37.4	2.5	2.5	2.5	26	21.7	2.5	12.4	32	11.2	12.4	14.4	2.5	21.7
G15	< 0.5	2.5	11.8	2.5	2.5	2.5	2.5	13.5	11.5	22.1	8.7	23	10.7	20.4	25	12.5	10.8
G16	< 0.5	2.5	7.4	2.5	5.4	8.7	14.7	2.5	2.5	2.5	12.4	12	6.9	14	6.9	8.1	6.9
G17	< 0.5	9	2.5	2.5	2.5	23.8	27.7	15.6	14.9	12.3	22	24.4	2.5	2.5	10.4	12.5	12.9
G18	< 0.5	9.8	2.5	11.7	8.9	9.3	16.8	8.2	2.5	24.5	21.4	19.6	9.9	2.5	2.5	2.5	6.3

6.2.3. Sediment Samples – Infauna

	G01	G02	G03	G04	G05	G06	G07	G08	G09	G10	G11	G12	G13	G14	G15	G16	G17	G18
Abra aegyptiaca	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	14	0
Alvania dorbignyi	3	0	0	1	0	0	0	12	6	2	0	0	6	3	5	0	0	0
Ammonia tepida	0	0	0	0	4	0	0	0	0	0	0	0	0	0	0	0	0	0
Amphibalanus amphitrite	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	5
Amphistegina lobifera	3	0	7	22	21	0	8	24	0	5	0	0	0	0	0	0	0	0
Anomia achaeus	0	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Bittium sp. (= Cerithium caeruleum)	0	0	0	0	0	0	7	0	0	0	0	0	0	0	10	0	0	0
Cellana rota	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0
Cerastoderma glaucum	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	3	0
Cerithidium sp. (= Cerithium caeruleum)	0	0	0	0	0	0	0	0	0	0	0	0	0	12	0	0	0	0
Cerithium caeruleum	3	0	2	1	4	6	0	6	5	3	0	2	10	0	0	5	3	0
Clithon cf. corona	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0
Ctena divergens	0	1	0	0	0	5	0	0	1	0	0	1	0	0	0	0	0	0
Cyclostrema gyalum	0	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Cytheropteron excisum	1	0	0	5	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Dentalium reevei	0	0	0	0	0	0	0	2	0	0	0	0	0	0	0	0	1	0
Diadema setosum	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0
Donax faba	0	0	0	0	0	0	0	0	0	0	0	0	0	2	0	2	0	0
Drupella cornus	0	1	0	0	0	0	0	0	1	0	0	0	0	0	4	0	0	0
Elphidium crispum	0	0	0	0	5	0	0	0	0	0	0	0	0	0	0	0	0	0
Eulimella sp.	0	0	0	0	0	0	0	3	0	0	0	0	0	0	0	0	0	0
Fragum sueziense	0	2	0	0	0	1	0	0	0	0	0	2	0	0	0	0	0	0
Gafrarium pectinatum	0	0	0	0	0	0	0	0	0	0	0	0	0	0	3	0	0	0
Homalopoma sanguineum	0	0	0	0	0	0	0	0	0	0	14	0	0	0	0	0	0	0
juvenile fragments	0	0	0	0	0	0	2	0	0	0	0	0	0	0	0	0	0	0
Laevichlamys andamanica	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	1	0	0

	G01	G02	G03	G04	G05	G06	G07	G08	G09	G10	G11	G12	G13	G14	G15	G16	G17	G18
Loxoconchella scottoi	0	0	0	0	0	0	0	0	0	0	4	0	0	0	0	0	0	0
Lyrocardium anaxium	0	0	0	0	0	0	0	0	0	0	0	0	0	3	0	0	0	0
Mimachlamys sanguinea	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	0	0	0
Miniacina miniacea	0	0	0	0	0	0	0	3	0	0	0	0	0	0	0	0	0	0
Mirapecten yaroni	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0
Mitrella menkeana	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0
Naticarius onca	0	0	0	0	0	0	0	0	1	0	0	0	1	3	0	1	1	0
Nerita orbignyana	0	10	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Neritina pulligera	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	0	0
Odostomia sp.	0	0	0	0	0	0	2	0	0	0	0	0	0	0	0	0	0	0
Oliva oliva	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0
Oliva oliva (= mis-ID Olivellidae)	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0
Operculina ammonoides	0	0	0	12	0	0	72	0	0	0	0	0	0	0	0	0	0	0
Paracytheridea aqabaensis	0	0	0	0	3	0	0	4	0	0	0	0	0	0	0	0	0	0
Paratapes textilis	0	0	0	0	0	0	0	0	0	0	4	0	0	0	0	0	0	0
Patelloida rolani	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0
Pecten erythraeensis	0	0	0	0	0	0	0	0	0	0	3	0	0	0	0	0	0	0
Pegophysema kora	0	0	0	0	0	0	0	4	0	0	0	0	0	0	0	0	0	0
Peneroplis planatus	5	0	0	8	0	0	3	7	0	15	0	0	0	0	0	0	0	0
Pitar hebraeus	3	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0
Polinices mammilla	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0
Quinqueloculina seminula	12	0	0	6	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Rissoina ambigua	0	0	0	0	0	4	3	0	0	0	4	0	0	0	0	0	0	0
Rochia (= Tectus) erythraea	0	0	0	0	0	0	0	0	0	0	0	17	0	0	0	0	0	0
Seila adamsii	0	8	0	0	0	0	0	0	0	0	0	2	0	0	0	0	0	0
Sorites orbiculus	21	0	0	19	11	0	0	28	0	5	0	0	0	0	0	0	0	0
Spirobranchus cf. tetraceros	0	1	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0
Tellina adenensis	0	0	0	0	0	0	0	0	0	0	3	0	0	0	0	0	0	0

	G01	G02	G03	G04	G05	G06	G07	G08	G09	G10	G11	G12	G13	G14	G15	G16	G17	G18
Tellina flacca	3	4	0	1	8	3	0	5	4	2	0	1	5	0	0	0	0	0
Terebra sp.	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0
Trachycardium lacunosum	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0
Tricolia indica	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	34
Triloculina seminula	0	0	4	0	6	0	0	0	0	9	0	0	0	0	0	0	0	0
Triphora cf. perversa	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2
Turbo radiatus	0	10	0	0	0	0	0	0	0	0	14	0	0	0	0	0	0	0
Turbonilla sp.	0	0	0	0	0	2	0	0	0	2	0	0	0	0	0	0	0	0
Turritella terebra	0	0	0	0	0	0	0	0	3	1	0	0	0	0	0	1	0	0

6.2.4. Water Samples – Water Quality

Station	NTU	Zeu (~m)	pH Surface	pH Mid	pH Bottom	Salinity Surface	Salinity Mid	Salinity Bottom	Temp Surface	Temp Mid	Temp Bottom	DO Surface	DO Mid	DO Bottom
S01	0.048	64	8.29	8.27	8.26	40.37	40.82	40.8	26.05	25.1	23.33	6.61	6.54	6.49
S02	0.049	63	8.3	8.28	8.28	40.79	40.85	40.91	26.19	25.84	25.62	6.6	6.57	6.5
S03	0.065	52	8.29	8.28	8.28	40.66	40.83	40.88	25.99	25.89	25.86	6.59	6.56	6.55
S05	0.054	59	8.29	8.26	8.27	39.35	40.91	41.19	26.09	25.58	24.35	6.6	6.57	6.54
S06	0.041	70	8.29		8.29	40.7	40.83	40.69	26.04	25.64	21.45	6.6		6.57
S08	0.039	72	8.3		8.28	40.14	40.38	40.64	25.97	23.8	21.6	6.6		6.56
S09	0.046	66	8.3	8.3	8.28	40.55	40.7	40.79	26.04	25.75	25.52	6.58	6.58	6.55
S10	0.06	55	8.3	8.27	8.25	40.79	40.86	40.89	26.12	25.84	25.75	6.6	6.54	6.51
S11	≤ 0.067	≥ 51	8.29			40.95	40.87	40.9	25.95	25.96	25.86	6.6		
S12	0.044	67	8.3			40.08	40.77	40.8	26.15	25.72	25.5	6.6		
S15	0.047	64	8.3			40.1	40.88	40.93	26.1	26	25.95	6.6		
S16	≤ 0.121	≥ 35	8.3		8.28	40.35	40.58	40.6	26.1	25.98	25.94	6.58		6.56
S17	≤ 0.320	≥ 19	8.28		8.28	40.78	40.77	40.82	26.21	26.07	26.06	6.57		6.56
S18	≤ 0.320	≥ 19	8.29			40.7	40.76	40.88	26.1	26.06	25.9	6.59		

6.2.5. Water Samples – Plankton

	S01	S02	S03	S05	S06	S08	S09	S10	S11	S12	S15	S16	S17	S18
Centropages furcatus	0	0	0	0	2	2	1	2	1	1	3	2	3	0
Chromadora nudicapitata	1	2	2	2	2	2	2	1	2	0	2	2	3	0
Clausocalanus furcatus	0	0	2	3	3	2	3	3	2	2	3	2	3	1
Decapod larvae	1	1	1	2	2	2	2	1	1	1	2	1	2	0
Desmodora communis	1	1	2	1	1	2	2	1	1	0	1	1	2	0
Fish larvae	0	3	2	2	0	0	2	1	4	0	4	2	2	1
Gastropod larvae	3	3	5	5	12	3	10	5	2	2	16	15	32	3
Globigerina bulloides	0	0	0	1	1	1	1	1	1	1	1	1	1	1
Oithona nana	2	1	4	4	6	5	4	5	4	3	5	4	6	2
Oncholaimus campylocercoides	2	3	3	3	2	3	5	2	3	0	4	4	6	1
Paracalanus parvus	2	1	4	6	7	6	5	6	4	4	6	5	7	2
Sagitta enflata	3	2	1	1	1	1	1	1	1	0	1	1	2	0

ROV Stations

ROV station	Rocky and Rubble (%)	Healthy Corals (%)	Sandy (%)	Seagrass (%)
3	0	0	100	0
5	70	20	30	0
10	25	10	75	0
11	50	20	50	0
13	90	20	10	0
15	85	15	10	0
16	70	5	30	0
16(2)	30	10	70	0
17	95	10	5	0
18	95	15	5	0
19	100	80	0	0
23	40	10	60	0
29	50	15	50	0
44	70	15	30	0
1	70	20	30	0
2	30	15	70	0
3	80	30	20	0
4	15	15	25	60
5	20	20	50	30
6	25	20	20	50
7	90	60	10	0
8	90	15	10	0
9	100	50	0	0
10	100	50	0	0
11	75	20	25	0
12	90	20	10	0
13	45	15	65	0
14	40	10	60	0
15	35	5	65	0
16	80	20	20	0
17	80	15	20	0
18	0	0	100	0
19	50	20	50	0
20	90	50	10	0
21	0	0	100	0
22	90	65	10	0
23	70	30	30	0
24	90	50	10	0
25	90	50	10	0
26	40	20	60	0
27	70	25	30	0
28	30	5	70	0
29	25	20	30	45

ROV station	Rocky and Rubble (%)	Healthy Corals (%)	Sandy (%)	Seagrass (%)
30	15	15	25	60
31	10	10	40	50
32	30	20	70	0
33	75	40	25	0
34	90	30	10	0
35	90	25	10	0
36	80	15	20	0
37	100	30	0	0
38	85	35	15	0
39	75	10	25	0
40	90	30	10	0

6.2.6. Diver Data – Species Abundance

6.2.6.1. TA01

Family	Genus	5m	10m	15m	20m	25m	30m
Dendrophylliidae	Turbinaria	2	19	3	3	7	2
Poritidae	Goniopora		1	9	6	1	7
Poritidae	Porites	4	3	9	12	20	7
Agariciidae	Leptoseris		1	2	2	15	4
Agariciidae	Pavona	3	2	6	9	17	6
Acroporidae	Acropora	8	23	35	28	39	6
Acroporidae	Alveopora			1	2	1	
Acroporidae	Astreopora	2	19	9	10	14	3
Acroporidae	Montipora	8	16		28	40	13
Euphylliidae	Galaxea	2		2	1	1	1
Siderastreidae	Siderastrea		1	1		2	1
Coscinaraeidae	Craterastrea					1	
Fungiidae	Fungia		1	1	1		1
Fungiidae	Herpolitha		2	3			
Fungiidae	Podabacia					3	1
Fungiidae	Danafungia			2	1	2	
Plesiastreidae	Plesiastrea		1	2			1
Lobophylliidae	Lobophyllia		21	13	6	15	4
Lobophylliidae	Echinophyllia	2		2	2	6	5
Lobophylliidae	Oxypora			4	2	1	
Lobophylliidae	Acanthastrea	1	1	3	3	3	4
Mirulinidae	Caulastraea	1	1	2			
Mirulinidae	Cyphastrea	1	9	11	5	15	7
Mirulinidae	Dipsastrea	13	40	38	38	44	16
Mirulinidae	Echinopora	2	8	13	5	9	4
Mirulinidae	Erythrastrea		4	1	2	1	
Mirulinidae	Favites	1	9	4	13	24	6
Mirulinidae	Paragoniastrea	1		1	1	4	1
Mirulinidae	Goniastrea	47	32	25	21	27	8
Mirulinidae	Hydnophora	10	1	1			
Mirulinidae	Mycedium		21	6	1	6	5
Mirulinidae	Paramontastrea	1	20	16	31	24	17
Mirulinidae	Platygyra	15	93	54	12	10	7
Pocilloporidae	Pocillopora	25	6	10	5	1	
Pocilloporidae	Seriatopora	2		4	1	1	3
Pocilloporidae	Stylophora	77	39	41	29	31	6
Pocilloporidae	Stylocoeniella	1	1	3	3	2	1
Psammocoridae	Psammocora	1	1	5	9	17	11
Incertae Sedis	Pachyseris						5
Incertae Sedis	Leptastrea			7	6	1	2
Incertae Sedis	Plerogyra		2	2	5	7	3

6.2.6.2. TA02

Family	Genus	5m	10m	15m	20m	25m	30m
Dendrophylliidae	Turbinaria	7	7	11	2	3	0
Poritidae	Goniopora	7	4	2	0	1	3
Poritidae	Porites	4	10	11	27	14	29
Agariciidae	Gardineroseris	1	3	0	0	0	0
Agariciidae	Leptoseris	0	1	0	0	5	12
Agariciidae	Pavona	11	33	4	9	18	31
Acroporidae	Acropora	29	31	11	43	12	25
Acroporidae	Astreopora	1	2	2	1	0	1
Acroporidae	Montipora	9	25	17	37	39	50
Euphylliidae	Galaxea	3	4	1	1	1	0
Coscinaraeidae	Coscinaraea	2	8	0	7	6	6
Fungiidae	Fungia	0	1	0	1	0	4
Fungiidae	Herpolitha	0	3	0	0	0	0
Fungiidae	Podabacia	0	0	0	0	0	2
Plesiastreidae	Plesiastrea	0	0	0	1	0	0
Lobophylliidae	Lobophyllia	4	27	18	13	2	6
Lobophylliidae	Echinophyllia	8	12	0	3	2	10
Lobophylliidae	Oxypora	0	4	0	2	3	0
Lobophylliidae	Acanthastrea	0	5	0	3	0	0
Mirulinidae	Cyphastrea	3	4	11	14	5	4
Mirulinidae	Dipsastrea	17	62	30	40	9	12
Mirulinidae	Echinopora	4	83	24	15	8	10
Mirulinidae	Favites	1	5	5	1	1	11
Mirulinidae	Paragoniastrea	0	1	5	3	0	2
Mirulinidae	Goniastrea	57	90	42	64	25	20
Mirulinidae	Hydnophora	5	3	1	0	0	0
Mirulinidae	Merulina	0	5	6	8	7	10
Mirulinidae	Mycedium	0	11	14	7	11	9
Mirulinidae	Paramontastrea	4	39	15	27	9	20
Mirulinidae	Platygyra	28	84	39	6	3	3
Mirulinidae	Leptoria	2	1	2	0	0	0
Mirulinidae	Oulophyllia	0	1	5	4	0	2
Pocilloporidae	Pocillopora	12	7	8	1	0	0
Pocilloporidae	Seriatopora	2	1	7	0	0	0
Pocilloporidae	Stylophora	136	135	31	29	26	21
Pocilloporidae	Stylocoeniella	1	3	2	0	2	1
Psammocoridae	Psammocora	0	4	3	9	7	12
Incertae Sedis	Pachyseris	0	0	0	2	4	16
Incertae Sedis	Leptastrea	14	34	11	12	15	16
Incertae Sedis	Blastomussa	0	0	0	1	0	2
Incertae Sedis	Plerogyra	1	1	5	3	4	1
Milleporidae	Millepora	6	1	0	9	3	0

6.2.6.3. TA03

Family	Genus	5m	10m	15m	20m	25m	30m
Dendrophylliidae	Turbinaria	2	14	3	2	4	1
Poritidae	Goniopora	16	10	2	2	1	0
Poritidae	Porites	24	12	17	48	55	86
Agariciidae	Leptoseris	0	1	0	0	0	8
Agariciidae	Pavona	40	21	15	15	27	51
Acroporidae	Acropora	20	40	58	46	56	59
Acroporidae	Alveopora	0	0	0	0	2	0
Acroporidae	Astreopora	4	2	1	4	2	1
Acroporidae	Montipora	18	20	45	66	64	75
Euphylliidae	Galaxea	4	3	6	2	0	0
Euphylliidae	Gyrosmilia	0	0	1	0	0	0
Coscinaraeidae	Coscinaraea	2	4	0	10	1	10
Fungiidae	Fungia	0	0	6	1	0	2
Fungiidae	Ctenactis	0	1	0	0	0	0
Fungiidae	Herpolitha	0	2	0	0	0	0
Fungiidae	Podabacia	0	0	0	0	0	4
Plesiastreidae	Plesiastrea	0	1	0	0	0	0
Lobophylliidae	Lobophyllia	9	23	49	26	11	11
Lobophylliidae	Echinophyllia	6	10	8	6	3	7
Lobophylliidae	Oxypora	0	2	0	1	2	4
Lobophylliidae	Acanthastrea	0	6	7	7	0	0
Mirulinidae	Cyphastrea	14	22	7	7	3	5
Mirulinidae	Dipsastrea	44	75	85	76	37	17
Mirulinidae	Echinopora	14	47	60	32	12	22
Mirulinidae	Erythrastrea	0	0	2	4	1	1
Mirulinidae	Favites	4	7	7	4	3	1
Mirulinidae	Paragoniastrea	0	1	1	0	0	0
Mirulinidae	Goniastrea	54	101	210	114	33	34
Mirulinidae	Hydnophora	17	4	0	0	0	0
Mirulinidae	Merulina	0	6	16	42	19	25
Mirulinidae	Mycedium	0	25	26	10	18	12
Mirulinidae	Paramontastrea	6	48	51	53	26	17
Mirulinidae	Platygyra	38	67	90	26	6	2
Mirulinidae	Leptoria	0	1	0	0	0	0
Mirulinidae	Oulophyllia	0	0	4	0	2	1
Pocilloporidae	Pocillopora	63	15	11	5	4	1
Pocilloporidae	Seriatopora	1	0	0	0	0	1
Pocilloporidae	Stylophora	128	159	84	53	45	39
Pocilloporidae	Stylocoeniella	0	3	1	1	0	0
Psammocoridae	Psammocora	2	0	1	3	9	18
Incertae Sedis	Pachyseris	0	0	0	1	6	20
Incertae Sedis	Leptastrea	21	31	35	45	25	19
Incertae Sedis	Plerogyra	0	3	5	17	12	3
Milleporidae	Millepora	3	5	6	7	0	2

6.2.6.4. TA04

Family	Genus	5m	10m	15m	20m	25m	30m
Dendrophylliidae	Turbinaria	4	7	7	9	7	2
Poritidae	Goniopora	1	13	9	6	1	2
Poritidae	Porites	2	5	9	31	64	114
Agariciidae	Gardineroseris	0	1	0	0	0	1
Agariciidae	Leptoseris	0	4	0	1	3	14
Agariciidae	Pavona	5	27	4	29	29	123
Acroporidae	Acropora	0	23	46	50	51	33
Acroporidae	Astreopora	3	0	11	21	2	4
Acroporidae	Montipora	3	19	35	31	54	56
Euphylliidae	Galaxea	0	1	5	4	1	1
Euphylliidae	Gyrosmilia	0	0	0	0	1	1
Coscinaraeidae	Coscinaraea	0	1	1	0	0	5
Fungiidae	Fungia	0	0	0	4	7	2
Fungiidae	Ctenactis	0	0	0	2	1	1
Fungiidae	Herpolitha	0	0	0	1	0	0
Fungiidae	Podabacia	0	0	0	0	1	0
Plesiastreidae	Plesiastrea	0	0	0	1	0	0
Lobophylliidae	Lobophyllia	4	26	45	64	31	14
Lobophylliidae	Echinophyllia	3	6	11	22	17	12
Lobophylliidae	Oxypora	0	1	2	38	20	7
Lobophylliidae	Acanthastrea	0	4	14	15	1	4
Mirulinidae	Cyphastrea	2	3	9	12	1	7
Mirulinidae	Dipsastrea	0	81	138	57	31	9
Mirulinidae	Echinopora	2	87	126	150	49	27
Mirulinidae	Favites	0	14	8	17	5	1
Mirulinidae	Paragoniastrea	0	0	9	2	0	1
Mirulinidae	Goniastrea	28	102	161	189	132	38
Mirulinidae	Hydnophora	7	15	10	12	0	0
Mirulinidae	Merulina	0	11	11	18	20	30
Mirulinidae	Mycedium	0	0	11	57	77	68
Mirulinidae	Paramontastrea	4	33	93	75	45	37
Mirulinidae	Platygyra	23	84	93	77	33	9
Mirulinidae	Oulophyllia	0	0	0	9	0	0
Pocilloporidae	Pocillopora	0	2	2	7	0	0
Pocilloporidae	Seriatopora	5	5	0	1	0	0
Pocilloporidae	Stylophora	30	137	91	67	47	65
Pocilloporidae	Stylocoeniella	0	0	1	2	0	3
Psammocoridae	Psammocora	1	2	5	4	2	5
Incertae Sedis	Pachyseris	0	0	2	1	6	20
Incertae Sedis	Leptastrea	6	31	40	32	6	4
Incertae Sedis	Blastomussa	0	0	0	0	1	0
Incertae Sedis	Plerogyra	0	12	6	41	16	11
Milleporidae	Millepora	2	0	6	2	1	1

6.2.6.5. TA05

Family	Genus	5m	10m	15m	20m	25m	30m
Dendrophylliidae	Turbinaria	5	22	12	8	6	1
Poritidae	Goniopora	3	10	9	6	7	4
Poritidae	Porites	3	20	30	72	88	108
Agariciidae	Gardineroseris	0	5	4	0	0	0
Agariciidae	Leptoseris	0	0	7	1	10	8
Agariciidae	Pavona	1	14	15	26	62	107
Acroporidae	Acropora	23	71	39	58	29	36
Acroporidae	Alveopora	0	0	0	1	0	0
Acroporidae	Astreopora	5	36	26	6	2	3
Acroporidae	Montipora	8	40	77	60	51	109
Euphylliidae	Galaxea	2	3	4	1	5	2
Euphylliidae	Gyrosmilia	0	2	1	0	0	0
Siderastreidae	Siderastrea	0	16	19	0	0	0
Coscinaraeidae	Coscinaraea	0	0	0	1	1	3
Fungiidae	Fungia	0	2	1	3	7	4
Fungiidae	Ctenactis	0	0	0	0	0	1
Fungiidae	Herpolitha	0	1	0	0	1	0
Fungiidae	Podabacia	0	1	1	0	1	3
Plesiastreidae	Plesiastrea	0	2	0	0	0	0
Lobophylliidae	Lobophyllia	0	57	36	34	41	18
Lobophylliidae	Echinophyllia	4	15	18	48	23	17
Lobophylliidae	Oxypora	0	4	13	10	17	7
Lobophylliidae	Acanthastrea	2	20	12	8	4	3
Mirulinidae	Cyphastrea	0	13	39	21	22	2
Mirulinidae	Dipsastrea	16	181	115	98	42	19
Mirulinidae	Echinopora	2	87	68	81	82	55
Mirulinidae	Erythrastrea	0	12	10	0	0	0
Mirulinidae	Favites	0	97	43	21	10	4
Mirulinidae	Paragoniastrea	0	8	9	5	3	0
Mirulinidae	Goniastrea	14	94	108	159	144	64
Mirulinidae	Hydnophora	6	18	4	4	5	2
Mirulinidae	Merulina	0	0	1	82	75	65
Mirulinidae	Mycedium	0	9	40	64	159	135
Mirulinidae	Paramontastrea	5	45	47	107	66	66
Mirulinidae	Platygyra	19	94	58	55	67	19
Mirulinidae	Oulophyllia	0	50	0	5	3	0
Pocilloporidae	Pocillopora	7	14	4	1	1	1
Pocilloporidae	Seriatopora	1	1	0	0	0	0
Pocilloporidae	Stylophora	39	91	63	47	87	85
Pocilloporidae	Stylocoeniella	4	17	5	4	3	7
Psammocoridae	Psammocora	0	5	22	6	3	7
Incertae Sedis	Pachyseris	0	0	0	2	6	27
Incertae Sedis	Leptastrea	4	22	7	26	7	19
Incertae Sedis	Blastomussa	0	0	0	1	0	0

Family	Genus	5m	10m	15m	20m	25m	30m
Incertae Sedis	Plerogyra	0	15	17	20	29	20
Milleporidae	Millepora	1	0	1	4	5	1

6.2.6.6. TA06

Family	Genus	5m	10m	15m	20m	25m	30m
Dendrophylliidae	Turbinaria	4	12	5	2	2	3
Poritidae	Goniopora		7	10	5		
Poritidae	Porites	96	36	61	45	32	56
Agariciidae	Leptoseris	4		5	3	22	30
Agariciidae	Pavona	19	7	49	20	12	38
Acroporidae	Acropora	49	60	95	58	33	27
Acroporidae	Alveopora	1		2	1		2
Acroporidae	Astreopora	7	23	26	22	4	3
Acroporidae	Montipora	9	22	51	30	38	37
Euphylliidae	Galaxea	1		3	1		2
Siderastreidae	Siderastrea	1		4	9		
Coscinaraeidae	Coscinaraea	1					14
Coscinaraeidae	Craterastrea						2
Fungiidae	Fungia	1	1	3		1	
Fungiidae	Ctenactis	1		2			
Fungiidae	Herpolitha	1	1	2	2	1	
Fungiidae	Podabacia						13
Fungiidae	Danafungia		2	2		1	
Fungiidae	Pleuractis			2			
Plesiastreidae	Plesiastrea				4		
Lobophylliidae	Lobophyllia	5	2	11	13	2	2
Lobophylliidae	Echinophyllia	2	6	9	2	4	
Lobophylliidae	Oxypora	1		4	3	6	1
Lobophylliidae	Acanthastrea	3	12	14	4	1	1
Mirulinidae	Caulastraea	1	1	2	4		
Mirulinidae	Cyphastrea	5	3	41	25	8	15
Mirulinidae	Dipsastrea	24	75	84	30	10	8
Mirulinidae	Echinopora	16	13	41	14	1	6
Mirulinidae	Erythrastrea			4	2		
Mirulinidae	Favites	11	40	33	27	4	7
Mirulinidae	Paragoniastrea	1			1		4
Mirulinidae	Goniastrea	17	73	110	55	24	19
Mirulinidae	Hydnophora	5	14	18	5	3	
Mirulinidae	Merulina			1			
Mirulinidae	Mycedium			1	10	8	16
Mirulinidae	Paramontastrea	4	4	4	14	8	
Mirulinidae	Platygyra	40	81	63	51	5	
Pocilloporidae	Pocillopora	22	22	3	4	2	2
Pocilloporidae	Seriatopora	16	104	65	3	2	

Family	Genus	5m	10m	15m	20m	25m	30m
Pocilloporidae	Stylophora	76	100	50	29	21	10
Pocilloporidae	Stylocoeniella		10	10	1	1	
Psammocoridae	Psammocora			7	16	10	5
Incertae Sedis	Pachyseris					7	16
Incertae Sedis	Leptastrea	3		6	7	3	1
Incertae Sedis	Plerogyra		5	12	1	1	2
Milleporidae	Millepora	37	5				

6.2.6.7. TA07

Family	Genus	5m	10m	15m	20m	25m	30m
Dendrophylliidae	Turbinaria	3	9	3	2		1
Poritidae	Goniopora		3	6			
Poritidae	Porites	2	14	13	4		2
Agariciidae	Leptoseris			6	3		14
Agariciidae	Pavona	2	16	18	1	1	5
Acroporidae	Acropora	6	26	10	4		
Acroporidae	Alveopora		4	1			
Acroporidae	Astreopora		7	15	3		
Acroporidae	Montipora		15	10	8	1	9
Euphylliidae	Galaxea		3	1			
Euphylliidae	Gyrosmilia				1		
Siderastreidae	Siderastrea		7	4	1		1
Fungiidae	Cycloseris		1				
Fungiidae	Cantharellus			1			
Fungiidae	Fungia		1		2		
Fungiidae	Ctenactis						
Fungiidae	Herpolitha			3			
Plesiastreidae	Plesiastrea				3		
Lobophylliidae	Lobophyllia		2	19	6		
Lobophylliidae	Echinophyllia		6	7	3		6
Lobophylliidae	Oxypora			2	3		7
Lobophylliidae	Acanthastrea	1	7	4	2		1
Mirulinidae	Cyphastrea		2	18	5		2
Mirulinidae	Dipsastrea	11	66	28	12		10
Mirulinidae	Echinopora	7	18	10	4		1
Mirulinidae	Erythrastrea			2			1
Mirulinidae	Favites	9	48	23	4		2
Mirulinidae	Paragoniastrea		1	1	2		1
Mirulinidae	Goniastrea		14	9	6		1
Mirulinidae	Hydnophora	4	5	1			
Mirulinidae	Merulina		1				
Mirulinidae	Mycedium			13	7	1	12
Mirulinidae	Paramontastrea		17	23	4		
Mirulinidae	Platygyra	10	58	18	5	1	5

Family	Genus	5m	10m	15m	20m	25m	30m
Pocilloporidae	Pocillopora	13	18	4	2		
Pocilloporidae	Seriatopora	1					
Pocilloporidae	Stylophora	70	125	22	2		3
Pocilloporidae	Madracis				1		
Psammocoridae	Psammocora		1	1			1
Incertae Sedis	Pachyseris			1	3		7
Incertae Sedis	Leptastrea				2		
Incertae Sedis	Plerogyra		6	5			3
Milleporidae	Millepora		3				
Tubiporidae	Tubipora		1				

6.2.6.8. TA08

Family	Genus	5m	10m	15m	20m	25m	30m
Dendrophylliidae	Turbinaria	1	2	2	2	1	
Poritidae	Goniopora	4	9	1		1	1
Poritidae	Porites	21	25		6	29	22
Agariciidae	Leptoseris					8	8
Agariciidae	Pavona		2	2	3	14	27
Acroporidae	Acropora	1	44	20	18	30	55
Acroporidae	Alveopora	1					
Acroporidae	Astreopora	1	9	3	2	6	7
Acroporidae	Montipora	14		7	9	9	39
Euphylliidae	Galaxea					2	
Euphylliidae	Gyrosmilia			1	2		3
Siderastreidae	Siderastrea			1	5	7	13
Coscinaraeidae	Coscinaraea	6			4	2	12
Fungiidae	Fungia					2	1
Fungiidae	Danafungia				1	1	2
Fungiidae	Pleuractis		1				
Lobophylliidae	Lobophyllia		2	2	2	8	14
Lobophylliidae	Echinophyllia	1		1	4	4	10
Lobophylliidae	Oxypora					4	3
Lobophylliidae	Acanthastrea	2	1	9	2	4	18
Mirulinidae	Caulastraea				1		1
Mirulinidae	Cyphastrea	4		1	2	1	8
Mirulinidae	Dipsastrea	2	31	16	29	20	36
Mirulinidae	Echinopora	2	5	2	4	9	22
Mirulinidae	Erythrastrea				3		3
Mirulinidae	Favites	2	25	3	13	32	20
Mirulinidae	Paragoniastrea					1	1
Mirulinidae	Goniastrea	3	18	2	5	16	15
Mirulinidae	Hydnophora	1			2	3	6
Mirulinidae	Merulina						2
Mirulinidae	Mycedium					3	3

Family	Genus	5m	10m	15m	20m	25m	30m
Mirulinidae	Paramontastrea				4	4	8
Mirulinidae	Platygyra	5	11	3	17	12	12
Pocilloporidae	Pocillopora	5		15	4	15	
Pocilloporidae	Seriatopora	27	44	14	4		
Pocilloporidae	Stylophora	12	159	68	71	38	28
Psammocoridae	Psammocora			1			1
Incertae Sedis	Pachyseris				1	4	5
Incertae Sedis	Leptastrea				1		1
Incertae Sedis	Blastomussa				2		2
Incertae Sedis	Plerogyra					1	1
Milleporidae	Millepora	1	2				

6.2.6.9. TB01

Family	Genus	5m	10m	15m	20m	25m	30m
Dendrophylliidae	Tubastrea	0	0	0	0	0	1
Dendrophylliidae	Turbinaria	1	1	1	4	0	4
Poritidae	Goniopora	0	0	0	1	2	5
Poritidae	Porites	0	1	2	8	22	44
Agariciidae	Gardineroseris	0	0	1	1	2	0
Agariciidae	Leptoseris	0	0	0	0	4	12
Agariciidae	Pavona	1	0	2	1	2	16
Acroporidae	Acropora	5	12	16	17	16	29
Acroporidae	Alveopora	0	0	1	0	0	0
Acroporidae	Astreopora	1	2	2	4	6	8
Acroporidae	Montipora	2	3	12	20	20	39
Euphylliidae	Galaxea	0	0	0	0	3	0
Euphylliidae	Gyrosmilia	0	0	0	0	0	0
Siderastreidae	Siderastrea	0	1	3	1	3	5
Coscinaraeidae	Coscinaraea	0	0	0	0	1	5
Fungiidae	Cycloseris	0	0	0	0	0	1
Fungiidae	Fungia	0	0	1	0	1	1
Fungiidae	Ctenactis	1	0	0	0	0	0
Fungiidae	Herpolitha	0	0	0	0	0	1
Fungiidae	Podabacia	0	0	0	0	0	2
Fungiidae	Danafungia	0	1	0	1	0	0
Lobophylliidae	Lobophyllia	0	0	1	6	2	9
Lobophylliidae	Echinophyllia	4	4	4	2	9	10
Lobophylliidae	Oxypora	0	0	1	2	4	14
Lobophylliidae	Acanthastrea	0	2	3	4	8	3
Mirulinidae	Caulastraea	0	0	0	0	3	5
Mirulinidae	Cyphastrea	0	0	4	6	17	21
Mirulinidae	Dipsastrea	4	24	20	42	54	47
Mirulinidae	Echinopora	1	0	1	2	4	0
Mirulinidae	Erythrastrea	0	0	0	2	0	3

Family	Genus	5m	10m	15m	20m	25m	30m
Mirulinidae	Favites	1	1	4	6	17	30
Mirulinidae	Paragoniastrea	0	0	0	0	7	9
Mirulinidae	Goniastrea	6	8	11	4	32	33
Mirulinidae	Hydnophora	0	0	2	1	0	0
Mirulinidae	Mycedium	0	0	0	0	5	50
Mirulinidae	Paramontastrea	0	1	10	10	20	33
Mirulinidae	Platygyra	0	1	1	8	6	8
Mirulinidae	Oulophyllia	1	5	4	13	13	11
Pocilloporidae	Pocillopora	20	13	3	3	1	0
Pocilloporidae	Seriatopora	0	2	9	6	9	1
Pocilloporidae	Stylophora	25	58	57	27	20	15
Pocilloporidae	Madracis	0	6	0	0	2	0
Pocilloporidae	Stylocoeniella	1	4	2	1	0	0
Psammocoridae	Psammocora	0	0	0	4	11	27
Incertae Sedis	Pachyseris	0	0	0	0	0	5
Incertae Sedis	Leptastrea	0	0	0	0	2	8
Incertae Sedis	Plerogyra	1	0	1	0	4	8
Milleporidae	Millepora	30	3	0	0	0	0
Tubiporidae	Tubipora	0	0	0	0	0	1

6.2.7. Diver Data - Benthic Cover

6.2.7.1. TA01

		TA01_05	TA01_10	TA01_15	TA01_20	TA01_25	TA01_30
hard coral	HC	15	21	23	18	32	18
soft coral	SC	2	6	2	1	9	5
sea anemones	SA	0	0	0	0	0	0
ascidians	AS	0	0	0	0	0	0
sponge	SP	0	0	1	0	1	3
clam	CL	0	0	0	0	0	0
algae	AG	0	0	0	0	0	0
rock	RC	11	29	25	25	24	20
sand	SD	68	28	37	24	21	16
rubble	RB	2	16	10	32	13	38
other	OT	1	0	1	0	0	0
recently killed coral	RKC	1	0	0	0	0	0
seagrass	SG	0	0	0	0	0	0
man-made objects	MM	0	0	0	0	0	0

6.2.7.2. TA02

		TA02_05	TA02_10	TA02_15	TA02_20	TA02_25	TA02_30
hard coral	HC	5	21	42	38	59	60
soft coral	SC	1	18	5	13	11	6
sea anemones	SA	0	0	0	0	0	0
ascidians	AS	0	0	0	0	0	0
sponge	SP	1	1	0	0	0	1
clam	CL	0	0	0	0	0	0
algae	AG	0	2	2	0	0	0
rock	RC	12	15	27	39	28	24
sand	SD	68	36	18	7	2	8
rubble	RB	7	5	6	3	0	1
other	OT	0	0	0	0	0	0
recently killed coral	RKC	0	2	0	0	0	0
seagrass	SG	6	0	0	0	0	0
man-made objects	MM	0	0	0	0	0	0

6.2.7.3. TA03

		TA03_05	TA03_10	TA03_15	TA03_20	TA03_25	TA03_30
hard coral	HC	6	10	38	44	55	55
soft coral	SC	5	24	7	7	6	3
sea anemones	SA	0	0	0	0	0	0
ascidians	AS	0	0	0	0	0	0
sponge	SP	0	0	0	0	0	0
clam	CL	0	0	0	0	0	0
algae	AG	0	2	3	0	0	0
rock	RC	11	13	14	31	27	26
sand	SD	76	42	23	17	8	15
rubble	RB	1	9	14	0	2	0
other	OT	0	0	0	0	0	0
recently killed coral	RKC	1	0	1	1	2	1
seagrass	SG	0	0	0	0	0	0
man-made objects	MM	0	0	0	0	0	0

6.2.7.4. TA04

		TA04_05	TA04_10	TA04_15	TA04_20	TA04_25	TA04_30
hard coral	HC	0	11	21	71	64	75
soft coral	SC	1	19	19	16	21	7
sea anemones	SA	0	0	0	0	0	0
ascidians	AS	0	0	0	0	0	0
sponge	SP	0	0	1	0	0	0
clam	CL	0	0	0	0	0	0
algae	AG	0	0	3	0	0	0
rock	RC	0	5	4	3	9	7
sand	SD	38	59	50	9	4	7
rubble	RB	0	2	1	1	1	4
other	OT	0	0	0	0	0	0
recently killed coral	RKC	0	2	1	0	1	0
seagrass	SG	61	2	0	0	0	0
man-made objects	MM	0	0	0	0	0	0

6.2.7.5. TA05

		TA05_05	TA05_10	TA05_15	TA05_20	TA05_25	TA05_30
hard coral	HC	3	21	46	48	73	84
soft coral	SC	1	22	17	20	11	4
sea anemones	SA	0	0	0	0	0	0
ascidians	AS	0	0	0	0	0	0
sponge	SP	0	0	0	0	0	3
clam	CL	0	0	0	0	0	0
algae	AG	0	0	1	0	0	0
rock	RC	0	1	11	11	12	6
sand	SD	39	55	25	20	3	2
rubble	RB	0	0	0	1	0	1
other	OT	0	0	0	0	0	0
recently killed coral	RKC	0	1	0	0	1	0
seagrass	SG	57	0	0	0	0	0
man-made objects	MM	0	0	0	0	0	0

6.2.7.6. TA06

		TA06_05	TA06_10	TA06_15	TA06_20	TA06_25	TA06_30
hard coral	HC	8	6	29	22	30	36
soft coral	SC	2	6	25	13	5	1
sea anemones	SA	0	0	0	0	0	0
ascidians	AS	0	0	0	0	0	0
sponge	SP	1	0	0	0	0	0
clam	CL	0	0	0	0	0	0
algae	AG	1	1	1	0	0	0
rock	RC	32	3	11	11	49	11
sand	SD	13	37	30	49	15	47
rubble	RB	1	0	0	3	1	5
other	OT	0	0	0	0	0	0
recently killed coral	RKC	1	7	4	2	0	0
seagrass	SG	41	40	0	0	0	0
man-made objects	MM	0	0	0	0	0	0

6.2.7.7. TA07

		TA07_05	TA07_10	TA07_15	TA07_20	TA07_25	TA07_30
hard coral	HC	1	7	22	5	10	28
soft coral	SC	2	3	2	0	0	0
sea anemones	SA	0	0	0	0	0	0
ascidians	AS	0	0	0	0	0	0
sponge	SP	0	0	0	1	0	0
clam	CL	0	0	0	0	0	0
algae	AG	0	0	0	0	0	0
rock	RC	2	11	40	57	72	53
sand	SD	42	78	32	37	18	19
rubble	RB	1	0	2	0	0	0
other	OT	0	0	2	0	0	0
recently killed coral	RKC	0	1	0	0	0	0
seagrass	SG	52	0	0	0	0	0
man-made objects	MM	0	0	0	0	0	0

6.2.7.8. TA08

		TA08_05	TA08_10	TA08_15	TA08_20	TA08_25	TA08_30
hard coral	HC	2	5	2	2	20	33
soft coral	SC	0	2	0	0	5	6
sea anemones	SA	0	0	0	0	0	0
ascidians	AS	0	0	0	0	0	0
sponge	SP	0	0	0	0	0	0
clam	CL	0	0	0	0	0	0
algae	AG	0	0	0	0	0	0
rock	RC	6	21	7	4	22	23
sand	SD	31	54	24	46	52	36
rubble	RB	0	1	0	2	0	1
other	OT	0	3	4	0	1	0
recently killed coral	RKC	0	0	2	1	0	1
seagrass	SG	61	14	61	45	0	0
man-made objects	MM	0	0	0	0	0	0

6.2.7.9. TB01

		TA08_05	TA08_10	TA08_15	TA08_20	TA08_25	TA08_30
hard coral	HC	13	12	15	19	29	44
soft coral	SC	0	1	1	1	3	3
sea anemones	SA	0	0	0	0	0	0
ascidians	AS	0	0	0	0	0	0
sponge	SP	1	0	0	0	0	0
clam	CL	0	0	0	0	0	0
algae	AG	0	0	0	0	0	0
rock	RC	36	11	10	24	23	20
sand	SD	37	76	74	55	45	32
rubble	RB	13	0	0	1	0	1
other	OT	0	0	0	0	0	0
recently killed coral	RKC	0	0	0	0	0	0
seagrass	SG	0	0	0	0	0	0
man-made objects	MM	0	0	0	0	0	0

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Appendix 6-5 Avifauna Potentially Present in the ESIA Study Area

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Appendix 6-5 Avifauna Potentially Present within ESIA Study Area

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Table 1-1: Avifauna Potentially Present within ESIA Study Area..... 1-3

1 Avifauna Potentially Present within ESIA Study Area

Table 1-1 present the full list of bird species potentially present in the ESIA Study Area, with an indication of which ones were recorded during field surveys, their IUCN Red List and Regional Red List category.

Table 1-1: Avifauna Potentially Present within ESIA Study Area

Scientific name	Common name	Confirmed during 2025 Surveys	IUCN Red List Category	Regional Red List Category
Accipiter brevipes	Levant Sparrowhawk		LC	-
Accipiter nisus	Eurasian Sparrowhawk	✓	LC	-
Acrocephalus melanopogon	Moustached Warbler		LC	NT
Acrocephalus palustris	Marsh Warbler		LC	-
Acrocephalus scirpaceus	Common Reed-warbler		LC	LC
Acrocephalus stentoreus	Clamorous Reed-warbler		LC	LC
Actitis hypoleucos	Common Sandpiper	✓	LC	-
Alauda arvensis	Eurasian Skylark		LC	-
Alcedo atthis	Common Kingfisher		LC	NT
Ammomanes deserti	Desert Lark	✓	LC	LC
Ammoperdix heyi	Sand Partridge	✓	LC	LC
Anas crecca	Common Teal	✓	LC	-
Anthropoides virgo	Demoiselle Crane		LC	-
Anthus campestris	Tawny Pipit		LC	LC
Anthus cervinus	Red-throated Pipit		LC	-
Anthus pratensis	Meadow Pipit		LC	-
Anthus spinoletta	Water Pipit		LC	-
Anthus trivialis	Tree Pipit		LC	-
Apus affinis	Little Swift	✓	LC	LC
Apus apus	Common Swift	✓	LC	LC
Apus pallidus	Pallid Swift		LC	LC
Aquila chrysaetos	Golden Eagle		LC	EN
Aquila heliaca	Eastern Imperial Eagle		VU	-
Aquila nipalensis	Steppe Eagle	✓	EN	EN
Aquila verreauxii	Verreaux's Eagle	✓	LC	EN
Ardea alba	Great White Egret		LC	-
Ardea cinerea	Grey Heron	✓	LC	NT

Scientific name	Common name	Confirmed during 2025 Surveys	IUCN Red List Category	Regional Red List Category
Ardea purpurea	Purple Heron		LC	NT
Ardeola ralloides	Squacco Heron		LC	LC
Arenaria interpres	Ruddy Turnstone		NT	-
Aythya nyroca	Ferruginous Duck		NT	NT
Bubulcus ibis	Cattle Egret		LC	LC
Burhinus oedicnemus	Eurasian Thick-knee		LC	LC
Buteo buteo vulpinus	Steppe Buzzard	✓	LC	LC
Buteo rufinus	Long-legged Buzzard	✓	LC	LC
Calandrella brachydactyla	Greater Short-toed Lark	✓	LC	LC
Calidris alba	Sanderling		LC	LC
Calidris alpina	Dunlin		NT	-
Calidris canutus	Red Knot		NT	-
Calidris falcinellus	Broad-billed Sandpiper		VU	-
Calidris ferruginea	Curlew Sandpiper		VU	-
Calidris minuta	Little Stint	✓	LC	-
Calidris pugnax	Ruff		LC	-
Caprimulgus aegyptius	Egyptian Nightjar		LC	LC
Carduelis carduelis	European Goldfinch		LC	EN
Carpodacus synoicus	Sinai Rosefinch	✓	LC	LC
Carpospiza brachydactyla	Pale Sparrow		LC	-
Cecropis daurica	Red-rumped Swallow	✓	LC	LC
Cercotrichas galactotes	Rufous-tailed Scrub-robin		LC	-
Cettia cetti	Cetti's Warbler		LC	LC
Charadrius alexandrinus	Kentish Plover	✓	LC	LC
Charadrius asiaticus	Caspian Plover		LC	-
Charadrius dubius	Little Ringed Plover		LC	LC
Charadrius hiaticula	Common Ringed Plover		LC	-
Charadrius leschenaultii	Greater Sandplover		LC	NT
Chlamydotis macqueenii	Asian Houbara		VU	-
Chloris chloris	European Greenfinch		LC	-
Ciconia ciconia	White Stork		LC	NT
Ciconia nigra	Black Stork	✓	LC	-

Scientific name	Common name	Confirmed during 2025 Surveys	IUCN Red List Category	Regional Red List Category
Cinnyris osea	Palestine Sunbird	✓	LC	LC
Circaetus gallicus	Short-toed Snake-eagle	✓	LC	VU
Circus aeruginosus	Western Marsh-harrier	✓	LC	NT
Circus cyaneus	Hen Harrier		LC	-
Circus macrourus	Pallid Harrier		NT	-
Circus pygargus	Montagu's Harrier		LC	-
Clamator glandarius	Great Spotted Cuckoo		LC	NT
Clanga clanga	Greater Spotted Eagle	✓	VU	-
Clanga pomarina	Lesser Spotted Eagle	✓	LC	-
Coccothraustes coccothraustes	Hawfinch		LC	-
Columba livia	Rock Dove	✓	LC	LC
Columba oenas	Stock Dove		LC	-
Coracias garrulus	European Roller		LC	NT
Corvus corone	Carrion Crow		LC	LC
Corvus monedula	Eurasian Jackdaw	✓	LC	LC
Corvus ruficollis	Brown-necked Raven	✓	LC	LC
Coturnix coturnix	Common Quail		LC	LC
Cuculus canorus	Common Cuckoo		LC	NT
Curruca cantillans	Subalpine Warbler		LC	-
Curruca communis	Common Whitethroat		LC	-
Curruca conspicillata	Spectacled Warbler		LC	-
Curruca crassirostris	Eastern Orphean Warbler	✓	LC	LC
Curruca curruca	Lesser Whitethroat	✓	LC	LC
Curruca melanocephala	Sardinian Warbler	✓	LC	LC
Curruca mystacea	Menetries's Warbler		LC	-
Curruca nana	Asian Desert Warbler		LC	-
Curruca ruppeli	RÃ‚Â¼ppell's Warbler		LC	-
Cursorius cursor	Cream-coloured Courser		LC	LC
Delichon urbicum	Western House Martin	✓	LC	LC
Egretta garzetta	Little Egret	✓	LC	LC
Elanus caeruleus	Black-winged Kite	✓	LC	VU

Scientific name	Common name	Confirmed during 2025 Surveys	IUCN Red List Category	Regional Red List Category
Emberiza caesia	Cretzschmar's Bunting		LC	LC
Emberiza calandra	Corn Bunting		LC	LC
Emberiza cia	Rock Bunting		LC	LC
Emberiza cineracea	Cinereous Bunting		NT	LC
Emberiza citrinella	Yellowhammer		LC	-
Emberiza melanocephala	Black-headed Bunting		LC	LC
Eremalauda eremodites	Arabian Lark		LC	-
Eremophila bilopha	Temminck's Lark	✓	LC	LC
Erithacus rubecula	European Robin		LC	-
Eudromias morinellus	Eurasian Dotterel		LC	-
Falco biarmicus	Lanner Falcon		LC	CR
Falco cherrug	Saker Falcon		EN	CR
Falco columbarius	Merlin		LC	-
Falco concolor	Sooty Falcon		VU	EN
Falco naumanni	Lesser Kestrel		LC	NT
Falco pelegrinus	Peregrin Falcon	✓	LC	VU
Falco peregrinus	Peregrine Falcon		LC	EN
Falco subbuteo	Eurasian Hobby		LC	-
Falco tinnunculus	Common Kestrel	✓	LC	LC
Falco vespertinus	Red-footed Falcon		VU	-
Ficedula albicollis	Collared Flycatcher		LC	-
Ficedula parva	Red-breasted Flycatcher		LC	-
Francolinus francolinus	Black Francolin		LC	EN
Fringilla coelebs	Common Chaffinch		LC	LC
Fringilla montifringilla	Brambling		LC	-
Fulica atra	Eurasian Coot		LC	LC
Galerida cristata	Crested Lark	✓	LC	LC
Gallinago gallinago	Common Snipe	✓	LC	-
Glareola nordmanni	Black-winged Pratincole		NT	-
Glareola pratincola	Collared Pratincole		LC	LC
Gyps fulvus	Griffon Vulture		LC	EN
Haematopus ostralegus	Eurasian Oystercatcher		NT	-

Scientific name	Common name	Confirmed during 2025 Surveys	IUCN Red List Category	Regional Red List Category
Haliaeetus albicilla	White-tailed Sea-eagle		LC	-
Hieraaetus pennatus	Booted Eagle	✓	LC	-
Himantopus himantopus	Black-winged Stilt		LC	LC
Hippolais languida	Upcher's Warbler		LC	LC
Hippolais olivetorum	Olive-tree Warbler		LC	LC
Hirundo rustica	Barn Swallow	✓	LC	-
Iduna pallida	Eastern Olivaceous Warbler	✓	LC	-
Ixobrychus minutus	Common Little Bittern		LC	LC
Ketupa zeylonensis	Brown Fish-owl		LC	CR
Lanius collurio	Red-backed Shrike	✓	LC	-
Lanius excubitor	Great Grey Shrike	✓	LC	-
Lanius isabellinus	Isabelline Shrike		LC	-
Lanius nubicus	Masked Shrike	✓	LC	-
Lanius phoenicuroides	Red-tailed Shrike		LC	-
Lanius senator	Woodchat Shrike	✓	NT	-
Larus armenicus	Armenian Gull		LC	-
Larus cachinnans	Caspian Gull		LC	-
Larus canus	Mew Gull		LC	-
Larus fuscus	Lesser Black-backed Gull		LC	-
Larus genei	Slender-billed Gull		LC	LC
Larus ichthyaetus	Pallas's Gull		LC	-
Larus michahellis	Yellow-legged Gull		LC	-
Larus ridibundus	Black-headed Gull		LC	-
Limosa limosa	Black-tailed Godwit		NT	-
Linaria cannabina	Common Linnet	✓	LC	-
Locustella fluviatilis	River Warbler		LC	-
Lullula arborea	Woodlark		LC	LC
Luscinia svecica	Bluethroat	✓	LC	-
Marmaronetta angustirostris	Marbled Duck		NT	NT
Melanocorypha calandra	Calandra Lark		LC	LC

Scientific name	Common name	Confirmed during 2025 Surveys	IUCN Red List Category	Regional Red List Category
Merops apiaster	European Bee-eater	✓	LC	-
Merops cyanophrys	Arabian Green Bee-eater	✓	LC	LC
Merops persicus	Blue-cheeked Bee-eater		LC	LC
Milvus migrans	Black Kite	✓	LC	-
Monticola solitarius	Blue Rock-thrush		LC	LC
Motacilla alba	White Wagtail	✓	LC	-
Motacilla cinerea	Grey Wagtail		LC	NT
Motacilla flava	Western Yellow Wagtail	✓	LC	-
Muscicapa striata	Spotted Flycatcher	✓	LC	LC
Neophron percnopterus	Egyptian Vulture	✓	EN	VU
Numenius arquata	Eurasian Curlew		NT	-
Oena capensis	Namaqua Dove	✓	LC	LC
Oenanthe cypriaca	Cyprus Wheatear		LC	-
Oenanthe deserti	Desert Wheatear	✓	LC	LC
Oenanthe finschii	Finsch's Wheatear		LC	LC
Oenanthe hispanica	Black-eared Wheatear		LC	LC
Oenanthe isabellina	Isabelline Wheatear	✓	LC	LC
Oenanthe leucopyga	White-crowned Wheatear	✓	LC	LC
Oenanthe lugens	Mourning Wheatear	✓	LC	LC
Oenanthe melanura	Blackstart	✓	LC	LC
Oenanthe moesta	Buff-rumped Wheatear	✓	LC	EN
Oenanthe monacha	Hooded Wheatear	✓	LC	LC
Oenanthe oenanthe	Northern Wheatear	✓	LC	LC
Oenanthe xanthoprymna	Kurdish Wheatear		LC	LC
Onychognathus tristramii	Tristram's Starling	✓	LC	LC
Otus brucei	Pallid Scops-owl		LC	LC
Otus scops	Eurasian Scops-owl		LC	LC
Oxyura leucocephala	White-headed Duck		EN	EN
Pandion haliaetus	Osprey		LC	LC
Passer domesticus	House Sparrow	✓	LC	LC
Passer hispaniolensis	Spanish Sparrow	✓	LC	LC

Scientific name	Common name	Confirmed during 2025 Surveys	IUCN Red List Category	Regional Red List Category
Passer moabiticus	Dead Sea Sparrow		LC	LC
Pelecanus onocrotalus	Great White Pelican	✓	LC	-
Pernis apivorus	European Honey-buzzard	✓	LC	-
Phoenicopterus roseus	Greater Flamingo		LC	LC
Phoenicurus ochruros	Black Redstart		LC	NT
Phoenicurus phoenicurus	Common Redstart	✓	LC	NT
Phylloscopus collybita	Common Chiffchaff	✓	LC	-
Phylloscopus trochilus	Willow Warbler	✓	LC	-
Pluvialis squatarola	Grey Plover		VU	-
Prunella modularis	Dunnock		LC	-
Pterocles alchata	Pin-tailed Sandgrouse		LC	LC
Pterocles orientalis	Black-bellied Sandgrouse		LC	EN
Pterocles senegallus	Spotted Sandgrouse		LC	LC
Ptyonoprogne obsoleta	Pale Rock Martin	✓	LC	LC
Ptyonoprogne rupestris	Eurasian Crag Martin		LC	LC
Pycnonotus xanthopygos	White-spectacled Bulbul	✓	LC	LC
Ramphocoris clotbey	Thick-billed Lark		LC	-
Recurvirostra avosetta	Pied Avocet		LC	NT
Remiz pendulinus	Eurasian Penduline-tit		LC	DD
Saxicola rubetra	Whinchat	✓	LC	-
Saxicola torquatus	Common Stonechat	✓	LC	LC
Scotocerca inquieta	Scrub Warbler	✓	LC	LC
Serinus serinus	European Serin		LC	LC
Serinus syriacus	Syrian Serin		VU	EN
Spatula querquedula	Garganey	✓	LC	-
Spilopelia senegalensis	Laughing Dove	✓	LC	LC
Spinus spinus	Eurasian Siskin		LC	-
Streptopelia decaocto	Eurasian Collared Dove	✓	LC	LC
Streptopelia turtur	European Turtle-dove		VU	LC
Sturnus vulgaris	Common Starling		LC	LC
Sylvia atricapilla	Eurasian Blackcap	✓	LC	LC

Scientific name	Common name	Confirmed during 2025 Surveys	IUCN Red List Category	Regional Red List Category
Sylvia borin	Garden Warbler		LC	-
Tachymarptis melba	Alpine Swift	✓	LC	LC
Tetrax tetrax	Little Bustard		NT	-
Thalasseus sandvicensis	Sandwich Tern		LC	-
Tringa erythropus	Spotted Redshank		LC	-
Tringa nebularia	Greenshank	✓	LC	-
Tringa ochropus	Green Sandpiper	✓	LC	-
Tringa totanus	Common Redshank		LC	-
Troglodytes troglodytes	Northern Wren		LC	LC
Turdus iliacus	Redwing		NT	-
Turdus merula	Eurasian Blackbird	✓	LC	LC
Turdus philomelos	Song Thrush		LC	-
Turdus pilaris	Fieldfare		LC	-
Turdus viscivorus	Mistle Thrush		LC	LC
Upupa epops	Common Hoopoe	✓	LC	LC
Vanellus gregarius	Sociable Lapwing		CR	-
Vanellus leucurus	White-tailed Lapwing		LC	LC
Vanellus spinosus	Spur-winged Lapwing	✓	LC	LC
Zapornia pusilla	Baillon's Crake		LC	-

Project: Aqaba-Amman Water Desalination and Conveyance (AAWDC)

2025 Environmental and Social Impact Assessment

Appendix 6-6 Avifauna Autumn Survey Report

PROJECT: AQABA AMMAN WATER CONVEYANCE AND DESALINATION PROJECT (AAWDCP)

Bird Survey Report for the Aqaba-Amman pipeline overhead transmission line (autumn 2025)

Client: National Conveyance Project Company

Date	Rev	Author	Checked	Approved
11 November 2025	1	L.M, F.C, D.P	M.C.	

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1. INTRODUCTION

1.1. Context and Objectives

This document is the "Autmn Bird Survey Report" prepared by The Biodiversity Consultancy (TBC) for the planned Overhead Transmission Line (OHTL) which is an associated facility for the Aqaba Amman Water Conveyance and Desalination Project (AAWDCP, the Project), based on the results of the autumn 2025 bird surveys.

Autumn bird surveys were conducted along the planned OHTL route by local ornithologists between the 8th of September and the 3rd of November 2025. An expert from TBC accompanied the site visit between the 5th and the 9th of October 2025, and included:

- Vantage Point (VP) surveys,
- bird counts at water bodies,
- line transect surveys, and
- carcass surveys (along the existing OHTL that runs nearby to the planned OHTL for this Project), as a proxy to estimating bird and bat mortality along the Project's OHTL.

This report aims to analyse and present summaries of the autumn survey data and discuss the key findings, including the significance of the study area for birds.

1.2. Project Overview

The AAWDC Project is located in Jordan, between the Aqaba area in the south and the Amman area in the north, and comprises three main components: marine works and desalination, conveyance and renewable energy facilities:

- Marine works and desalination plant - intake system (including some limited offshore works) composed of a pumping station, three parallel pipelines (4 for intake and 2 for outtake) to convey seawater to the desalination plant. Reverse osmosis seawater desalination plant sized to produce 300 million cubic meters per year of desalinated water through four independent parallel production lines, located in the Aqaba area.
- Conveyance system - composed of a 438 km long underground water pipeline of variable diameter (76" to 90"), three tanks and four pumping stations to convey water to the Aqaba turnout (located c. 10 km from the desalination plant) and to the existing reservoirs of Abu Alanda and Al Muntazah near Amman.
- Solar power plant - with production capacity equal to 281 MWp near the Wadi Rum, area next to the existing Quweira solar plant and about 55 km from the Desalination Plant site.

The OHTL will be developed by the National Electric Power Company (NEPCO) and is considered as an associated facility to the Project. The OHTL is a new 132 kV transmission line running between the solar power plant and the Desalination plant, with an approximate length of 65 km, to transport electricity to the Desalination plant. Electricity grid expansion works will be carried out by NEPCO1, JEPCO2 and EDCO3.

1.3. Biodiversity Context of the Project: Avifauna

The southern section of the OHTL crosses the Aqaba Coast and Mountains Key Biodiversity Area (KBA) and Important Bird Area (IBA)[1] (Figure 1). This area was designated due to the migratory passage of Levant Sparrowhawks (*Accipiter brevipes,* IUCN Least Concern). Around 3,000 individuals of this species are expected to cross the area each spring, which represents up to 30% of the global population estimate of 10,000.

[1] https://datazone.birdlife.org/site/factsheet/aqaba-coast-and-mountains

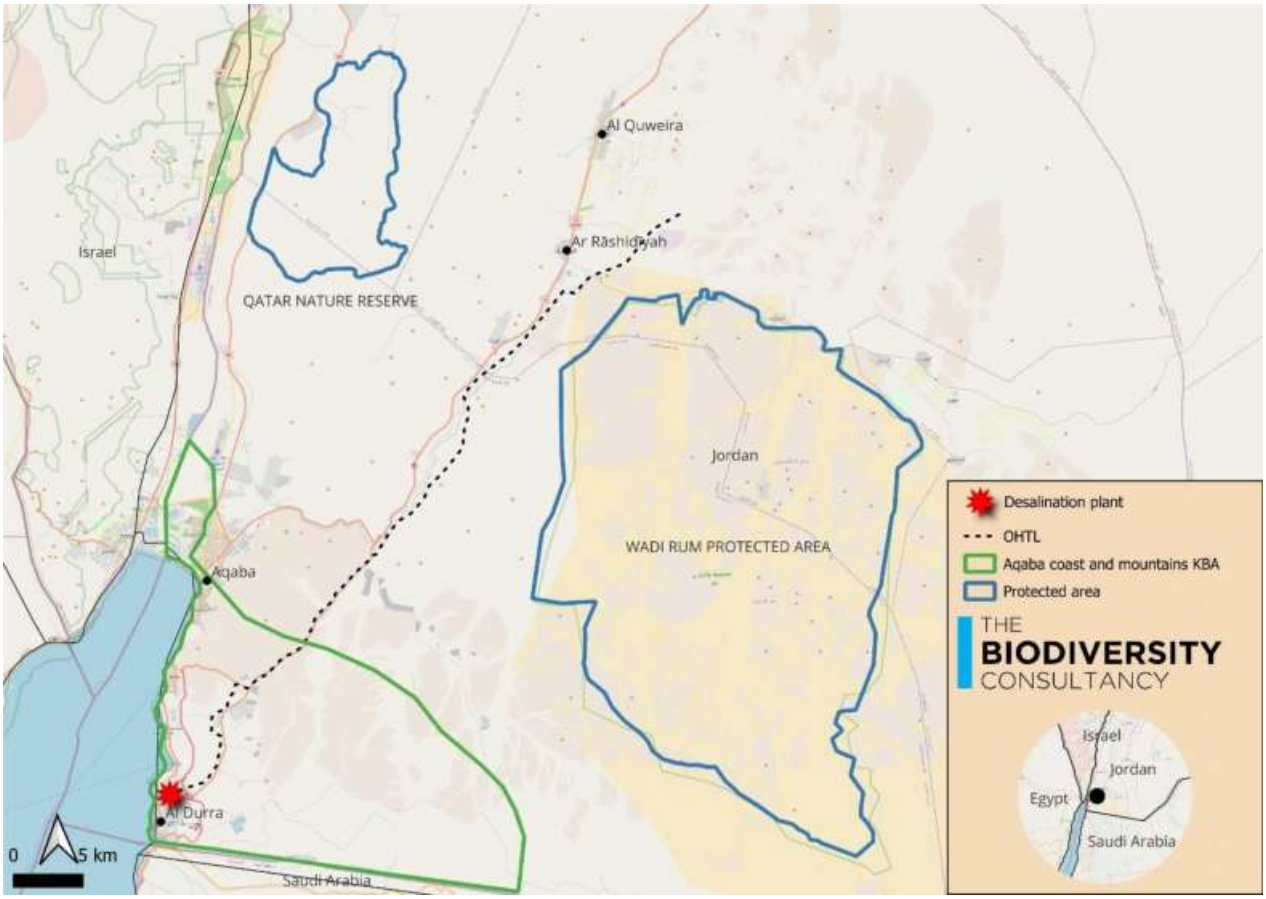


Figure 1: Location of the Project's Overhead Transmission Line (OHTL)

This area is considered a migratory bottleneck site within the Rift Valley/Red Sea Flyway, which is one of the most important routes for migratory soaring birds in the world. Each spring and autumn, 37 species of migratory soaring birds navigate this flyway, with over a million birds passing in the major bottlenecks (Porter 2005; Jobson *et al.* 2021).

The Aqaba Coast and Mountains IBA/KBA has a peak estimate of 50,000-99,000 soaring birds (BirdLife International 2025), and apart from the Levant Sparrowhawk, other relevant soaring birds that migrate through the area include Egyptian Vulture (*Neophron percnopterus*, IUCN Endangered), Steppe Eagle (*Aquila nipalensis*, IUCN Endangered), Greater Spotted Eagle (*Clanga clanga*, IUCN Vulnerable), Lesser Spotted Eagle (*Clanga pomarina,* IUCN Least Concern), White Stork (*Ciconia ciconia*, IUCN Least Concern), European Honey Buzzard (*Pernis apivorus*, IUCN Least Concern) and Steppe Buzzard (*Buteo buteo vulpinus*, IUCN Least Concern).

Migration along the Aqaba coast and mountains is more intense in spring, as opposed to autumn where migration tends to occur in a broad front and is considered insignificant at this site (Khoury 2017; BirdLife International 2025). In spring, most soaring birds enter Jordan from the Eilat (southern Israel) bottleneck, which is located to the North of the Aqaba coast and mountains. Most birds follow north from there, thus not entering the area. However, some other birds may cross the gulf of Aqaba and follow the Saudi and Jordanian coast northwards or arrive from the Arabian Peninsula. Those are the soaring birds that concentrate in the Aqaba mountains and coast, which represent a relatively small percentage of the numbers that occur at the Eilat bottleneck (Andrews 1996; Jobson *et al.* 2021).

Other species (non-soaring birds) with populations that meet IBA/KBA criteria that occur in the Aqaba mountains and coast are the Arabian Warbler (*Curruca leucomelaena*), Arabian Babbler (*Turdoides squamiceps*), Tristam's Starling (*Onychognathus tristamii*) and Hooded Wheatear (*Oenanthe monacha*), all IUCN Least Concern.

1.4. Main Impacts of Power Lines On Birds

Powerlines can cause bird mortality through collisions and electrocution. Collisions occur mainly on high voltage transmission lines, especially with the thin, and hard to see, earth wire. Susceptible species include large birds with low manoeuvrability (high weight to wing area ratio), birds that fly very fast, especially if they move in flocks and/or species with a reduced visual field (Prinsen *et al.* 2011; Bennun *et al.* 2021; BirdLife International & CMS Energy Task Force 2023).

Birds can be electrocuted when perched on pylons or power lines and this may be the of cause decline of some long-lived species, namely birds of prey and other large perching birds. Electrocution is more frequent on distribution lines since the distance between charged elements is higher in transmission lines. However, it also possible in transmission lines, especially if large species build their nests on the pylons or if several bird perch very close to each other (especially during rainy days) (Angelov *et al.* 2013; Bennun *et al.* 2021; Biasotto *et al.* 2021).

2. METHODOLOGY

Field surveys were conducted by a team of local ornithologists (provided by ECO Consult) in three campaigns during the autumn of 2025. These included vantage point surveys, line transects, water body counts and carcass surveys. The approach and methodology for this survey was designed and provided by TBC (TBC 2025).

2.1. Vantage Point (VP) Surveys

Vantage points comprise a series of watches from a fixed location to quantify the flight activity of birds and its distribution at a proposed development site. This method is especially adequate to detect and track the movements of soaring birds (e.g. diurnal raptors), or other diurnal medium-large size birds that actively migrate or commute between foraging and/or roosting sites (e.g. Scottish Natural Heritage 2017, BID Invest and IFC 2019).

Eleven VPs were defined along the expected layout of the OHTL, appropriately spaced and located in areas with good visibility (Figure 2).

Each VP watch lasted for three continuous hours. Because three campaigns were performed (

Table 1), each vantage point was surveyed for nine hours in total during the autumn period. Surveys were conducted between 1h 30 min after sunrise and 1h 30 min before sunset.

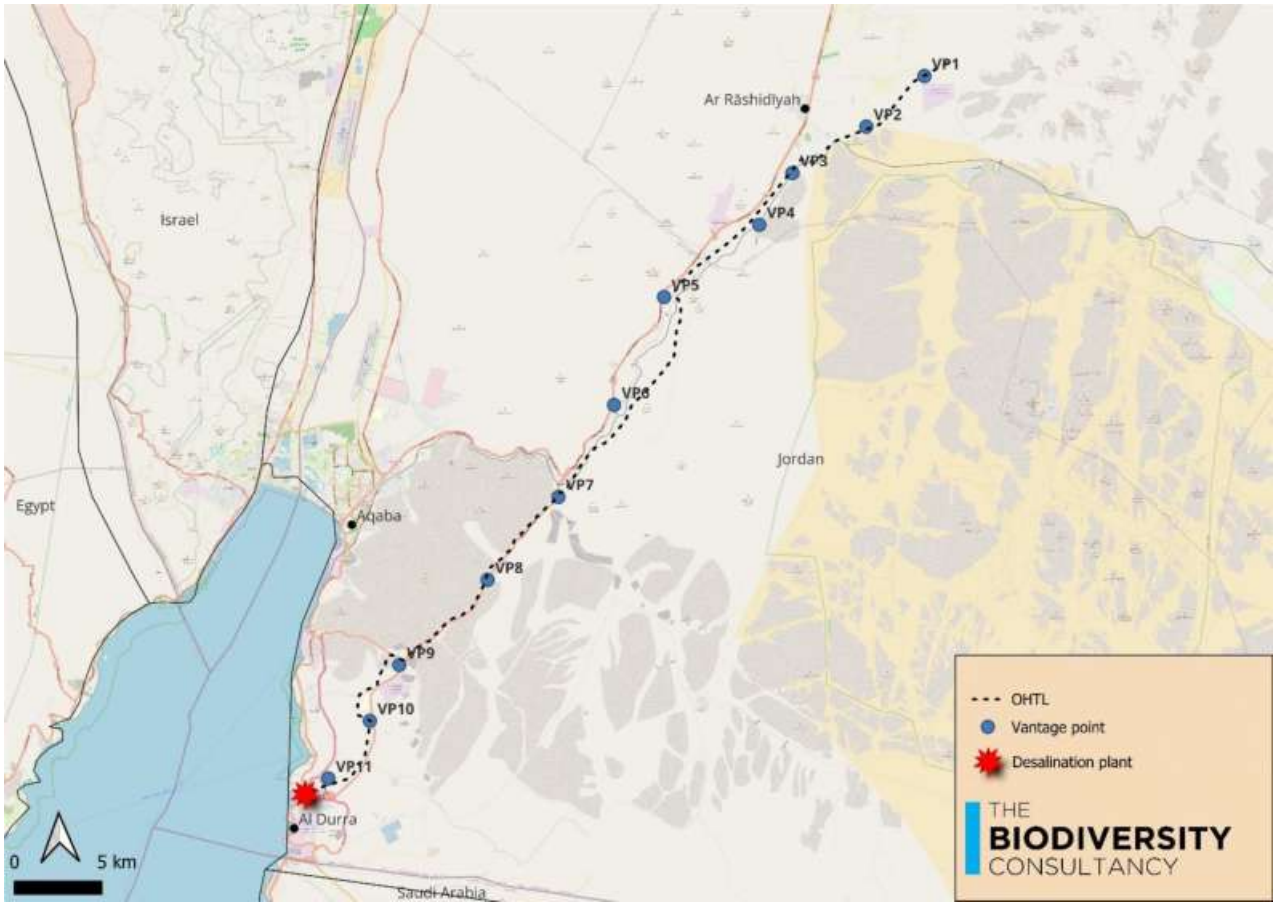


Figure 2: Location of Vantage Points

Table 1: Survey Period for the three Autumn Campaigns

	Number of points	Start date	End date
Campaign 1	11	8th September 2025	21st September 2025
Campaign 2	11	30th September 2025	16th October 2025
Campaign 3	11	19th October 2025	3rd November 2025

Observations at each vantage point were conducted by two observers equipped with binoculars, recording and identifying every flight of medium/large bird species detected (every bird with a size equal or larger than a Collared Dove (*Streptopelia decaocto*), or flocks of 10 or more birds of every species (e.g. swallows, swifts). Birds that could not be identified to species level were identified to the nearest level (e.g. Unidentified Raptor). During each period, observers recorded:

- Number of the VP
- Date
- Time (start and finish)
- Observer ID
- Weather variables (e.g. temperature, wind speed and direction, rain, cloud cover)

For each record:

- Species ID
- Number of birds
- Time
- Flight height in predetermined classes (1 - < 20m, 2 – 20-50 m, 3 – 50-100 m, 4 100-200 m, 5 > 200 m)
- Flight distance to the proposed OHTL (1- crosses the line, 2 - <100 m from the line, 3 – 100-500 m from the line, 4 - > 500 m from the line)
- Bird interactions with the existing OHTL (avoidance and perching)
- Other information (sex, age etc.)

2.2. Water Body Counts

Water body counts were directed at aquatic bird species. Six observation points were established along the OHTL at water bodies and flood barrier dams, at locations that allow the visual inspection of the water surface and of 200 m of the water margin to each side Figure 3.

Observations at each water body point count were conducted by two observers equipped with binoculars in the periods described in Table 2.

Table 2: Number of Water Body Counts and Survey Dates

	Number of points	Start date	End date
Campaign 1	4	9th September 2025	23th September 2025
Campaign 2	6	1st October 2025	9th October 2025
Campaign 3	5	20th October 2025	2nd November 2025

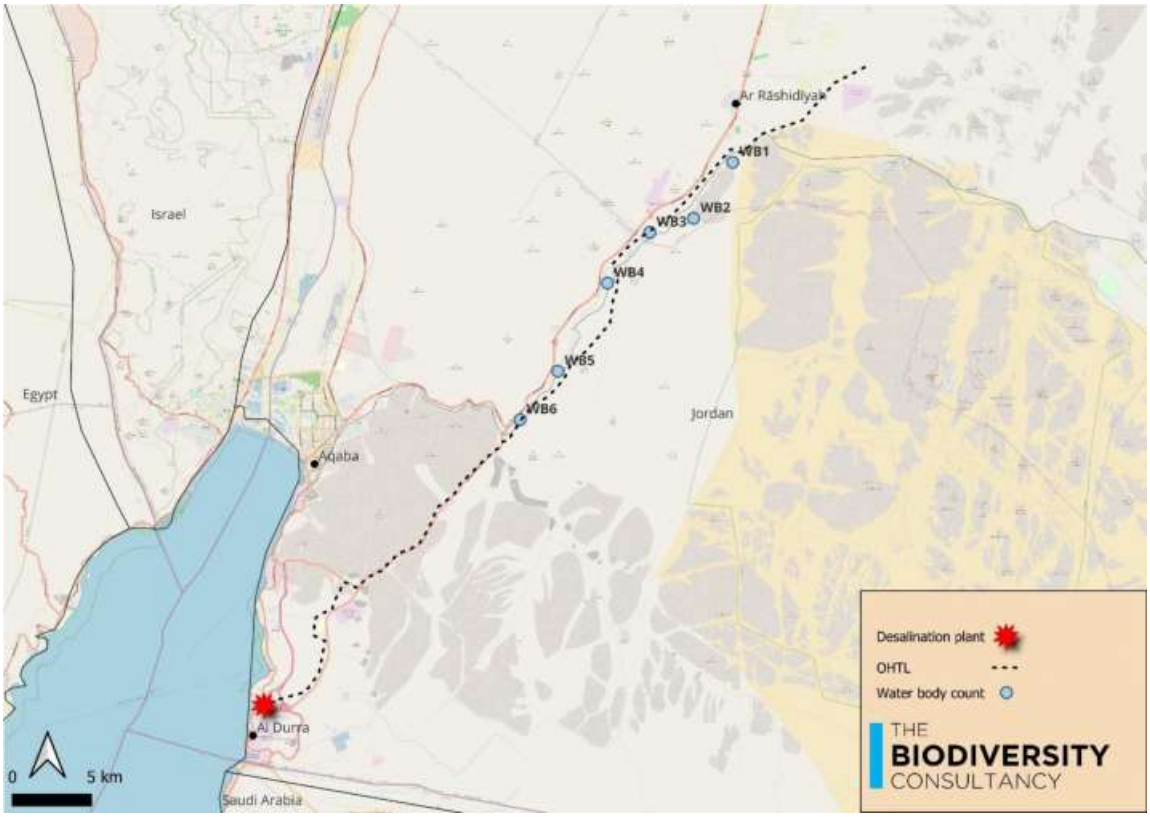


Figure 3: Locations of Water Body Point Counts

Every bird at (interacting with) each water body was counted. The presence (or lack of) water was recorded using four classes (1 – no water, 2 – some pools, 3 – half full, 4 – the dam is full). If no water was present, there are no birds associated with the water body even if some birds are present in the area. Water body counts occurred preferentially after a period of rainfall, even if they had already been counted during that campaign. Observers recorded:

- Number of water body
- Date
- Time
- Observer
- Weather variables
- Water presence (4 classes)
- Number of birds of each species
- Notes

2.3. Line Transect Surveys

Line transects were conducted to survey the non-soaring terrestrial birds. Twenty transects were defined (and georeferenced) along the expected OHTL route, sufficiently spaced apart to minimize double counting (Figure 4). Transects were surveyed in three campaigns in the dates shown in Table 3.

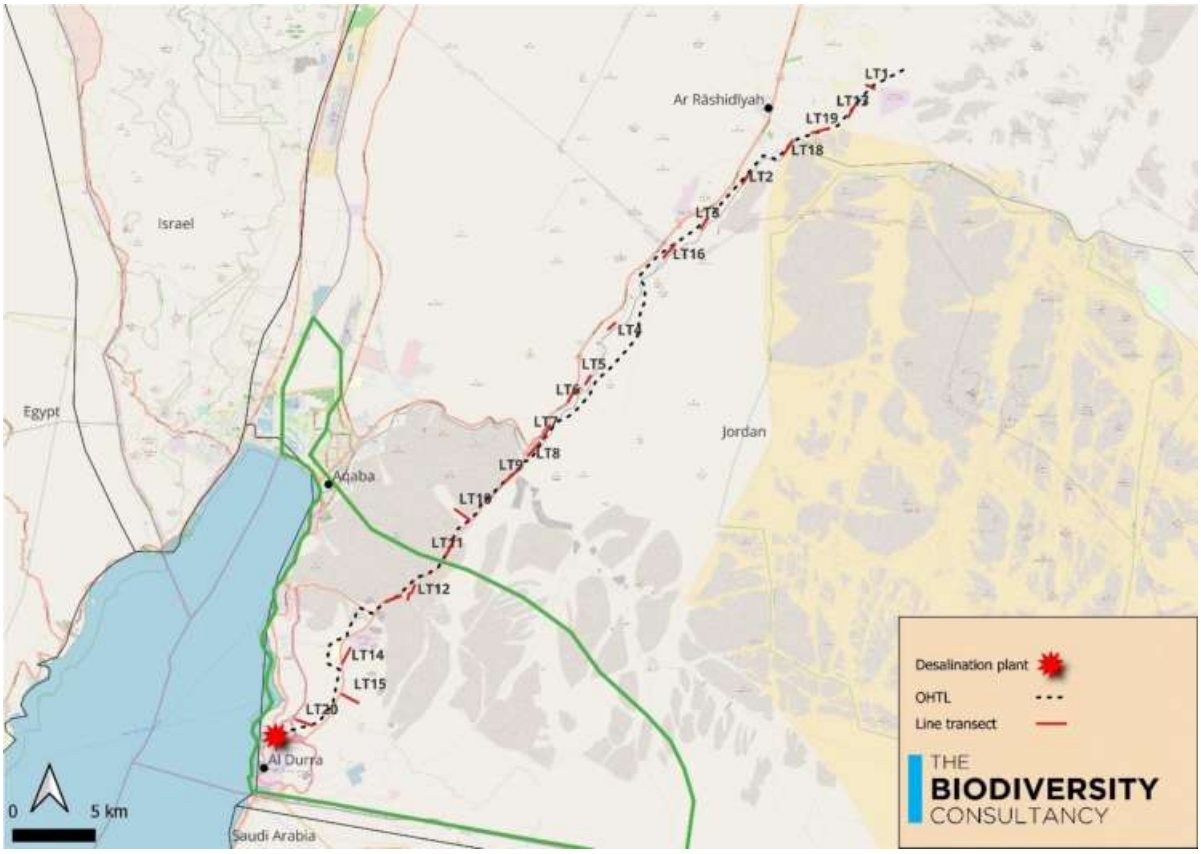


Figure 4: Locations of Line Transect Surveys

Table 3: Number of Line Transects and Survey Dates

	Number of transects	Start date	End date
Campaign 1	4	9th September 2025	24th September 2025
Campaign 2	20	30th September 2025	16th October 2025
Campaign 3	5	19th October 2025	3rd November 2025

Observers moved along the transects at a slow and steady pace. Every bird detected, by sight or sound, along a 500 m line transect was identified and counted. If a bird song/call could not be identified, an effort was made to spot the bird to allow for identification. Transects surveys were conducted during the first three hours after sunrise (peak bird activity), and in appropriate weather conditions (absence of rain or strong wind). Observers recorded:

- Number of transect
- Date
- Time
- Observer
- Weather variables
- Number of individuals of each species at < or > 50 meters from the transect
- Notes (e.g., if there were noisy activities/people in the area that reduced bird detectability or affected bird behaviour, confirmed breeding, etc.)

2.4. Carcass Surveys

Searches for carcasses were undertaken along the existing OHTL that runs nearby to the planned OHTL for this Project, in accordance to the methodology described in Post-construction Bird and Bat Fatality Monitoring (PCFM) for Onshore Wind Energy Facilities in Emerging Market Countries: Good Practice Handbook and Decision Support Tool (IFC *et al.* 2023).

Within the Aqaba Coast and Mountains IBA, the existing OHTL was divided into 1 km sections. PCFM was conducted by two observers along 500 m of each 1 km segment. Outside of the IBA, the existing OHTL was divided into 5 km segments and PCFM conducted within 1 km.

Within the search width (40 m to each side), transects were undertaken parallel to the centreline, spaced at an appropriate distance so that the whole survey area was covered. The searches were undertaken between September and November (see Table 4).

Table 4: Carcass Search Periods

	Start date	End date
Campaign 1	9th September 2025	23th September 2025
Campaign 2	30th September 2025	16th October 2025
Campaign 3	19th October 2025	3rd November 2025

Results (bird and bat carcasses) were recorded using forms informed by the PCFM good practice handbook (IFC *et al.* 2023). Observers recorded:

- Number of the search plot
- Date
- Time (start and finish)
- Observer ID
- Weather variables (e.g. temperature, wind speed and direction, rain, cloud cover)

And for each record:

- ID
- Date
- Time
- Observer
- Species (age and sex if possible)
- Type of remains (e.g. full bird, a wing, just bones, feathers)
- Estimate of the date of death based on the decomposing state
- Location (GPS coordinates)
- Distance to the line
- Photo (with scale)

2.4.1 Searcher efficiency trials

Search detection efficiency trials were conducted during two campaigns (Table 5) using three sizes of bird dummies (Figure 5) along four transects, with two transects in each season. Prior to each campaign, an independent team member (not involved in carcass searches) placed the decoys within the search areas. The number of bird dummies used in the trials ranged from 18 to 27.

Table 5: Search efficiency periods

	Start date	End date
Campaign 2	7th October 2025	8th October 2025
Campaign 3	20th October 2025	29th October 2025



Figure 5: Illustration of some of the bird dummies used in the search efficiency trials.

3. RESULTS

Across all survey methodologies, a total of 74 species of birds were recorded (Appendix 1).

3.1. Vantage Point (VP) Surveys

Vantage Point (VP) surveys recorded a total of 26 species across all three campaigns, including 18 soaring bird species (see Table 6). Five species of conservation concern were recorded. These include the Black-winged Kite (*Elanus caeruleus*, 1 individual), which is globally Least Concern (LC) but regionally classified as Vulnerable (VU); the Egyptian Vulture (*Neophron percnopterus*, 1 individual), globally Endangered (EN) and regionally VU; the Greater Spotted Eagle (*Clanga clanga*, 1 individual), globally VU and not evaluated regionally; the Short-toed Eagle (*Circaetus gallicus*, 4 individuals), globally LC but regionally VU; and the Steppe Eagle (*Aquila nipalensis*, 84 individuals), globally EN and not evaluated regionally.

Relatively high numbers of Steppe Buzzards (*Buteo buteo)* were recorded during the second campaign, while higher numbers of Steppe Eagles were observed in the third campaign.

The Black-winged Kite was observed flying at the transmission line location and below 20 m. The individual of Greater Spotted Eagle, along with 25% of the Short-toed Eagle flights and 62% of the Steppe Eagle flights, crossed the transmission line corridor but mostly at high altitudes. The Egyptian Vulture that was recorded, was far from the OHTL and at high altitude.

Least Concern species that were within 100 m of the OHTL and were flying below 50 m high, which may represent a higher risk of collisions with the OHTL, include the Eurasian Collared Dove (*Streptopelia decaocto*), the Eurasian Linnet (*Linaria cannabina*), the Rock Dove (*Columba livia*), the Grey heron (*Ardea cinerea*), the Little Egret (*Egretta garzetta*), the Brown-necked Raven (*Corvus ruficollis*), and the soaring birds Black Kite (*Milvus migrans*), Common Kestrel (*Falco tinnunculus*), Eurasian Sparrowhawk (*Accipiter nisus*), Long-legged Buzzard (*Buteo rufinus*), and Western Marsh Harrier (*Circus aeruginosus*). The Booted Eagle (*Hieraaetus pennatus*) and the Lesser Spotted Eagle (*Clanga pomarine*) were also detected crossing the transmission line but a high altitude.

Table 6: Summary of results from Vantage point (VP) surveys

Species		Conservation status		No. of individuals recorded in Campaign 1	No. of individuals recorded in Campaign 2	No. of individuals recorded in Campaign 3	% of points where it was recorded	Distance to OHTL		Flight height	
Common (English) name	Latin name	Global (IUCN) conservation status[2]	Regional (Arabian Peninsula) conservation status[3]					% of birds that crossed the OHTL	% of birds that were <100 m from the OHTL	% of birds flying <20 m high	% of birds flying 20-50 m high
Arabian Bee-eater	*Merops cyanophrys*	LC	LC	0	3	0	9	100%	0%	100%	0%
Black Kite	*Milvus migrans*	LC	LC	3	16	7	64	4%	23%	0%	23%
Black stork	*Ciconia nigra*	LC	-	0	3	2	18	0%	0%	0%	0%
Black-winged Kite	*Elanus caeruleus*	LC	**VU**	0	1	0	9	100%	0%	100%	0%
Booted Eagle	*Hieraaetus pennatus*	LC	NA	5	0	0	18	20%	80%	0%	0%
Brown-necked Raven	*Corvus ruficollis*	LC	LC	6	54	12	82	13%	15%	8%	42%
Common Kestrel	*Falco tinnunculus*	LC	LC	3	14	5	73	32%	23%	18%	36%
Egyptian Vulture	*Neophron percnopterus*	**EN**	**VU**	1	0	0	9	0%	0%	0%	0%
Eurasian Collared Dove	*Streptopelia decaocto*	LC	LC	2	2	23	55	19%	81%	56%	44%
Eurasian Linnet	*Linaria cannabina*	LC	LC	35	0	0	9	0%	100%	100%	0%
Eurasian Sparrowhawk	*Accipiter nisus*	LC	-	2	5	1	45	75%	13%	13%	50%
European Bee-eater	*Merops apiaster*	LC	LC	100	0	0	9	0%	0%	0%	0%
Great White Pelican	*Pelecanus onocrotalus*	LC	-	0	0	16	9	0%	0%	0%	0%
Greater Spotted Eagle	*Clanga clanga*	**VU**	-	0	0	1	9	100%	0%	0%	0%
Grey heron	*Ardea cinerea*	LC	NT	0	26	0	18	0%	100%	0%	100%
Lesser Spotted Eagle	*Clanga pomarina*	LC	-	0	0	1	9	100%	0%	0%	0%
Little Egret	*Egretta garzetta*	LC	LC	1	0	0	9	0%	100%	0%	100%

[2] (IUCN 2025)
[3] (Symes *et al.* 2015)

Species		Conservation status		No. of individuals recorded in Campaign 1	No. of individuals recorded in Campaign 2	No. of individuals recorded in Campaign 3	% of points where it was recorded	Distance to OHTL		Flight height	
Common (English) name	Latin name	Global (IUCN) conservation status[2]	Regional (Arabian Peninsula) conservation status[3]					% of birds that crossed the OHTL	% of birds that were <100 m from the OHTL	% of birds flying <20 m high	% of birds flying 20-50 m high
Little Swift	*Apus affinis*	LC	LC	50	0	0	9	0%	100%	0%	100%
Long-legged Buzzard	*Buteo rufinus*	LC	LC	9	2	0	18	9%	18%	9%	36%
Rock Dove	*Columba livia*	LC	LC	0	27	14	36	7%	80%	12%	78%
Short-toed eagle	*Circaetus gallicus*	LC	**VU**	0	4	0	18	25%	0%	0%	0%
Steppe Buzzard	*Buteo buteo*	LC	LC	21	53	6	82	21%	20%	0%	14%
Steppe Eagle	*Aquila nipalensis*	**EN**	-	0	17	67	73	62%	2%	1%	1%
Tristram's Starling	*Onychognathus tristramii*	LC	LC	0	27	0	18	93%	0%	0%	0%
Western House Martin	*Delichon urbicum*	LC	LC	20	0	0	9	0%	100%	0%	100%
Western Marsh Harrier	*Circus aeruginosus*	LC	NT	2	0	1	18	33%	67%	33%	67%

3.2. Water Body Counts

During the surveys, four of the waterbodies (1, 2, 4, and 5) remained dry (Table 7). Water was consistently present in waterbodies 3 and 6, which were half full.

Table 7: Water Levels During the Water Body Counts (1 – No Water, 2 – Some Pools, 3 – Half Full, 4 – The Dam Is Full)

Campaign	Point	Water level
1	1	1
	2	1
	3	3
	4	1
	5	1
	6	3
2	1	1
	2	1
	3	3
	4	1
	5	1
	6	3
3	1	1
	2	1
	3	3
	4	1
	5	1
	6	3

Water body counts recorded a total of seven waterbird species (see Table 8), none of which are of conservation concern: Common Sandpiper (*Actitis hypoleucos*), Common Teal (*Anas crecca*), Garganey Duck (*Spatula querquedula*), Green Sandpiper (*Tringa ochropus*), Grey Heron (*Ardea cinerea*), Little Egret (*Egretta garzetta*) and Spur-winged Lapwing (*Vanellus spinosus*).

All seven waterbirds recorded during the water body counts were only observed when the water level was half-full (Table 9). No waterbirds were observed during the four counts when the water level was lower and in the "some pools" category. The species that was recorded more frequently and in higher numbers was the Spur-winged Lapwing.

Table 8: Summary of Results from Water Body Counts

Species		Conservation status		No. of individuals recorded in Campaign 1	No. of individuals recorded in Campaign 2	No. of individuals recorded in Campaign 3	% of points where it was recorded
Common (English) name	Latin name	Global (IUCN) conservation status[4]	Regional (Arabian Peninsula) conservation status[5]				
Common Sandpiper	*Actitis hypoleucos*	LC	-	0	1	0	17
Common Teal	*Anas crecca*	LC	-	0	2	0	33
Garganey Duck	*Spatula querquedula*	LC	-	0	2	3	33
Green Sandpiper	*Tringa ochropus*	LC	-	0	1	0	17
Grey Heron	*Ardea cinerea*	LC	NT	0	0	1	17
Little Egret	*Egretta garzetta*	LC	LC	9	0	0	17
Spur-winged Lapwing	*Vanellus spinosus*	LC	LC	2	11	7	33

Table 9: Results of the Water Body Counts 1 – No Water, 2 – Some Pools, 3 – Half Full, 4 – The Dam Is Full)

Species	Campaign	Point	Water level	No. of birds
Common Sandpiper	2	6	3	1
Common Teal	2	3	3	1
	2	6	3	1
Garganey Duck	2	6	3	2
	3	3	3	1
	3	6	3	2
Green Sandpiper	3	6	3	1
Grey Heron	3	6	3	1
Little Egret	1	3	3	9
Spur-winged Lapwing	1	3	3	2
	2	6	3	11
	3	3	3	3
	3	6	3	4

3.3. Line Transect Surveys

Line transects surveys recorded 56 species across all three campaigns (Table 10). Two species of regional conservation concern, considered threatened in the Arabian Peninsula, were observed (one individual of each species was recorded): Verreaux's Eagle (*Aquila verreauxii*), classified as Endangered regionally, and the Peregrine Falcon (*Falco peregrinus*), classified as Vulnerable. Both are globally listed as Least Concern.

Except for this species, all other birds that were recorded belong to common resident species or species that are common migrants in the region.

[4] (IUCN 2025)
[5] (Symes *et al.* 2015)

Among the most abundant and widespread species are the Blackstart (*Oenanthe melanura*), the Brown-necked Raven, the Crested Lark (*Galerida cristata*), the Desert Lark (*Ammomanes deserti*), the House Sparrow (*Passer domesticus*) and the Rock Dove (*Columba livia*).

Table 10: Summary of Results from Line Transect Surveys

Species		Conservation status		Kilometric Abundance Index in Campaign 1	Kilometric Abundance Index in Campaign 2	Kilometric Abundance Index in Campaign 3	% of transects where it was recorded (average between campaigns)
Common (English) name	Latin name	Global (IUCN) conservation status[6]	Regional (Arabian Peninsula) conservation status[7]				
Arabian Green Bee-eater	*Merops cyanophrys*	LC	LC	0.00	0.22	0.56	30
Barn Swallow	*Hirundo rustica*	LC	LC	0.00	0.22	0.61	30
Blackstart	*Oenanthe melanura*	LC	LC	0.45	2.12	1.79	85
Blue throat	*Luscinia svecica*	LC	-	0.00	0.00	0.11	10
Booted Eagle	*Hieraaetus pennatus*	LC	-	0.00	0.06	0.06	10
Brown-necked Raven	*Corvus ruficollis*	LC	LC	0.11	0.45	1.28	55
Common Chiffchaff	*Phylloscopus collybita*	LC	-	0.17	0.17	0.00	15
Common Snipe	*Gallinago gallinago*	*LC*	-	0.00	0.00	0.06	5
Common Stonechat	*Saxicola torquatus*	LC	LC	0.00	0.22	0.22	20
Common Swift	*Apus apus*	LC	LC	0.00	0.00	0.11	5
Crested Lark	*Galerida cristata*	LC	LC	0.22	2.85	2.51	90
Desert Lark	*Ammomanes deserti*	LC	LC	0.22	3.74	2.96	100
Desert Wheatear	*Oenanthe deserti*	LC	LC	0.00	0.06	0.06	10
Eastern Olivaceous Warbler	*Iduna pallida*	LC	LC	0.11	0.00	0.00	5
Eastern Orphean Warbler	*Curruca crassirostris*	LC	LC	0.06	0.00	0.00	5
Eurasian blackcap	*Sylvia atricapilla*	LC	LC	0.28	0.28	0.00	20
Eurasian Collared Dove	*Streptopelia decaocto*	LC	LC	0.73	5.19	2.12	85
Eurasian Hoopoe	*Upupa epops*	LC	LC	0.06	0.00	0.00	5
Eurasian Jackdaw	*Corvus monedula*	LC	LC	0.00	0.11	0.00	5

[6] (IUCN 2025)
[7] (Symes *et al.* 2015)

Species		Conservation status		Kilometric Abundance Index in Campaign 1	Kilometric Abundance Index in Campaign 2	Kilometric Abundance Index in Campaign 3	% of transects where it was recorded (average between campaigns)
Common (English) name	Latin name	Global (IUCN) conservation status[6]	Regional (Arabian Peninsula) conservation status[7]				
Eurasian Linnet	*Linaria cannabina*	LC	LC	0.17	1.12	0.00	15
Eurasian Sparrowhawk	*Accipiter nisus*	LC	-	0.00	0.11	0.06	15
Great Grey Shrike	*Lanius excubitor*	LC	LC	0.00	0.00	0.06	5
Great White Pelican	*Pelecanus onocrotalus*	LC	-	0.00	0.95	0.00	5
Greater Short-toed Lark	*Calandrella brachydactyla*	LC	LC	0.00	0.22	0.06	10
Hooded Wheatear	*Oenanthe monacha*	LC	LC	0.00	0.22	0.17	10
House Sparrow	*Passer domesticus*	LC	LC	1.23	5.86	5.14	65
Isabelline Wheatear	*Oenanthe isabellina*	LC	LC	0.00	0.11	0.00	10
Laughing Dove	*Spilopelia senegalensis*	LC	LC	0.28	3.52	0.33	55
Lesser Whitethroat	*Curruca curruca*	LC	LC	0.28	0.39	0.00	30
Masked Shrike	*Lanius nubicus*	LC	LC	0.06	0.06	0.00	10
Mourning Wheatear	*Oenanthe lugens*	LC	LC	0.00	0.06	0.06	10
Palestine Sunbird	*Cinnyris osea*	LC	LC	0.89	0.45	0.33	35
Peregrin Falcon	*Falco pelegrinus*	LC	**VU**	0.00	0.06	0.00	5
Red start	*Phoenicurus phoenicurus*	LC	NT	0.00	0.00	0.22	15
Red-backed Shrike	*Lanius collurio*	LC	-	0.22	0.33	0.45	45
Red-rumped Swallow	*Cecropis daurica*	LC	LC	0.00	0.00	0.78	15
Rock Dove	*Columba livia*	LC	LC	0.33	1.62	4.35	70
Rock Martin	*Ptyonoprogne obsoleta*	LC	LC	0.22	0.61	0.67	45
Sand Partridge	*Ammoperdix heyi*	LC	LC	0.00	0.22	0.00	10
Scrub Warbler	*Scotocerca inquieta*	LC	LC	0.06	0.50	0.11	35
Sinai Rosefinch	*Carpodacus synoicus*	LC	LC	0.00	1.62	0.78	20

Species		Conservation status		Kilometric Abundance Index in Campaign 1	Kilometric Abundance Index in Campaign 2	Kilometric Abundance Index in Campaign 3	% of transects where it was recorded (average between campaigns)
Common (English) name	Latin name	Global (IUCN) conservation status[6]	Regional (Arabian Peninsula) conservation status[7]				
Spanish Sparrow	*Passer hispaniolensis*	LC	LC	0.00	1.06	1.67	15
Spotted Flycatcher	*Muscicapa striata*	LC	LC	0.06	0.17	0.06	20
Spur-winged Lapwing	*Vanellus spinosus*	LC	LC	0.00	0.00	0.17	5
Steppe Buzzard	*Buteo buteo*	LC	LC	0.06	0.00	0.00	5
Tristram's Starling	*Onychognathus tristramii*	LC	LC	0.00	1.73	1.67	15
Verreaux's Eagle	*Aquila verreauxii*	LC	**EN**	0.00	0.06	0.00	5
Western House martin	*Delichon urbicum*	LC	LC	0.06	1.12	0.00	10
Western Marsh Harrier	*Circus aeruginosus*	LC	NT	0.00	0.00	0.06	5
Whinchat	*Saxicola rubetra*	LC	-	0.00	0.00	0.11	5
White Wagtail	*Motacilla alba*	LC		0.00	0.00	0.28	10
White-crowned Wheatear	*Oenanthe leucopyga*	LC	LC	0.11	1.06	1.56	90
White-spectacled Bulbul	*Pycnonotus xanthopygos*	LC	LC	0.11	0.00	0.28	15
Willow Warbler	*Phylloscopus trochilus*	LC	-	0.00	0.67	0.95	65
Woodchat Shrike	*Lanius senator*	NT	LC	0.00	0.06	0.11	15
Yellow Wagtail	*Motacilla flava*	LC	-	0.00	0.06	0.17	10

3.4. Carcass Surveys

No bird fatalities were observed during the 2025 autumn survey campaigns.

3.4.1 Searcher efficiency trials

Search efficiency across the campaigns ranged from 92% to 100%. In Campaign 2, only one small-sized dummy bird was missed out of a total of 27 birds of all size categories included in the trial. Similarly, in Campaign 3, two small-sized dummy birds were missed, again from a total of 27 birds of various sizes.

4. DISCUSSION

Seven species of conservation concern, all migratory soaring birds, were recorded during the autumn survey, the Black-winged Kite, the Egyptian Vulture, the Greater Spotted Eagle, Peregrine Falcon, the Short-toed Eagle, the Steppe Eagle and the Verreaux's Eagle

Vantage point surveys confirmed that the area is crossed by high numbers of soaring birds during this season, particularly Steppe Buzzards and Steppe Eagles, along with eleven other migratory soaring bird species. Some species, such as the threatened Black-winged Kite, Black Kite, Common Kestrel, Eurasian Sparrowhawk, Long-legged Buzzard, and Western Marsh Harrier, were observed crossing the transmission line at heights that pose a collision risk.

The Levant Sparrowhawk, the key species behind the designation of the Aqaba Mountains and Coast as an IBA and KBA, was also not detected during the autumn surveys.

Carcass surveys did not reveal any carcasses during the autumn surveys. Search trials indicated high searcher efficiency, suggesting a low likelihood of missed carcasses. However, carcass removal, that may occur due to the presence of numerous stray dogs in the area—could have contributed to the non-detection of carcasses.

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Appendix 1 Full list of species recorded

Table 11: List of All Species Recorded Across All Autumn Surveys (Species of Conservation Concern Are Shown in Bold)

Species	Latin name	Global IUCN conservation status[8]	Regional (Arabian Peninsula) conservation status[9]
Arabian Green Bee-eater	*Merops cyanophrys*	LC	LC
Barn Swallow	*Hirundo rustica*	LC	LC
Black Kite	*Milvus migrans*	LC	LC
Black Stork	*Ciconia nigra*	LC	-
Blackcap	*Sylvia atricapilla*	LC	LC
Blackstart	*Oenanthe melanura*	LC	LC
Black-winged Kite	***Elanus caeruleus***	**LC**	**VU**
Bluethroat	*Luscinia svecica*	LC	-
Booted Eagle	*Hieraaetus pennatus*	LC	-
Brown-necked Raven	*Corvus ruficollis*	LC	LC
Common Chiffchaff	*Phylloscopus collybita*	LC	-
Common Kestrel	*Falco tinnunculus*	LC	LC
Common Sandpiper	*Actitis hypoleucos*	LC	-
Common Snipe	*Gallinago gallinago*	LC	
Common Stonechat	*Saxicola torquatus*	LC	LC
Common Swift	*Apus apus*	LC	LC
Common Teal	*Anas crecca*	LC	-
Crested Lark	*Galerida cristata*	LC	LC
Desert Lark	*Ammomanes deserti*	LC	LC
Desert Wheatear	*Oenanthe deserti*	LC	LC
Eastern Olivaceous Warbler	*Iduna pallida*	LC	LC
Eastern Orphean Warbler	*Curruca crassirostris*	LC	LC
Egyptian Vulture	***Neophron percnopterus***	**EN**	**VU**
Eurasian Collared Dove	*Streptopelia decaocto*	LC	LC
Eurasian Hoopoe	*Upupa epops*	LC	LC
Eurasian Jackdaw	*Corvus monedula*	LC	LC
Eurasian Linnet	*Linaria cannabina*	LC	LC
Eurasian Sparrowhawk	*Accipiter nisus*	LC	-
European Bee-eater	*Merops apiaster*	LC	LC
European Honey-buzzard	*Pernis apivorus*	LC	-

[8] (IUCN 2025)
[9] (Symes et al. 2015)

Species	Latin name	Global IUCN conservation status[8]	Regional (Arabian Peninsula) conservation status[9]
Garganey	*Spatula querquedula*	LC	-
Great Grey Shrike	*Lanius excubitor*	LC	LC
Great White Pelican	*Pelecanus onocrotalus*	LC	-
Greater Short-toed Lark	*Calandrella brachydactyla*	LC	LC
Greater Spotted Eagle	***Clanga clanga***	**VU**	**-**
Green Sandpiper	*Tringa ochropus*	LC	-
Grey heron	*Ardea cinerea*	LC	NT
Hooded Wheatear	*Oenanthe monacha*	LC	LC
House Sparrow	*Passer domesticus*	LC	LC
Isabelline Wheatear	*Oenanthe isabellina*	LC	LC
Laughing Dove	*Spilopelia senegalensis*	LC	LC
Lesser Spotted Eagle	*Clanga pomarina*	LC	-
Lesser Whitethroat	*Curruca curruca*	LC	LC
Little Egret	*Egretta garzetta*	LC	LC
Little Swift	*Apus affinis*	LC	LC
Long-legged Buzzard	*Buteo rufinus*	LC	LC
Masked Shrike	*Lanius nubicus*	LC	LC
Mourning Wheatear	*Oenanthe lugens*	LC	LC
Palestine Sunbird	*Cinnyris osea*	LC	LC
Peregrin Falcon	***Falco peregrinus***	**LC**	**VU**
Redstart	*Phoenicurus phoenicurus*	LC	NT
Red-backed Shrike	*Lanius collurio*	LC	-
Red-rumped Swallow	*Cecropis daurica*	LC	LC
Rock Dove	*Columba livia*	LC	LC
Rock Martin	*Ptyonoprogne obsoleta*	LC	LC
Sand Partridge	*Ammoperdix heyi*	LC	LC
Scrub Warbler	*Scotocerca inquieta*	LC	LC
Short-toed eagle	***Circaetus gallicus***	**LC**	**VU**
Sinai Rosefinch	*Carpodacus synoicus*	LC	LC
Spanish Sparrow	*Passer hispaniolensis*	LC	LC
Spotted Flycatcher	*Muscicapa striata*	LC	LC
Spur-winged Lapwing	*Vanellus spinosus*	LC	LC
Steppe Buzzard	*Buteo buteo*	LC	LC
Steppe Eagle	***Aquila nipalensis***	**EN**	**EN**
Tristram's Starling	*Onychognathus tristramii*	LC	LC
Verreaux's Eagle	***Aquila verreauxii***	**LC**	**EN**
Western House Martin	*Delichon urbicum*	LC	LC
Western Marsh Harrier	*Circus aeruginosus*	LC	NT
Whinchat	*Saxicola rubetra*	Lc	-

Species	Latin name	Global IUCN conservation status[8]	Regional (Arabian Peninsula) conservation status[9]
White Wagtail	*Motacilla alba*	LC	
White-crowned Wheatear	*Oenanthe leucopyga*	LC	LC
White-spectacled Bulbul	*Pycnonotus xanthopygos*	LC	LC
Willow Warbler	*Phylloscopus trochilus*	LC	-
Woodchat Shrike	*Lanius senator*	NT	LC
Yellow Wagtail	*Motacilla flava*	LC	-

Project: Aqaba-Amman Water Desalination and Conveyance (AAWDC)

2025 Environmental and Social Impact Assessment

Appendix 6-7 Table of Species Identified in the Terrestrial Baseline Survey

Project: Aqaba-Amman Water Desalination and Conveyance (AAWDC)

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Appendix 6-7 Table of Species Identified in the Terrestrial Baseline Survey

Table 1: Species Identified in the Terrestrial Baseline Survey

Species	Desk Study Location	Survey Location	Global status	National Status
Mammals				
European Free-tailed Bat *Tadarida teniotis*	Aqaba Wadi Rum		LC	LC
Kuhl's Pipistrelle *Pipistrellus kuhli*	Aqaba		LC	LC
Wagner's Gerbil *Gerbillus dasyurus*	Al Jafr, Wadi Rum	Segment 4	LC	LC
Eastern Spiny Mouse *Acomys dimidiatus*	Aqaba, Wadi Rum	Segment 2	LC	LC
Golden Spiny Mouse *Acomys russatus*	Aqaba, Wadi Rum		LC	LC
Lesser Egyptian Gerbil *Gerbillus gerbillus*	Aqaba		LC	LC
Baluchistan Gerbil *Gerbillus nanus*	Aqaba, Wadi Rum		LC	LC
Pygmy gerbil *Gerbillus henleyi*		Segment 6	LC	LC
Sundevall's (Libyan) Jird *Meriones crassus*	Aqaba, Wadi Rum	Segment 3, 4 (poss), 6 (poss)	LC	LC
Fat Sand Jird *Psammomys obesus*	Aqaba, Wadi Rum	Segment 4 (possible)	LC	LC
Arabian Hare *Lepus capensis*	Aqaba Highway, Wadi Rum	Segment 6,7	LC	EN
The Nubian Ibex *Capra nubiana*	Aqaba Mountains, Wadi Rum	Segment 2	VU	VU
Wolf, *Canis lupus*	Aqaba, Wadi Rum	Segment 6	LC	EN
Sand Fox *Vulpes rueppellii*	2km SE Aqaba		LC	NT
Red Fox *Vulpes vulpes*	Wadi Rum	Segment 5,6,7	LC	LC
Ethiopian Hedgehog *Paraechinus aethiopicus*	Wadi Rum	Segment 6	LC	LC

Species	Desk Study Location	Survey Location	Global status	National Status
Asiatic Jackal *Canis aureus*	Wadi Rum		LC	LC
Blanford's Fox *Vulpes cana*	Wadi Rum		LC	EN
Sand Cat *Felis margarita*	Wadi Rum		LC	CR
Geoffroy's Horseshoe Bat *Rhinolophus clivosus*	Wadi Rum		LC	LC
Lesser Horseshoe Bat *Rhinolophus hipposideros*	Wadi Rum		LC	NT
Hemprich's Long eared bat *Otonectris hemprichii*	Wadi Rum		LC	LC
Desert Pipistrelle *Hypsugo ariel*	Wadi Rum		DD	LC
Asian Barbastelle *Barbastella leucomelas*	Wadi Rum		LC	NT
Botta's Serotine *Eptesicus bottae*	Wadi Rum		LC	LC
Northeast African Long Ear Bat *Plecotus christii*	Wadi Rum		DD	LC
Southwest Asian Garden Dormouse *Eliomys melanurus*	Wadi Rum		LC	NT
Three Toed Jerboa *Jaculus jaculus*	Wadi Rum		LC	LC
Cheeseman's Gerbil *Gerbillus cheesmani*	Wadi Rum		LC	LC
Bushy Tailed Jird *Sekeetamys calurus*	Wadi Rum	Segment 5	LC	LC
Rock Hyrax *Procavia capensis*	Wadi Rum		LC	EN
Middle Eastern Blind Mole-rat *Spalax ehrenbergi*		Segment 9	LC	LC

Species	Desk Study Location	Survey Location	Global status	National Status
Striped hyaena *Hyaena hyaena*	Wadi al Yutum area	Segment 6	NT	EN
Marbled Polecat *Vormela peregusna*	S Amman area		VU	LC
Herptiles				
Ablepharus rueppellii Rueppel's Snake-eyed Skink	Wadi Rum		LC	
Acanthodactylus ahmaddisii	Daba'a (Segment 7)		EN	Endemic
Acanthodactylus boskianus Bosk's Fringe-toed Lizard	Aqaba, Wadi Rum	Segment 3,4,6	LC	LC
Acanthodactylus opheodurus Arnold's Fringe-fingered Lizard	Wadi Rum	Segment 6	LC	LC
Acanthodactylus schmidti Schmidt's Fringe-toed Lizard	Wadi Rum	Segment 5	LC	LC
Bufotes sitibundus Variable Green Toad		Segment 5,6	LC	LC
Bunospus tuberculatus The Baluch Ground Gecko	Aqaba, Wadi Rum	Segment 7	LC	LC
Cerastes gasperettii gasperettii The Arabian Horned Viper	Wadi Rum		LC	
Chalcides ocellatus Ocellated Skink	Aqaba, Wadi Rum		LC	LC
Chamaeleo chamaeleon Common Chameleon	Wadi Rum		LC	
Cyrtopodion scabrum Rough Bent-toed Gecko	Aqaba		LC	LC
Echis coloratus The Arabian Saw-Scaled Viper	Aqaba, Wadi Rum		LC	LC

Species	Desk Study Location	Survey Location	Global status	National Status
Eirenis coronella The Crowned Dwarf Snake	Wadi Rum		LC	
Eumeces schneiderii Schneider's Skink		Dab'a	LC	LC
Hemidactylus dawudazraqi Azraq Half-toed Gecko		Segment 7		
Hemidactylus mindiae Mount Sinai-Gecko	Wadi Rum		LC	
Laudakia vulgaris Egyptian rock agama		Segment 2,7	LC	LC
Lytorhynchus diadema Awl-Headed Snake	Wadi Rum		LC	
Mesalina brevirostris Blanford's Short-nosed Desert Lizard	Aqaba, Wadi Rum		LC	LC
Mesalina guttulata Small-spotted Lizard	Wadi Rum		LC	
Mesalina olivieri Olivier's Sand Lizard	Aqaba, Wadi Rum		LC	LC
Myriopholis macrorhynchus The Hook-billed Blind Snake	Wadi Rum		LC	
Ophisops elegans Snake-eyed lizard		Segment 7, Dab'a	LC	LC
Phoenicolacerta kulzeri khazaliensis The Rock Lizard of Wadi Ramm	Wadi Rum		EN	
Phrynocephelus nejdensis Arabian Toadhead Agama	Wadi Rum		LC	
Platyceps elegantissimus The Most Beautiful Whip Snake	Wadi Rum		DD	NT

Species	Desk Study Location	Survey Location	Global status	National Status
Platyceps rhodorachis Jan's Whip Snake	Aqaba, Wadi Rum		LC	LC
Platyceps sinai Sinai Banded Snake	Wadi Rum		NT	NT
Pristurus rupestris Blanford's Semaphore Gecko	Wadi Rum		LC	
Psammophis schokari Forskål's Sand Snake	Aqaba, Wadi Rum	Segment 7	LC	LC
Pseudotrapelus aqabensis Aqaba Agama	Aqaba	Segment 1		LC
Pseudotrapelus sinaitus Sinai Agama	Wadi Rum	Segment 5,6, Dab'a	LC	LC
Ptyodactylus guttatus Sinai Fan-fingered Gecko	Aqaba, Wadi Rum		LC	LC
Ptyodactylus hasselquistii Hasselquist's Fan-footed Gecko	Aqaba, Wadi Rum	Segment 6	LC	LC
Scincus scincus The Sandfish	Wadi Rum		LC	
Spalerosophis diadema Clifford's Snake	Aqaba, Wadi Rum		LC	LC
Stellagama stellio brachydactyla Southern Starred Agama	Wadi Rum		LC	
Stenodactylus doriae Middle Eastern Short-fingered Gecko	Wadi Rum		LC	
Stenodactylus grandiceps Jordan short-fingered Gecko		Segment 6	LC	LC
Stenodactylus sthenodactylus	Wadi Rum		LC	

Species	Desk Study Location	Survey Location	Global status	National Status
Elegant Thin-Toed Gecko				
Telescopus dhara The North- African Cat Snake	Aqaba, Wadi Rum		LC	LC
Testudo graeca Spur thighed tortoise		Segment 8	VU	
Trapelus agnetae Northern Arabian Plain Agama		Segment 6	LC	LC
Tropiocolotes nattereri Natterer's Pigmy Gecko	Aqaba, Wadi Rum		LC	LC
Uromastyx aegyptia Egyptian Spiny–tailed Lizard	Aqaba, Wadi Rum	Segment 1(suspected),6	VU	NT
Varanus griseus Desert Monitor	Wadi Rum	Segment 6 (Tracks)	LC	LC
Plants				
Achillea fragrantissima		Segment 6,7		
Aizoon canariense		Segment 1,3		
Anabasis articulata		Segment 6,7		
Anabasis setifera		Segment 2		
Anvillea garcinii		Segment 5		
Artemesia jordanica	Segment 5 (ESIA 2022)			EN
Artemesia judaica		Segment 5		VU
Artemesia monosperma		Segment 5		NT
Artemesia sieberi		Segment 3,6		
Asteriscus graveolens		Segment 6		
Astragalus spinosus		Segment 6		
Atriplex leucoclada		Segment 7		
Calligonum comosum	Wadi Rum	Segment 5		EN
Calotropis procera		Segment 5		

Species	Desk Study Location	Survey Location	Global status	National Status
Carex pachystylis		Segment 5		
Ceratonia siliqua		Segment 8,9		
Citrullus colocynthis		Segment 5,6		
Cleome droserifolia	Wadi Rum	Segment 1,2		EN
Conyza canadensis		Segment 5		
Crotalaria aegyptiaca		Segment 2		
Cupressus sempervirens		Segment 9		
Cynodon dactylon		Segment 5,6		
Diplotaxis harra		Segment 6		
Fagonia bruguieri		Segment 6		
Fagonia mollis		Segment 3,5,6		
Farsetia aegyptiaca		Segment 6		
Haloxylon persicum		Segment 4,5	LC	VU
Hammada salicornica		Segment 3,4,5		
Hammada scoparia		Segment 2,6		
Heliotropum rotundifolium		Segment 5		VU
Hordeum marinum		Segment 7		
Hyosyamus desertorum		Segment 5		
Hyoscyamus muticus		Segment 5		CR
Ifloga spicata	Desk study only			
Iris nigricans	Desk study only		VU	EN
Kickxia aegyptiaca		Segment 6		
Launaea spinosa		Segment 3		
Lavandula coronopifolia		Segment 2		NT
Leopoldia bicolor	Desk study only		NT	LC
Malva parviflora		Segment 7		
Ochradenus baccatus		Segment 1,2,3		
Ononis spinosa		Segment 5		

Species	Desk Study Location	Survey Location	Global status	National Status
Peganum harmala		Segment 6,7		
Pergularia tomentosa		Segment 5		
Phragmites australis		Segment 5,6		
Pinus halepensis		Segment 8,9		
Polycarpaea repens		Segment 1		
Pulicaria crispa		Segment 5		
Pulicaria undulata		Segment 5,6		
Retama raetam		Segment 3,4,5,6		
Ricinus communis		Segment 5		
Salsola barysoma		Segment 1,2,3,4		
Salsola tragus		Segment 4		
Schismus arabicus	Desk study only			
Seidlitzia rosmarinus	Desk study only			
Stipagrostis plumosa		Segment 6		
Stipagrostis sp.		Segment 1	?	?
Tamarix aphylla		Segment 6		
Tamarix nilotica		Segment 4,6,7		
Traganum nudatum		Segment 5		
Typha elephantina		Segment 5		
Vachellia gerrardii		Segment 4,6		VU
Vachellia tortilis		Segment 1,2	LC	VU
Zilla spinosa		Segment 2,3,4,5,6		

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Appendix 6-8 Baseline Avifauna OHTL

Baseline Avifauna

1 Study area

The Project comprises four main components: marine works and desalination plant; a conveyance system (composed of a 438 km underground pipeline, tanks and pumping stations), a solar plant and an overhead transmission line (Figure 1). Because birds are generally highly mobile, the study area considered for this baseline assessment was a 10 km buffer around the Project footprint, encompassing all infrastructure.

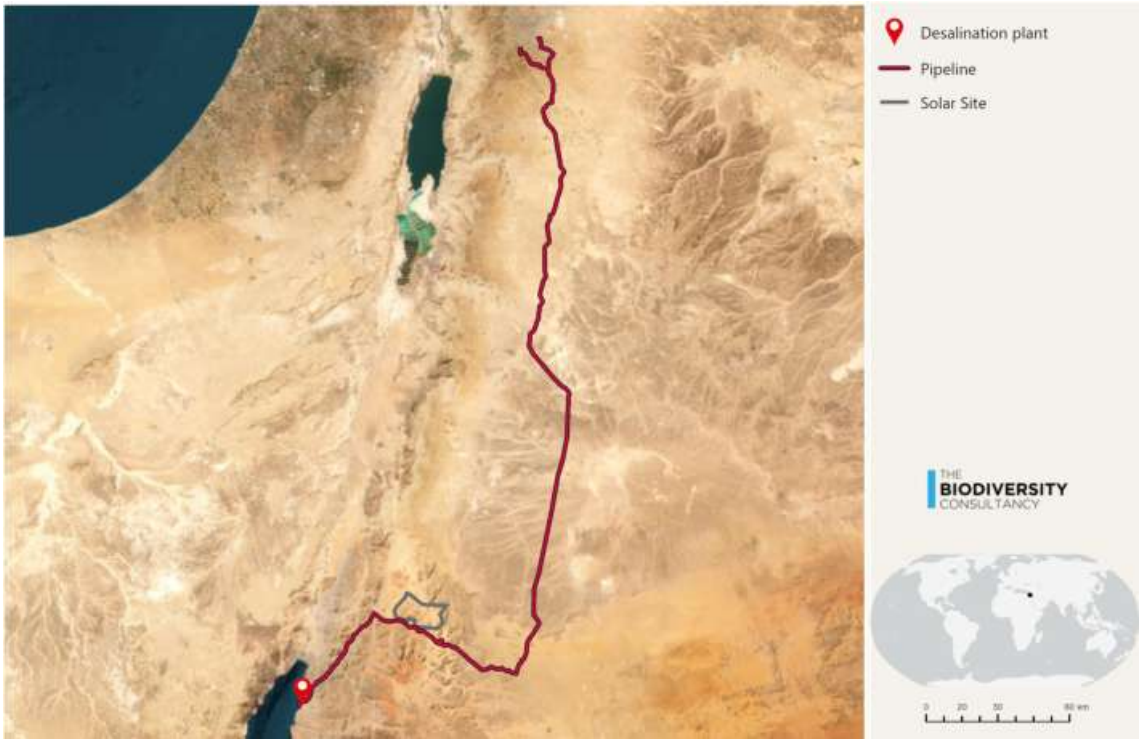


Figure 1: Location of Project infrastructure

This baseline assessment is based on a desktop review and the results of field surveys conducted to date. The potential impacts of the Project's various infrastructure components differ, but field survey efforts focused primarily on the overhead transmission line, which was considered to pose the greatest risk to birds, since the temporary works on the buried pipeline are not considered to have significant impacts on birds, and overhead transmission lines are known to cause mortality through electrocution and, particularly, collisions (Prinsen *et al.* 2011; APLIC 2012; Bennun *et al.* 2021). Additionally, part of the transmission line overlaps a Key Biodiversity Area (KBA), the Aqaba Mountains and Coast KBA Figure 2, designated specifically due to the high numbers of the migratory Levant Sparrowhawk (*Accipiter brevipes*), which had also been flagged as a potential critical habitat trigger for the Project (TBC 2024).

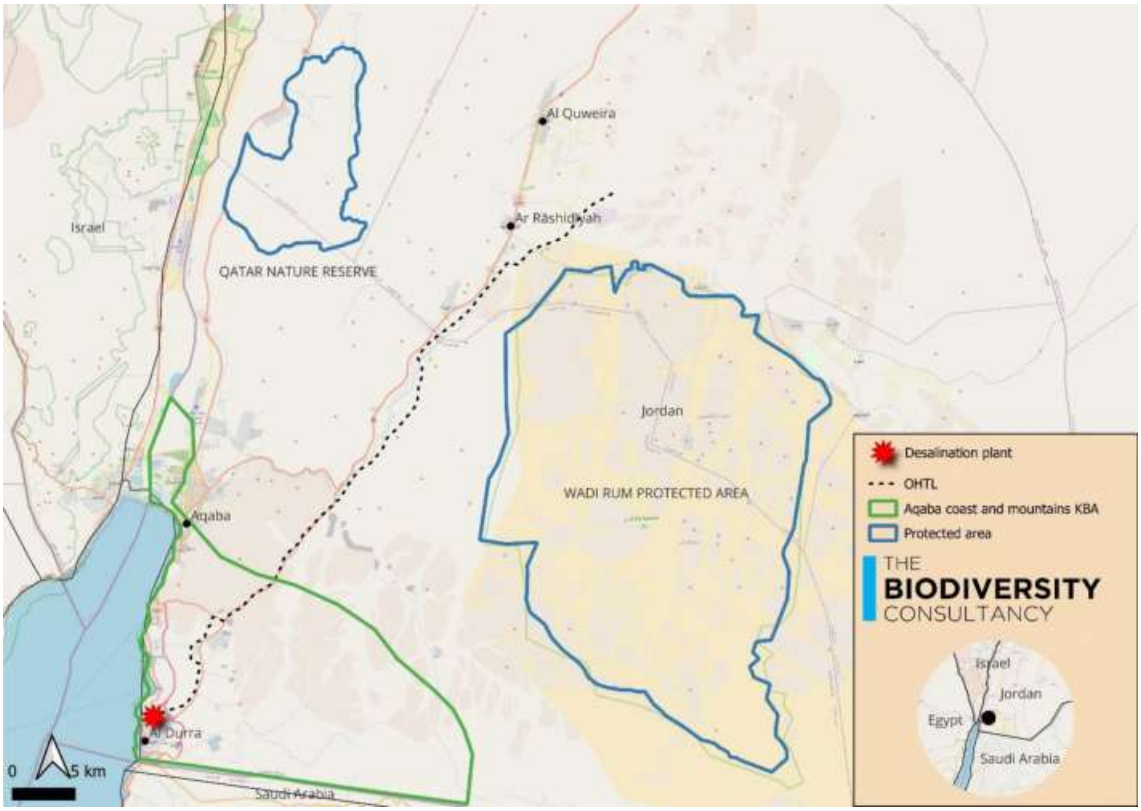


Figure 2: Protected Areas and other designated areas overlapping or in the vicinity of the Project's overhead transmission line.

2 Literature review

The Integrated Biodiversity Assessment Tool (IBAT)[1], a source of globally authoritative biodiversity datasets, including the IUCN Red List of Threatened Species, the World Database on Protected Areas, and the World Database of Key Biodiversity Areas (including Important Bird and Biodiversity Areas) was used to identify all bird species potentially present in the study area.

In addition to IBAT, several internationally and nationally relevant datasets and assessments were consulted including:

- The conservation status and distribution of the breeding birds of the Arabian peninsula (Symes *et al.* 2017)
- The Global Biodiversity Information Facility (GBIF) (https://www.gbif.org/)
- eBird (http://www.ebird.org)
- BirdLife data zone (http://datazone.birdlife.org/home)
- Jordan BirdWatch (JBW) (https://www.jordanbirdwatch.com/)

[11] Integrated Biodiversity Assessment Tool

3 Field survey methods

Field surveys were conducted across six campaigns in 2025 (duration approx. 13 days, each), with three carried out during the spring and three during the autumn. These were performed along the expected layout of the overhead transmission line and included vantage point observations, line transects, waterbody counts and carcass surveys. For details on the methods see TBC 2025a, 2025b, 2025c.

Vantage points

Vantage points (VP) comprised a series of watches from a fixed location (3-hour duration each) to quantify the flight activity of birds and its distribution at the proposed development site. This method is especially adequate to detect and track the movements of soaring birds or other diurnal medium-large sized birds that actively migrate or commute between foraging and/or roosting sites (Scottish Natural Heritage 2017; BID Invest and IFC 2019). Eleven VPs were distributed along the expected layout of the overhead transmission line, appropriately spread and located in areas of good visibility (Figure 3)

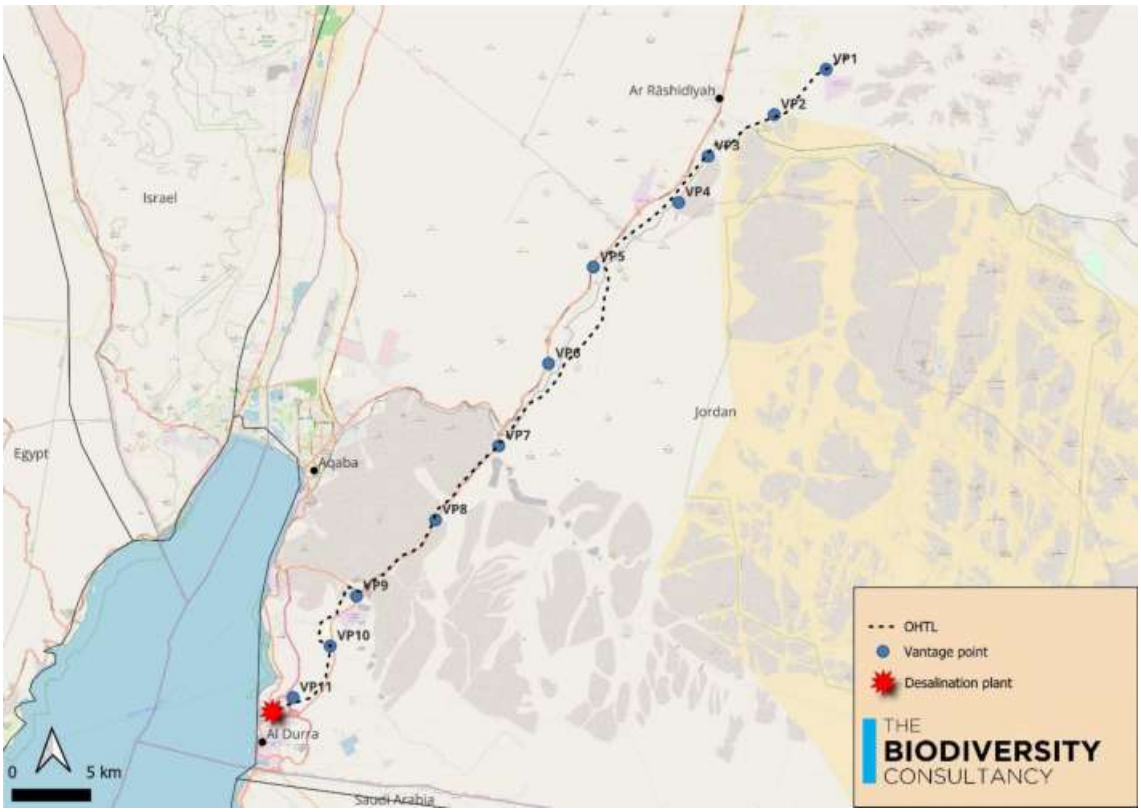


Figure 3: Location of Vantage Points

Line transects

Line transects were conducted to survey the non-soaring terrestrial birds. Twenty 500 m transects were defined along the expected overhead transmission line route, sufficiently spaced apart to minimise double counting (Figure 4).

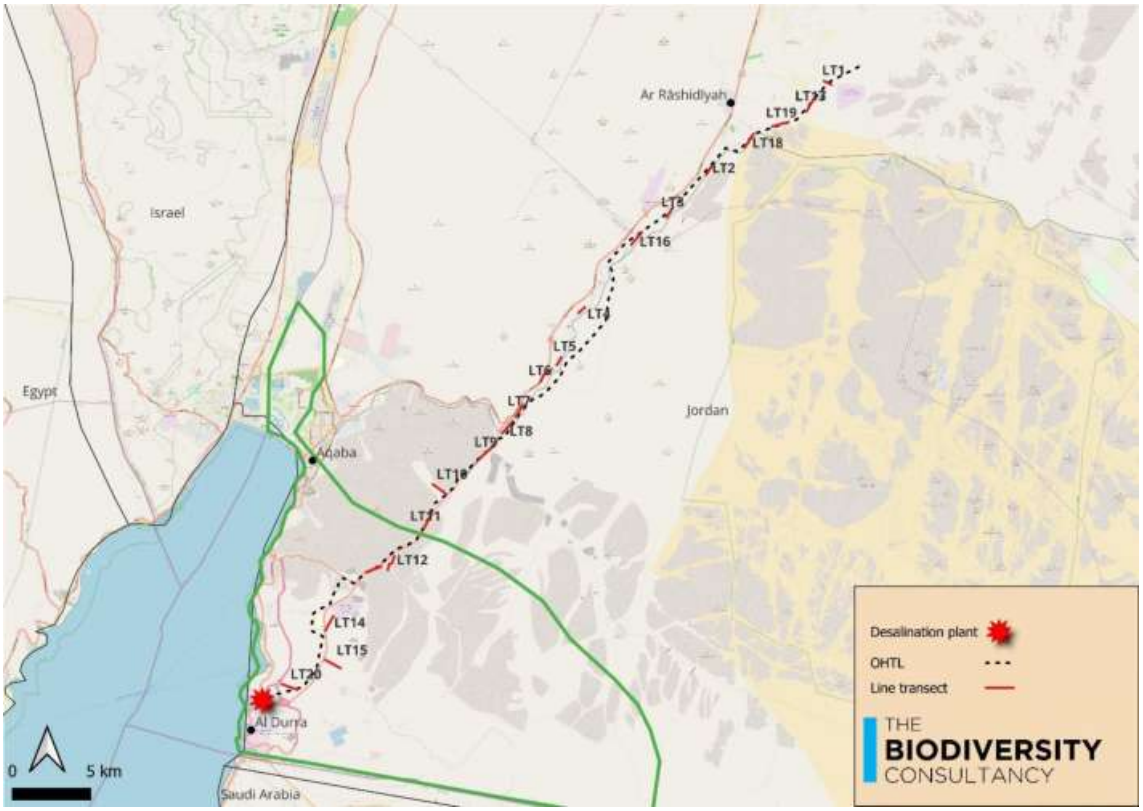


Figure 4: Location of line transect surveys

Waterbody counts

Waterbody counts were directed at aquatic bird species. Six observation points were established along the overhead transmission line at waterbodies and flood barrier dams, at locations that allow the visual inspection of the water surface and 200 m of the water margin to each side (Figure 5). Every water bird present, either in the water or on the banks, was recorded

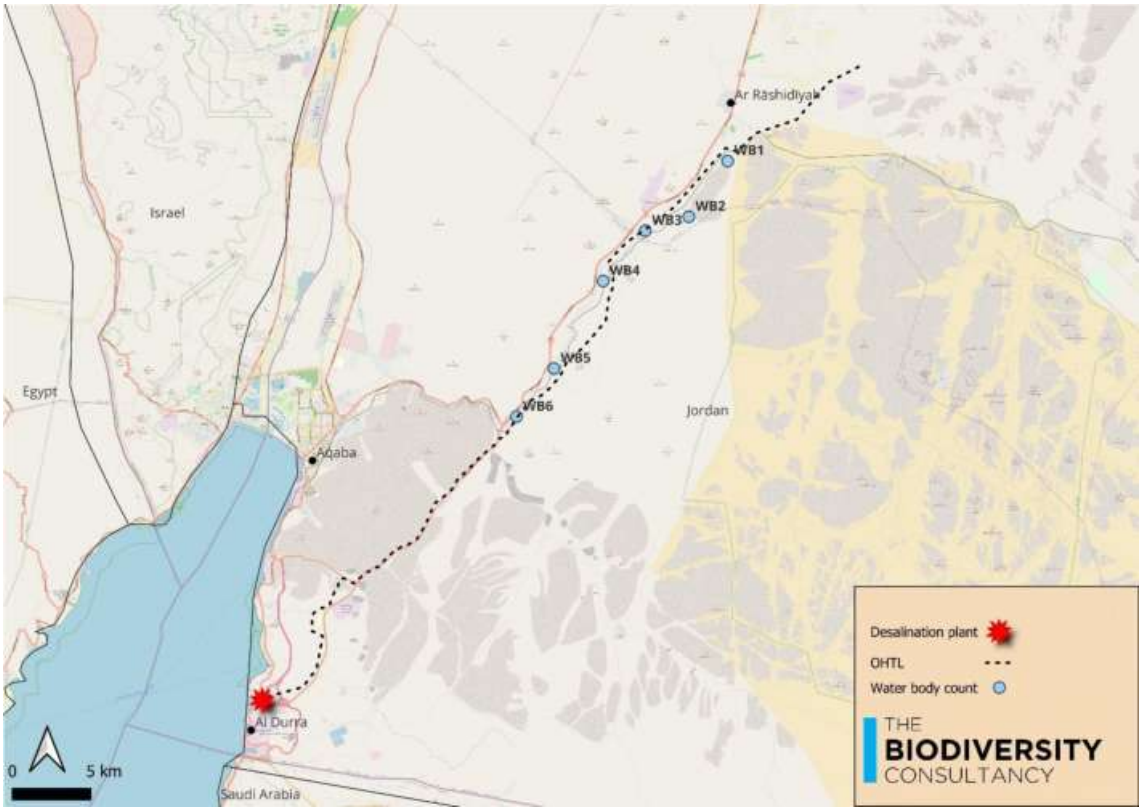


Figure 5: Locations of waterbody counts

Carcass surveys

Searches for carcasses were undertaken along the existing OHTL that runs nearby (parallel) to the planned OHTL for this Project, in accordance to the methodology described in Post-construction Bird and Bat Fatality Monitoring (PCFM) for Onshore Wind Energy Facilities in Emerging Market Countries: Good Practice Handbook and Decision Support Tool (IFC *et al.* 2023). Searching the parallel line was conducted as a proxy to assess future mortality at the planned transmission line.

Within the Aqaba Coast and Mountains KBA/IBA, the existing OHTL was divided into 1 km sections. PCFM was conducted by two observers along 500 m of each 1 km segment. Outside of the IBA, the existing OHTL was divided into 5 km segments and PCFM conducted within 1 km. Carcass surveys were conducted three times in spring and three times in autumn.

4 Results of desktop review and baseline avian surveys

According to the desktop review, a total of 224 bird species may potentially occur within the study area, of which 85 have been confirmed so far during the field surveys (Table 3). It should be noted that only the southern portion of the study area was surveyed (along the proposed

transmission line), that some of the 224 species are rare and/or localized, and that some groups of species, such as seabirds and nocturnal species, were not targeted by the surveys.

4.1 Soaring birds

Jordan is part of the Rift Valley/Red Sea migratory flyway, which is one of the most important routes in the world for migratory soaring birds (MSB), such as raptors, storks and pelicans. Each spring and autumn, 37 species of MSBs navigate this flyway, with over a million birds passing through the larger bottlenecks (Porter 2005; Jobson *et al.* 2021). The proliferation of wind energy projects and power lines poses a major threat to these species during the spring and autumn migratory periods (Khoury 2017).

In Jordan, soaring bird migration is more noticeable in spring when birds tend to concentrate their journey along the Rift Vally. The majority of MSBs enter the country from the Eilat (Israel) bottleneck, in the Northern tip of the Gulf of Aqaba, before travelling northwards. This explains why MSB counts in Eilat in spring are much higher than records along the Aqaba Mountains and Coast. Nevertheless, this area is considered as a KBA, designated for important concentrations of Levant Sparrowhawk, while some globally threatened soaring birds also occur, such as the Egyptian Vulture (*Neophron percnopterus*), the Steppe Eagle *(Aquila nipalensis*), the Saker Falcon (*Falco cherrug*), all Endangered according to the IUCN Red List; the Eastern Imperial Eagle (*Aquila heliacal*), the Greater Spotted Eagle (*Clanga clanga*), the Sooty Falcon (*Falco concolor*) and the Red-footed Falcon (*Falco vespertinus*), all Vulnerable. In total, more than 50,000 soaring birds are expected to migrate through Aqaba each spring (BirdLife International 2025; Key Biodiversity Areas Partnership 2025).

Two raptor species are considered Critically Endangered in the Arabic Peninsula: Lanner Falcon (*Falco biarmicus*) and the Saker Falco. Both are very rare/occasional in the study area.

In autumn, soaring bird migration is less visible as birds do not tend to concentrate in one route, migrating in a broad front over the whole country (Jobson *et al.* 2021).

Table 1 shows the species that can potentially be found in the study area with an indication of the ones that have been detected so far and their numbers.

As expected, the number of soaring birds recorded from vantage points in spring was much higher than the one recorded in autumn (Table 1), especially driven by relatively high numbers of Steppe Buzzards (*Buteo buteo*), Honey Buzzards (*Pernis apivorus*), Black Kites (*Milvus migrans*) and Booted Eagles (*Hieraaetus pennatus*), which are all common soaring bird migrants in the region.

It should be noted that the globally Endangered Steppe Eagle was recorded in both seasons, with high numbers (84) in autumn. Other threatened species that were recorded were the Egyptian Vulture (both seasons) and the Greater Spotted Eagle (one individual in autumn).

Most of the individuals of the threatened species were observed flying at altitudes much higher than the transmission line, indicating that they were likely performing long range migratory movements. This translates into a lower risk of collision.

Verreaux's Eagle (*Aquila verreauxii*) is globally Least Concern, but Endangered in the Arabian Peninsula (Symes *et al.* 2017). An adult bird of this species was recorded during the field surveys,

and since these eagles are not migratory in the region, it is likely breeding in the Aqaba Mountains.

Table 1: Soaring bird species likely to be present in the area, with confirmation during field work for the Project, indication of the total number of individuals recorded in the vantage point surveys, and their IUCN Red List and Regional Red List (Symes et al. *2017) category.*

Scientific name	Common name	Confirmation	Total count in spring 2025	Total count in autumn 2025	IUCN Red List Category	Regional Red List Category
Accipiter brevipes	Levant Sparrowhawk				LC	-
Accipiter nisus	Eurasian Sparrowhawk	✓		8	LC	-
Anthropoides virgo	Demoiselle Crane				LC	-
Aquila chrysaetos	Golden Eagle				LC	EN
Aquila heliaca	Eastern Imperial Eagle				VU	-
Aquila nipalensis	Steppe Eagle	✓	6	84	EN	-
Aquila verreauxii	Verreaux's Eagle	✓			LC	EN
Buteo buteo	Steppe Buzzard	✓	396	80	LC	-
Buteo rufinus	Long-legged Buzzard	✓	3	11	LC	
Ciconia ciconia	White Stork	✓			LC	-
Ciconia nigra	Black Stork	✓		5	LC	-
Circaetus gallicus	Short-toed Snake-eagle	✓		4	LC	-
Circus aeruginosus	Western Marsh-harrier			3	LC	-
Circus cyaneus	Hen Harrier				LC	-
Circus macrourus	Pallid Harrier				NT	-
Circus pygargus	Montagu's Harrier				LC	-
Clanga clanga	Greater Spotted Eagle	✓		1	VU	-
Clanga pomarina	Lesser Spotted Eagle	✓		1	LC	-
Elanus caeruleus	Black-shouldered Kite	✓		1	LC	VU
Falco biarmicus	Lanner Falcon				LC	CR
Falco cherrug	Saker Falcon				EN	CR
Falco columbarius	Merlin				LC	-
Falco concolor	Sooty Falcon				VU	EN

Scientific name	Common name	Confirmation	Total count in spring 2025	Total count in autumn 2025	IUCN Red List Category	Regional Red List Category
Falco naumanni	Lesser Kestrel				LC	-
Falco peregrinus	Peregrine Falcon	✓			LC	EN
Falco subbuteo	Eurasian Hobby				LC	-
Falco tinnunculus	Common Kestrel	✓		22	LC	-
Falco vespertinus	Red-footed Falcon				VU	-
Gyps fulvus	Griffon Vulture				LC	EN
Haliaeetus albicilla	White-tailed Sea-eagle				LC	-
Hieraaetus pennatus	Booted Eagle	✓	36	5	LC	-
Milvus migrans	Black Kite	✓	55	26	LC	-
Neophron percnopterus	Egyptian Vulture	✓	1	1	EN	-
Pandion haliaetus	Osprey	✓			LC	-
Pelecanus onocrotalus	Great-white Pelican	✓		16	LC	-
Pernis apivorus	European Honey-buzzard	✓	170		LC	-
TOTAL			**667**	**268**		

4.2 Waterbirds and seabirds

Several species of shore birds can be found migrating or even overwintering across the coast of Jordan (and to a lesser extent, inland) and very few of them breed in the country (eBird 2025). Three of these species are classified as Vulnerable by IUCN: Broad-billed Sandpiper (*Calidris falcinellus*), Curlew Sandpiper (*Calidris ferruginea*) and Grey Plover (*Pluvialus squatarola*). These species are rare along the coast and are not expected to occur inland. The same can also be said of seven other shore bird species that are considered Nearly Threatened by IUCN (see Table 3 in the appendix A). Waterbodies in the vicinity of the Project are very scarce and most of them correspond to artificial dams that were built to reduce the severity of the effects of fast floods on urban areas. Therefore, few waterbird species were found, and none of conservation concern (Table 2).

Table 2: Water bird species counted during waterbody surveys.

Scientific name	Common name	Total count in spring	Total count in autumn	IUCN Red List Category	Regional Red List Category
Actitis hypoleucus	Common Sandpiper		1	LC	-
Anas crecca	Teal	60	2	LC	-
Ardea cinerea	Grey Heron		1	LC	NT
Calidris minuta	Little stint	5		LC	-
Egretta garzetta	Little Egret		9	LC	LC
Spatula querquedula	Garganey		3	LC	-
Tringa nebularia	Common Greenshank	2		LC	-
Tringa ochropus	Green Sandpiper		1	LC	-
Vanellus spionosus	Spur-winged Lapwing	16	20	LC	LC

None of the gull and tern species that are present in the area are of conservation concern.

No specific surveys were conducted targeting pelagic seabirds, but they are quite rare in the region, and they seldom approach the coast, with the exception of the Brown Booby (*Sula leucogaster*), which is considered Least Concern by IUCN.

Some waterfowl also migrate along the coast of the Gulf of Aqaba, including the globally Endangered White-headed Duck (*Oxyura leucocephala*). However, it is considered very unlikely that this species occurs within the study area, since there are no records on eBird or GBIF of this species in Jordan, and there is no suitable habitat in the area.

4.3 Other species of concern

Jordan is also important concerning the migration of passerines and other small birds. One of these species, the Sociable Lapwing (*Vanellus gregarious*), is listed as Critically Endangered (CR) in the IUCN Red List. In Jordan, it occurs as a very rare passage migrant and is likely to appear only occasionally within the study area, potentially as a vagrant.

The only other globally threatened species that were not mentioned in the sections above are the MacQueens' Bustard (*Chlamydotis macqueenii*), the Syrian Serin (*Serinus syriacus*) and the European Turtle-dove (*Streptopelia turtur*), all of them classified as Vulnerable by IUCN.

MacQueen's Bustard is considered to be very rare in Jordan, with very few recent records and none of which in the vicinity of the Project (eBird 2025).

The Syrian Serin breeds in submontane and montane open woodland and bushy slopes, usually dominated by sparse cedar (*Cedrus* spp.), pine (*Pinus* spp.), fir (*Abies* spp.) and Juniper (*Juniperus* spp.) woods, also small Palestine Oak (*Quercus calliprinos*) and orchards, at 900-1800 m elevation. None of these habitats occur in the study area. During the post-breeding dispersal, it can be found at lower levels in southwestern Jordan, including the study area. It is an erratic species that can change its wintering distribution every year (Clement & de Juana 2020).

The European Turtle-dove is a scarce passage migrant in the study area. It favours areas with some vegetation.

Some desert species are of regional concern, such as the Buff-rumped Wheatear (*Oenanthe Moesta*, globally Least Concern and regionally Endangered), which was detected during the field surveys, but is expected to be uncommon in the area. Other regionally endangered species that were not detected during the field surveys, but may be present in the study area is the Black-bellied Sandgrouse (*Pterocles orientalis*).

4.4 Bird mortality along the transmission line

Carcass search along the existing parallel transmission line revealed very low mortality (only one Quail *Coturnix coturnix*). Searcher efficiency trials showed high efficiency, which

5 Key sensitivities

The southern portion of the Project area overlaps the Aqaba Mountains and Coast KBA which is an important area for soaring bird migration, especially during spring. Some of the species that occur in the area can potentially trigger critical habitat (*sensu* IFC PS6 and EBRD PR6, see TBC 2025b). These are the Steppe Eagle, the Levant Sparrowhawk and the Sooty Falcon. Levant Sparrowhawk and Sooty Falcon are relatively small and agile birds of prey that can be considered low risk regarding transmission line impacts (Prinsen *et al.* 2011; Thaxter *et al.* 2017). However, the Steppe Eagle, which was detected in high numbers in the study area, is known to suffer from collisions and electrocutions (more frequently in distribution lines), so it is imperative to ensure that the transmission line pylon is insulated in order to prevent electrocutions and bird flight diverters are installed all along the line following good international industry practice (APLIC 2012; Prinsen *et al.* 2012; BirdLife International & CMS Energy Task Force 2023).

Another species that is also likely to trigger critical habitat is the Syrian Serin, but impacts on this species are unlikely to be significant.

6 Limitations and further surveys

Field surveys were only conducted for a relatively small portion (~15%) of the study area corresponding to the planned overhead transmission line. This area is likely to be one of the most important to survey in detail, since it overlaps with the Aqaba Coast and Mountains KBA and is the most important area in the country for soaring bird migration.

The surveys conducted so far were quite intensive, covering three campaigns in spring and three campaigns in autumn, with a wide range of methodologies (vantage points, line transects, waterbody counts) that allow to record a wide range of species. However, even if these surveys covered long periods, they did not cover the whole of the migratory season. In autumn, surveys were initiated only in September, which probably meant that the migratory peak of the species that migrate early in the season (such as the White Stork *Ciconia ciconia*) were missed.

The Levant Sparrowhawk, the key species behind the designation of the Aqaba Mountains and Coast as an IBA and KBA was not detected during the surveys. This species is known to migrate in very large flocks, often comprising a significant proportion of the population. As a result, if surveys do not cover the full duration of the migratory period, there is a high likelihood that no individuals will be recorded. There is also some evidence that at least some birds migrate at night, especially those migrating later in the season (Stark & Liechti 1993; Spaar *et al.* 1998).

To overcome these limitations, an additional spring terrestrial biodiversity survey covering the whole study area is planned in 2026. This survey will include bird surveys with a similar methodological approach as the one followed during the previous surveys to cover all the species groups: vantage points (directed at soaring birds and other large sized species), line transects (directed at all avifauna, especially passerines and other small species) and waterbody counts (directed at waterbird species). These surveys will be conducted by experienced ornithologists.

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TBC (2025) Project: Aqaba Amman Water Conveyance and Desalination Project (AAWDCP): Terrestrial Critical Habitat Assessment

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Appendix A

Table 3: List of bird species potentially present in the study area, with an indication of which ones were recorded during field surveys, their IUCN Red List and Regional Red List (Symes et al. *2017) category*

Scientific name	Common name	Confirmed during 2025 Surveys	IUCN Red List Category	Regional Red List Category
Accipiter brevipes	Levant Sparrowhawk		LC	-
Accipiter nisus	Eurasian Sparrowhawk	✓	LC	-
Acrocephalus melanopogon	Moustached Warbler		LC	NT
Acrocephalus palustris	Marsh Warbler		LC	-
Acrocephalus scirpaceus	Common Reed-warbler		LC	LC
Acrocephalus stentoreus	Clamorous Reed-warbler		LC	LC
Actitis hypoleucos	Common Sandpiper	✓	LC	-
Alauda arvensis	Eurasian Skylark		LC	-
Alcedo atthis	Common Kingfisher		LC	NT
Ammomanes deserti	Desert Lark	✓	LC	LC
Ammoperdix heyi	Sand Partridge	✓	LC	LC
Anas crecca	Common Teal	✓	LC	-
Anthropoides virgo	Demoiselle Crane		LC	-
Anthus campestris	Tawny Pipit		LC	LC
Anthus cervinus	Red-throated Pipit		LC	-
Anthus pratensis	Meadow Pipit		LC	-
Anthus spinoletta	Water Pipit		LC	-
Anthus trivialis	Tree Pipit		LC	-
Apus affinis	Little Swift	✓	LC	LC
Apus apus	Common Swift	✓	LC	LC

Scientific name	Common name	Confirmed during 2025 Surveys	IUCN Red List Category	Regional Red List Category
Apus pallidus	Pallid Swift		LC	LC
Aquila chrysaetos	Golden Eagle		LC	EN
Aquila heliaca	Eastern Imperial Eagle		VU	-
Aquila nipalensis	Steppe Eagle	✓	EN	EN
Aquila verreauxii	Verreaux's Eagle	✓	LC	EN
Ardea alba	Great White Egret		LC	-
Ardea cinerea	Grey Heron	✓	LC	NT
Ardea purpurea	Purple Heron		LC	NT
Ardeola ralloides	Squacco Heron		LC	LC
Arenaria interpres	Ruddy Turnstone		NT	-
Aythya nyroca	Ferruginous Duck		NT	NT
Bubulcus ibis	Cattle Egret		LC	LC
Burhinus oedicnemus	Eurasian Thick-knee		LC	LC
Buteo buteo vulpinus	Steppe Buzzard	✓	LC	LC
Buteo rufinus	Long-legged Buzzard	✓	LC	LC
Calandrella brachydactyla	Greater Short-toed Lark	✓	LC	LC
Calidris alba	Sanderling		LC	LC
Calidris alpina	Dunlin		NT	-
Calidris canutus	Red Knot		NT	-
Calidris falcinellus	Broad-billed Sandpiper		VU	-
Calidris ferruginea	Curlew Sandpiper		VU	-
Calidris minuta	Little Stint	✓	LC	-
Calidris pugnax	Ruff		LC	-
Caprimulgus aegyptius	Egyptian Nightjar		LC	LC
Carduelis carduelis	European Goldfinch		LC	EN
Carpodacus synoicus	Sinai Rosefinch	✓	LC	LC

Scientific name	Common name	Confirmed during 2025 Surveys	IUCN Red List Category	Regional Red List Category
Carpospiza brachydactyla	Pale Sparrow		LC	-
Cecropis daurica	Red-rumped Swallow	✓	LC	LC
Cercotrichas galactotes	Rufous-tailed Scrub-robin		LC	-
Cettia cetti	Cetti's Warbler		LC	LC
Charadrius alexandrinus	Kentish Plover	✓	LC	LC
Charadrius asiaticus	Caspian Plover		LC	-
Charadrius dubius	Little Ringed Plover		LC	LC
Charadrius hiaticula	Common Ringed Plover		LC	-
Charadrius leschenaultii	Greater Sandplover		LC	NT
Chlamydotis macqueenii	Asian Houbara		VU	-
Chloris chloris	European Greenfinch		LC	-
Ciconia ciconia	White Stork		LC	NT
Ciconia nigra	Black Stork	✓	LC	-
Cinnyris osea	Palestine Sunbird	✓	LC	LC
Circaetus gallicus	Short-toed Snake-eagle	✓	LC	VU
Circus aeruginosus	Western Marsh-harrier	✓	LC	NT
Circus cyaneus	Hen Harrier		LC	-
Circus macrourus	Pallid Harrier		NT	-
Circus pygargus	Montagu's Harrier		LC	-
Clamator glandarius	Great Spotted Cuckoo		LC	NT
Clanga clanga	Greater Spotted Eagle	✓	VU	-
Clanga pomarina	Lesser Spotted Eagle	✓	LC	-
Coccothraustes coccothraustes	Hawfinch		LC	-
Columba livia	Rock Dove	✓	LC	LC
Columba oenas	Stock Dove		LC	-
Coracias garrulus	European Roller		LC	NT

Scientific name	Common name	Confirmed during 2025 Surveys	IUCN Red List Category	Regional Red List Category
Corvus corone	Carrion Crow		LC	LC
Corvus monedula	Eurasian Jackdaw	✓	LC	LC
Corvus ruficollis	Brown-necked Raven	✓	LC	LC
Coturnix coturnix	Common Quail		LC	LC
Cuculus canorus	Common Cuckoo		LC	NT
Curruca cantillans	Subalpine Warbler		LC	-
Curruca communis	Common Whitethroat		LC	-
Curruca conspicillata	Spectacled Warbler		LC	-
Curruca crassirostris	Eastern Orphean Warbler	✓	LC	LC
Curruca curruca	Lesser Whitethroat	✓	LC	LC
Curruca melanocephala	Sardinian Warbler	✓	LC	LC
Curruca mystacea	Menetries's Warbler		LC	-
Curruca nana	Asian Desert Warbler		LC	-
Curruca ruppeli	RÃ□Â¼ppell's Warbler		LC	-
Cursorius cursor	Cream-coloured Courser		LC	LC
Delichon urbicum	Western House Martin	✓	LC	LC
Egretta garzetta	Little Egret	✓	LC	LC
Elanus caeruleus	Black-winged Kite	✓	LC	VU
Emberiza caesia	Cretzschmar's Bunting		LC	LC
Emberiza calandra	Corn Bunting		LC	LC
Emberiza cia	Rock Bunting		LC	LC
Emberiza cineracea	Cinereous Bunting		NT	LC
Emberiza citrinella	Yellowhammer		LC	-
Emberiza melanocephala	Black-headed Bunting		LC	LC
Eremalauda eremodites	Arabian Lark		LC	-
Eremophila bilopha	Temminck's Lark	✓	LC	LC

Scientific name	Common name	Confirmed during 2025 Surveys	IUCN Red List Category	Regional Red List Category
Erithacus rubecula	European Robin		LC	-
Eudromias morinellus	Eurasian Dotterel		LC	-
Falco biarmicus	Lanner Falcon		LC	CR
Falco cherrug	Saker Falcon		EN	CR
Falco columbarius	Merlin		LC	-
Falco concolor	Sooty Falcon		VU	EN
Falco naumanni	Lesser Kestrel		LC	NT
Falco pelegrinus	Peregrin Falcon	✓	LC	VU
Falco peregrinus	Peregrine Falcon		LC	EN
Falco subbuteo	Eurasian Hobby		LC	-
Falco tinnunculus	Common Kestrel	✓	LC	LC
Falco vespertinus	Red-footed Falcon		VU	-
Ficedula albicollis	Collared Flycatcher		LC	-
Ficedula parva	Red-breasted Flycatcher		LC	-
Francolinus francolinus	Black Francolin		LC	EN
Fringilla coelebs	Common Chaffinch		LC	LC
Fringilla montifringilla	Brambling		LC	-
Fulica atra	Eurasian Coot		LC	LC
Galerida cristata	Crested Lark	✓	LC	LC
Gallinago gallinago	Common Snipe	✓	LC	-
Glareola nordmanni	Black-winged Pratincole		NT	-
Glareola pratincola	Collared Pratincole		LC	LC
Gyps fulvus	Griffon Vulture		LC	EN
Haematopus ostralegus	Eurasian Oystercatcher		NT	-
Haliaeetus albicilla	White-tailed Sea-eagle		LC	-
Hieraaetus pennatus	Booted Eagle	✓	LC	-

Scientific name	Common name	Confirmed during 2025 Surveys	IUCN Red List Category	Regional Red List Category
Himantopus himantopus	Black-winged Stilt		LC	LC
Hippolais languida	Upcher's Warbler		LC	LC
Hippolais olivetorum	Olive-tree Warbler		LC	LC
Hirundo rustica	Barn Swallow	✓	LC	-
Iduna pallida	Eastern Olivaceous Warbler	✓	LC	-
Ixobrychus minutus	Common Little Bittern		LC	LC
Ketupa zeylonensis	Brown Fish-owl		LC	CR
Lanius collurio	Red-backed Shrike	✓	LC	-
Lanius excubitor	Great Grey Shrike	✓	LC	-
Lanius isabellinus	Isabelline Shrike		LC	-
Lanius nubicus	Masked Shrike	✓	LC	-
Lanius phoenicuroides	Red-tailed Shrike		LC	-
Lanius senator	Woodchat Shrike	✓	NT	-
Larus armenicus	Armenian Gull		LC	-
Larus cachinnans	Caspian Gull		LC	-
Larus canus	Mew Gull		LC	-
Larus fuscus	Lesser Black-backed Gull		LC	-
Larus genei	Slender-billed Gull		LC	LC
Larus ichthyaetus	Pallas's Gull		LC	-
Larus michahellis	Yellow-legged Gull		LC	-
Larus ridibundus	Black-headed Gull		LC	-
Limosa limosa	Black-tailed Godwit		NT	-
Linaria cannabina	Common Linnet	✓	LC	-
Locustella fluviatilis	River Warbler		LC	-
Lullula arborea	Woodlark		LC	LC
Luscinia svecica	Bluethroat	✓	LC	-

Scientific name	Common name	Confirmed during 2025 Surveys	IUCN Red List Category	Regional Red List Category
Marmaronetta angustirostris	Marbled Duck		NT	NT
Melanocorypha calandra	Calandra Lark		LC	LC
Merops apiaster	European Bee-eater	✓	LC	-
Merops cyanophrys	Arabian Green Bee-eater	✓	LC	LC
Merops persicus	Blue-cheeked Bee-eater		LC	LC
Milvus migrans	Black Kite	✓	LC	-
Monticola solitarius	Blue Rock-thrush		LC	LC
Motacilla alba	White Wagtail	✓	LC	-
Motacilla cinerea	Grey Wagtail		LC	NT
Motacilla flava	Western Yellow Wagtail	✓	LC	-
Muscicapa striata	Spotted Flycatcher	✓	LC	LC
Neophron percnopterus	Egyptian Vulture	✓	EN	VU
Numenius arquata	Eurasian Curlew		NT	-
Oena capensis	Namaqua Dove	✓	LC	LC
Oenanthe cypriaca	Cyprus Wheatear		LC	-
Oenanthe deserti	Desert Wheatear	✓	LC	LC
Oenanthe finschii	Finsch's Wheatear		LC	LC
Oenanthe hispanica	Black-eared Wheatear		LC	LC
Oenanthe isabellina	Isabelline Wheatear	✓	LC	LC
Oenanthe leucopyga	White-crowned Wheatear	✓	LC	LC
Oenanthe lugens	Mourning Wheatear	✓	LC	LC
Oenanthe melanura	Blackstart	✓	LC	LC
Oenanthe moesta	Buff-rumped Wheatear	✓	LC	EN
Oenanthe monacha	Hooded Wheatear	✓	LC	LC
Oenanthe oenanthe	Northern Wheatear	✓	LC	LC
Oenanthe xanthoprymna	Kurdish Wheatear		LC	LC

Scientific name	Common name	Confirmed during 2025 Surveys	IUCN Red List Category	Regional Red List Category
Onychognathus tristramii	Tristram's Starling	✓	LC	LC
Otus brucei	Pallid Scops-owl		LC	LC
Otus scops	Eurasian Scops-owl		LC	LC
Oxyura leucocephala	White-headed Duck		EN	EN
Pandion haliaetus	Osprey		LC	LC
Passer domesticus	House Sparrow	✓	LC	LC
Passer hispaniolensis	Spanish Sparrow	✓	LC	LC
Passer moabiticus	Dead Sea Sparrow		LC	LC
Pelecanus onocrotalus	Great White Pelican	✓	LC	-
Pernis apivorus	European Honey-buzzard	✓	LC	-
Phoenicopterus roseus	Greater Flamingo		LC	LC
Phoenicurus ochruros	Black Redstart		LC	NT
Phoenicurus phoenicurus	Common Redstart	✓	LC	NT
Phylloscopus collybita	Common Chiffchaff	✓	LC	-
Phylloscopus trochilus	Willow Warbler	✓	LC	-
Pluvialis squatarola	Grey Plover		VU	-
Prunella modularis	Dunnock		LC	-
Pterocles alchata	Pin-tailed Sandgrouse		LC	LC
Pterocles orientalis	Black-bellied Sandgrouse		LC	EN
Pterocles senegallus	Spotted Sandgrouse		LC	LC
Ptyonoprogne obsoleta	Pale Rock Martin	✓	LC	LC
Ptyonoprogne rupestris	Eurasian Crag Martin		LC	LC
Pycnonotus xanthopygos	White-spectacled Bulbul	✓	LC	LC
Ramphocoris clotbey	Thick-billed Lark		LC	-
Recurvirostra avosetta	Pied Avocet		LC	NT
Remiz pendulinus	Eurasian Penduline-tit		LC	DD

Scientific name	Common name	Confirmed during 2025 Surveys	IUCN Red List Category	Regional Red List Category
Saxicola rubetra	Whinchat	✓	LC	-
Saxicola torquatus	Common Stonechat	✓	LC	LC
Scotocerca inquieta	Scrub Warbler	✓	LC	LC
Serinus serinus	European Serin		LC	LC
Serinus syriacus	Syrian Serin		VU	EN
Spatula querquedula	Garganey	✓	LC	-
Spilopelia senegalensis	Laughing Dove	✓	LC	LC
Spinus spinus	Eurasian Siskin		LC	-
Streptopelia decaocto	Eurasian Collared Dove	✓	LC	LC
Streptopelia turtur	European Turtle-dove		VU	LC
Sturnus vulgaris	Common Starling		LC	LC
Sylvia atricapilla	Eurasian Blackcap	✓	LC	LC
Sylvia borin	Garden Warbler		LC	-
Tachymarptis melba	Alpine Swift	✓	LC	LC
Tetrax tetrax	Little Bustard		NT	-
Thalasseus sandvicensis	Sandwich Tern		LC	-
Tringa erythropus	Spotted Redshank		LC	-
Tringa nebularia	Greenshank	✓	LC	-
Tringa ochropus	Green Sandpiper	✓	LC	-
Tringa totanus	Common Redshank		LC	-
Troglodytes troglodytes	Northern Wren		LC	LC
Turdus iliacus	Redwing		NT	-
Turdus merula	Eurasian Blackbird	✓	LC	LC
Turdus philomelos	Song Thrush		LC	-
Turdus pilaris	Fieldfare		LC	-
Turdus viscivorus	Mistle Thrush		LC	LC

Scientific name	Common name	Confirmed during 2025 Surveys	IUCN Red List Category	Regional Red List Category
Upupa epops	Common Hoopoe	✓	LC	LC
Vanellus gregarius	Sociable Lapwing		CR	-
Vanellus leucurus	White-tailed Lapwing		LC	LC
Vanellus spinosus	Spur-winged Lapwing	✓	LC	LC
Zapornia pusilla	Baillon's Crake		LC	-

Project: Aqaba-Amman Water Desalination and Conveyance (AAWDC)

2025 Environmental and Social Impact Assessment

Appendix 6-9 Annual Bird Survey Report OHTL

PROJECT: AQABA AMMAN WATER CONVEYANCE AND DESALINATION PROJECT (AAWDCP)

Annual Bird Survey Report for the Aqaba-Amman pipeline overhead transmission line (2025)

Client: National Conveyance Project Company

Date	Rev	Author	Checked	Approved
13 November 2025	1	F.C., D.P., L.M.	M.C.	

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1. INTRODUCTION

1.1. Context and Objectives

This report is the "Annual Bird Survey Report - 2025" prepared by The Biodiversity Consultancy (TBC) for the planned Overhead Transmission Line (OHTL) which is an associated facility for the Aqaba Amman Water Conveyance and Desalination Project (AAWDCP, the Project), based on the results of the spring and autumn 2025 bird surveys.

Bird surveys were conducted along the planned OHTL route by local ornithologists (contracted by ECO Consult) with guidance from TBC experts, and included:

- Vantage Point (VP) surveys,
- bird counts at water bodies,
- line transect surveys, and
- carcass surveys (along the existing OHTL that runs nearby to the planned OHTL for this Project), as a proxy to estimating bird and bat mortality along the Project's OHTL.

This report aims to analyse and present summaries of the 2025 spring and autumn survey data, discuss the key findings, including the significance of the study area for birds.

1.2. Project Overview

The AAWDC Project is located in Jordan, between the Aqaba area in the south and the Amman area in the north, and comprises three main components: marine works and desalination, conveyance and renewable energy facilities:

- Marine works and desalination plant - intake system (including some limited offshore works) composed of a pumping station, three parallel pipelines (4 for intake and 2 for outtake) to convey seawater to the desalination plant. Reverse osmosis seawater desalination plant sized to produce 300 million cubic meters per year of desalinated water through four independent parallel production lines, located in the Aqaba area.
- Conveyance system - composed of a 438 km long underground water pipeline of variable diameter (76" to 90"), three tanks and four pumping stations to convey water to the Aqaba turnout (located c. 10 km from the desalination plant) and to the existing reservoirs of Abu Alanda and Al Muntazah near Amman.
- Solar power plant - with production capacity equal to 281 MWp near the Wadi Rum, area next to the existing Quweira solar plant and about 55 km from the Desalination Plant site.

The OHTL will be developed by the National Electric Power Company (NEPCO) and is considered as an associated facility to the Project. The OHTL is a new 132 kV transmission line running between the solar power plant and the Desalination plant, with an approximate length of 65 km, to transport electricity to the Desalination plant. Electricity grid expansion works will be carried out by NEPCO1, JEPCO2 and EDCO3.

1.3. Biodiversity Context of the Project: Avifauna

The southern section of the OHTL crosses the Aqaba Coast and Mountains Key Biodiversity Area (KBA) and Important Bird Area (IBA)[1] (Figure 1). This area was designated due to the migratory passage of Levant Sparrowhawks (*Accipiter brevipes,* IUCN Least Concern). Around 3,000 individuals of this species are expected to cross the area each spring, which represents up to 30% of the global population estimate of 10,000.

[1] https://datazone.birdlife.org/site/factsheet/aqaba-coast-and-mountains

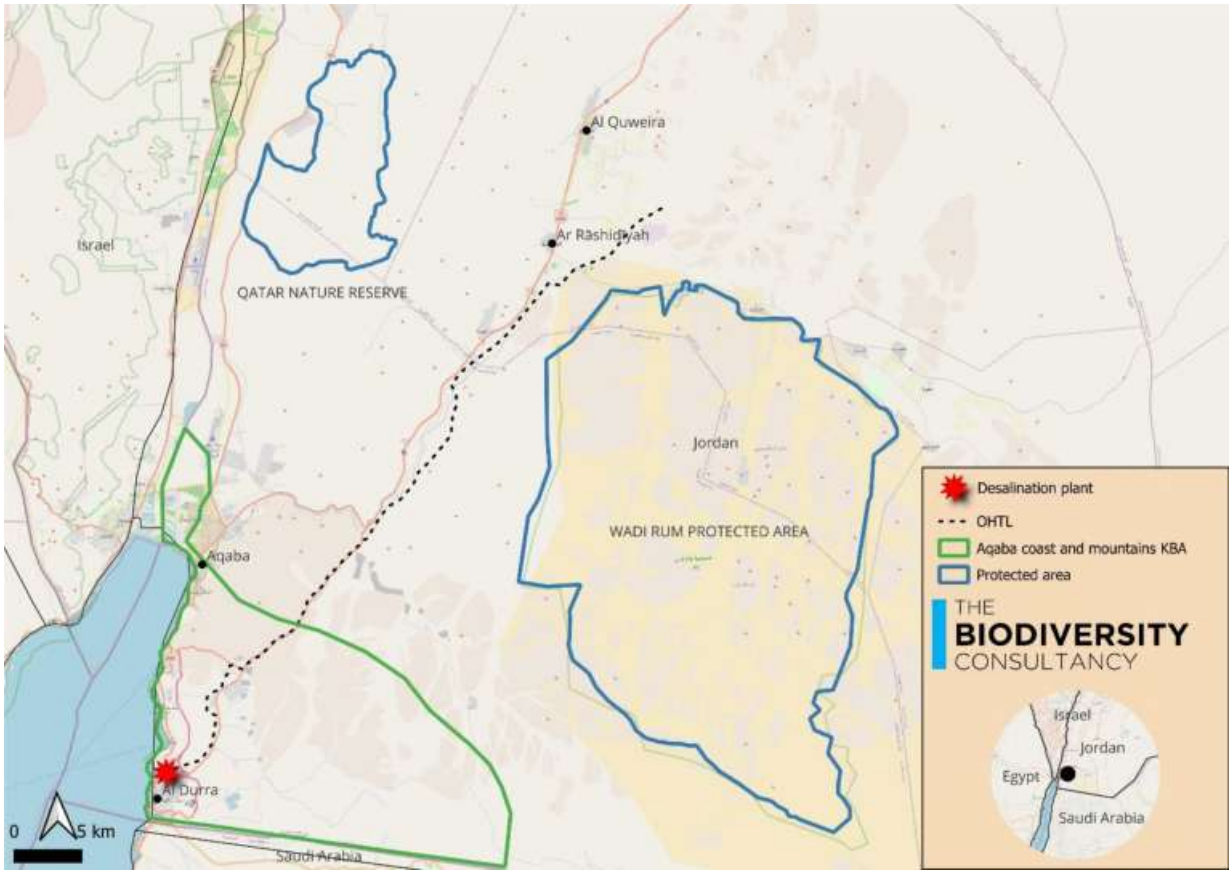


Figure 1: Location of the Project's Overhead Transmission Line (OHTL)

This area is considered a migratory bottleneck site within the Rift Valley/Red Sea Flyway, which is one of the most important routes for migratory soaring birds in the world. Each spring and autumn, 37 species of migratory soaring birds navigate this flyway, with over a million birds passing in the major bottlenecks (Porter 2005; Jobson *et al.* 2021).

The Aqaba Coast and Mountains IBA/KBA has a peak estimate of 50,000-99,000 soaring birds (BirdLife International 2025), and apart from the Levant Sparrowhawk, other relevant soaring birds that migrate through the area include Egyptian Vulture (*Neophron percnopterus*, IUCN Endangered), Steppe Eagle (*Aquila nipalensis*, IUCN Endangered), Greater Spotted Eagle (*Clanga clanga*, IUCN Vulnerable), Lesser Spotted Eagle (*Clanga pomarina,* IUCN Least Concern), White Stork (*Ciconia ciconia*, IUCN Least Concern), European Honey Buzzard (*Pernis apivorus*, IUCN Least Concern) and Steppe Buzzard (*Buteo buteo vulpinus*, IUCN Least Concern).

Migration along the Aqaba coast and mountains is more intense in spring, as opposed to autumn where migration tends to occur in a broad front and is considered insignificant at this site (Khoury 2017; BirdLife International 2025). In spring, most soaring birds enter Jordan from the Eilat (southern Israel) bottleneck, which is located to the North of the Aqaba coast and mountains. Most birds follow north from there, thus not entering the area. However, some other birds may cross the gulf of Aqaba and follow the Saudi and Jordanian coast northwards or arrive from the Arabian Peninsula. Those are the soaring birds that concentrate in the Aqaba mountains and coast, which represent a relatively small percentage of the numbers that occur at the Eilat bottleneck (Andrews 1996; Jobson *et al.* 2021).

Other species (non-soaring birds) with populations that meet IBA/KBA criteria that occur in the Aqaba mountains and coast are the Arabian Warbler (*Curruca leucomelaena*), Arabian Babbler (*Turdoides squamiceps*), Tristam's Starling (*Onychognathus tristamii*) and Hooded Wheatear (*Oenanthe monacha*), all IUCN Least Concern.

1.4. Main Impacts of Power Lines On Birds

Powerlines can cause bird mortality through collisions and electrocution. Collisions occur mainly on high voltage transmission lines, especially with the thin, and hard to see, earth wire. Susceptible species include large birds with low manoeuvrability (high weight to wing area ratio), birds that fly very fast, especially if they move in flocks and/or species with a reduced visual field (Prinsen *et al.* 2011; Bennun *et al.* 2021; BirdLife International & CMS Energy Task Force 2023).

Birds can be electrocuted when perched on pylons or power lines and this may be the of cause decline of some long-lived species, namely birds of prey and other large perching birds. Electrocution is more frequent on distribution lines since the distance between charged elements is higher in transmission lines. However, it also possible in transmission lines, especially if large species build their nests on the pylons or if several bird perch very close to each other (especially during rainy days) (Angelov *et al.* 2013; Bennun *et al.* 2021; Biasotto *et al.* 2021).

2. METHOLODGY

Field surveys were conducted by a team of local ornithologists (provided by ECO Consult) in six campaigns during the spring and autumn seasons of 2025 (three in each season). These included vantage point surveys, line transects, water body counts and carcass surveys. The approach and methodology for this survey was designed and provided by TBC (TBC 2025). An expert from TBC accompanied one campaign in spring (between 3 and 9 March) and another in autumn (between 5 and 9 October).

2.1. Vantage Point (VP) Surveys

Vantage points comprise a series of watches from a fixed location to quantify the flight activity of birds and its distribution at a proposed development site. This method is especially adequate to detect and track the movements of soaring birds (e.g. diurnal raptors), or other diurnal medium-large size birds that actively migrate or commute between foraging and/or roosting sites (e.g. Scottish Natural Heritage 2017, BID Invest and IFC 2019).

Eleven VPs were defined along the expected layout of the OHTL, appropriately spaced and located in areas with good visibility (Figure 2).

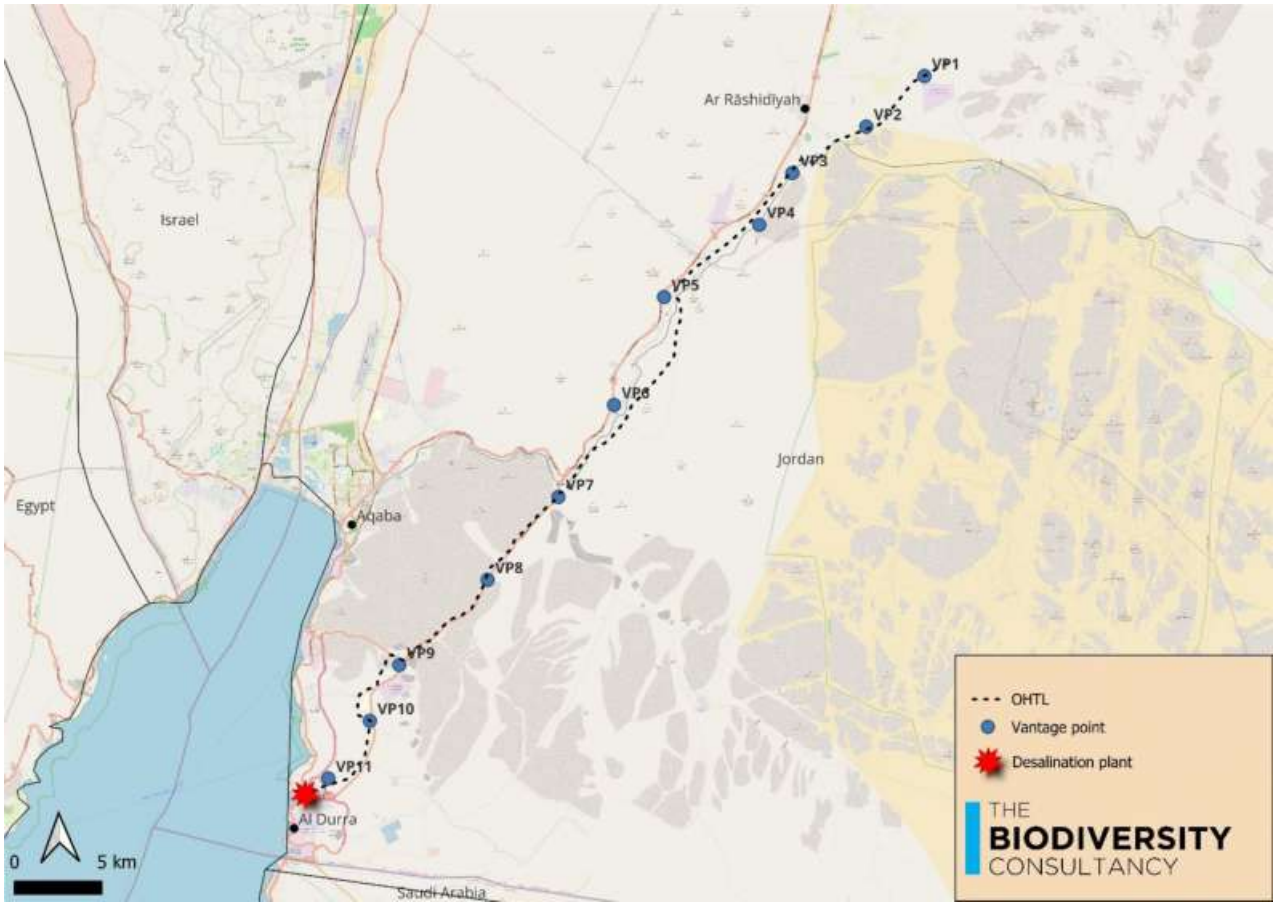


Figure 2: Location of Vantage Points

Each VP watch lasted for 3 continuous hours. Because six campaigns were performed (Table 1), each vantage point was surveyed for 18 hours in total during the spring and autumn periods. Surveys were conducted between 1h 30 min after sunrise and 1h 30 min before sunset.

Table 1: Survey Period for the field Campaigns

	Number of points	Start date	End date
Spring Campaign 1	10*	3rd March 2025	13th March 2025
Spring Campaign 2	11	20th March 2025	8th April 2025
Spring Campaign 3	11	23rd April 2025	3rd May 2025
Autum Campaign 1	11	8th September 2025	21st September 2025
Autum Campaign 2	11	30th September 2025	16th October 2025
Autum Campaign 3	11	19th October 2025	3rd November 2025

*monitoring was not conducted at VP 7 in spring due to rain and poor visibility

Observations at each vantage point were conducted by two observers equipped with binoculars, recording and identifying every flight of medium/large bird species detected (every bird with a size equal or larger than a Collared Dove (*Streptopelia decaocto*), or flocks of 10 or more birds of every species (e.g. swallows, swifts). Birds that could not be identified to species level were identified to the nearest level (e.g. Unidentified Raptor). During each period, observers recorded:

- Number of the VP
- Date
- Time (start and finish)
- Observer ID
- Weather variables (e.g. temperature, wind speed and direction, rain, cloud cover)

For each record:

- Species ID
- Number of birds
- Time
- Flight height in predetermined classes (1 - < 20m, 2 – 20-50 m, 3 – 50-100 m, 4 100-200 m, 5 > 200 m)
- Flight distance to the proposed OHTL (1- crosses the line, 2 - <100 m from the line, 3 – 100-500 m from the line, 4 - > 500 m from the line)
- Bird interactions with the existing OHTL (avoidance and perching)
- Other information (sex, age etc.)

2.2. Water Body Counts

Water body counts were directed at aquatic bird species. Six observation points were established along the OHTL at water bodies and flood barrier dams, at locations that allow the visual inspection of the water surface and of 200 m of the water margin to each side (Figure 3).

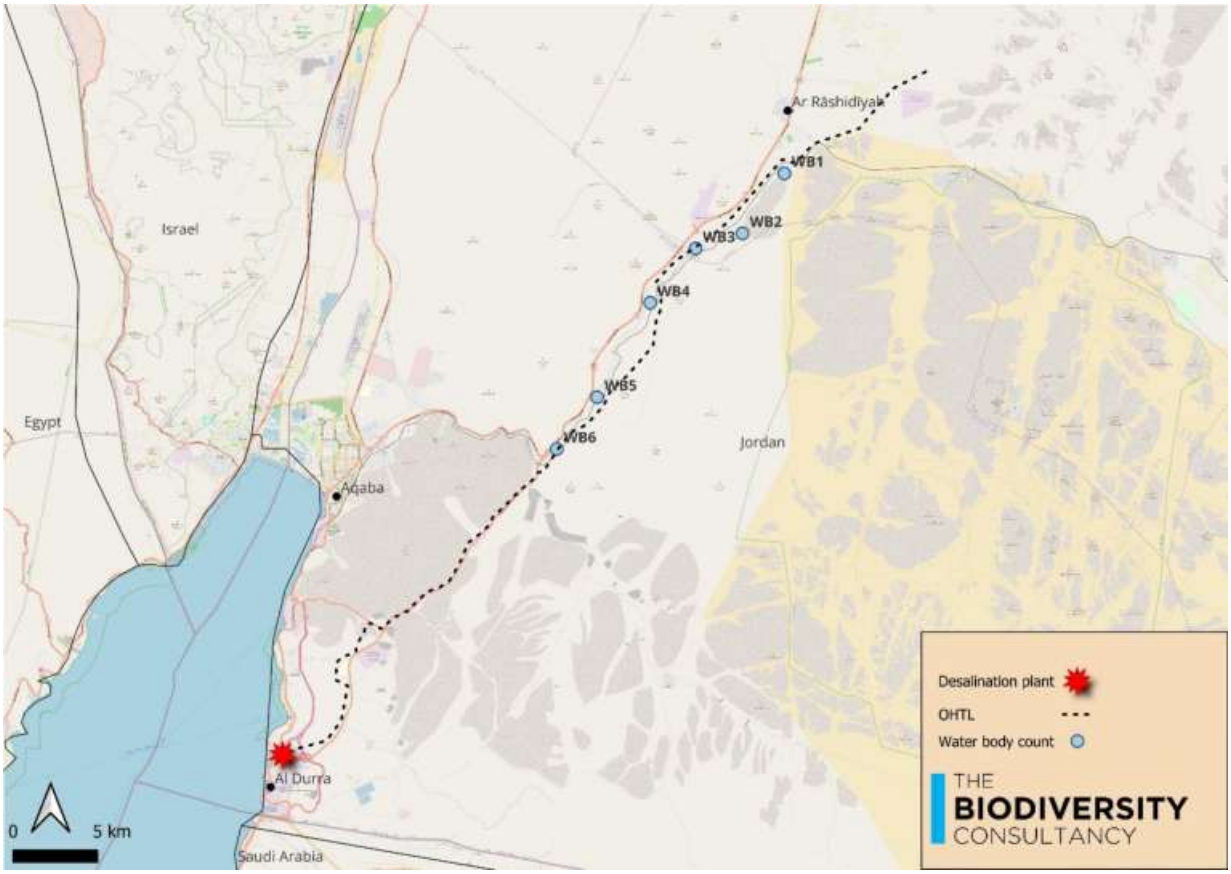


Figure 3: Locations of Water Body Point Counts

Observations at each water body point count were conducted by two observers equipped with binoculars in the periods described in Table 2.

Table 2: Number of Water Body Counts and Survey Dates

	Number of points	Start date	End date
Spring Campaign 1	4	5th March 2025	15th March 2025
Spring Campaign 2	6	24th March 2025	9th April 2025
Spring Campaign 3	5	26th April	5th May 2025
Autumn Campaign 1	6	9th September 2025	23rd September 2025
Autumn Campaign 2	6	1st October 2025	9th October 2025
Autumn Campaign 3	6	20th October 2025	2nd November 2025

Every bird at (interacting with) each water body was counted. The presence (or lack of) water was recorded using four classes (1 – no water, 2 – some pools, 3 – half full, 4 – the dam is full). If no water was present, there are no birds associated with the water body even if some birds are present in the area. Water body counts occurred preferentially after a period of rainfall, even if they had already been counted during that campaign. Observers recorded:

- Number of water body
- Date
- Time

- Observer
- Weather variables
- Water presence (4 classes)
- Number of birds of each species
- Notes

2.3. Line Transect Surveys

Line transects were conducted to survey the non-soaring terrestrial birds. Twenty transects were defined (and georeferenced) along the expected OHTL route, sufficiently spaced apart to minimize double counting (Figure 4).

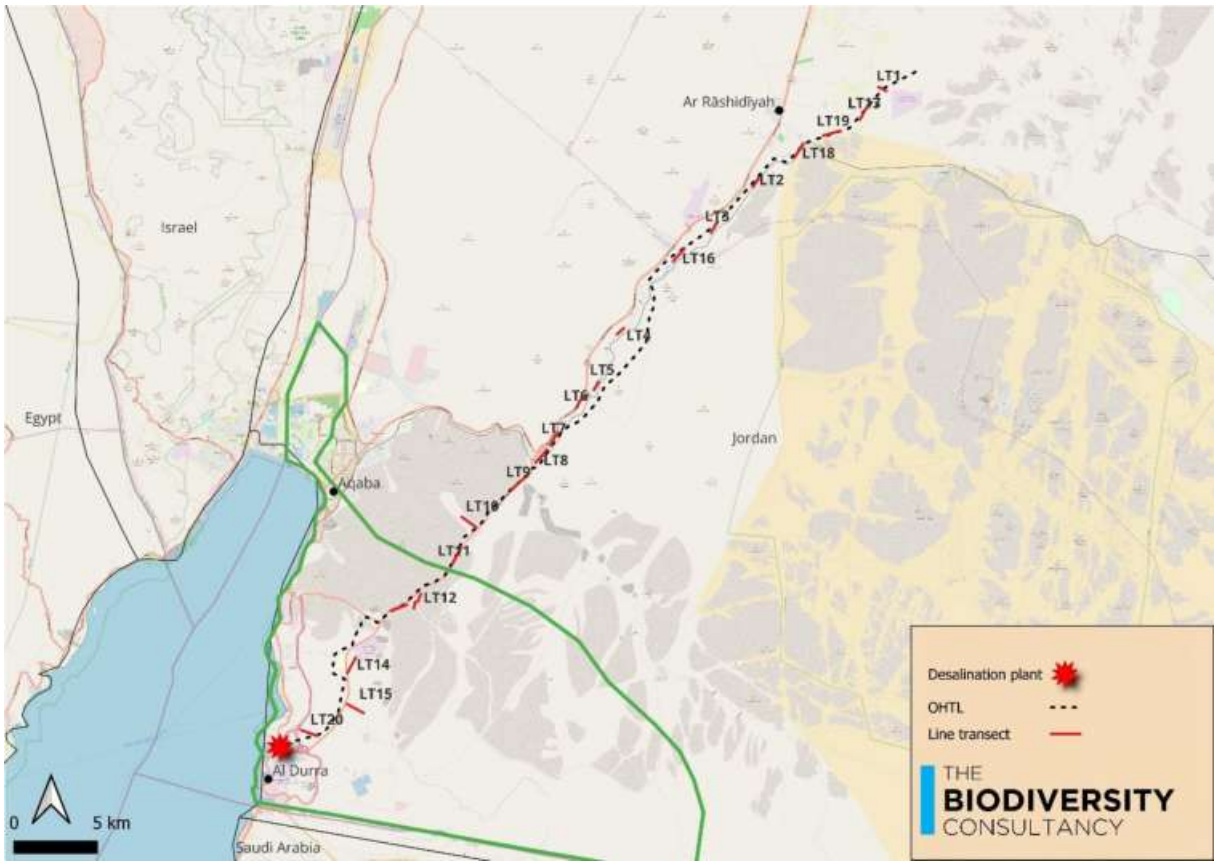


Figure 4: Locations of Line Transect Surveys

Transects were surveyed in three campaigns in the dates shown in Table 3.

Table 3: Number of Line Transects and Survey Dates

	Number of transects	Start date	End date
Spring Campaign 1	4	3rd March 2025	13th March 2025
Spring Campaign 2	20	20th March 2025	9th April 2025
Spring Campaign 3	5	23rd April 2025	5th May 2025
Autumn Campaign 1	8	9th September 2025	24th September 2025
Autumn Campaign 2	20	30th September 2025	16th October 2025
Autumn Campaign 3	20	19th October 2025	3rd November 2025

Observers moved along the transects at a slow and steady pace. Every bird detected, by sight or sound, along a 500 m line transect was identified and counted. If a bird song/call could not be identified, an effort was made to spot the bird to allow for identification. Transects surveys were conducted during the first three hours after sunrise (peak bird activity), and in appropriate weather conditions (absence of rain or strong wind). Observers recorded:

- Number of transect
- Date
- Time
- Observer
- Weather variables
- Number of individuals of each species at < or > 50 meters from the transect
- Notes (e.g., if there were noisy activities/people in the area that reduced bird detectability or affected bird behaviour, confirmed breeding, etc.)

2.4. Carcass Surveys

Carcass surveys were conducted along existing adjacent OHTLs that run parallel and adjacent to the Project OHTL. The results of these surveys are meant to serve as a proxy to inform the Environmental Impact and Social Assessment (ESIA) of potential risks posed by the Project OHTL to birds.

Searches for carcasses were undertaken along the existing OHTL, following a methodology informed by the Post-construction Bird and Bat Fatality Monitoring (PCFM) for Onshore Wind Energy Facilities in Emerging Market Countries: Good Practice Handbook and Decision Support Tool (IFC *et al.* 2023).

Within the Aqaba Coast and Mountains IBA, the existing OHTL was divided into 1 km sections. PCFM was conducted by two observers along 500 m of each 1 km segment. Outside of the IBA, the existing OHTL was divided into 5 km segments and PCFM conducted within 1 km.

Within the search width (40 m to each side), transects were undertaken parallel to the centreline, spaced at an appropriate distance so that the whole survey area was covered. The searches were undertaken at two-week intervals within the periods listed in Table 4.

Table 4: Carcass Search Periods

	Start date	End date
Spring Campaign 1	4th March 2025	15th March 2025
Spring Campaign 2	22nd March 2025	10th April 2025
Spring Campaign 3	25th April 2025	4th May 2025
Autumn Campaign 1	9th September 2025	23rd September 2025
Autumn Campaign 2	30th September 2025	16th October 2025
Autumn Campaign 3	19th October 2025	3rd November 2025

Results were recorded using forms informed by the PCFM good practice handbook (IFC *et al.* 2023). Bats were also recorded. Observers recorded:

- Number of the search plot
- Date
- Time (start and finish)

- Observer ID
- Weather variables (e.g. temperature, wind speed and direction, rain, cloud cover)

And for each record:

- ID
- Date
- Time
- Observer
- Species (age and sex if possible)
- Type of remains (e.g. full bird, a wing, just bones, feathers)
- Estimate of the date of death based on the decomposing state
- Location (GPS coordinates)
- Distance to the line
- Photo (with scale)

2.4.1 Searcher efficiency trials

Search detection efficiency trials were conducted during two campaigns during the autumn survey season (Table 5) using three sizes of bird dummies (Figure 5) along four transects, with two transects in each campaign. Prior to each campaign, an independent team member (not involved in carcass searches) placed the decoys within the search areas. The number of bird dummies used in the trials ranged from 18 to 27.

Table 5: Search efficiency periods

	Start date	End date
Campaign 2	7th October 2025	8th October 2025
Campaign 3	20th October 2025	29th October 2025



Figure 5: Illustration of some of the bird dummies used in the search efficiency trials.

2.4.1 Carcass persistency trials

Since this study is not part of a Post-Construction Fatality Monitoring Program, but an exercise conducted with the aim to provide additional information to assess potential collision and electrocution impacts in the Project ESIA, it was not deemed necessary to sacrifice animals for these trials. Since no carcasses were available from mortality observed in other projects, carcass persistency trials were planned to be conducted using the carcasses that were found during the carcass surveys.

3. RESULTS

Across all survey methodologies and seasons, a total of 85 bird species were recorded in 2025, 44 in spring and 74 in autumn (Appendix 1).

3.1. Vantage Point (VP) Surveys

Vantage Point (VP) surveys recorded a total of 30 species in the two sampling seasons, including 14 migratory soaring bird species (Table 6, Appendix 2). Five species of conservation concern were recorded.

These include the Black-winged Kite (*Elanus caeruleus*, one individual in autumn), which is globally Least Concern (LC) but regionally classified as Vulnerable (VU); the Egyptian Vulture (*Neophron percnopterus*, one individual in spring and another in autumn), globally Endangered (EN) and regionally VU; the Greater Spotted Eagle (*Clanga clanga*, one individual in autumn), globally VU and not evaluated regionally; the Short-toed Eagle (*Circaetus gallicus*, two individuals in autumn), globally LC but regionally VU; and the Steppe Eagle (*Aquila nipalensis*, 6 individuals in spring and 84 in autumn), globally EN and not evaluated regionally.

During the spring season relatively high numbers of Steppe Buzzards and European Honey Buzzards were recorded. During the autumn campaign higher numbers of Steppe Eagles and of the Steppe Buzzards were also recorded. Other migratory soaring birds with high counts across both seasons were the Black Kite (*Milvus migrans*) and the Booted Eagle (*Hieraaetus pennatus*).

Several species of migratory soaring birds were detected flying within 100 m of the overhead transmission line (OHTL) and at heights below 50 m, which may pose a higher risk of collision. During the spring season, 4% of Black Kite flights and 7% of Steppe Buzzard flights were recorded within the high-risk height class.

In autumn, some species of conservation concern were also observed at collision-risk heights. The Black-winged Kite was recorded flying at the transmission line location and below 20 m, while a Greater Spotted Eagle individual, along with 25% of Short-toed Eagle flights and 62% of Steppe Eagle flights, crossed the transmission line corridor but mostly at high altitudes (Table 7). The Egyptian Vultures that was recorded, were far from the OHTL and at high altitude.

Species of Least Concern, such as the Black Kite, Common Kestrel (*Falco tinnunculus*), Eurasian Sparrowhawk (*Accipiter nisus*), Long-legged Buzzard (*Buteo rufinus*), and Western Marsh Harrier (*Circus aeruginosus*), were also detected within 100 m of the OHTL and flying below 50 m. The Booted Eagle (*Hieraaetus pennatus*) and Lesser Spotted Eagle (*Clanga pomarina*) were observed crossing the transmission line at high altitude.

Other species recorded within the zone of higher collision risk included the Kentish Plover (*Charadrius alexandrinus*) and Brown-necked Raven (*Corvus ruficollis*) during spring. In autumn, the Eurasian Collared Dove (*Streptopelia decaocto*), Eurasian Linnet (*Linaria cannabina*), Rock Dove (*Columba livia*), Grey Heron (*Ardea cinerea*), Little Egret (*Egretta garzetta*), and again the Brown-necked Raven were recorded.

It should be noted that wildfowl is a bird group particularly sensitive to power line collisions (Prinsen et al. 2011) and all Common Teal (*Anas crecca*) recorded in spring were flying at altitudes associated with high collision risk.

Table 6: Bird abundance and occurrence from Vantage point (VP) surveys

Species		Conservation status		Spring		Autumn	
Common (English) name	Latin name	Global (IUCN) conservation status[2]	Regional (Arabian Peninsula) conservation status[3]	No. of individuals	% of points where it was recorded	No. of individuals	% of points where it was recorded
Alpine Swift	*Tachymarptis melba*	LC	LC	18	9	0	0
Arabian Bee-eater	*Merops cyanophrys*	LC	LC	0	0	3	9
Black Kite	*Milvus migrans*	LC	LC	55	45	26	64
Black Stork	*Ciconia nigra*	LC	-	0	0	5	18
Black-winged Kite	*Elanus caeruleus*	LC	**VU**	0	0	1	9
Booted Eagle	*Hieraaetus pennatus*	LC	-	36	18	5	18
Brown-necked Raven	*Corvus ruficollis*	LC	LC	17	64	72	82
Common Kestrel	*Falco tinnunculus*	LC	LC	6	36	22	73
Common Teal	*Anas crecca*	LC	-	39	9	0	0
Egyptian Vulture	*Neophron percnopterus*	**EN**	**VU**	1	9	1	9
Eurasian Collared Dove	*Streptopelia decaocto*	LC	LC	1	9	27	55
European Honey Buzzard	*Pernis apivorus*	LC	-	170	36	0	0
Eurasian Linnet	*Linaria cannabina*	LC	LC	0	0	35	9
Eurasian Sparrowhawk	*Accipiter nisus*	LC	-	0	0	8	45
European Bee-eater	*Merops apiaster*	LC	LC	0	0	100	9
Great White Pelican	*Pelecanus onocrotalus*	LC	-	0	0	16	9
Greater Spotted Eagle	*Clanga clanga*	**VU**	-	0	0	1	9
Grey heron	*Ardea cinerea*	LC	NT	0	0	26	18
Lesser Spotted Eagle	*Clanga pomarina*	LC	-	0	0	1	9

[2] (IUCN 2025)

[3] (Symes *et al.* 2015)

Species		Conservation status		Spring		Autumn	
Common (English) name	Latin name	Global (IUCN) conservation status[2]	Regional (Arabian Peninsula) conservation status[3]	No. of individuals	% of points where it was recorded	No. of individuals	% of points where it was recorded
Little Egret	*Egretta garzetta*	LC	LC	0	0	1	9
Little Swift	*Apus affinis*	LC	LC	0	0	50	9
Kentish Plover	*Charadrius alexandrinus*	LC	LC	1	9	0	0
Long-legged Buzzard	*Buteo rufinus*	LC	LC	3	27	11	18
Rock Dove	*Columba livia*	LC	LC	1	9	41	36
Short-toed eagle	*Circaetus gallicus*	LC	**VU**	0	0	4	18
Steppe Buzzard	*Buteo buteo*	LC	LC	396	91	80	82
Steppe Eagle	*Aquila nipalensis*	**EN**	-	6	27	84	73
Tristram's Starling	*Onychognathus tristramii*	LC	LC	0	0	27	18
Western House Martin	*Delichon urbicum*	LC	LC	0	0	20	9
Western Marsh Harrier	*Circus aeruginosus*	LC	NT	0	0	3	18
Unidentified Raptor	-	-	-	22	9	0	0

Table 7: Bird flights height and distance to OHTL from Vantage point (VP) surveys

Species	Distance to OHTL		Flight height		Distance to OHTL		Flight height	
Common (English) name	% of birds that crossed the OHTL	% of birds that were <100 m from the OHTL	% of birds flying <20 m high	% of birds flying 20-50 m high	% of birds that crossed the OHTL	% of birds that were <100 m from the OHTL	% of birds flying <20 m high	% of birds flying 20-50 m high
Alpine Swift	0%	100%	0%	0%	0%	0%	0%	0%
Arabian Bee-eater	0%	0%	0%	0%	100%	0%	100%	0%
Black Kite	11%	2%	0%	4%	4%	23%	0%	23%
Black Stork	0%	0%	0%	0%	0%	0%	0%	0%
Black-winged Kite	0%	0%	0%	0%	100%	0%	100%	0%

Species	Distance to OHTL		Flight height		Distance to OHTL		Flight height	
Common (English) name	% of birds that crossed the OHTL	% of birds that were <100 m from the OHTL	% of birds flying <20 m high	% of birds flying 20-50 m high	% of birds that crossed the OHTL	% of birds that were <100 m from the OHTL	% of birds flying <20 m high	% of birds flying 20-50 m high
Booted Eagle	0%	0%	0%	0%	20%	80%	0%	0%
Brown-necked Raven	9%	50%	45%	41%	13%	15%	8%	42%
Common Kestrel	0%	0%	0%	50%	32%	23%	18%	36%
Common Teal	0%	0%	0%	100%	0%	0%	0%	0%
Egyptian Vulture	0%	0%	0%	0%	0%	0%	0%	0%
Eurasian Collared Dove	0%	0%	100%	0%	19%	81%	56%	44%
European Honey Buzzard	90%	1%	<1%	0%	0%	0%	0%	0%
Eurasian Linnet	0%	0%	0	0%	0%	100%	100%	0%
Eurasian Sparrowhawk	0%	0%	0	0%	75%	13%	13%	50%
European Bee-eater	0%	0%	0	0%	0%	0%	0%	0%
Great White Pelican	0%	0%	0	0%	0%	0%	0%	0%
Greater Spotted Eagle	0%	0%	0	0%	100%	0%	0%	0%
Grey heron	0%	0%	0	0%	0%	100%	0%	100%
Lesser Spotted Eagle	0%	0%	0	0%	100%	0%	0%	0%
Little Egret	0%	0%	0	0%	0%	100%	0%	100%
Little Swift	0%	0%	0	0%	0%	100%	0%	100%
Kentish Plover	0%	100%	100%	0%	0%	0%	0%	0%
Long-legged Buzzard	0%	0%	0%	0%	9%	18%	9%	36%
Rock Dove	0%	0%	100%	0%	7%	80%	12%	78%
Short-toed eagle	0%	0%	0%	0%	25%	0%	0%	0%
Steppe Buzzard	2%	3%	<1%	7%	21%	20%	0%	14%
Steppe Eagle	17%	0%	0%	0%	62%	2%	1%	1%

Species	Distance to OHTL		Flight height		Distance to OHTL		Flight height	
Common (English) name	% of birds that crossed the OHTL	% of birds that were <100 m from the OHTL	% of birds flying <20 m high	% of birds flying 20-50 m high	% of birds that crossed the OHTL	% of birds that were <100 m from the OHTL	% of birds flying <20 m high	% of birds flying 20-50 m high
Tristram's Starling	0%	0%	0%	0%	93%	0%	0%	0%
Western House Martin	0%	0%	0%	0%	0%	100%	0%	100%
Western Marsh Harrier	0%	0%	0%	0%	33%	67%	33%	67%
Unidentified Raptor	0%	0%	0%	0%	0%	0%	0%	0%

3.2. Water Body Counts

In spring there was always water present in every water body that was surveyed (half full or with some pools, Table 8), while in autumn, four of the waterbodies (1, 2, 4, and 5) remained dry. Water was consistently present in waterbodies 3 and 6, which were half full.

Table 8: Water Levels During the Water Body Counts (1 – No Water, 2 – Some Pools, 3 – Half Full, 4 – The Dam Is Full)

Campaign	Point	Water level	
		Spring	Autumn
1	1	3	1
	2	3	1
	3	2	3
	4	2	1
	5	-	1
	6	-	3
2	1	3	1
	2	3	1
	3	2	3
	4	3	1
	5	2	1
	6	2	3
3	1	3	1
	2	3	1
	3	2	3
	4	2	1
	5	2	1
	6	-	3

Waterbody surveys recorded a total of eight waterbird species, four in spring and seven in autumn (Table 9, Appendix 3), none of which are of conservation concern: Common Sandpiper (*Actitis hypoleucos*), Common Greenshank, (*Tringa nebularia*), Common Teal (*Anas crecca*), Garganey Duck (*Spatula querquedula*), Green Sandpiper (*Tringa ochropus*), Grey Heron (*Ardea cinerea*), Little Egret and Spur-winged Lapwing (*Vanellus spinosus*).

The species with the highest counts were the Common Teal, most of which were recorded during spring, and the Spur-winged Lapwing, which showed similar numbers across both survey season.

Table 9: Summary of Results from Water Body Counts

Species		Conservation status		Spring		Autumn	
Common (English) name	Latin name	Global (IUCN) conservation status[4]	Regional (Arabian Peninsula) conservation status[5]	No. of individuals	% of points where it was recorded	No. of individuals	% of points where it was recorded
Common Sandpiper	*Actitis hypoleucos*	LC	-	0	0	1	17
Common Greenshank	*Tringa nebularia*	LC	-	2	17	0	0
Common Teal	*Anas crecca*	LC	-	60	33	2	33
Garganey Duck	*Spatula querquedula*	LC	-	0	0	5	33
Green Sandpiper	*Tringa ochropus*	LC	-	0	0	1	17
Grey Heron	*Ardea cinerea*	LC	NT	0	0	1	17
Little Egret	*Egretta garzetta*	LC	LC	0	0	9	17
Little Stint	*Calidris minuta*	LC	-	5	33	0	0
Spur-winged Lapwing	*Vanellus spinosus*	LC	LC	16	33	20	33

All eight waterbirds recorded during the water body counts were only observed when the water level was half full or with some pools (Table 10).

[4] (IUCN 2025)

[5] (Symes *et al.* 2015)

Table 10: Results of the Water Body Counts (1 – No Water, 2 – Some Pools, 3 – Half Full, 4 – The Dam Is Full)

Campaign	Point	Spring					Autumn							
		Water Level	Common Greenshank	Common Teal	Little Stint	Spur-winged Lapwing	Water Level	Common Sandpiper	Common Teal	Garganey Duck	Green Sandpiper	Grey Heron	Little Egret	Spur-winged Lapwing
1	1	3	0	45	1	3	1	0	0	0	0	0	0	0
	2	3	2	3	0	1	1	0	0	0	0	0	0	0
	3	2	0	0	0	0	3	0	0	0	0	0	9	2
	4	2	0	0	0	0	1	0	0	0	0	0	0	0
	5	-	0	0	0	0	1	0	0	0	0	0	0	0
	6	-	0	0	0	0	3	0	0	0	0	0	0	0
2	1	3	0	0	1	6	1	0	0	0	0	0	0	0
	2	3	0	12	3	3	1	0	0	0	0	0	0	0
	3	2	0	0	0	0	3	0	1	0	0	0	0	0
	4	3	0	0	0	0	1	0	0	0	0	0	0	0
	5	2	0	0	0	0	1	0	0	0	0	0	0	0
	6	2	0	0	0	0	3	1	1	2	0	0	0	11
3	1	3	0	0	0	2	1	0	0	0	0	0	0	0
	2	3	0	0	0	1	1	0	0	0	0	0	0	0
	3	2	0	0	0	0	3	0	0	1	0	0	0	3
	4	2	0	0	0	0	1	0	0	0	0	0	0	0
	5	2	0	0	0	0	1	0	0	0	0	0	0	0
	6	-	0	0	0	0	3	0	0	2	1	1	0	4

3.3. Line Transect Surveys

Line transect surveys recorded a total of 63 species across the two survey seasons, 25 in autumn and 56 in spring (Table 11, Appendix 4). Three species of regional conservation concern (Symes *et al.* 2017), considered threatened in the Arabian Peninsula, were observed (one individual of each was recorded): the Red-rumped Wheatear (*Oenanthe moesta*), observed in spring, and the Verreaux's Eagle (*Aquila verreauxii*), recorded in autumn—both classified as Endangered regionally—and the Peregrine Falcon (*Falco peregrinus*), also recorded in autumn and classified as Vulnerable. All three species are globally listed as Least Concern.

Except for these species, all other birds recorded were either common residents species or regular migrants in the region.

During the spring survey, the House Sparrow (*Passer domesticus*) and Spanish Sparrow (*Passer hispaniolensis*) were the most abundant species, while the Eurasian Collared Dove (*Streptopelia decaocto*), Blackstart (*Oenanthe melanura*), Rock Dove (*Columba livia*), and Desert Lark (*Ammomanes deserti*) were among the most widespread.

In autumn, the Blackstart, Brown-necked Raven, Crested Lark (*Galerida cristata*), Desert Lark, House Sparrow, and Rock Dove were among the most abundant and widespread species.

Table 11: Summary of Results from Line Transect Surveys

Species		Conservation status		Spring		Autumn	
Common (English) name	Latin name	Global (IUCN) conservation status[6]	Regional (Arabian Peninsula) conservation status[7]	Kilometric Abundance Index (average between campaigns)	% of transects where it was recorded	Kilometric Abundance Index (average between campaigns)	% of transects where it was recorded (average between campaigns)
Arabian Green Bee-eater	*Merops cyanophrys*	LC	LC	0.04	10	0.26	30
Barn Swallow	*Hirundo rustica*	LC	LC	2.02	18	0.28	30
Blackcap	*Sylvia atricapilla*	LC	LC	0.27	23	0.00	0
Blackstart	*Oenanthe melanura*	LC	LC	0.89	37	1.45	85
Bluethroat	*Luscinia svecica*	LC	-	0.00	0	0.04	10
Booted Eagle	*Hieraaetus pennatus*	LC	-	0.00	0	0.04	10
Brown-necked Raven	*Corvus ruficollis*	LC	LC	1.10	28	0.61	55
Common Chiffchaff	*Phylloscopus collybita*	LC	-	0.54	18	0.11	15
Common Snipe	*Gallinago gallinago*	*LC*	-	0.00	0	0.02	5
Common Stonechat	*Saxicola torquatus*	LC	LC	0.00	0	0.15	20

[6] (IUCN 2025)

[7] (Symes *et al.* 2015)

Species		Conservation status		Spring		Autumn	
Common (English) name	Latin name	Global (IUCN) conservation status[6]	Regional (Arabian Peninsula) conservation status[7]	Kilometric Abundance Index (average between campaigns)	% of transects where it was recorded	Kilometric Abundance Index (average between campaigns)	% of transects where it was recorded (average between campaigns)
Common Swift	*Apus apus*	LC	LC	2.63	17	0.04	5
Crested Lark	*Galerida cristata*	LC	LC	1.13	25	1.86	90
Desert Lark	*Ammomanes deserti*	LC	LC	1.31	32	2.31	100
Desert Wheatear	*Oenanthe deserti*	LC	LC	0.00	0	0.04	10
Eastern Olivaceous Warbler	*Iduna pallida*	LC	LC	0.00	0	0.04	5
Eastern Orphean Warbler	*Curruca crassirostris*	LC	LC	0.00	0	0.02	5
Eurasian Blackbird	*Turdus merula*	LC	LC	0.39	23	0.00	0
Eurasian blackcap	*Sylvia atricapilla*	LC	LC	0.00	0	0.19	20
Eurasian Collared Dove	*Streptopelia decaocto*	LC	LC	1.50	40	2.68	85
Eurasian Hoopoe	*Upupa epops*	LC	LC	0.00	0	0.02	5
Eurasian Jackdaw	*Corvus monedula*	LC	LC	0	0	0.0366667	5
Eurasian Linnet	*Linaria cannabina*	LC	LC	0.00	0	0.43	15
Eurasian Sparrowhawk	*Accipiter nisus*	LC	-	0.00	0	0.06	15
Great Grey Shrike	*Lanius excubitor*	LC	LC	0.00	0	0.02	5
Great White Pelican	*Pelecanus onocrotalus*	LC	-	0.00	0	0.32	5
Greater Short-toed Lark	*Calandrella brachydactyla*	LC	LC	0.00	0	0.09	10
Hooded Wheatear	*Oenanthe monacha*	LC	LC	0.00	0	0.13	10
House Sparrow	*Passer domesticus*	LC	LC	6.73	28	4.08	65
Isabelline Wheatear	*Oenanthe isabellina*	LC	LC	0.17	15	0.04	10

Species		Conservation status		Spring		Autumn	
Common (English) name	Latin name	Global (IUCN) conservation status[6]	Regional (Arabian Peninsula) conservation status[7]	Kilometric Abundance Index (average between campaigns)	% of transects where it was recorded	Kilometric Abundance Index (average between campaigns)	% of transects where it was recorded (average between campaigns)
Laughing Dove	*Spilopelia senegalensis*	LC	LC	1.04	25	1.38	55
Lesser Whitethroat	*Curruca curruca*	LC	LC	0.00	0	0.22	30
Masked Shrike	*Lanius nubicus*	LC	LC	0.00	0	0.04	10
Mourning Wheatear	*Oenanthe lugens*	LC	LC	0.06	10	0.04	10
Palestine Sunbird	*Cinnyris osea*	LC	LC	0.86	25	0.56	35
Peregrin Falcon	*Falco peregrinus*	LC	**VU**	0.00	0	0.02	5
Red start	*Phoenicurus phoenicurus*	LC	NT	0.00	0	0.07	15
Red-backed Shrike	*Lanius collurio*	LC	-	0.00	0	0.33	45
Red-rumped Wheatear	*Oenanthe moesta*	LC	**EN**	0.02	5	0.00	0
Red-rumped Swallow	*Cecropis daurica*	LC	LC	0.00	0	0.26	15
Rock Dove	*Columba livia*	LC	LC	1.16	33	2.10	70
Rock Martin	*Ptyonoprogne obsoleta*	LC	-	0.24	10	0.50	45
Sand Partridge	*Ammoperdix heyi*	LC	LC	0.00	0	0.07	10
Sardinian Warbler	*Curruca melanocephala*	LC	LC	0.37	23	0.00	0
Scrub Warbler	*Scotocerca inquieta*	LC	LC	0.00	0	0.22	35
Sinai Rosefinch	*Carpodacus synoicus*	LC	LC	0.00	0	0.80	20
Spanish Sparrow	*Passer hispaniolensis*	LC	LC	4.38	27	0.91	15
Spotted Flycatcher	*Muscicapa striata*	LC	LC	0.00	0	0.10	20
Spur-winged Lapwing	*Vanellus spinosus*	LC	LC	0.00	0	0.06	5
Steppe Buzzard	*Buteo buteo*	LC	LC	0.00	0	0.02	5

Species		Conservation status		Spring		Autumn	
Common (English) name	Latin name	Global (IUCN) conservation status[6]	Regional (Arabian Peninsula) conservation status[7]	Kilometric Abundance Index (average between campaigns)	% of transects where it was recorded	Kilometric Abundance Index (average between campaigns)	% of transects where it was recorded (average between campaigns)
Streaked Scrub-warbler	*Scotocerca inquieta*	LC	LC	0.37	18	0.00	0
Tristram's Starling	*Onychognathus tristramii*	LC	LC	0.00	0	1.13	15
Verreaux's Eagle	*Aquila verreauxii*	LC	**EN**	0.00	0	0.02	5
Warbler Sp	-	-	-	0.50	23	0.00	0
Western House martin	*Delichon urbicum*	LC	LC	0.00	0	0.39	10
Western Marsh Harrier	*Circus aeruginosus*	LC	NT	0.00	0	0.02	5
Whinchat	*Saxicola rubetra*	LC	-	0.00	0	0.04	5
White Wagtail	*Motacilla alba*	LC		0.00	0	0.09	10
White-crowned Wheatear	*Oenanthe leucopyga*	LC	LC	0.00	0	0.91	90
White-spectacled Bulbul	*Pycnonotus xanthopygos*	LC	LC	0.02	5	0.13	15
White-crowned Wheatear	*Oenanthe leucopyga*	LC	LC	0.59	28	0.00	0
Willow Warbler	*Phylloscopus trochilus*	LC	-	0.00	0	0.54	65
Woodchat Shrike	*Lanius senator*	NT	LC	0.00	0	0.06	15
Yellow Wagtail	*Motacilla flava*	LC	-	0.04	5	0.08	10

3.4. Carcass Surveys

Only one bird fatality was recorded across both seasons along the existing OHTL. This was a female Common Quail *Coturnix coturnix* (IUCN Least Concern) that was found in the first spring campaign (Figure 6). The carcass was fresh, and thus fatality occurred sometime before 5th March 2025. The carcass was found at the southern end of the existing OHTL near Aqaba, ~300 m from the Project's proposed OHTL.



Figure 6: Common Quail carcass found during carcass surveys

Common Quail is expected to be a relatively common migrant in the region, but difficult to detect via VP and line transect surveys, since it is a nocturnal migrant which is difficult to detect when resting (it is mostly silent during migration).

Search efficiency trials were only conducted in Campaigns 2 and 3 in autumn. Across the autumn campaigns, efficiency ranged from 92% to 100%. In Campaign 2, only one small-sized dummy bird was missed out of a total of 27 birds of all size categories included in the trial. Similarly, in Campaign 3, two small-sized dummy birds were missed, again from a total of 27 birds of various sizes.

Since only one small carcass was found (which was removed between consecutive visits), carcass persistency trials could not be performed and are considered inconclusive.

4. DISCUSSION

Eight species of conservation concern were recorded during spring and autumn surveys in 2025, seven of which are raptors: Black-winged Kite, Egyptian Vulture, Greater Spotted Eagle, Peregrine Falcon, Short-toed Eagle, Steppe Eagle and the Verreaux's Eagle. The other species is a resident passerine – the Red-rumped Wheatear.

The Verreaux's Eagle is a resident species. The juveniles may disperse over long distance, but the adults only move between close patches of hilly habitat (Kemp *et al.* 2020a). In eBird there are abundant records along the mountains north of Eilat and a few records in Wadi Rum, but not in Aqaba mountains. It is likely that this current record may correspond to a pair that is installing in the area or even breeding.

The are a few known records of the Black-winged Kite in Eilat and along the Aqaba coast, but not further inland (eBird). This species is known to be nomadic (Kemp *et al.* 2020b), so it expected that the individual that was recorded may come from this coastal population, as the habitat in the study area is not ideal for the species. The only individual that was recorded, was flying at a high collision risk altitude, but this is a species with high manoeuvrability which is not usually a victim of collisions with power lines (Prinsen *et al.* 2011).

The other raptors of conservation concern are all migratory. In fact, vantage point surveys allowed to confirm that the area is crossed by high numbers of soaring birds, especially Steppe Buzzards and European Honey Buzzards in spring, as expected. Most of these birds were mostly recorded flying at high altitudes, above any transmission lines, making collisions unlikely. However, some of the soaring species hunt and rest during migration and can be observed in high-risk altitudes, which was the case of the Black Kite, Eurasian Sparrowhawk, Western Marsh Harrier, Common Kestrel and Long-legged Buzzard (these last two species also have resident population in the area, being impossible to distinguish between resident and migratory individuals).

The Levant Sparrowhawk, the key species behind the designation of the Aqaba Mountains and Coast as an IBA and KBA was not detected during the surveys in either seasons. This species is known to migrate in very large flocks, often comprising a significant proportion of the population. As a result, if surveys do not cover the full duration of the migratory period, there is a high likelihood that no individuals will be recorded. There is also some evidence that at least some birds migrate at night, especially those migrating later in the season (Stark & Liechti 1993, Spar *et al.* 1998).

Carcass surveys of an existing OHTL parallel to the proposed transmission line revealed the presence of only one carcass of a Common Quail, which seems to confirm that mortality along this OHTL is probably low. Searcher efficiency was very high, which was expected, since the area has very sparce vegetation, making it relatively easy to spot any carcasses. This provides extra support to this conclusion. However, it was not possible to assess carcass removal (see Methods section), which could be high because of the presence of many stray dogs in the area.

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Appendix 1 Full list of species recorded

Table 12: List of All Bird Species Recorded Across All Spring and Autumn Surveys in 2025 (Species of Conservation Concern Are Shown in Bold)

Species	Latin name	Global IUCN conservation status[8]	Regional (Arabian Peninsula) conservation status[9]	Spring	Autumn
Alpine Swift	*Tachymarptis melba*	LC	LC	x	-
Arabian Green Bee-eater	*Merops cyanophrys*	LC	LC	x	x
Barn Swallow	*Hirundo rustica*	LC	LC	x	x
Black Kite	*Milvus migrans*	LC	LC	x	x
Black Stork	*Ciconia nigra*	LC	-	-	x
Blackcap	*Sylvia atricapilla*	LC	LC	x	x
Blackstart	*Oenanthe melanura*	LC	LC	x	x
Black-winged Kite	***Elanus caeruleus***	**LC**	**VU**	**-**	**x**
Bluethroat	*Luscinia svecica*	LC	-	-	x
Booted Eagle	*Hieraaetus pennatus*	LC	-	x	x
Brown-necked Raven	*Corvus ruficollis*	LC	LC	x	x
Common Chiffchaff	*Phylloscopus collybita*	LC	-	x	x
Common Kestrel	*Falco tinnunculus*	LC	LC	x	x
Common Sandpiper	*Actitis hypoleucos*	LC	-	-	x
Common Snipe	*Gallinago gallinago*	LC	-	-	x
Common Stonechat	*Saxicola torquatus*	LC	LC	x	x
Common Swift	*Apus apus*	LC	LC	x	x
Common Teal	*Anas crecca*	LC	-	x	x
Crested Lark	*Galerida cristata*	LC	LC	x	x
Desert Lark	*Ammomanes deserti*	LC	LC	x	x
Desert Wheatear	*Oenanthe deserti*	LC	LC	-	x
Eastern Olivaceous Warbler	*Iduna pallida*	LC	LC	-	x
Eastern Orphean Warbler	*Curruca crassirostris*	LC	LC	-	x
Egyptian Vulture	***Neophron percnopterus***	**EN**	**VU**	**x**	**x**

[8] (IUCN 2025)

[9] (Symes et al. 2015)

Species	Latin name	Global IUCN conservation status[8]	Regional (Arabian Peninsula) conservation status[9]	Spring	Autumn
Eurasian Blackbird	*Turdus merula*	LC	LC	X	-
Eurasian Collared Dove	*Streptopelia decaocto*	LC	LC	X	x
Eurasian Hoopoe	*Upupa epops*	LC	LC	-	x
Eurasian Jackdaw	*Corvus monedula*	LC	LC	-	x
Eurasian Linnet	*Linaria cannabina*	LC	LC	-	x
Eurasian Sparrowhawk	*Accipiter nisus*	LC	-	-	x
European Bee-eater	*Merops apiaster*	LC	LC	-	x
European Honey-buzzard	*Pernis apivorus*	LC	-	X	-
Garganey	*Spatula querquedula*	LC	-	-	x
Great Grey Shrike	*Lanius excubitor*	LC	LC	-	x
Great White Pelican	*Pelecanus onocrotalus*	LC	-	-	x
Greater Short-toed Lark	*Calandrella brachydactyla*	LC	LC	-	x
Greater Spotted Eagle	***Clanga clanga***	**VU**	**-**	**-**	**x**
Green Sandpiper	*Tringa ochropus*	LC	-	-	x
Greenshank	*Tringa nebularia*	LC	-	X	-
Grey heron	*Ardea cinerea*	LC	NT	-	x
Hooded Wheatear	*Oenanthe monacha*	LC	LC	X	x
House Sparrow	*Passer domesticus*	LC	LC	X	x
Isabelline Wheatear	*Oenanthe isabellina*	LC	LC	X	x
Kentish Plover	*Charadrius alexandrinus*	LC	LC	X	-
Laughing Dove	*Spilopelia senegalensis*	LC	LC	X	x
Lesser Spotted Eagle	*Clanga pomarina*	LC	-	-	x
Lesser Whitethroat	*Curruca curruca*	LC	LC	-	x
Little Egret	*Egretta garzetta*	LC	LC	-	x
Little Stint	*Calidris minuta*	LC	-	X	-
Little Swift	*Apus affinis*	LC	LC	-	x
Long-legged Buzzard	*Buteo rufinus*	LC	LC	X	x
Masked Shrike	*Lanius nubicus*	LC	LC	-	x
Mourning Wheatear	*Oenanthe lugens*	LC	LC	X	x
Northern Wheatear	*Oenanthe oenanthe*	LC	LC	X	-
Palestine Sunbird	*Cinnyris osea*	LC	LC	X	x
Peregrin Falcon	***Falco peregrinus***	**LC**	**VU**	**-**	**x**
Redstart	*Phoenicurus phoenicurus*	LC	NT	-	x
Red-backed Shrike	*Lanius collurio*	LC	-	-	x
Red-rumped Swallow	*Cecropis daurica*	LC	LC	-	x
Red-rumped Wheatear	***Oenanthe moesta***	**LC**	**EN**	**X**	**-**
Rock Dove	*Columba livia*	LC	LC	X	x
Rock Martin	*Ptyonoprogne obsoleta*	LC	LC	X	x

Species	Latin name	Global IUCN conservation status[8]	Regional (Arabian Peninsula) conservation status[9]	Spring	Autumn
Sand Partridge	*Ammoperdix heyi*	LC	LC	-	x
Sardinian Warbler	*Curruca melanocephala*	LC	LC	x	-
Scrub Warbler	*Scotocerca inquieta*	LC	LC	x	x
Short-toed eagle	***Circaetus gallicus***	**LC**	**VU**	**-**	**x**
Sinai Rosefinch	*Carpodacus synoicus*	LC	LC	-	x
Spanish Sparrow	*Passer hispaniolensis*	LC	LC	x	x
Spotted Flycatcher	*Muscicapa striata*	LC	LC	-	x
Spur-winged Lapwing	*Vanellus spinosus*	LC	LC	x	x
Steppe Buzzard	*Buteo buteo*	LC	LC	x	x
Steppe Eagle	***Aquila nipalensis***	**EN**	**EN**	**x**	**x**
Temminck's Lark	*Eremophila bilopha*	LC	LC	x	-
Tristram's Starling	*Onychognathus tristramii*	LC	LC	-	x
Verreaux's Eagle	***Aquila verreauxii***	**LC**	**EN**	**-**	**x**
Western House Martin	*Delichon urbicum*	LC	LC	x	x
Western Marsh Harrier	*Circus aeruginosus*	LC	NT	-	x
Whinchat	*Saxicola rubetra*	Lc	-	-	x
White Wagtail	*Motacilla alba*	LC	-	-	x
White-crowned Wheatear	*Oenanthe leucopyga*	LC	LC	x	x
White-spectacled Bulbul	*Pycnonotus xanthopygos*	LC	LC	x	x
Willow Warbler	*Phylloscopus trochilus*	LC	-	-	x
Woodchat Shrike	*Lanius senator*	NT	LC	-	x
Yellow Wagtail	*Motacilla flava*	LC	-	x	x

Appendix 2 Vantage Points surveys results

Table 13: Bird observations across Vantage Points during the 2025 Spring and Autumn campaigns

Species		Spring			Autumn		
Common (English) name	Latin name	No. of individuals recorded in Campaign 1	No. of individuals recorded in Campaign 2	No. of individuals recorded in Campaign 3	No. of individuals recorded in Campaign 1	No. of individuals recorded in Campaign 2	No. of individuals recorded in Campaign 3
Alpine Swift	*Tachymarptis melba*	18	0	0	0	0	0
Arabian Bee-eater	*Merops cyanophrys*	0	0	0	0	3	0
Black Kite	*Milvus migrans*	2	53	0	3	16	7
Black Stork	*Ciconia nigra*	0	0	0	0	3	2
Black-winged Kite	*Elanus caeruleus*	0	0	0	0	1	0
Booted Eagle	*Hieraaetus pennatus*	0	35	1	5	0	0
Brown-necked Raven	*Corvus ruficollis*	6	7	4	6	54	12
Common Kestrel	*Falco tinnunculus*	3	1	2	3	14	5
Common Teal	*Anas crecca*	39	0	0	0	0	0
Egyptian Vulture	*Neophron percnopterus*	0	1	0	1	0	0
Eurasian Collared Dove	*Streptopelia decaocto*	1	0	0	2	2	23
European Honey Buzzard	*Pernis apivorus*	1	13	156	0	0	0
Eurasian Linnet	*Linaria cannabina*	0	0	0	35	0	0
Eurasian Sparrowhawk	*Accipiter nisus*	0	0	0	2	5	1
European Bee-eater	*Merops apiaster*	0	0	0	100	0	0
Great White Pelican	*Pelecanus onocrotalus*	0	0	0	0	0	16
Greater Spotted Eagle	*Clanga clanga*	0	0	0	0	0	1
Grey heron	*Ardea cinerea*	0	0	0	0	26	0

Species		Spring			Autumn		
Common (English) name	Latin name	No. of individuals recorded in Campaign 1	No. of individuals recorded in Campaign 2	No. of individuals recorded in Campaign 3	No. of individuals recorded in Campaign 1	No. of individuals recorded in Campaign 2	No. of individuals recorded in Campaign 3
Lesser Spotted Eagle	*Clanga pomarina*	0	0	0	0	0	1
Little Egret	*Egretta garzetta*	0	0	0	1	0	0
Little Swift	*Apus affinis*	0	0	0	50	0	0
Kentish Plover	*Charadrius alexandrinus*	1	0	0	0	0	0
Long-legged Buzzard	*Buteo rufinus*	2	1	0	9	2	0
Rock Dove	*Columba livia*	1	0	0	0	27	14
Short-toed eagle	*Circaetus gallicus*	0	0	0	0	4	0
Steppe Buzzard	*Buteo buteo vulpinus*	151	239	6	21	53	6
Steppe Eagle	*Aquila nipalensis*	6	0	0	0	17	67
Tristram's Starling	*Onychognathus tristramii*	0	0	0	0	27	0
Western House Martin	*Delichon urbicum*	0	0	0	20	0	0
Western Marsh Harrier	*Circus aeruginosus*	0	0	0	2	0	1
Unidentified Raptor	-	0	22	0	0	0	0

Appendix 3 Water Body Counts results

Table 14: Bird observations across Water Body Counts during the 2025 Spring and Autumn campaigns

Species		Spring			Autumn		
Common (English) name	Latin name	No. of individuals recorded in Campaign 1	No. of individuals recorded in Campaign 2	No. of individuals recorded in Campaign 3	No. of individuals recorded in Campaign 1	No. of individuals recorded in Campaign 2	No. of individuals recorded in Campaign 3
Common Sandpiper	*Actitis hypoleucos*	*0*	*0*	*0*	0	*1*	0
Common Greenshank	*Tringa nebularia*	2	0	0	0	0	0
Common Teal	*Anas crecca*	48	12	0	0	2	0
Garganey Duck	*Spatula querquedula*	0	0	0	0	2	3
Green Sandpiper	*Tringa ochropus*	0	0	0	0	1	0
Grey Heron	*Ardea cinerea*	0	0	0	0	0	1
Little Egret	*Egretta garzetta*	0	0	0	9	0	0
Little Stint	*Calidris minuta*	1	4	0	0	0	0
Spur-winged Lapwing	*Vanellus spinosus*	4	9	3	2	11	7

Appendix 4 Transect surveys results

Table 15: Bird observations across Transect Spring and Autumn campaigns in 2025

Species		Spring			Autumn		
Common (English) name	Latin name	Kilometric Abundance Index in Campaign 1	Kilometric Abundance Index in Campaign 2	Kilometric Abundance Index in Campaign 3	Kilometric Abundance Index in Campaign 1	Kilometric Abundance Index in Campaign 2	Kilometric Abundance Index in Campaign 3
Arabian Green Bee-eater	*Merops cyanophrys*	0	0.11	0	0	0.22	0.56
Barn Swallow	*Hirundo rustica*	3.11	0.45	2.51	0	0.22	0.61
Blackcap	*Sylvia atricapilla*	0.44	0	0.36	0	0	0
Blackstart	*Oenanthe melanura*	1.33	0.28	1.07	0.45	2.12	1.79
Blue throat	*Luscinia svecica*	0	0	0	0	0	0.11
Booted Eagle	*Hieraaetus pennatus*	0	0	0	0	0.06	0.06
Brown-necked Raven	*Corvus ruficollis*	2.67	0.28	0.36	0.11	0.45	1.28
Common Chiffchaff	*Phylloscopus collybita*	0.44	0.45	0.72	0.17	0.17	0
Common Snipe	*Gallinago gallinago*	0	0	0	0	0	0.06
Common Stonechat	*Saxicola torquatus*	0	0	0	0	0.22	0.22
Common Swift	*Apus apus*	4	0.67	3.22	0	0	0.11
Crested Lark	*Galerida cristata*	2.22	0.11	1.07	0.22	2.85	2.51
Desert Lark	*Ammomanes deserti*	2.22	1	0.72	0.22	3.74	2.96
Desert Wheatear	*Oenanthe deserti*	0	0	0	0	0.06	0.06
Eastern Olivaceous Warbler	*Iduna pallida*	0	0	0	0.11	0	0
Eastern Orphean Warbler	*Curruca crassirostris*	0	0	0	0.06	0	0
Eurasian Blackbird	*Turdus merula*	0.44	0	0.72	0	0	0
Eurasian blackcap	*Sylvia atricapilla*	0	0	0	0.28	0.28	0
Eurasian Collared Dove	*Streptopelia decaocto*	2.22	0.84	1.43	0.73	5.19	2.12

Species		Spring			Autumn		
Common (English) name	Latin name	Kilometric Abundance Index in Campaign 1	Kilometric Abundance Index in Campaign 2	Kilometric Abundance Index in Campaign 3	Kilometric Abundance Index in Campaign 1	Kilometric Abundance Index in Campaign 2	Kilometric Abundance Index in Campaign 3
Eurasian Hoopoe	*Upupa epops*	0	0	0	0.06	0	0
Eurasian Jackdaw	*Corvus monedula*	0	0	0	0	0.11	0
Eurasian Linnet	*Linaria cannabina*	0	0	0	0.17	1.12	0
Eurasian Sparrowhawk	*Accipiter nisus*	0	0	0	0	0.11	0.06
Great Grey Shrike	*Lanius excubitor*	0	0	0	0	0	0.06
Great White Pelican	*Pelecanus onocrotalus*	0	0	0	0	0.95	0
Greater Short-toed Lark	*Calandrella brachydactyla*	0	0	0	0	0.22	0.06
Hooded Wheatear	*Oenanthe monacha*	0	0	0	0	0.22	0.17
House Sparrow	*Passer domesticus*	11.11	4.41	4.66	1.23	5.86	5.14
Isabelline Wheatear	*Oenanthe isabellina*	0.44	0.06	0	0	0.11	0
Laughing Dove	*Spilopelia senegalensis*	3.11	0	0	0.28	3.52	0.33
Lesser Whitethroat	*Curruca curruca*	0	0	0	0.28	0.39	0
Masked Shrike	*Lanius nubicus*	0	0	0	0.06	0.06	0
Mourning Wheatear	*Oenanthe lugens*	0	0.17	0	0	0.06	0.06
Palestine Sunbird	*Cinnyris osea*	0.89	0.61	1.07	0.89	0.45	0.33
Peregrin Falcon	*Falco peregrinus*	0	0	0	0	0.06	0
Redstart	*Phoenicurus phoenicurus*	0	0	0	0	0	0.22
Red-backed Shrike	*Lanius collurio*	0	0	0	0.22	0.33	0.45
Red-rumped Wheatear	*Oenanthe moesta*	0	0.06	0	0	0	0
Red-rumped Swallow	*Cecropis daurica*	0	0	0	0	0	0.78

Species		Spring			Autumn		
Common (English) name	Latin name	Kilometric Abundance Index in Campaign 1	Kilometric Abundance Index in Campaign 2	Kilometric Abundance Index in Campaign 3	Kilometric Abundance Index in Campaign 1	Kilometric Abundance Index in Campaign 2	Kilometric Abundance Index in Campaign 3
Rock Dove	*Columba livia*	0.89	1.17	1.43	0.33	1.62	4.35
Rock Martin	*Ptyonoprogne obsoleta*	0	0.73	0	0.22	0.61	0.67
Sand Partridge	*Ammoperdix heyi*	0	0	0	0	0.22	0
Sardinian Warbler	*Curruca melanocephala*	0.89	0.22	0	0	0	0
Scrub Warbler	*Scotocerca inquieta*	0	0	0	0.06	0.5	0.11
Sinai Rosefinch	*Carpodacus synoicus*	0	0	0	0	1.62	0.78
Spanish Sparrow	*Passer hispaniolensis*	6.67	1.45	5.02	0	1.06	1.67
Spotted Flycatcher	*Muscicapa striata*	0	0	0	0.06	0.17	0.06
Spur-winged Lapwing	*Vanellus spinosus*	0	0	0	0	0	0.17
Steppe Buzzard	*Buteo buteo*	0	0	0	0.06	0	0
Streaked Scrub-warbler	*Scotocerca inquieta*	0.89	0.22	0	0	0	0
Tristram's Starling	*Onychognathus tristramii*	0	0	0	0	1.73	1.67
Verreaux's Eagle	*Aquila verreauxii*	0	0	0	0	0.06	0
Warbler Sp	-	0.44	0	1.07	0	0	0
Western House martin	*Delichon urbicum*	0	0	0	0.06	1.12	0
Western Marsh Harrier	*Circus aeruginosus*	0	0	0	0	0	0.06
Whinchat	*Saxicola rubetra*	0	0	0	0	0	0.11
White Wagtail	*Motacilla alba*	0	0	0	0	0	0.28
White-crowned Wheatear	*Oenanthe leucopyga*	0	0	0	0.11	1.06	1.56

Species		Spring			Autumn		
Common (English) name	Latin name	Kilometric Abundance Index in Campaign 1	Kilometric Abundance Index in Campaign 2	Kilometric Abundance Index in Campaign 3	Kilometric Abundance Index in Campaign 1	Kilometric Abundance Index in Campaign 2	Kilometric Abundance Index in Campaign 3
White-spectacled Bulbul	*Pycnonotus xanthopygos*	0	0.06	0	0.11	0	0.28
White-crowned Wheatear	*Oenanthe leucopyga*	0.89	0.17	0.72	0	0	0
Willow Warbler	*Phylloscopus trochilus*	0	0	0	0	0.67	0.95
Woodchat Shrike	*Lanius senator*	0	0	0	0	0.06	0.11
Yellow Wagtail	*Motacilla flava*	0	0.11	0	0	0.06	0.17

Project: Aqaba-Amman Water Desalination and Conveyance (AAWDC)

2025 Environmental and Social Impact Assessment

Appendix 6-10 Interim Bird Survey Report OHTL (Spring 2025)

PROJECT: AQABA AMMAN WATER CONVEYANCE AND DESALINATION PROJECT (AAWDCP)

Interim Bird Survey Report for the Aqaba-Amman pipeline overhead transmission line (spring 2025)

Client: National Conveyance Project Company

Date	Rev	Author	Checked	Approved
July 2025	1	L.M, F.C, D.P	L.Z	L.Z

July 2025	2	L.M, F.C, D.P

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1. INTRODUCTION

1.1. Context and Objectives

This report is the "Interim Spring Bird Survey Report" prepared by The Biodiversity Consultancy (TBC) for the planned Overhead Transmission Line (OHTL) which as an associated facility for the Project (the Aqaba Amman Water Conveyance and Desalination Project), based on the results of the spring 2025 bird surveys.

Spring bird surveys were conducted along the planned OHTL route by local ornithologists between 3 March and 5 May 2025 with guidance from expert from TBC between 3 and 9 March 2025, and included:

- Vantage Point (VP) surveys,
- bird counts at water bodies,
- line transect surveys, and
- carcass surveys (along the existing OHTL that runs nearby to the planned OHTL for this Project), as a proxy to estimating bird and bat mortality along the Project's OHTL.

This report aims to analyse and present summaries of the spring survey data, discuss the key findings, including the significance of the study area for birds, and recommend next steps for the Project.

1.2. Project Overview

The AAWDC Project is located in Jordan, between the Aqaba area in the south and the Amman area in the north, and comprises three main components: marine works and desalination, conveyance and renewable energy facilities:

- Marine works and desalination plant - intake system (including some limited offshore works) composed of a pumping station, three parallel pipelines (4 for intake and 2 for outtake) to convey seawater to the desalination plant. Reverse osmosis seawater desalination plant sized to produce 300 million cubic meters per year of desalinated water through four independent parallel production lines, located in the Aqaba area.
- Conveyance system - composed of a 438 km long underground water pipeline of variable diameter (76" to 90"), three tanks and four pumping stations to convey water to the Aqaba turnout (located c. 10 km from the desalination plant) and to the existing reservoirs of Abu Alanda and Al Muntazah near Amman.
- Solar power plant - with production capacity equal to 281 MWp near the Wadi Rum, area next to the existing Quweira solar plant and about 55 km from the Desalination Plant site.

The OHTL will be developed by NEPCO and is considered as an associated facility. The OHTL is a new 132kV transmission line running between the solar power plant and the Desalination plant, with an approximate length of 65 km, to transport electricity to the Desalination plant. Electricity grid expansion works will be carried out by NEPCO1, JEPCO2 and EDCO3.

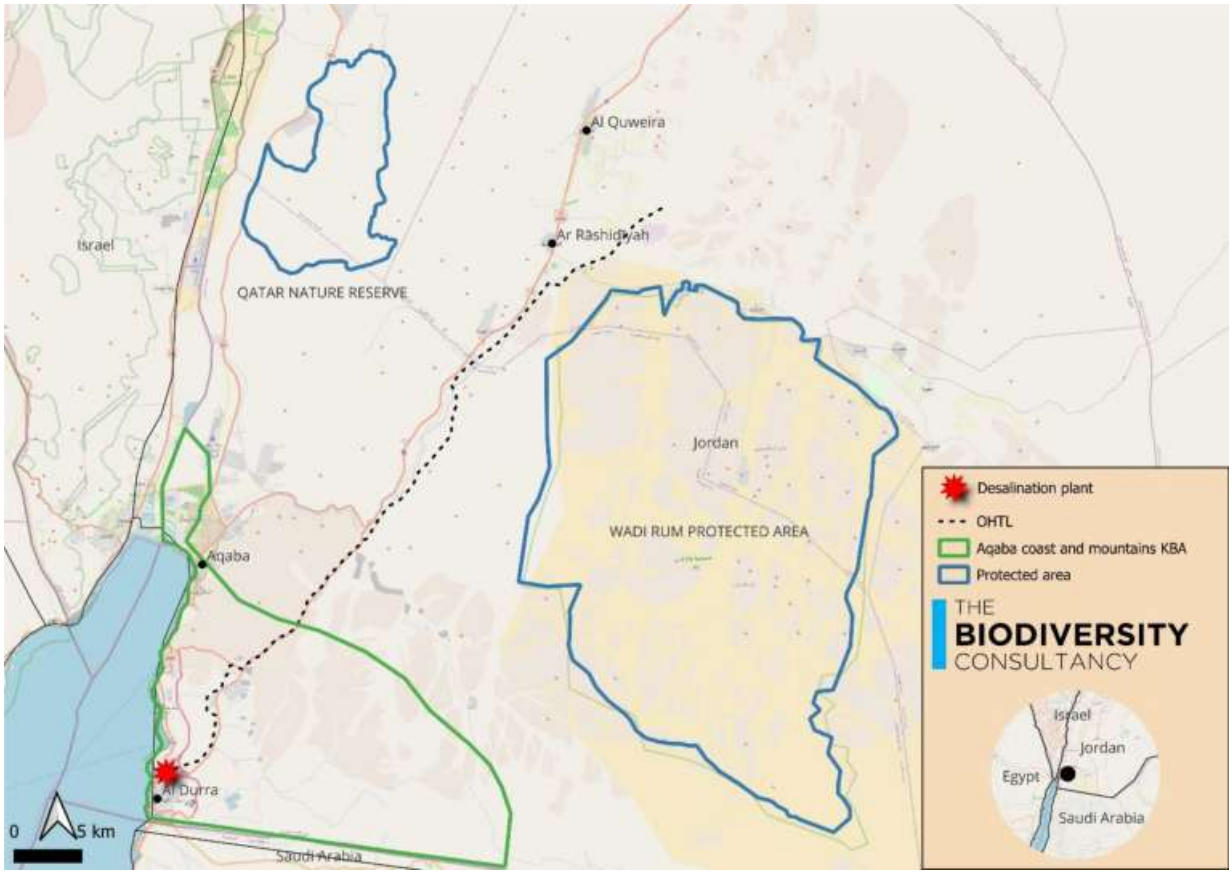


Figure 1: Location of the Project's Overhead Transmission Line (OHTL)

1.3. Biodiversity Context of the Project: Avifauna

The southern section of the OHTL crosses the Aqaba coast and mountains Key Biodiversity Area (KBA) and Important Bird Area (IBA)[1] (Figure 1). This area was designated due to the migratory passage of Levant Sparrowhawks (*Accipiter brevipes,* IUCN Least Concern). Around 3,000 individuals of this species are expected to cross the area each spring, which represents up to 30% of the global population estimate of 10,000.

This area is considered a migratory bottleneck site within the Rift Valley/Red Sea Flyway, which is one of the most important routes for migratory soaring birds in the world. Each spring and autumn, 37 species of migratory soaring birds navigate this flyway, with over a million birds passing in the major bottlenecks (Porter 2005; Jobson *et al.* 2021).

The Aqaba coast and mountains has a peak estimate of 50,000-99,000 soaring birds (BirdLife International 2025), and apart from the Levant Sparrowhawk, other relevant soaring birds that migrate through the area include Egyptian Vulture (*Neophron percnopterus*, IUCN Endangered), Steppe Eagle (*Aquila nipalensis*, IUCN Endangered), Greater Spotted Eagle (*Clanga clanga*, IUCN Vulnerable), Lesser Spotted Eagle (*Clanga pomarina,* IUCN Least Concern), White Stork (*Ciconia ciconia*, IUCN Least Concern), European Honey Buzzard (*Pernis apivorus*, IUCN Least Concern) and Steppe Buzzard (*Buteo buteo vulpinus*, IUCN Least Concern).

Migration along the Aqaba coast and mountains is more intense in spring, as opposed to autumn where migration tends to occur in a broad front and is considered insignificant at this site (Khoury 2017; BirdLife International 2025). In spring, most soaring birds enter Jordan from the Eilat (southern Israel) bottleneck, which is located to the North of the Aqaba coast and mountains. Most birds follow north from there, thus not entering the area. However, some other birds may cross the gulf of Aqaba and follow the Saudi and

[1] https://datazone.birdlife.org/site/factsheet/aqaba-coast-and-mountains

Jordanian coast northwards or arrive from the Arabian Peninsula. Those are the soaring birds that concentrate in the Aqaba mountains and coast, which represent a relatively small percentage of the numbers that occur at the Eilat bottleneck (Andrews 1996; Jobson *et al.* 2021).

Other species (non-soaring birds) with populations that meet IBA/KBA criteria that occur in the Aqaba mountains and coast are the Arabian Warbler (*Curruca leucomelaena*), Arabian Babbler (*Turdoides squamiceps*), Tristam's Starling (*Onychognathus tristamii*) and Hooded Wheatear (*Oenanthe monacha*), all IUCN Least Concern.

1.4. Main Impacts of Power Lines On Birds

Powerlines can cause bird mortality through collisions and electrocution. Collisions occur mainly on high voltage transmission lines, especially with the thin, and hard to see, earth wire. Susceptible species include large birds with low manoeuvrability (high weight to wing area ratio), birds that fly very fast, especially if they move in flocks. And/or species with a reduced visual field (Prinsen *et al.* 2011; Bennun *et al.* 2021; BirdLife International & CMS Energy Task Force 2023).

Birds can be electrocuted when perched on pylons or power lines and this may be the of cause decline of some long-lived species, namely birds of prey and other large perching birds. Electrocution is more frequent on distribution lines since the distance between charged elements is higher in transmission lines. However, it also possible for transmission lines, especially if large species build their nests on the pylons or if several bird perch very close to each other (especially during rainy days) (Angelov *et al.* 2013; Bennun *et al.* 2021; Biasotto *et al.* 2021).

2. METHOLODGY

Field surveys were conducted by local ornithologist team provided by ECO Consult in three campaigns during the spring of 2025. These included vantage point surveys, line transects, water body counts and carcass surveys. The approach for this survey was provided by TBC.

2.1. Vantage Point (VP) Surveys

Vantage points comprise a series of watches from a fixed location to quantify the flight activity of birds and its distribution at a proposed development site. This method is especially adequate to detect and track the movements of soaring birds (e.g. diurnal raptors), or other diurnal medium-large size birds that actively migrate or commute between foraging and/or roosting sites (e.g. Scottish Natural Heritage 2017, BID Invest and IFC 2019).

11 VPs were defined along the expected layout of the OHTL, appropriately spaced and located in areas on good visibility Figure 2.

Each VP watch lasted for 3 continuous hours. Because three campaigns were performed (

Table 1), each vantage point was surveyed for 9 hours in total during the spring period. Surveys were conducted between 1h 30 min after sunrise and 1h 30 min before sunset.

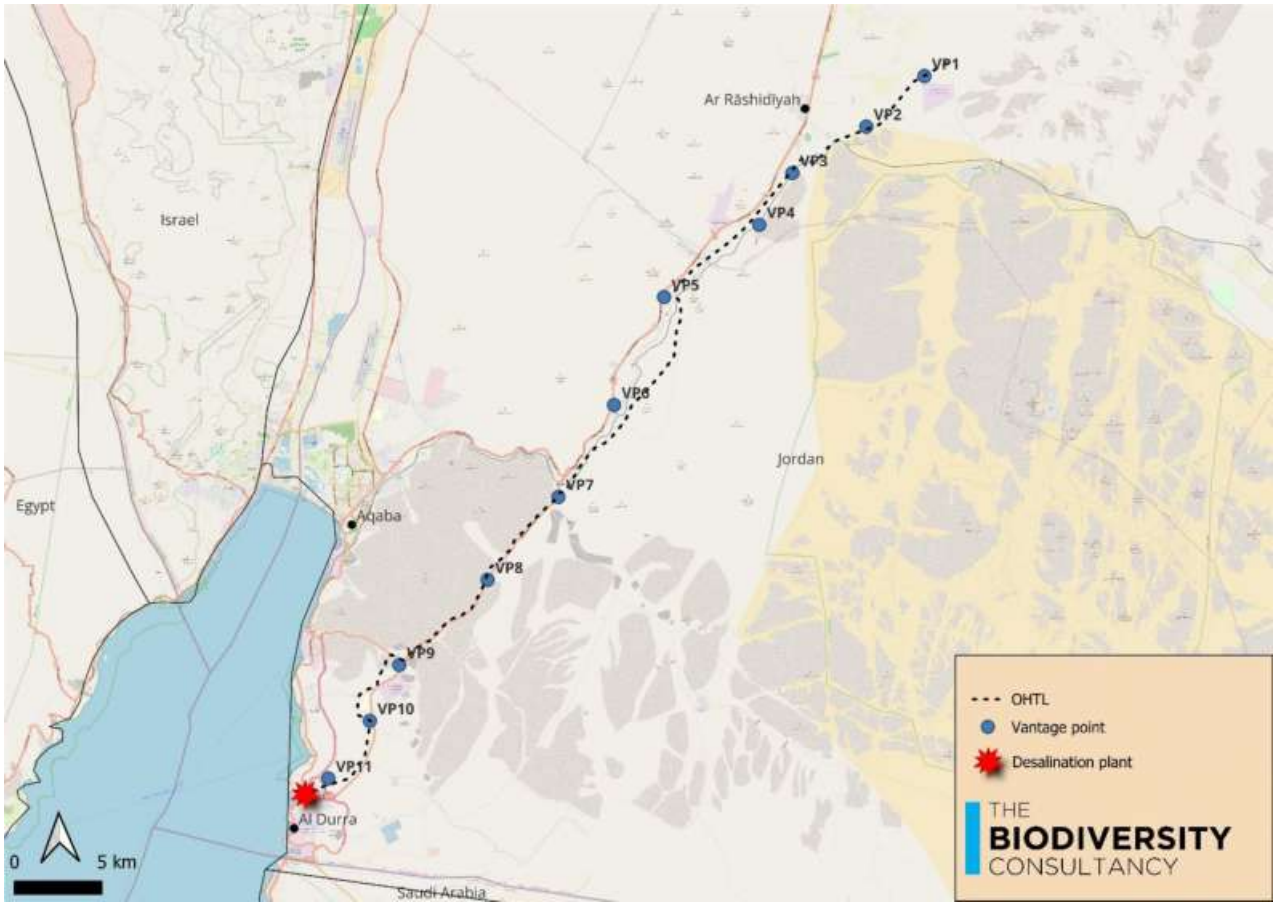


Figure 2: Location of Vantage Points

Table 1: Survey Period for the Three Spring Campaigns

	Number of points	Start date	End date
Campaign 1	10*	3rd March 2025	13th March 2025
Campaign 2	11	20th March 2025	8th April 2025
Campaign 3	11	23rd April 2025	3rd May 2025

*monitoring was not conducted at VP 7 due to rain and poor visibility

Observations at each vantage point were conducted by two observers equipped with binoculars and a telescope, recording and identifying every flight of medium/large bird species detected (every bird with a size equal or larger than a Collared Dove (*Streptopelia decaocto*), or flocks of 10 or more birds of every species (e.g. swallows, swifts). Birds that could not be identified to species level were identified to the nearest level (e.g. Unidentified Raptor). During each period, observers recorded:

- Number of the VP
- Date
- Time (start and finish)
- Observer ID
- Weather variables (e.g. temperature, wind speed and direction, rain, cloud cover)

For each record:

- Species ID
- Number of birds
- Time
- Flight height in predetermined classes (1 - < 20m, 2 – 20-50 m, 3 – 50-100 m, 4 100-200 m, 5 > 200 m)
- Flight distance to the proposed OHTL (1- crosses the line, 2 - <100 m from the line, 3 – 100-500 m from the line, 4 - > 500 m from the line)
- Bird interactions with the existing OHTL (avoidance and perching)
- Other information (sex, age etc.)

2.2. Water Body Counts

Water body counts were directed at aquatic bird species. Six observation points were established along the OHTL at water bodies and flood barrier dams, at locations that allow the visual inspection of the water surface and of 200 m of the water margin to each side Figure 3.

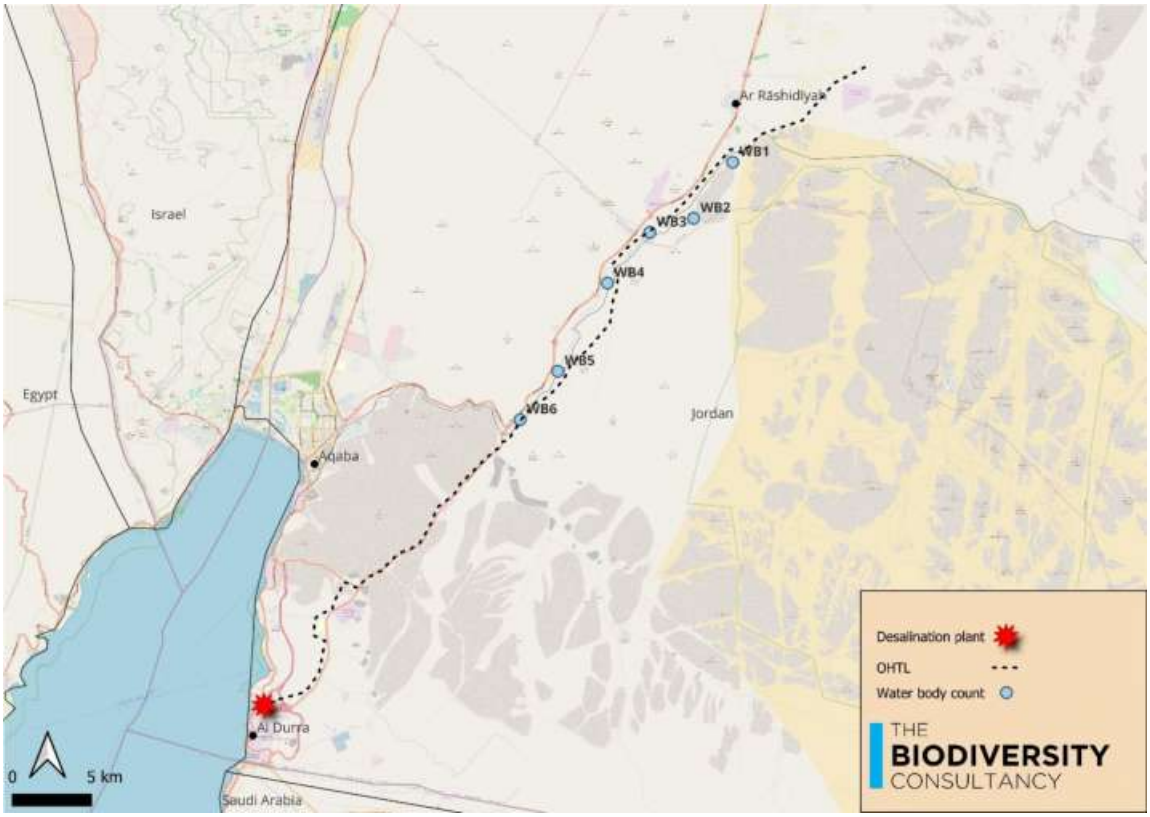


Figure 3: Locations of Water Body Counts

Observations at each water body point count were conducted by two observers equipped with binoculars and a telescope in the periods described in Table 2.

Table 2: Number of Water Body Counts and Survey Dates

	Number of points	Start date	End date
Campaign 1	4	5th March 2025	15th March 2025
Campaign 2	6	24th March 2025	9th April 2025
Campaign 3	5	26th April	5th May 2025

Every bird at (interacting with) each water body was counted. The presence (or lack of) water was recorded using four classes (1 – no water, 2 – some pools, 3 – half full, 4 – the dam is full). If no water was present, there are no birds associated with the water body even if some birds are present in the area. Water body counts occurred preferentially after a period of rainfall, even if they had already been counted during that campaign. Observers recorded:

- Number of water body
- Date
- Time
- Observer
- Weather variables
- Water presence (4 classes)
- Number of birds of each species
- Notes

2.3. Line Transect Surveys

Line transects were conducted to survey the non-soaring terrestrial birds. 20 transects were defined (and georeferenced) along the expected OHTL route, sufficiently spaced apart to minimize double counting (Figure 4). Transects were surveyed in three campaigns in the dates shown in Table 3.

Table 3: Number of Line Transects and Survey Dates

	Number of transects	Start date	End date
Campaign 1	4	3rd March 2025	13th March 2025
Campaign 2	20	20th March 2025	9th April 2025
Campaign 3	5	23rd April 2025	5th May 2025

Observers moved along the transects at a slow and steady pace. Every bird detected, by sight or sound, along a 500 m line transect was identified and counted. If a bird song/call could not be identified, an effort was made to spot the bird to allow for identification. Transects surveys were be conducted during the first three hours after sunrise (peak bird activity), and in appropriate weather conditions (absence of rain or strong wind). Observers recorded:

- Number of transect
- Date
- Time
- Observer
- Weather variables
- Number of individuals of each species at < or > 50 meters from the transect
- Notes (e.g., if there were noisy activities/people in the area that reduced bird detectability or affected bird behaviour, confirmed breeding, etc.)

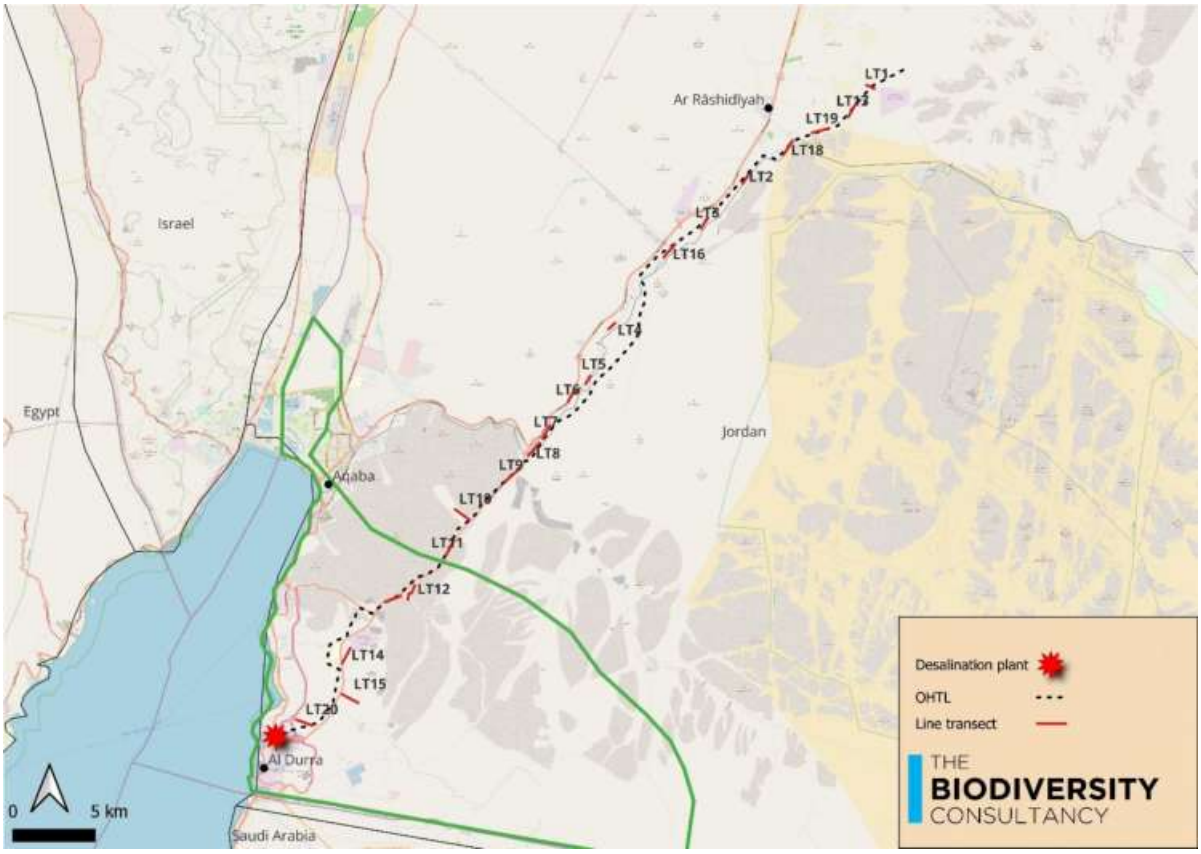


Figure 4: Locations of Line Transect Surveys

2.4. Carcass Surveys

Searches for carcasses were undertaken along the existing OHTL that runs nearby to the planned OHTL for this Project, in accordance to the methodology described in Post-construction Bird and Bat Fatality Monitoring (PCFM) for Onshore Wind Energy Facilities in Emerging Market Countries: Good Practice Handbook and Decision Support Tool (IFC *et al.* 2023).

Within the Aqaba coast and mountains IBA, the existing OHTL was divided into 1 km sections. PCFM was conducted by two observers along 500 m of each 1 km segment. Outside of the IBA, the existing OHTL was divided into 5 km segments and PCFM conducted within 1 km.

Within the search width (40 m to each side), transects were undertaken parallel to the centreline, spaced at an appropriate distance so that the whole survey area was covered. The searches were undertaken at two-week intervals between February and end of April (see Table 4).

Table 4: Carcass Search Periods

	Start date	End date
Campaign 1	4th March 2025	15th March 2025
Campaign 2	22nd March 2025	10th April 2025
Campaign 3	25th April 2025	4th May 2025

Results were recorded using forms informed by the PCFM good practice handbook (IFC *et al.* 2023). Bats were also recorded. Observers recorded:

- Number of the search plot
- Date

- Time (start and finish)
- Observer ID
- Weather variables (e.g. temperature, wind speed and direction, rain, cloud cover)

And for each record:

- ID
- Date
- Time
- Observer
- Species (age and sex if possible)
- Type of remains (e.g. full bird, a wing, just bones, feathers)
- Estimate of the date of death based on the decomposing state
- Location (GPS coordinates)
- Distance to the line
- Photo (with scale)

3. RESULTS

Across all survey methodologies, a total of 44 species were recorded (Appendix 1).

3.1. Vantage Point (VP) Surveys

Vantage Point (VP) surveys recorded a total of 14 species across all three campaigns, including eight migratory soaring bird species (see Table 5). Two species of conservation concern were recorded; the Egyptian Vulture (1 individual) which is globally Endangered and regionally Vulnerable in the Arabian Peninsula, and the Steppe Eagle (6 individuals) which is globally Endangered. Both these species were recorded far from the OHTL and at high altitudes.

Relatively high numbers of Steppe Buzzards were recorded in the first two campaigns and of European Honey Buzzards in the third campaign.

Table 5: Summary of results from Vantage point (VP) surveys

Species		Conservation status		No. of individuals recorded in Campaign 1	No. of individuals recorded in Campaign 2	No. of individuals recorded in Campaign 3	% of points where it was recorded	Distance to OHTL		Flight height	
Common (English) name	Latin name	Global (IUCN) conservation status[2]	Regional (Arabian Peninsula) conservation status[3]					% of birds that crossed the OHTL	% of birds that were <100 m from the OHTL	% of birds flying <20 m high	% of birds flying 20-50 m high
Alpine Swift	*Tachymarptis melba*	LC	LC	18	0	0	9%	0%	100%	0%	0%
Black Kite	*Milvus migrans*	LC	LC	2	53	0	45%	11%	2%	0%	4%
Booted Eagle	*Hieraaetus pennatus*	LC	-	0	35	1	18%	0%	0%	0%	0%
Brown-necked Raven	*Corvus ruficollis*	LC	LC	6	7	4	64%	9%	50%	45%	41%
Common Kestrel	*Falco tinnunculus*	LC	LC	3	1	2	36%	0%	0%	0%	50%
Common Teal	*Anas crecca*	LC	-	39	0	0	9%	0%	0%	0%	100%
Egyptian Vulture	*Neophron percnopterus*	**EN**	**VU**	0	1	0	9%	0%	0%	0%	0%
Eurasian Collared Dove	*Streptopelia decaocto*	LC	LC	1	0	0	9%	0%	0%	100%	0%
European Honey Buzzard	*Pernis apivorus*	LC	-	1	13	156	36%	90%	1%	<1%	0%
Kentish Plover	*Charadrius alexandrinus*	LC	LC	1	0	0	9%	0%	100%	100%	0%
Long-legged Buzzard	*Buteo rufinus*	LC	LC	2	1	0	27%	0%	0%	0%	0%
Rock Dove	*Columba livia*	LC	LC	1	0	0	9%	0%	0%	100%	0%
Steppe Buzzard	*Buteo buteo vulpinus*	LC	LC	151	239	6	91%	2%	3%	<1%	7%
Steppe Eagle	*Aquila nipalensis*	**EN**	-	6	0	0	27%	17%	0%	0%	0%
Unidentified Raptor	-	-	-	0	22	0	9%	0%	0%	0%	0%

[2] (IUCN 2025)
[3] (Symes *et al.* 2015)

Species that were within 100 m of the OHTL and were flying <50 m high, that may be of higher risk of collisions with the OHTL, include the Kentish Plover (*Charadrius alexandrinus*), Brown-necked Raven (*Corvus ruficollis*), Steppe Buzzard and Black Kite (*Milvus migrans*). It should be noted that wildfowl is a bird group that is sensitive to power line collisions (Prinsen et al. 2011) and all the Common Teal recorded were flying at high collision risk altitudes. The two migratory soaring bird species that were recorded at high-risk altitudes, the Black Kite and the Steppe Buzzard, were more frequently recorded at higher altitudes. In fact, only 4 and 7% of the Black Kites and Steppe Buzzards, respectively, were recorded in the high-risk height class.

3.2. Water Body Counts

There was always water present in every water body that was surveyed (half full or with some pools, Table 6).

Table 6: Water Levels During the Water Body Counts (1 – No Water, 2 – Some Pools, 3 – Half Full, 4 – The Dam Is Full)

Campaign	Point	Water level
1	1	3
	2	3
	3	2
	4	2
2	1	3
	2	3
	3	2
	4	3
	5	2
	6	2
3	1	3
	2	3
	3	2
	4	2
	5	2

Water body counts recorded a total of four waterbird species (see Table 7), none of which are of conservation concern: Common Teal (*Anas crecca*), Common Greenshank (*Tringa nebularia*), Little Stint (*Calidris minuta*) and Spur-winged Lapwing (*Vanellus spinosus*).

Table 7: Summary of Results from Water Body Counts

Species		Conservation status		No. of individuals recorded in Campaign 1	No. of individuals recorded in Campaign 2	No. of individuals recorded in Campaign 3	% of points where it was recorded
Common (English) name	Latin name	Global (IUCN) conservation status[4]	Regional (Arabian Peninsula) conservation status[5]				
Common Teal	*Anas crecca*	LC	-	48	12	0	33%
Common Greenshank	*Tringa nebularia*	LC	-	2	0	0	17%
Little Stint	*Calidris minuta*	LC	-	1	4	0	33%
Spur-winged Lapwing	*Vanellus spinosus*	LC	LC	4	9	3	33%

[4] (IUCN 2025)
[5] (Symes *et al.* 2015)

All four waterbirds recorded during the water body counts were only observed when the water level was half-full (see Table 8). No waterbirds were observed during the four counts when the water level was lower and in the "some pools" category. The species that was more frequently recorded was the Spur-winged Lapwing, but the Common Teal, which recorded only on three occasions, was recorded in higher numbers.

Table 8: Results of the Water Body Counts 1 – No Water, 2 – Some Pools, 3 – Half Full, 4 – The Dam Is Full)

Species	Campaign	Point	Water level	No. of birds
Common Teal	1	1	3	45
	1	2	3	3
	2	1	3	12
Common Greenshank	1	1	3	2
Little Stint	1	1	3	1
	2	1	3	1
	2	4	3	3
Spur-winged Lapwing	1	1	3	3
	1	2	3	1
	2	1	3	6
	2	2	3	3
	3	1	3	2
	3	2	3	1

3.3. Line Transect Surveys

Line transect surveys recorded a total of 25 species across all three campaigns. One species of conservation concern was recorded, the Red-rumped Wheatear *Oenanthe moesta* (1 individual) which is globally Least Concern but regionally Endangered in the Arabian Peninsula. With the exception of this species, all other birds that were recorded belong to common resident species or species that are common migrants in the region.

Table 9: Summary of Results from Line Transect Surveys

Species		Conservation status		Kilometric Abundance Index in Campaign 1	Kilometric Abundance Index in Campaign 2	Kilometric Abundance Index in Campaign 3	% of transects where it was recorded (average between campaigns)
Common (English) name	Latin name	Global (IUCN) conservation status[6]	Regional (Arabian Peninsula) conservation status[7]				
Arabian Green Bee-eater	*Merops cyanophrys*	LC	LC	0	0.11	0	10%
Barn Swallow	*Hirundo rustica*	LC	LC	3.11	0.45	2.51	18%
Blackcap	*Sylvia atricapilla*	LC	LC	0.44	0	0.36	23%
Blackstart	*Oenanthe melanura*	LC	LC	1.33	0.28	1.07	37%
Brown-necked Raven	*Corvus ruficollis*	LC	LC	2.67	0.28	0.36	28%
Common Chiffchaff	*Phylloscopus collybita*	LC	-	0.44	0.45	0.72	18%
Common Swift	*Apus apus*	LC	LC	4.00	0.67	3.22	17%
Crested Lark	Galerida cristata	LC	LC	2.22	0.11	1.07	25%
Desert Lark	*Ammomanes deserti*	LC	LC	2.22	1	0.72	32%
Eurasian Blackbird	Turdus merula	LC	LC	0.44	0	0.72	23%
Eurasian Collared Dove	*Streptopelia decaocto*	LC	LC	2.22	0.84	1.43	40%
House Sparrow	*Passer domesticus*	LC	LC	11.11	4.41	4.66	28%
Isabelline Wheatear	*Oenanthe isabellina*	LC	LC	0.44	0.06	0	15%
Laughing Dove	*Spilopelia senegalensis*	LC	LC	3.11	0	0	25%
Mourning Wheatear	*Oenanthe lugens*	LC	LC	0	0.17	0	10%
Palestine Sunbird	*Cinnyris osea*	LC	LC	0.89	0.61	1.07	25%
Red-rumped Wheatear	*Oenanthe moesta*	LC	**EN**	0	0.06	0	5%
Rock Dove	*Columba livia*	LC	LC	0.89	1.17	1.43	33%
Rock Martin	*Ptyonoprogne obsoleta*	LC	-	0	0.73	0	10%

[6] (IUCN 2025)
[7] (Symes *et al.* 2015)

Species		Conservation status		Kilometric Abundance Index in Campaign 1	Kilometric Abundance Index in Campaign 2	Kilometric Abundance Index in Campaign 3	% of transects where it was recorded (average between campaigns)
Common (English) name	Latin name	Global (IUCN) conservation status[6]	Regional (Arabian Peninsula) conservation status[7]				
Sardinian Warbler	*Curruca melanocephala*	LC	LC	0.89	0.22	0	23%
Spanish Sparrow	*Passer hispaniolensis*	LC	LC	6.67	1.45	5.02	27%
Streaked Scrub-warbler	*Scotocerca inquieta*	LC	LC	0.89	0.22	0	18%
Warbler Sp	-	-	-	0.44	0	1.07	23%
White-spectacled Bulbul	*Pycnonotus xanthopygos*	LC	LC	0	0.06	0	5%
White-crowned Wheatear	*Oenanthe leucopyga*	LC	LC	0.89	0.17	0.72	28%
Yellow Wagtail	*Motacilla flava*	LC	-	0	0.11	0	5%

3.4. Carcass Surveys

Only one fatality was recorded during the carcass surveys of Campaign 1. This was a female Common Quail *Coturnix coturnix* (IUCN Least Concern). The carcass was fresh, and thus fatality occurred sometime before 5th March 2025. The carcass was found at the southern end of the OHTL near Aqaba, ~300 m from the Project's OHTL.

Common Quail is expected to be a relatively common migrant in the region, but difficult to detect via VP and line transect surveys, since it is a nocturnal migrant which is difficult to detect when resting (it is mostly silent during migration).

Searcher efficiency and carcass removal trials have not yet been undertaken, so it is not yet possible to produce mortality estimates.

4. DISCUSSION

Only three species of conservation concern were recorded so far in the area. Two of these are migratory soaring birds: the Egyptian Vulture Steppe Eagle, and the other one, a resident passerine – the Red-rumped Wheatear.

Vantage point surveys allowed to confirm that the area is crossed by high numbers of soaring birds, especially Steppe Buzzards and European Honey Buzzards, along with six other migratory soaring bird species. These birds were mostly recorded flying at high altitudes, above any transmission lines, making collisions unlikely.

The Levant Sparrowhawk, the key species behind the designation of the Aqaba Mountains and Coast as an IBA and KBA was not detected during the surveys. This species is known to migrate in very large flocks, often comprising a significant proportion of the population. As a result, if surveys do not cover the full duration of the migratory period, there is a high likelihood that no individuals will be recorded. There is also some evidence that at least some birds migrate at night, especially those migrating later in the season (Stark & Liechti 1993, Spar *et al.* 1998).

Carcass surveys revealed the presence of only one carcass of a Common Quail. Since searcher efficiency and carcass removal trials were not yet conducted, it is not possible yet to draw conclusions from this result. However, it is likely that searcher efficiency is high, especially for large species, since the area has very sparce vegetation, making it relatively easy to spot any carcasses. Carcass removal, on the other hand may be high because of the presence of many stray dogs in the area.

4.1. Recommendations and Next Steps

For the forthcoming monitoring seasons, surveys should be conducted in all the survey points and transects (when weather conditions don't allow the surveys to be conducted, they should be completed on another date).

It is also very important to conduct searcher efficiency and carcass removal trials following good international industry practice (IFC *et al.* 2023) and to estimate the searchable area for each transect. The results from these trials will allow to use Genest to estimate fatalities in the adjacent OHTL, allowing to predict actual fatalities for the Project's OHTL.

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Appendix 1 Full list of species recorded

Table 10: List of All Species Recorded Across All Spring Surveys (Species of Conservation Concern Are Shown in Bold)

Species	Latin name	Global IUCN conservation status[8]	Regional (Arabian Peninsula) conservation status[9]
Alpine Swift	*Tachymarptis melba*	LC	LC
Arabian Green Bee-eater	*Merops cyanophrys*	LC	LC
Barn Swallow	*Hirundo rustica*	LC	LC
Black Kite	*Milvus migrans*	LC	LC
Blackcap	*Sylvia atricapilla*	LC	LC
Blackstart	*Oenanthe melanura*	LC	LC
Booted Eagle	*Hieraaetus pennatus*	LC	-
Brown-necked Raven	*Corvus ruficollis*	LC	LC
Common Chiffchaff	*Phylloscopus collybita*	LC	-
Common House Martin	*Delichon urbicum*	LC	LC
Common Kestrel	*Falco tinnunculus*	LC	LC
Common Stonechat	*Saxicola torquatus*	LC	LC
Common Swift	*Apus apus*	LC	LC
Common Teal	*Anas crecca*	LC	-
Crested Lark	*Galerida cristata*	LC	LC
Desert Lark	*Ammomanes deserti*	LC	LC
Egyptian Vulture	*Neophron percnopterus*	**EN**	**VU**
Eurasian Blackbird	*Turdus merula*	LC	LC
Eurasian Collared Dove	*Streptopelia decaocto*	LC	LC
European Honey-buzzard	*Pernis apivorus*	LC	-

[8] (IUCN 2025)
[9] (Symes et al. 2015)

Species	Latin name	Global IUCN conservation status[8]	Regional (Arabian Peninsula) conservation status[9]
Greenshank	*Tringa nebularia*	LC	-
Hooded Wheatear	*Oenanthe monacha*	LC	LC
House Sparrow	*Passer domesticus*	LC	LC
Isabelline Wheatear	*Oenanthe isabellina*	LC	LC
Kentish Plover	*Charadrius alexandrinus*	LC	LC
Laughing Dove	*Spilopelia senegalensis*	LC	LC
Little Stint	*Calidris minuta*	LC	-
Long-legged Buzzard	*Buteo rufinus*	LC	LC
Mourning Wheatear	*Oenanthe lugens*	LC	LC
Northern Wheatear	*Oenanthe oenanthe*	LC	LC
Palestine Sunbird	*Cinnyris osea*	LC	LC
Red-rumped Wheatear	*Oenanthe moesta*	LC	**EN**
Rock Dove	*Columba livia*	LC	LC
Rock Martin	*Ptyonoprogne obsoleta*	LC	-
Sardinian Warbler	*Curruca melanocephala*	LC	LC
Spanish Sparrow	*Passer hispaniolensis*	LC	LC
Spur-winged Lapwing	*Vanellus spinosus*	LC	LC
Steppe Buzzard	*Buteo buteo*	LC	LC
Steppe Eagle	*Aquila nipalensis*	**EN**	-
Streaked Scrub-warbler	*Scotocerca inquieta*	LC	LC
Temminck's Lark	*Eremophila bilopha*	LC	LC
White-crowned Wheatear	*Oenanthe leucopyga*	LC	LC
White-spectacled Bulbul	*Pycnonotus xanthopygos*	LC	LC
Yellow Wagtail	*Motacilla flava*	LC	-

Project: Aqaba-Amman Water Desalination and Conveyance (AAWDC)

2025 Environmental and Social Impact Assessment

Appendix 6-11 Terrestrial Baseline Survey Report

Aqaba-Amman Water Desalination and Conveyance Project (AAWDCP)

Fauna and Flora Field Studies



Submitted to ECO Consult

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Annex 1. Vegetation species richness and plant cover.

1. EXECUTIVE SUMMARY

Jordan is relatively a small country. Its position as part of the Eastern Mediterranean region along with its geological properties, has created several bioclimatic regions within the country and hence a variety of ecosystems habitats and species. As part of Jordan's commitment to conserve its biological heritage and satisfy its obligations to international conventions, and national laws and regulations it became mandatory that any planned development will need to assess its impact on biological diversity and implement environmental management of such developments to mitigate anticipated impacts and protect biodiversity.

The current study aims at informing the development agencies by providing ecological and biological baseline information at planed development areas so that development can mitigate any expected adverse impacts on diversity of species as well as ecological integrity within the country. The current study is an attempt to describe the biodiversity within the Aqaba-Amman Water Desalination and Conveyance Project area.0

The proposed pipeline route was sub-divided by the study team to ease the description of the biological diversity, ecosystems and habitats. This division of the route resulted into nine segments taking into consideration the biogeographical setting, ecosystem integrity, habitats and nature of the landscape. It is recommended that before commencing the planned excavation this ecological baseline study and the preparation of impact assessment be updated to accommodate alterations from the currently assessed proposed pipeline route.

Based on the field studies, segment 6 was the most interesting with the presence of species that require protection. The Egyptian Spiny-tailed Lizard, *Uromastyx aegypia* (Vulnerable), was found in different locations along segment 6. In addition, *Vachellia gerrardii* (Vulnerable), was found to occupy a relatively confined areas along the pipeline. Other species of interest includes *Vachellia tortilis* (Vulnerable), *Haloxylon persicum* (Vulnerable).

The current study was conducted through combined multi database desktop (literature review) studies and ground truthing field surveys. These studies aimed at defining the biogeographical regions influencing biodiversity at each of the sections and accordingly defining the general vegetation types occurring within each of these sections and emphasis on species diversity both flora and fauna occurring within the boundaries of these sections. More details were given on status of species recorded or expected to occur within the boundaries of these sections.

TEAM COMPOSITION

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2. BIOGEOGRAPHICAL SETTINGS

2.1 Biogeographical Regions of Jordan

Jordan is influenced by four major biogeographic regions. Vegetation cover, soil texture, altitude and annual rain fall are among the major factors that shaped these biogeographic regions. Al-Eisawi (1985) and Disi & Amr (1998) agreed on the delineation of these four regions based on vegetation cover as well as animal distribution in Jordan. However, Taifour (2022) resented the most updated map for the biogeographical regions of Jordan that is based on vegetation map and other variables (Figure 1).

1. The Mediterranean region: This region is represented by the mountain ranges extending from the north near Irbid, to Ras Al Naqb in the south. It consists of forested vegetation with an abundance of *Juniperus phoenicea, Retama raetam*, *Pistacia atlantica, Pinus halepensis, Quercus calliprinos, Quercus coccifera* and *Quercus ithaburensis*. Open areas are characterized by high cover of the Thorny Burnet, *Sarcopoterium spinosum.* The altitude varies from 700 to 1500 m asl, with an average annual rain fall of 400-600 mm. The soil consists of several types, *terra rosa*, sandy and sandy-loamy due to erosion of the Nubian sandstone that dominates much of southern part of Jordan, and calcareous soil in the centre and north. Irano-Turanian region: This region is represented by a narrow strip that surrounds the Mediterranean ecozone except in the far north.
2. The Irano-Turanian region extends to the north-east, joining the Syrian Desert. The vegetation is dominated by *Anabasis articulata, Artemesia herba-alba, Astragulus spinosum, Retama raetam, Urginea maritima***,** *Ziziphus lotus, Zygophyllum dumosum* and *scattered Juniperus phoenicea* and *Pistacia atlantica* trees (Fig. 7 and 8). The altitude ranges from 400 to 700 m asl, with average annual rainfall of 50-100 mm. The layer of surface soil is very thin or absent in some instances and surface rockiness is very high.
3. Saharo-Sindian - Nubo-Sindian subzon: This region extends from the south near Aqaba along Wadi Araba reaching as far north as Dayr Alla in the Jordan Valley, then extends to south eastern Jordan around Wadi Rum, with sandstone mountains and granite mountains to the east. Acacia subtropical vegetation extends from 0 to 400 m asl, with annual precipitation of less than 50 mm. Trees of both *Acacia raddiana* and *Acacia tortilis* are common in varying densities. Other trees such as *Tamarix* spp., *Ziziphus spina-christi*, *Zygophyllum dumosum,* are also common. Shrubs including *Aanabasis articulata, Gymnocarpos decandrum, Haloxylon persicum,* and *Lycium* sp. are abundant. Soil is mostly sandy with rocky areas. Wadis are filled with alluvial materials washed from the calcareous sandstones.
4. Saharo-Sindian - Arabian regional subzone: This is the largest biogeographical region of Jordan and covers over 70% of the total area of the country. It is located to the east bordering the Irano-Turanian region from the west and the Sudanian Penetration region from the southwest. The sand dune desert vegetation is dominated by *Haloxylon persicum, Hammada scoparia* and *Ochradenus baccatus.* Open areas and wadi beds are characterized by *Achillea fragrantissima*, *Artemisia herba-alba,* and *Astragalus* sp. Few scattered *Acacia tortilis* are also found. The soil mostly consists of gravel, sandy Hamada, saline and sandy soils. The altitude ranges from 100 m bsl to 800 m asl, with rainfall not exceeding 50 mm annually. Within this region, Azraq Oasis, stands as landmark in the middle of Jordan's east.

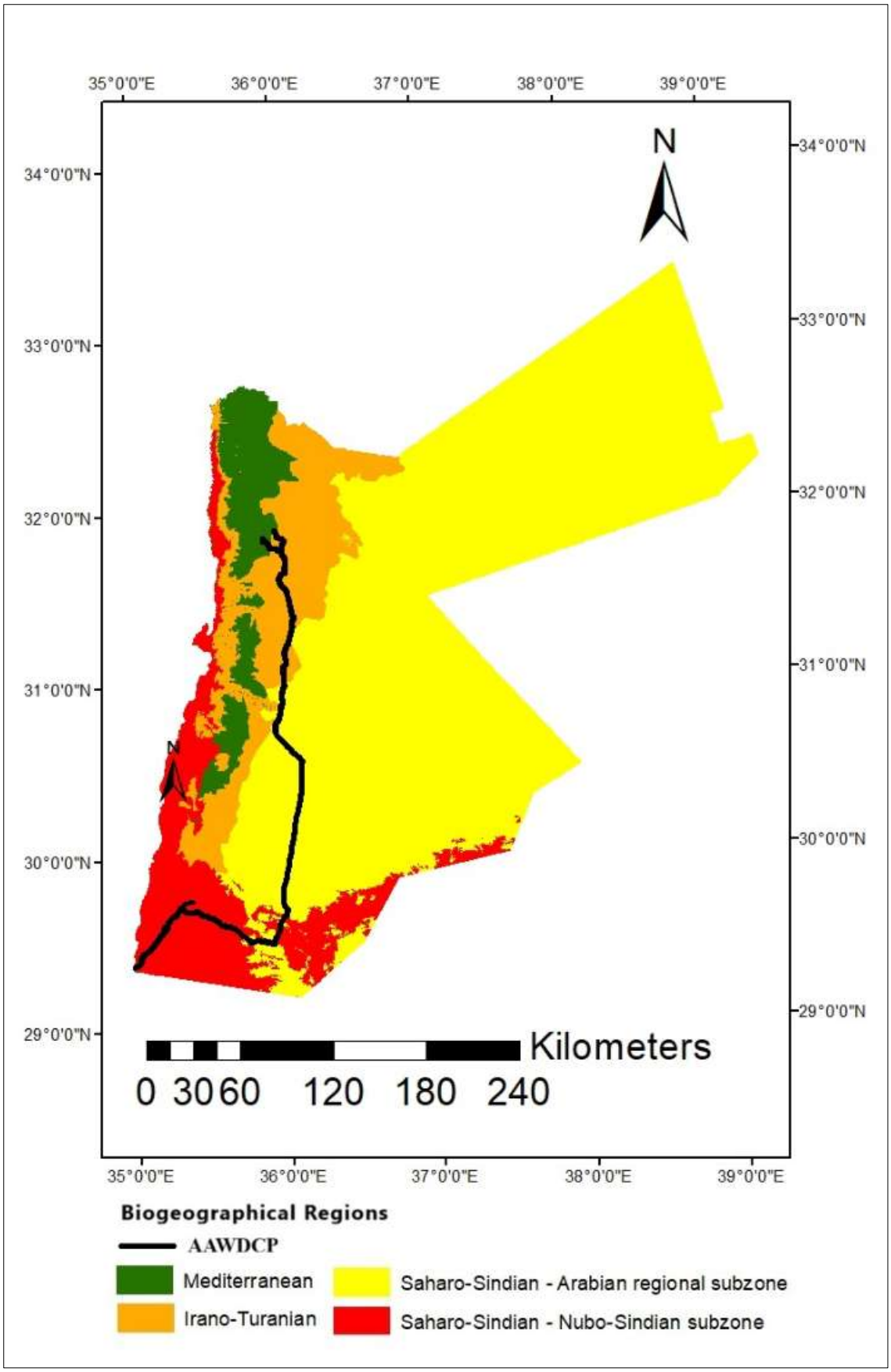


Figure 1. Biogeographical regions of Jordan based on Taifour et al. (2022).

Segments 1-5 are within the Sudanian Penetration region, while segment 6 is mostly within the Saharo-Arabian region. Segment 7 is associated with the Irano-Turanian region that surrounds the Mediterranean region to the east and extends along the desert high to Amman. Segment 8 is a mix of both the Mediterranean and the Irano-Turanian regions, whereas its southern end is Irano-Turanian. Segment 9 is strictly Mediterranean with *terra rossa* soil and small forests of *Pinus halepensis*.

2.2 Vegetation types of Jordan

Vegetation types of Jordan were studied by several authors, however, the most comprehensive and applicable maps were produced by Al-Eisawi (1985) and Alberts *et al.* (2004). Both maps are similar with minor modifications. Al-Eisawi (1985) recognized 13 vegetation types; pine forests, Evergreen pine forests, deciduous oak forests, Junipers forests, Mediterranean non-forest, steppe, Hamada, saline (halophytic), tropical, sand dunes, and rocky Sudanian, water (hydrophytic) and mud flat vegetation.

Nineteen different vegetation types were identified by Alberts *et al*. (2004) including *Artemisia herba-alba* steppe, *Noaea mucronata* brush, grass land steppe, mixed steppe and Saharo-Arabian, basalt scrub, chert Hamada, sandy hamada, Acacia woodlands, *Ziziphus spina-christi* and *Balanites aegyptiacus*, weathered sand stone and granite scrub, sand dunes, aquatic and saline marshlands, slat and mud flats, *Quercus calliprinos* maquis, deciduous oak forests, *Pinus halepensis* forests, Phoenician Juniper forests, batha steppe and Mediterranean non-forest batha vegetation.

Taifour et al. (2022) Based on satellite image interpretation, proposed two maps created: an unsupervised land cover/land use map and a supervised map of present-day vegetation types, both consisting of 18 categories. These new maps should inform ecosystem management and conservation planning decisions in Jordan over the coming years (Figure 2).

Segments 1-3 are within the granite and sandstone shrubland, while segments 4 and 5 are influenced by granite and sandstone shrubland and sand dune vegetation around the northern edge of Wadi Rum. Segment 6 is mostly withing the sandy gravel hammada vegetation with *Vachellia gerrardii, Artemisia judaica*, and *Hammada scoparia.*

Segment 7 represents steppes vegetation that associated with the Irano-Turanian biogeographical region. On the other hand, segment 8 is also considered as steppes, with very little of the Garrigue and batha. Segment 9 Garrigue and batha is within the Mediterranean region that do not support forests under current physical and climatic conditions, represented by *Sarcopoterium spinosum*, among other small shrubs

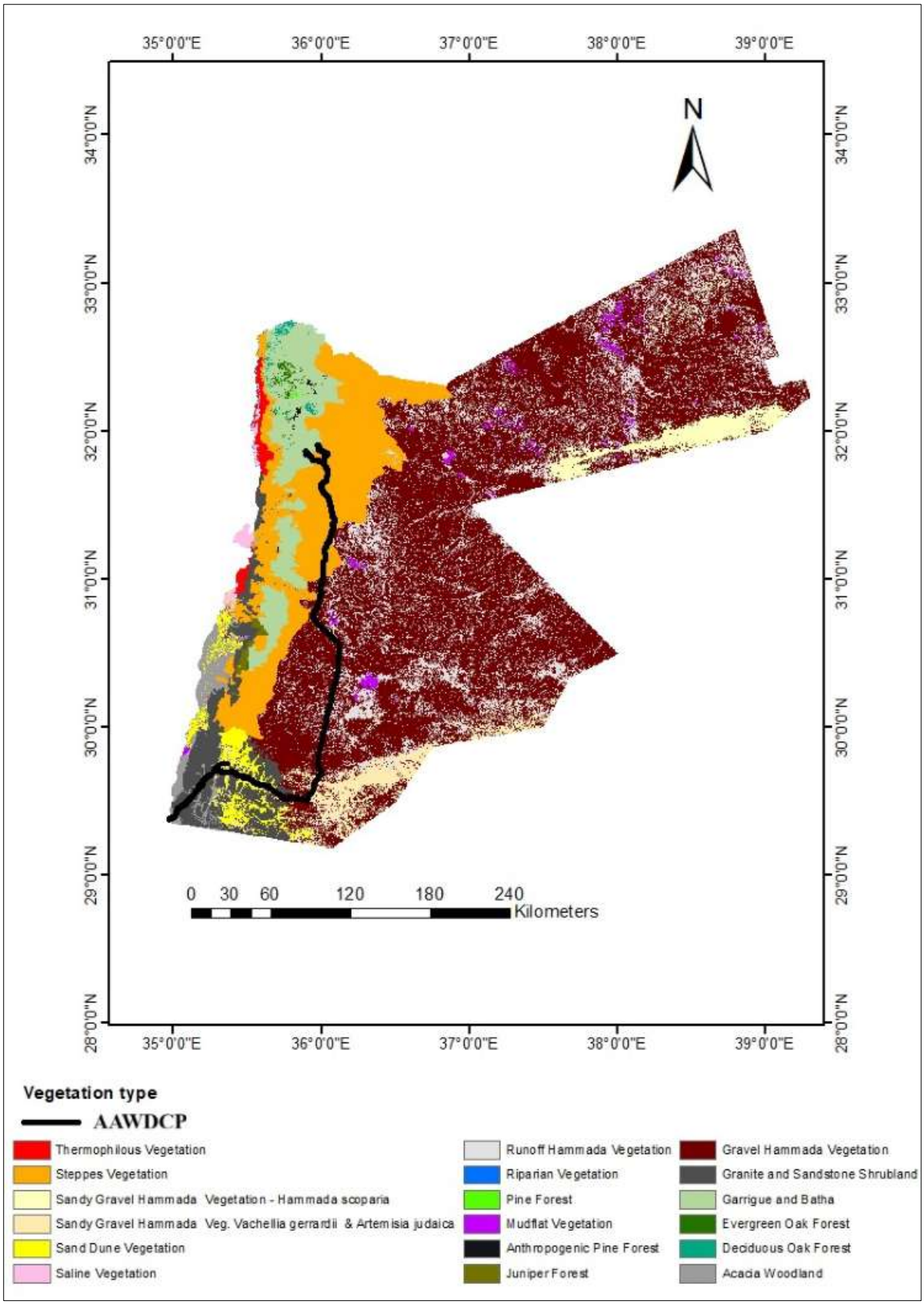


Figure 2. Vegetation map of Jordan based on Taifour et al. (2022).

2.3 Established Protected Areas

Twelve protected areas have been declared, 11 are under the supervision of the Royal Society for the Conservation of Nature, and one, Wadi Rum, is operated by Aqaba Special Economic Zone. Segments 4 and 5 are within the northern boundaries of Wadi Rum Protected area (



Figure 3).



Figure 3. Established protected areas in Jordan.

Proposed Aqaba Mountains PA

The following information were provided by the Royal Society for Conservation of Nature.

"The Aqaba Mountains Proposed Protected Area covers approximately 105 km^2 in southern Jordan, forming part of the rugged mountainous terrain overlooking the Gulf of Aqaba at the southernmost tip of the Rift Valley.

Ecologically, the Aqaba Mountains Proposed Protected Area is of outstanding significance due to its distinctive Sudanian vegetation and high diversity of desert-adapted flora and fauna. The granite slopes and wadis support *Acacia tortilis* woodlands and Sudanian rocky desert vegetation, both rare and underrepresented in Jordan's protected area network. These habitats serve as vital refuges for wildlife such as the Nubian ibex, Arabian wolf, and numerous reptile and bird species, including migratory birds moving along the Rift Valley corridor. The area's rugged terrain, intact vegetation layers, and minimal human disturbance enhance its conservation value and resilience to climate change, while contributing to the ecological connectivity between terrestrial and marine ecosystems around the Gulf of Aqaba.

Geologically, the Aqaba Mountains exhibit exceptional diversity and scientific value, representing one of the most complex segments of the Arabo-Nubian Shield along the Dead Sea Transform Fault. The region comprises ancient Precambrian basement rocks, including the Aqaba and Araba complexes, intruded by multiple granite suites such as the Yutum, Rahma, and Rumman suites. These are intersected by numerous doleritic and andesitic dykes that reveal the area's long tectono-magmatic history. Overlying these are Cambrian to Cenozoic sedimentary formations, including the Ram Group sandstones and Naur Limestone, recording ancient fluvial and marine environments. The landscape's faulted and tilted structures, coupled with recent alluvial and coral deposits, make the Aqaba Mountains a natural laboratory for studying the geological evolution of the Red Sea Rift system and the tectonic interaction between the African and Arabian plates."

2.4 Important Bird Areas

So far, 27 IBA's have been identified representing a wide variety of areas including the eastern desert, Jordan Vallley northern mountains, Wadi Araba and Wadi Rum area (Figure 4).

Segments 4 and 5 are within the northern end of Hisma Basin-Rum. This is an isolated tract of huge, precipitous, sandstone and granite mountains, ranging up to 1754 m (Jebel Rum), separated from each other by flat sandy corridors. Main use is tourism and pastoralism.

Breeding birds include Short-toed Eagle, Verraux's Eagle (former breeder), Lanner Falcon (rare), Barbary and Sooty Falcons, Lesser Kestrel (rare), Lammergeier (former breeder), Griffon Vulture (rare), Sand Partridge, Chukar, Hume's Tawny Owl, Hooded, Mourning and White-crowned Black Wheatears, Arabian Babbler, Tristram's Grackle, Sinai Rosefinch and Trumpeter Finch. Winter visitors include Steppe Eagle, Saker (rare), Desert Warbler and Pale Rock Sparrow (rare). Imperial Eagle, Honey Buzzard, Egyptian Vulture (may breed), Crane and White Stork are uncommon autumn migrants (Jbour, 2018).



Figure 4. Important bird areas in Jordan.

Uncontrolled off-road driving is causing destruction of the sand dune habitats. Parts of this site have been declared protected, while other areas at Disi and Sahl As-Suwwan are used for intensive agricultural.

2.5 Key Biodiversity Areas

The pipeline crosses two key biodiversity areas, the Aqaba mountains at segment 1 and 2, and then at segment 4 and 5 in Wadi Rum area. The Aqaba mountains area is very much degraded as observed during the survey. It is mostly used by trucks, causing considerable damage to the area by the amount of garbage resulted from old tires and oil spells. The northern part of Rum key biodiversity area is still intact, with evidence of degradation near human settlements and agricultural areas, in addition to tourism activities (Figure 5).

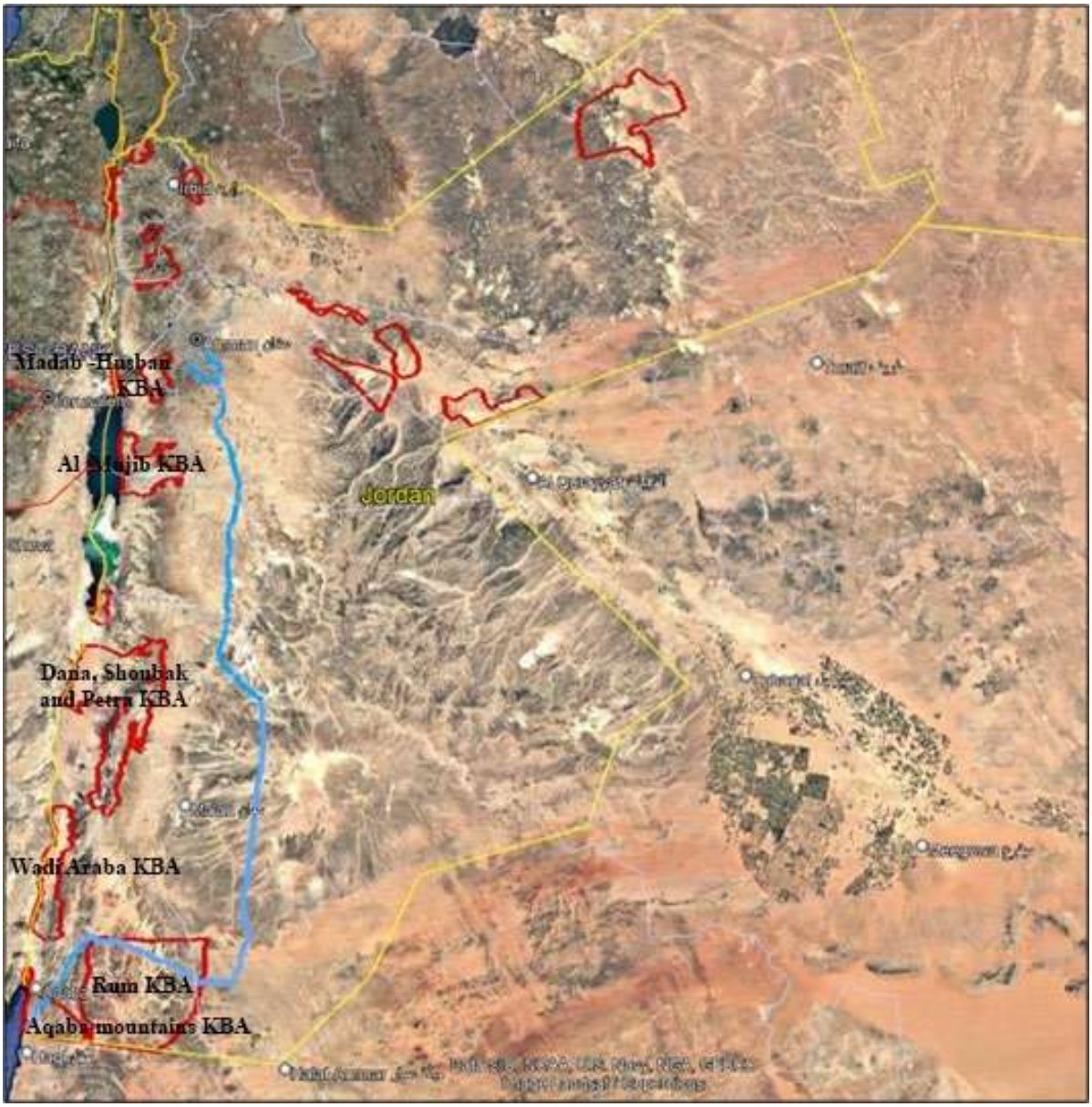


Figure 5. Key biodiversity areas in Jordan.

2.6 Rangeland Reserves

A total of 22 rangeland reserves have been idntfied in Jordan (Figure 6). Dab'a Grazing Reserve is the only rangeland reserve that is in close vicinity of the pipeline rout. It is located about 10 km east of the desert highway. We visited this reserve two times in order to establish the presence of Jordan's fringe-fingered lizard, *Acanthodactylus ahmaddisii*. We did not observed this lizard within the rangeland or within the three locations in Dab'a.



Figure 6. Rangeland reserves in Jordan.

3. LITERATURE REVIEW

3.1 Flora of Southern Jordan (Aqaba, Wadi Rum, Al-Jafr)

3.1.1 VEGETATION COVER OF SOUTHERN JORDAN: A LITERATURE REVIEW FOR AQABA, WADI RUM, AND AL-JAFR

This literature review synthesizes current knowledge on the vegetation cover of the southern region of Jordan specifically Aqaba, Wadi Rum, and the Al-Jafr depression. Building on recent vegetation mapping and biogeographic analyses, we summarize dominant habitat types, characteristic and indicator species, altitudinal and edaphic controls, seasonality, and conservation concerns. Where possible, we integrate satellite-derived insights on cover and trend, and highlight priorities for monitoring and restoration.

1. Study Area and Physical Setting

The focus area spans the Saharo-Arabian desert belt at the southern tip of Jordan, including the coastal mountains overlooking Aqaba, the granite and Nubian sandstone massifs and dune corridors of Wadi Rum, and the broad, dish-shaped Qaa' Al-Jafr depression to the east. Elevations range from approximately 150 m below sea level along the Araba valley to over 1,800 m at Jabal Umm Ad Dami, driving sharp climatic and floristic gradients. Geomorphology alternates between rocky massifs, glacis and alluvial fans, mobile and semi-stabilized dunes, mudflats (qaas), and ephemeral wadi systems.

2. Phytogeographical Context

Southern Jordan lies primarily within the Saharo-Arabian (Saharo-Sindian/Nubo-Sindian) regional subzone with embayments of Sudanian (thermophilous) elements along the Dead Sea–Araba corridor and localized Mediterranean enclaves on high, cooler slopes (e.g., the Ras an-Naqab–Sharah range). This juxtaposition produces a mosaic of desert, halophytic, and enclavic woodland/shrubland communities.

3. Evidence Base and Methods

This synthesis draws from Jordan-wide vegetation maps and theses, classical regional floras, Red List assessments, and topographic and morphologic atlases. We also incorporate habitat-level species lists and eco-indicator relationships reported for southern deserts, complemented by remote-sensing interpretations where relevant.

4. Major Habitat Types and Communities

4.1 Sand Dune Vegetation (Wadi Rum & Southern Wadi Araba)

Weathered Nubian sandstone and extensive dune fields, interdigitating with flat sand corridors between granite–sandstone massifs. Cover is typically sparse (1–15%, often ~5%) but visually dominant across >60% of the Wadi Rum landscape. Altitudinal envelope spans ~200 m below sea level to ~1,400 m above sea level.

Early successional grasses (e.g., *Stipellula capensis*) and sedges (*Carex divisa*) yield to dune-binding shrubs such as *Panicum turgidum* and *Zilla spinosa*, with a late-successional/edaphic climax dominated by *Haloxylon persicum* (white saxaul). Frequent associates include *Retama raetam, Hammada salicornica, Anabasis articulata*, and *Caroxylon tetrandrum*; characteristic annuals include *Neurada procumbens*.

Dune stabilization depends on episodic wet years and protection from trampling. Saxaul and Retama serve as keystone nurse shrubs, enhancing microsite moisture and facilitating herbaceous diversity. (Figure 6).



Figure 7: Sand dune vegetation.

4.2 Granite & Sandstone Shrubland (Rum–Sharah Range; Petra Highlands)

Granite and sandstone massifs from Wadi Rum through Petra and into the Dead Sea mountains. Vegetation occupies rock pavements, crevices, and colluvial pockets on slopes and benches.

Open shrubland with scattered small trees. Characteristic trees include *Pistacia khinjuk* and *Ficus palmata;* shrubs and subshrubs such as Lavandula pubescens and *Daphne mucronata* subsp. *linearifolia* mark cooler, rocky refugia. Succulent and chamaephyte elements (e.g., *Caralluma europaea*) are locally frequent*; Poa sinaica* occurs in sheltered microsites.

These habitats function as climatic refugia with higher beta-diversity than adjacent dunes; they also harbour localized endemics and disjunct Mediterranean elements on north-facing ledges. (Figure 6)



Figure 8: Granite and sandstone shrubland vegetation.

4.3 Acacia Woodland (Aqaba Mountains & Wadi Araba)

Gravelly plains, glacis, and alluvial fans; denser stands occur along mountain piedmonts and in wadi beds where runoff concentrates. Canopy is typically discontinuous, with shrub and annual layers responding to episodic rainfall pulses.

Dominant trees are *Vachellia tortilis* subsp. *tortilis* and *V. tortilis* subsp. *raddiana*. Frequent shrub/herb associates include *Hammada salicornica, Anabasis articulata, Senna italica*, and *Asteriscus graveolens*. Where groundwater is accessible, *Phoenix dactylifera* and *Tamarix* spp. may interface with riparian pockets.

Recruitment is episodic and tightly linked to rare wet years; browsing pressure and fuelwood cutting reduce sapling survival. Long inter-recruitment intervals render populations vulnerable to climate-driven aridification. (Figure 6)



Figure 9: Acacia woodland.

4.4 Mudflat (Qaa') Vegetation (Al-Jafr Depression and Southern Pans)

Fine-grained silt–clay pans with saline–alkaline tendencies, often inundated after major storms and desiccating to polygonal crusts. Vegetation is concentrated at edges and micro-elevations.

Halophytic shrubs and subshrubs dominate edges and hummocks. Common large shrubs include *Capparis ovata/leucophylla, Nitraria retusa, and Tamarix spp.;* smaller halophytes include *Frankenia hirsuta* and *Suaeda* spp.; *Aeluropus littoralis* may form graminoid patches. Overall cover is sparse (often ~2%).

Pans function as ephemeral wetlands with high spatiotemporal variability. Vehicle tracks and overgrazing increase salinization and inhibit recovery of edge vegetation. (Figure 6)



Figure 10: Mudflat (Qaa') vegetation

4.5 Halophytic and Thermophilous Enclaves (Dead Sea–Araba Corridor)

Halophytic communities occupy saline alluvium and sabkha margins with *Tamarix* spp., *Atriplex* spp., *Suaeda fruticosa,* and *Nitraria retusa*. Thermophilous enclaves *Ziziphus spina-christi, Balanites aegyptiaca, Calotropis procera, and Moringa peregrina* occur in warm wadis and south-facing slopes, particularly toward Aqaba. (Figure 6)



Figure 11: Halophytic and thermophilous enclaves,

4.6 Riparian pockets (Springs, wadis, and oases)

Highly localized perennial-flow habitats support *Populus euphratica*, *Tamarix spp., Nerium oleander, Phragmites australis,* and *Phoenix dactylifera.* These systems provide critical drought refuges and corridors for fauna and flora, but are extremely sensitive to groundwater abstraction and flash-flood scouring (Figure 6). This type is not present within the study area.



Figure 12: Riparian vegetation.

5. Species Richness, Endemism, and Indicators

While absolute species richness is lower than in northern Mediterranean districts, southern desert habitats host specialized xerophytes and several regionally significant taxa. Indicator species include *Haloxylon persicum* and *Retama raetam* for stabilized dunes; *Vachellia tortilis* (s.l.) for desert woodlands; *Frankenia hirsuta* and *Suaeda* spp. for saline pans; and *Ziziphus spina-christi* and *Balanites aegyptiaca* for thermophilous enclaves. Local endemics and Mediterranean relicts persist in granite–sandstone refugia.

6. Pressures and Threats

Key pressures include: (1) grazing and browsing (especially acacia seedling/sapling removal), (2) fuelwood cutting, (3) off-road vehicle disturbance on dunes, (4) groundwater abstraction reducing riparian refugia, and (5) climate-driven aridification that lengthens inter-recruitment intervals for keystone shrubs and trees. Projected futures suggest relative persistence of Rum's dunes, localized contraction of granite–sandstone shrublands, and retreat of acacia woodlands from the hottest, driest exposures by late century, particularly under high-emission scenarios.

3.2 Fauna of Southern Jordan (Aqaba, Wadi Rum, eastern desert and Al-Jafr)

3.2.1 DIVERSITY OF MAMMALS IN AQABA

The study site in particular was not studied in detail in previous faunal studies. However, scattered records from Aqaba area are scanty (Table 1). Two bats, seven small rodents, one hare, one artiodactyle

and three carnivores were recorded from Aqaba area (Allen, 1915; Bromage, 1954; Kock & Nader, 1983; Qumsiyeh *et al*., 1986 and 1993; Disi & Amr, 1988; Benda et al., 2010; Amr, 2012).

Table 1. Terrestrial mammals recorded from the vicinity of the study area.

Common Name	Scientific Name	Localities	Reference
European Free-tailed Bat	*Tadarida teniotis*	Aqaba	(Benda et al., 2010)
Kuhl'sPipistrelle	*Pipistrellus kuhli*	Aqaba	(Benda et al., 2010)
Wagner's Gerbil	*Dipodillus dasyurus*	Al Jafr	(Qumsiyeh et al., 1986;Disi&Amr, 1988)
Eastern Spiny Mouse	*Acomys dimidiatus*	Aqaba	(Allen, 1915; Disi&Amr, 1988)
Golden Spiny Mouse	*Acomys russatus*	Aqaba	(Amr, 2012)
Lesser Egyptian Gerbil	*Gerbillus gerbillus*	Aqaba	Allen (1915)
Baluchistan Gerbil	*Gerbillus nanus*	Aqaba	Allen (1915; Kock& Nader, 1983)
Sundevall'sJird	*Meriones crassus*	Aqaba	(Disi&Amr, 1988)
Fat Sand Jird	*Psammomys obesus*	Aqaba	(Amr, 2012)
Arabian Hare	*Lepus capensis*	Aqaba Highway	(Amr&Disi, 1988)
The Nubian Ibex	*Capra nubiana*	Aqaba Mountains	(Amr, 2012)
The Wolf,	*Canis lupus*	Aqaba	(Bromage, 1954)
Sand Fox	*Vulpes rueppellii*	2 Km SE Aqaba	(Qumsiyeh*et al*., 1993)
Red Fox	*Vulpes vulpes*	observed	Amr observation

Table 2. Status of mammals recorded from Aqaba area.

Common Name	Scientific Name	IUCN status	Local status
European Free-tailed Bat	*Tadarida teniotis*	LC	C
Kuhl'sPipistrelle	*Pipistrellus kuhli*	LC	C
Wagner's Gerbil	*Dipodillus dasyurus*	LC	C
Eastern Spiny Mouse	*Acomys dimidiatus*	LC	C
Golden Spiny Mouse	*Acomys russatus*	LC	C
Lesser Egyptian Gerbil	*Gerbillus gerbillus*	LC	C
Baluchistan Gerbil	*Gerbillus nanus*	LC	C
Sundevall'sJird	*Meriones crassus*	LC	C
Fat Sand Jird	*Psammomys obesus*	LC	C
Arabian Hare	*Lepus capensis*	LC	C
The Nubian Ibex	*Capra nubiana*	V	T
The Wolf,	*Canis lupus*	LC	T
Sand Fox	*Vulpes rueppellii*	LC	T
Red Fox	*Vulpes vulpes*	LC	C

3.2.2 DIVERSITY OF REPTILES IN AQABA

Virtually very little is known about the reptiles of Aqaba area. All records are extracted from Disi *et al.* (2001), Amr & Disi (2011) and for the newly described species from nearby Aqaba, *Pseudotrapelus aqabensis* (Melnikov *et al*., 2012).

Family Gekkonidae includes six species (Table 3). Other noteworthy species of limited distribution in Jordan are *Tropiocolotes nattereri* and *Pristurus guweirensis.* Family Agamidae includes two species. Species of special interests include the Egyptian Spiny–tailed Lizard*, Uromastyx aegyptia.* It remains to clarify the taxonomic status of *Pseudotrapelus sinaitus,* after the description of the new species, *Pseudotrapelus aqabensis* by Melnikov *et al*. (2012) from nearby Aqaba. Further specimens should be collected to verify the presence of this species within Aqaba region.

Family Lacertidae or the true lizards are represented by three species. All are common species with a wide range of distribution. Family Scincidae includes one species. *Chalcides ocellatus.*Family Colubridae: This family is represented by five species (Table 3). The genus *Platyceps*is represented by two species, one of which is rare and can be considered as key species; *Platyceps elegantissimus.* FamilyViperidae is represented by one venomous species, the Arabian Saw-Scaled Viper, *Echis coloratus.* It is confined to the rocky habitats of Aqaba Mountains

Table 3. Reptiles recorded from Aqaba area.

Species	Common Name	IUCN Status	Local Status
Family Gekkonidae			
Bunospus tuberculatus	The Baluch Ground Gecko	LC	C
Cyrtopodion scabrum			
Pristurus guweirensis	Blanford's Semaphore Gecko	LC	C
Ptyodactylus guttatus	Sinai Fan-fingered Gecko	LC	C
Ptyodactylus hasselquistii	Hasselquist's Fan-footed Gecko	LC	C
Tropiocolotes nattereri	Natterer's Pigmy Gecko	LC	C
Family Agamidae			
Pseudotrapelus aqabensis	Aqaba Agama	?	?
Uromastyx aegyptia	Egyptian Spiny–tailed Lizard	NT	NT
Family Lacertidae			
Acanthodactylus boskianus	Bosk's Fringe-toed Lizard	LC	C
Mesalina brevirostris	Blanford's Short-nosed Desert Lizard	LC	C
Mesalina olivieri	Olivier's Sand Lizard	LC	C
Family Scincidae			
Chalcides ocellatus	Ocellated Skink	LC	C
Family Colubridae			
Platyceps elegantissimus	The Most Beautiful Whip Snake	DD	T
Platyceps rhodorachis	Jan's Whip Snake	LC	C
Psammophis schokari	Forskål's Sand Snake	LC	C
Spalerosophis diadema	Clifford's Snake	LC	C
Telescopus dhara	The North- African Cat Snake	LC	C
Family Viperidae			
Echis coloratus	The Arabian Saw-Scaled Viper	LC	C

3.3 Animal Biodiversity of Wadi Ramm

3.3.1 DIVERSITY OF REPTILES IN WADI RAMM

Few studies focused on the reptiles of Wadi Ramm and its vicinity. The earliest studies were those of Amr *et al*. (1994), Modrý *et al*. (1999), Al-Oran (2000), Disi *et al.* (2001) Rifai *et al*. (2003) and Amr & Disi (2012). Later, two main papers discussed in detail the herpetofauna of Wadi Ramm (Abu Baker *et al*., 2004; Amr *et al.,* 2007). The outstanding find of a new subspecies from Wadi Ramm, *Phoenicolacerta kulzeri khazaliensis,* was published by Modrý *et al*. (2013). Melnikov *et al*. (2014) revised the taxonomic status of *Phrynocephelus arabicus,* where they replaced this species with *Phrynocephelus nejdensis* for Jordan.

Table 4 shows the number of species per family, whereas Gekkonidae, Lacertidae and Colubridae constituted the highest number of species.

Table 4. Reptilian species composition by family.

Family	No. of species	% of total species
Gekkonidae	8	22.9
Chamaeleonidae	1	2.9
Agamidae	4	11.4
Lacertidae	7	20
Scincidae	3	8.5
Varanidae	1	2.9
Leptotyphlopidae	1	2.9
Colubridae	8	22.9
Viperidae	2	5.6
Total	35	100

The desert of Wadi Ramm enjoys a comparatively rich reptilian biodiversity. A total of 35 species of reptiles representing nine families (Gekkonidae, Chamaeleonidae, Agamidae, Lacertidae, Scincidae, Varanidae, Leptotyphlopidae, Colubridae, and Viperidae) were recorded from different habitats in Wadi Ramm and its closest vicinity (Table 4).

Family Gekkonidae includes eight species (Figure 13). The most striking species of Wadi Ramm is *Hemidactylus mindiae.* This species was mistaken for many years as *Hemidactylus turcicus.* It prefers walls of canyons in Khazali Mountain and Al Nughra area, where it was first recorded. Other noteworthy species of limited distribution in Jordan are *Tropiocolotes nattereri* and *Pristurus guweirensis.* One more species to be explored, *Ptyodactylus ananjevae,* the newly described species from Al Mudawra, Jordan (Nazarov *et al*., 2013)

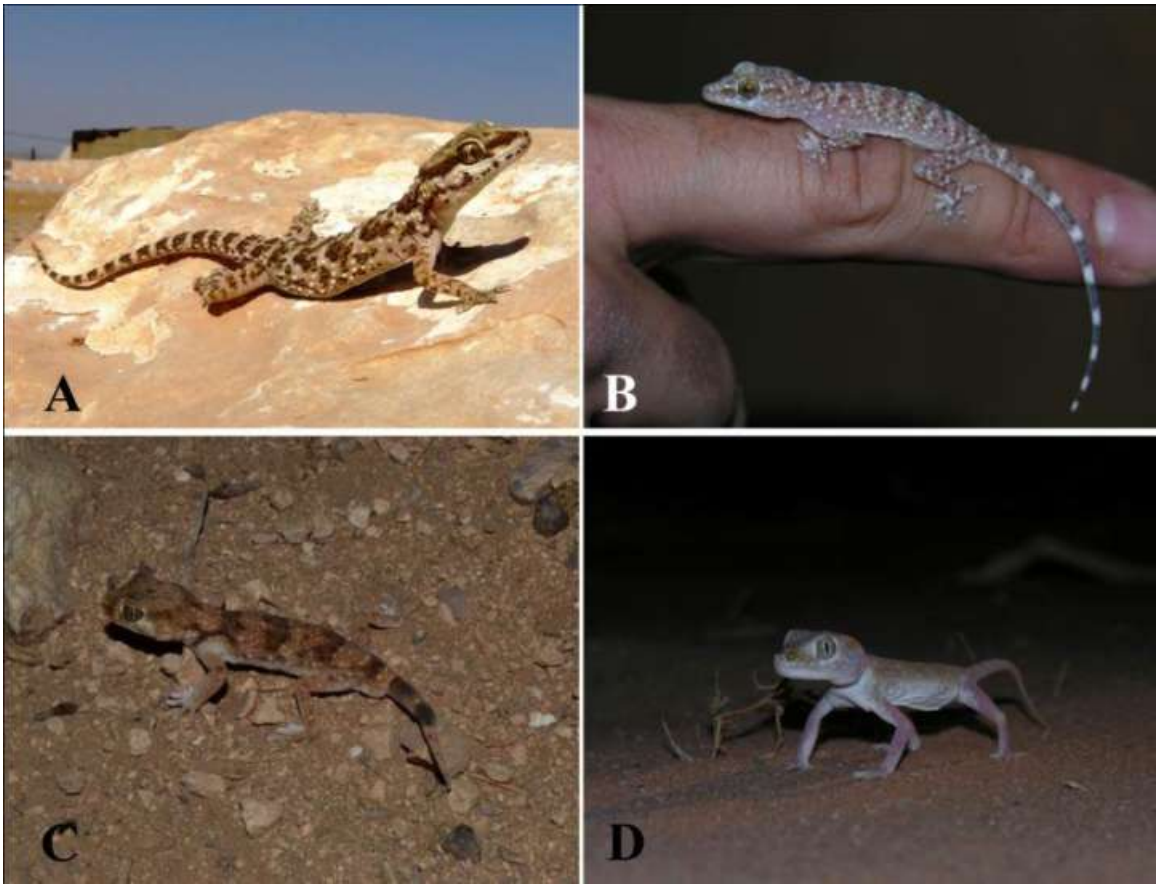


Figure 13: Representative of family Gekkonidae in Wadi Ramm. A. *Bunospus tuberculatus*. B. *Hemidactylus mindiae*. C. *Stenodactylus sthenodactylus*. D. *Stenodactylus doriae*.

Family Chamaeleonidae is represented by one species, *Chamaeleo* cf. *chamaeleon.* A single chameleon specimen was video-taped near Jabal Moharraq on the eastern border of the reserve among bushes of *Retama raetam* on the substrate consisting of hard sand surrounded by sand stone rocks (Abu Baker *et al*., 2004). No further specimens we collected from Wadi Ramm.

Family Agamidae includes four species (Table 5,Figure 14). Species of special interests include *Phrynocephelus nejdensis,* where it reaches its most northern distribution from the Arabian Peninsula, and the Southern Starred Agama, *Stellagama stellio brachydactyla.* This subspecies is confined to southern Jordan and northern Arabia. It remains to clarify the taxonomic status of *Pseudotrapelus sinaitus,* after the description of the new species, *Pseudotrapelus aqabensis* by Melnikov *et al*. (2012) from nearby Aqaba. Further specimens should be collected to verify the presence of this species within Wadi Ramm.

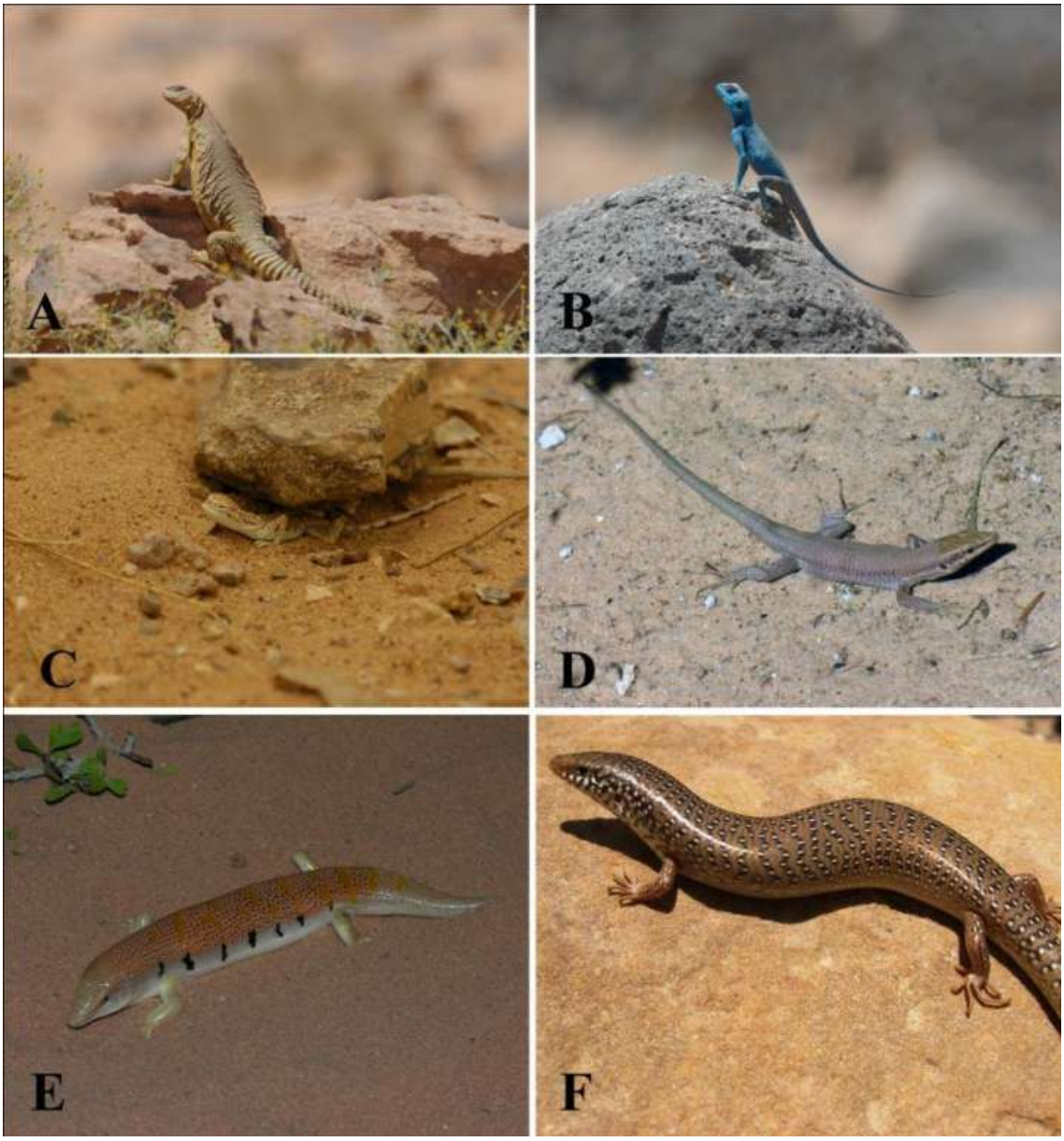


Figure 14: Some selected reptiles of Wadi Ramm. A. *Uromastyx aegyptia*. B. *Pseudotrapelus sinaitus*. C. *Phrynocephelus nejdensis*. D. *Phoenicolacerta kulzeri khazaliensis*. E. *Scincus scincus*. F. *Chalcides ocellatus*.

Family Lacertidae or the true lizards are represented by eight species. Majority are common species with a wide range of distribution. The Rock Lizard of Wadi Ramm, *Phoenicolacerta kulzeri khazaliensis* (Figure 14D), was described recently as new subspecies from the deep canyon of Jabal Khazali (Modrý *et al*., 2014). This subspecies is endemic to Wadi Ramm area.

Family Scincidae includes three species. *Scincus scincus* (Figure 14) is a sand dwelling species and seems to be common among sand dunes. On the other hand, *Ablepharus rueppellii,* represent a relict population in this desert habitat. It was initially reported by Sindaco *et al*. (1995). However, Disi & Amr (1998) were skeptical on this record. Abu Baker *et al*. (2004) found specimens from Wadi Shallaleh. The area consists of a humid hilly area with abundance of vegetation and small dripping springs. The vegetation cover is dominated by *Ficus pseudo-sycomorus*, *Retama raetam*. Family Varanidae is represented by the Desert Monitor, *Varanus griseus.* This is a desert species with a wide range of arid habitats throughout Jordan.

Family Leptotyphlopidae or the thread bind snakes: A single species, *Myriopholis macrorhynchus,* has been reported from Wadi Ramm. This species has a wide range of habitats in Jordan, including the Safawi, Petra and other humid areas (Amr & Disi, 2012).

Family Colubridae: This family is represented by eight species within 6 genera (Table 1). The genus *Platyceps* is represented by three species, two of which are rare and can be considered as key species; *Platyceps elegantissimus* and *Platyceps sinai* (Figure 15 A and B). Sand-adapted species are represented by *Lytorhynchus diadema.*

Family Viperidae is represented by two venomous species, The Arabian Horned Viper, *Cerastes gasperettii gasperettii,* and The Arabian Saw-Scaled Viper, *Echis coloratus.* The former species inhabits sandy areas while the later is confined to the rockky habitats of Wadi Ramm.

3.3.2 KEY SPECIES OF REPTILES IN WADI RAMM

At least six species of reptiles can be considered as key species to the herpetofauna of Wadi Ramm. This is based on their limited range of distribution in Jordan as well as their rarity. Some species have a confined distribution and known only for Jordan from Wadi Ramm. This group includes the Rock Lizard of Wadi Ramm, *Phoenicolacerta kulzeri khazaliensis* and *Hemidactylus mindiae.* Other species that reaches their most northern range of distribution include *Pristurus guweirensis, Phrynocephelus nejdensis, Platyceps elegantissimus* and *Platyceps sinai*

Key Species	
Phoenicolacerta kulzeri khazaliensis	Described from Wadi Ram
Hemidactylus mindiae	Known only from Wadi Ramm to the herpetofauna of Jordan
Pristurus guweirensis	Known only from Wadi Ramm to the herpetofauna of Jordan
Phrynocephelus nejdensis	Known only from Wadi Ramm to the herpetofauna of Jordan
Platyeps elegantissimus	Known from few localities in Jordan
Platyceps sinai	Known from few localities in Jordan



Figure 15:Representative of family Colubridae. A. *Platyceps elegantissimus. B. Platyceps sinai. C. Eirenis coronella. D. Lytorhynchus diadema. E. Psammophis schokari. F. Spalerosophis diadema.*

3.3.3 DISTRIBUTION OF REPTILES BY HABITAT TYPE

Four main habitat types are recognized in Wadi Ramm, including sand, rocky slopes, hammada, and transitional areas. Species associated with sand habitat include *Bunopus tuberculatus, Stenodactylus doriae, Phrynocephelus nejdensis, Acanthodactylus opheodurus, Acanthodactylus schmidti, Scincus scincus, Varanus griseus, Lytorhynchus diadema* and *Cerastes gasperettii.* Reptiles inhabiting rocky areas covers *Hemidactylus mindiae, Pristurus guweirensis, Ptyodactylus guttatus, Phoenicolacerta kulzeri khazaliensis, Stellagama stellio brachydactyla, Pseudotrapelus sinaitus* and *Echis coloratus.* On the other hand, the Hamada habitat hosts many species; some are shared with both sand and rocky habitats such as *Bunopus tuberculatus, Stenodactylus sthenodactylus, Tropiocolotes nattereri, Uromastyx aegyptia, Acanthodactylus boskianus, Mesalina brevirostris, Mesalina guttulata, Mesalina olivieri, Varanus griseus, Coluber rhodorachis, Eirenis coronella, Psammophis schokari, Spalerosophis diadema* and *Telescopus dhara*.

The transitional zone lies between the sand areas and rocky outcrops, with a number of species including *Chamaeleo chamaeleon, Bunopus tuberculatus, Tropiocolotes nattereri, Acanthodactylus boskianus, Acanthodactylus opheodurus, Mesalina brevirostris, Mesalina olivieri, Chalcides ocellatus, Varanus griseus, Myriopholis macrorhynchus, Platyceps elegantissimus*, *Platyceps*

rhodorachis, Platyceps sinai, *Lytorhynchus diadema, Psammophis schokari, Spalerosophis diadema,* and *Telescopus dhara.*

3.3.4 ZOOGEOGRAPHICAL ANALYSIS OF THE REPTILES OF WADI RAMM

This herpetofaunal assemblage of Wadi Ramm consists of reptiles of different zoogeographical affinities; Arabian (*B. tuberculatus*, *P. guttatus*, *S. doriae*, *T. nattereri*, *A. opheodurus*, *A. schmidti*, *P. arabicus*, *C. elegantissimus*, *C. sinai*, *E. coronella*, *C. gasperettii*, and *E. coloratus*), African (*C. chamaeleon*), and Mediterranean elements (*Ablepharus rueppelii*, *Phoenicolacerta kulzeri khazaliensis*).

Wadi Ramm represents the most northern limit of distribution for several Arabian species such as *Pristurus rupestris, Tropiocolotes nattereri* and *Phrynocephelus nejdensis*. On the other hand, species from the western side of the Red Sea penetrated eastwards reaching Wadi Ramm escarpment (i.e. *Coluber sinai, Tropiocolotes nattereri,* and *Hemidactylus mindiae*).

Three species (*Phoenicolacerta kulzeri khazaliensis*, *Chamaeleo cf. chamaeleon*, and *Ablepharus rueppellii*) are considered to represent relicts from earlier, more humid periods. All these three species are considered as Palaearctic elements that survived after the radical changes in the landscape of Wadi Ramm. The rest of the herpetofauna are mostly desert adapted species with a known wide range of distribution across North Africa, Arabian reaching as far as Afghanistan.

Table 5. List of reptiles reported from Wadi Ramm.

Species	Common Name	IUCN Status
Family Gekkonidae		
Bunospus tuberculatu	The Baluch Ground Gecko	LC
Hemidactylus mindiae	Mount Sinai-Gecko	LC
Pristurus guweirensis	Blanford's Semaphore Gecko	LC
Ptyodactylus guttatus	Sinai Fan-fingered Gecko	LC
Ptyodactylus hasselquistii	Hasselquist's Fan-footed Gecko	LC
Stenodactylus doriae	Middle Eastern Short-fingered Gecko	LC
Stenodactylus sthenodactylus	Elegant Thin-Toad Gecko	LC
Tropiocolotes nattereri	Natterer's Pigmy Gecko	LC
Family Chamaeleonidae		
Chamaeleo chamaeleon	Common Chameleon	LC
Family Agamidae		
Stellagama stellio brachydactyla	Southern Starred Agama	LC
Phrynocephelus nejdensis	Arabian Toadhead Agama	LC
Pseudotrapelus sinaitus	Sinai Agama	LC
Uromastyx aegyptia	Egyptian Spiny–tailed Lizard	NT
Family Lacertidae		
Acanthodactylus boskianus	Bosk's Fringe-toed Lizard	LC
Acanthodactylus opheodurus	Arnold's Fringe-fingered Lizard	LC
Acanthodactylus schmidti	Schmidt's Fringe-toed Lizard	LC
Phoenicolacerta kulzeri khazaliensis	The Rock Lizard of Wadi Ramm	EN
Mesalina brevirostris	Blanford's Short-nosed Desert Lizard	LC
Mesalina guttulata	Small-spotted Lizard	LC
Mesalina olivieri	Olivier's Sand Lizard	LC
Family Scincidae		
Ablepharus rueppellii	Rueppel's Snake-eyed Skink	LC
Chalcides ocellatus	Ocellated Skink	LC
Scincus scincus	The Sandfish	LC
Family Varanidae		
Varanus griseus	Desert Monitor	LC
Family Leptotyphlopidae		
Myriopholis macrorhynchus	The Hook-billed Blind Snake	LC
Family Colubridae		
Platyceps elegantissimus	The Most Beautiful Whip Snake	DD
Platyceps rhodorachis	Jan's Whip Snake	LC
Platyceps sinai	Sinai Banded Snake	DD
Eirenis coronella	The Crowned Dwarf Snake	LC
Lytorhynchus diadema	Awl-Headed Snake	LC
Psammophis schokari	Forskål's Sand Snake	LC
Spalerosophis diadema	Clifford's Snake	LC
Telescopus dhara	The North- African Cat Snake	LC
Family Viperidae		
Cerastes gasperettii gasperettii	The Arabian Horned Viper	LC
Echis coloratus	The Arabian Saw-Scaled Viper	LC

3.3.5 DIVERSITY OF MAMMALS IN WADI RAMM

Earliest records of mammals from Wadi Ramm were included in Mountfort (1965), with vey brief mention of some mammals observed. Other fragmentary records were included in Amr & Disi (1988). The Sand Cat, *Felis margarita*, was recorded from Jordan based on an observation made by Mountfort (1965) in Wadi Rum during the Second Jordan International Expedition. Later, its presence was substantiated in Wadi Rum by finding a skull (Hemmer, 1978). Hays & Bandak (1997) and Catullo *et al*. (1996) included records of the Nubian Ibex from Ramm area. A detailed account on the Arabian Leopard was published by Qarqaz & Abu Baker (2006), including mention to leopard hunting in Wadi Ramm. Bates & Harrison (1989) recorded two bat species; *Eptesicus bottae* and *Otonycteris hemprichii* at the Lawrence's Pool in the Wadi Ramm. Abu Baker & Amr (2004) studied the rodents of Wadi Ramm, with a total of 10 species recorded from Ramm area and its vicinity. Records of the

Afghan Fox, *Vulpes cana*, and its distribution in Wadi Ramm was documented by Abu Baker *et al*. (2004).

Benda *et al*. (2010) recorded eight species of bats from Wadi Ramm and its vicinity. This includes the record of *Barbastella leucomelas,* from Al Ghal, a new record to the bat fauna of Jordan.

The total number of confirmed mammalian species is around 27 (

Table 6, Figure 16,Figure 17), with two species of IUCN status. They are represented by 12 families. Bats and rodents are the most common mammals with a total of eight and 10 species respectively.

Family Erinaceidae is represented by a single species, the Ethiopian Hedgehog, Paraechinus aethiopicus. This is a true desert species adapted to survive in arid habitats.

As for the carnivores, they are represented by two families; Canidae with four species, most impotently is the Afghan Fox, *Vulpes cana*. This is a rare species of Jordan with limited distribution in sandstone deserts. Cats are represented by a single species, the Sand Cat, Felis margarita. Even recorded on the base of cranial remains, this species is considered as a near threatened according to the IUCN.

Chiroptera or bats are represented by eight species within three families. All are desert adapted species. Horseshoe bats are exemplified by two species *Rhinolophus clivosus* and *Rhinolophus hipposideros.* The Lesser Horseshoe Bat, *Rhinolophus hipposideros,* is found as a solitary animal in caves, ruins, and other dark dwellings. It was observed near Al Ghal village. Family Vespertilionidae includes five species, including the rare Asian Barbastelle, *Barbastella leucomelas.* Family Molossidae is represented by a single species, the European Free-tailed Bat, with a wide range of distbution.

Order Rodentia is represented by three families. The Southwest Asian Garden Dormouse, *Eliomys melanurus,* of the family Gliridae is a relict species. This species became adapted to a non-arboreal life style 1.2 million years ago. This species has a remarkable distribution pattern, despite being originally an arboreal species. Populations of this species may represent relicts in the deserts of Jordan. Family Muridae includes eight species. The Bushy-tailed Jird, *Sekeetamys calurus,* has a limited distribution in Jordan, with all records coming from Sothern Jordan. The Three-toed Jerboa, *Jaculus jaculus,* is the only representative of jerboas in Wadi Ramm.

Table 6. Mammals recorded from Wadi Ramm.

Family	Scientific Name	Common Name	IUCN status
Erinaceidae	Paraechinus aethiopicus	Ethiopian Hedgehog	LC
Canidae	*Canis aureus*	Asiatic Jackal	LC
	Canis lupus	Wolf	LC
	Vulpes cana	Blanford's Fox	LC
	Vulpes vulpes	The Red Fox	LC
Felidae	Felis margarita	The Sand Cat	NT
Rhinolophidae	*Rhinolophus clivosus*	Geoffroy's Horseshoe Bat	LC
	Rhinolophus hipposideros	Lesser Horseshoe Bat	LC
Vespertilionidae	*Otonectris hemprichii*	Hemprich's Long eared Bat	LC
	Hypsugo ariel	Desert Pipistrelle	LC
	Barbastella leucomelas	Asian Barbastelle	LC
	Eptesicus bottae	Botta's Serotine Bat	LC
	Plecotus christii	Northeast African Long Ear Bat	DD
Molossidae	*Tadarida teniotis*	European Free-tailed Bat	LC
Gliridae	*Eliomys melanurus*	The Southwest Asian Garden Dormouse	LC
Diplodidae	*Jaculus jaculus*	Three-toed Jerboa	LC
Muridea	*Acomys russatus*	Golden Spiny Mouse	LC
	Acomys dimidiatus	Eastern Spiny Mouse	LC
	Gerbillus nanus	Baluchistan Gerbil	LC
	Gerbillus cheesmani	Chessman's Gerbil	LC

	Gerbillus dasyurus	Wagner's Gerbil	LC
	Merionus crassus	Sand evall's Gerbil	LC
	Psammomys obesus	Fat Sand Rat	LC
	Sekeetamys calurus	The Bushy-tailed Jird	LC
Leporidae	Lepus capensis	Arabian Hare	LC
Procaviidae	*Procavia capensis*	Rock Hyrax	LC
Bovidae	*Capra nubiana*	Nubian Ibex	V

The remaining species, Arabian Hare, the Rock Hyrax and the Nubian Ibex are under pressure of hunting.

3.3.6 KEY SPECIES OF MAMMALS IN WADI RAMM

At least nine species of mammals can be considered as key species to the mammalian fauna of Wadi Ramm. This is based on their limited range of distribution in Jordan as their rarity and various forms of threats they are facing, mostly hunting (*Canis lupus, Canis aureus,* Lepus capensis, *Procavia capensis* and *Capra nubiana*). Some species have a confined distribution and represent relicts as in the case of the Southwest Asian Garden Dormouse.

Key Species

Felis margarita	Known from few localities in Jordan
Vulpes cana	Known from few localities in Jordan
Canis lupus	Under pressure of hunting
Canis aureus	Under pressure of hunting
Sekeetamys calurus	Known from few localities in Jordan
Eliomys melanurus	Relict species
Lepus capensis	Under pressure of hunting
Procavia capensis	Under pressure of hunting
Capra nubiana	Under pressure of hunting



Figure 16: Representative of some mammals from Wadi Ramm. A. *Vulpes cana. B. Sekeetamys calurus. C. Psammomys obesus. D. Grebillus dasyrus.*

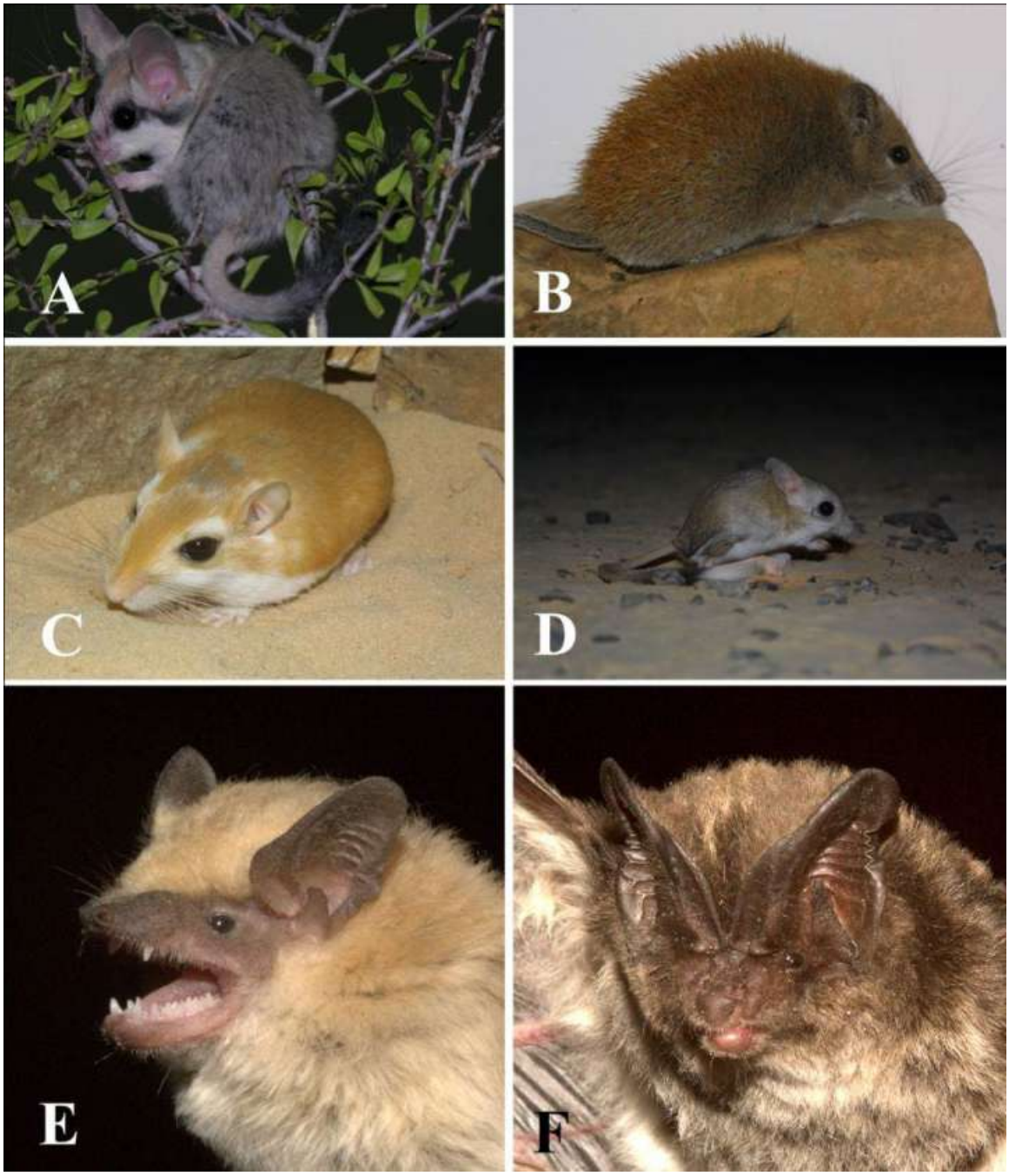


Figure 17: Representative of some mammals from Wadi Ramm. A. *Eliomys melanurus. B. Acomys russatus. C. Gerbillus cheesmani. D. Jaculus jaculus. E. Eptesicus bottae. F. Barbastella leucomelas*.

3.3.7 DISTRIBUTION OF MAMMALS BY HABITAT TYPE

Four main habitat types are recognized in Wadi Ramm, including sand, rocky slopes, hammada, and transitional areas. Species associated with rocky habitat include *Eliomys melanurus, Acomys russatus, Acomys dimidiatus, Sekeetamys calurus, Procavia capensis, Capra nubiana* and *Vulpes cana.* All bat species take refuge in rocky crvices and go to open areas for hunting insects at night. Mammals inhabiting open areas are represented by *Jaculus jaculus, Grebillus dasyrus, Psammomys obesus,* and Paraechinus aethiopicus. On the other hand, sandy areas are inhabited by *Gerbillus cheesmani*. Carnivores have a wide range of habitats, perhaps with their dens in rocky areas.

3.3.8 ZOOGEOGRAPHICAL ANALYSIS OF THE MAMMALS OF WADI RAMM

This mammalian assemblage of Wadi Ramm consists of mammals of different zoogeographical affinities. For example, *Sekeetamys calurus* reaches its most northern range of distribution in southern Jordan including Wadi Ramm. African elements are represented by the Rock Hyrax, *Procavia capensis*, the Ethiopian Hedgehog, Paraechinus aethiopicus and the Nubian Ibex, *Ibex nubiana*. Relicts are exemplified by *Eliomys melanurus.*

3.3.9 EASTERN DESERT AND AL JAFR AREA

Reptiles

Little information is available on the study site. Previous studies focused on nearby regions such as Bayer area, in addition to other scattered localities along the desert highway (Al Qatranah, Jiza, Wadi Dhaba'). Disi *et al*. (2001) included several records from around the Desert and Azraq-Bayer highways and from Bayer area. All these forms are typical desert inhabitants (Table 7).

Schmidt (1930) described the False-horned Viper, *Pseudocerastes fieldi*, from Bayer Wells. Haas (1943) collected *Eirenis coronella* between Ma‘an and Jiza, *Eirenis coronelloides* between Ammān-Al Qaṭrānah. Roger’s snake, *Platyceps rogersi*, was collected from Wadi Dhaba'ah (Haas, 1951; Disi *et al*., 1988). The Diademed Sand-snake, *Lytorhynchus diadema,* was recovered from Al Jafr (Al-Oran, 2000). The Diadem Snake, *Spalerosophis diadema cliffordii*, was collected from several localities around the study area including W Dhaba'ah (Haas, 1951); Al Qatranah (Amr *et al*., 1994; El Oran *et al*., 1994), Al Jafr, Al Qatraneh and Dhaba'ah (Disi *et al*., 1988) and Al Jafr, (Lahony *et al*., 2002).

The False-horned Viper *Pseudocerastes fieldi,* was originally described from Bayir Wells (Schmidt, 1930). Other collections were made from Wadi Dhoba'i (Haas, 1951), Al Jafr, and 25 km E Al Karak (Disi, 1983), Al Muwaqqar (Disi *et al*., 1988), Al Jafr and Ma‘ān (El Oran *et al*., 1994).

At least 17 reptilian species are known to occur in the study area, including three geckos, three agamids, four lacretids, six non-venomous colubrid snakes and one viper (Table 7).

Table 7. list of reptilian species reported from the vicinity of the study area.

Common name	Scientific name	Distribution	Reference
Family Gekkonidae			
The Mediterranean Gecko	*Hemidactylus turcicus*	Eastern desert	Disi *et al*. (2001)
Large-headed Thin–toed Gecko	*Stenodactylus grandiceps*	Eastern desert	Disi *et al*. (2001)
Sinai Fan-fingered Gecko	*Ptyodactylus guttatus*	Eastern desert	Disi *et al*. (2001)
Family Agamidae			
The Sinai Agama	*Pseudotrapelus sinaitus*	Eastern desert	Disi *et al*. (2001)
The Pale Agama	*Trapelus pallidus agnetae*	Eastern desert	Disi *et al*. (2001)
The Spiny Tailed Lizard	*Uromastyx aegyptius microlepis*	Eastern desert	Disi *et al*. (2001)
Family Lacertidae			
Small-spotted Lizard	*Mesalina guttulata*	Eastern desert	Disi *et al*. (2001)
Short-snouted Lizard,	*Mesalina brevirostris*	Eastern desert	Disi *et al*. (2001)
The Bosk's Fringe-toed Lizard	*Acanthodactylus boskianus*	Eastern desert	Disi *et al*. (2001)
Giant Fringe-fingered Lizard	*Acanthodactylus grandis*	Eastern desert	Disi *et al*. (2001)
Family Colubridae			

The Middle-eastern Dwarf Snake	*Eirenis coronella*	Eastern desert, Ma'an and Jiza	Haas (1943), Disi *et al.* (2001)
	Eirenis rothi	Eastern desert	Disi et al. (2001)
The False Cobra	*Malpolon moilensis*	Eastern desert	Disi et al. (2001)
The Diademed Sand-snake	*Lytorhynchus diadema*	Al Jafr	Al-Oran (2000)
Roger's Snake	*Platyceps rogersi*	Eastern desert, Wadi Dhaba'ah	Haas (1951), Disi *et al*., 1988, 2001)
Schokari Sand Racer	*Psammophis schokari*	Eastern desert	Disi et al. (2001)
Diadem Snake	*Spalerosophis diadema cliffordii*	W Dhaba'ah, Al Qatranah, Al Jafr	Haas, (1951), Amr *et al*., (1994), El Oran *et al*. (1994), Disi *et al*., (1988), Lahony *et al*. (2002), Disi *et al.* (2001)
Family Viperidae			
False Horned Viper	*Pseudocerastes fieldi*	Bayer and Al Jafr, Wadi Dhoba'i, 25 km E Al Karak, Ma'ān	Schmidt (1930), Haas (1951), Disi (1983), Disi *et al*. (1988), El Oran *et al*. (1994). Disi *et al*. (2001)

Mammals

Table 8 summarizes mammals known to occur within the vicinity of the study area. At least 11 species are most likely to be present within the range of the area. Most of knowledge on the mammals of south-eastern Jordan is mainly based on Attalah (1967). Most of his collections were made near Al Jafr area including several species of rodents (the Three-toad Jerboa, *Jaculus jaculus;* Wagner's Gerbil, *Gerbillus dasyurus;* Henly's Gerbil, *Gerbillus henleyi* and Sundevall's Jird, *Meriones crassus*). More comprehensives studies by Amr & Disi (1988) and Abu Baker & Amr (2004) add extra localities of several rodent species in the eastern desert. Historical records as well as recent records indicated the presence of *Eliomys melanurus* within the vicinity of the study area (Tristram, 1877; Amr & Disi, 1988). The Fat Sand Jird, *Psammomys obesus,* is quite common within wadis vegetated by *Anabasis* sp. Within the range of the study area with similar habitat (Amr & Saliba, 1985).

Only one species of hedgehogs, the Ethiopian Hedgehog, *Paraechinus aethiopicus*, is known to occur within the eastern desert close to the study area (Atallah, 1967; Amr, 2000).

Of the Carnivores, two species were recorded previously within the vicinity of the study site. The Striped Hyeana, *Hyaena hyaena,* has a wide home range that intersects with the core study area (Amr, 2000; Qarqaz *et al*., 2004). Additionally, the Red Fox, *Vulpes vulpes*, is most certainly a resident of the study area, owing its wide range of distribution (Amr, 2000). Despite its declining numbers, the Arabian Cape Hare, *Lepus capensis*, used to be common within Bayer and Al Jafer area (Atallah, 1967; Amr, 2000).

Table 8. Mammals recorded from the vicinity of the study area.

Common name	Species	Locality	Reference
Order Insectivora			
Family Erinaceidae			
The desert hedgehog	*Paraechinus aethiopicus*	Several localities in the eastern desert	Atallah (1967), Amr (2000)
Order Carnivora			
Family Canidae			
The Red Fox	*Vulpes vulpes*	Several localities in the eastern desert	Amr (2000)
Family Hyaenidae			
The Striped Hyeana	*Hyaena hyaena*	Several localities in the eastern desert	Qarqaz *et al*. (2004)

Order Lagomorpha			
Family Leporidae			
The Arabian Hare	*Lepus capensis*	Several localities in the eastern desert	Amr (2000)
Order Rodentia			
Family Dipodidae			
the Three-toad Jerboa	*Jaculus jaculus*	El Jafr	Atallah (1967)
Family Muridae			
Wagner's Gerbil	*Gerbillus dasyurus*	El Jafr, Mowaqqar	Atallah (1967), Amr & Saliba (1985)
Henly's Gerbil	*Gerbillus henleyi*	El Jafr	Atallah & Harrison (1967)
the Libyan Jird	*Meriones libycus*	Qatrana, EI-Jafr	Amr & Disi (1988)
Sundevall's Jird	*Meriones crassus*	El Jafr, Azraq, Qatrana	Amr & Disi (1988) Atallah (1967)
The Fat Sand Jird	*Psammomys obesus*	Mowaqqar, 60 km S Amman	Amr & Disi (1988), Amr & Saliba (1985)
Family Gliridae			
The Southwest Asian Garden Dormouse	*Eliomys melanurus*	Jiza, Um Rasas, Daba'ah	Tristram (1877), Amr & Disi (1988)

4. MATERIALS AND METHODS

After the Rapid Assessment that was undertaken during the 7th of July 2025 to the 17th of July 2025, and led by Dr. Amrita de Soyza, covering the entire study area, it was agreed to study about 80 locations along the pipeline route.

4.1 Flora Survey

4.1.1 LINE INTERCEPT METHOD (TRANSECT)

A Line Intercept Method, which was a slightly modified version of the method first described by Canfield (1941) and now widely used for characterizing and monitoring rangelands, was used to quantify AAWDCP vegetation.

4.1.2 EQUIPMENT

The following equipment was required:

1. 3 × 100 m metric surveyors' tapes with graduations every 1 cm and 1 m.
2. 1 × 1 m measurement stick (1 cm graduations) or a metric retractable tape measure.
3. 6 × metal stakes to attach the surveyors' tape at the beginning and endpoints.
4. 1 × Handheld GPS.
5. 1 × Digital camera.
6. 1 × Clinometer.
7. 1 × Compass.
8. Photo Sheets (1 for each transect line).
9. Data Record Sheets.

4.1.3 ESTABLISHING A LINE INTERCEPT TRANSECT

A 100 m long surveyor's tape (0 m end) was attached at the start point of the transect, pulled out 100 m to the end location, the tape reel was locked, and it was secured to the ground using a metal stake (e.g., metal reinforcement bar; rebar). The person walking the tape to the end point was guided by a surveyor standing at the zero point with a compass. The tape was kept as straight as possible and positioned above the canopy whenever possible.

4.1.4 DISTRIBUTION OF TRANSECTS

The AAWDCP used two distinct types of distribution for the Line Intercept Transects. For linear features such as the pipeline, transect lines were oriented perpendicular to the pipeline and parallel to each other, as shown inFigure 18, Figure 19.

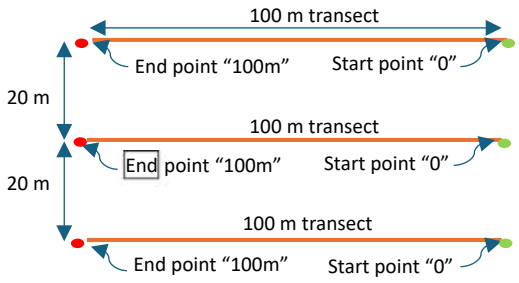


Figure 18: Diagram depicting layout of line intercept transects at a linear feature for vegetation/habitat survey.



Figure 19: Line transects method used in the study.

For the AAWDCP proposed pipeline corridor, the line intercept transects were positioned on both sides of the pipeline route as shown in Figure 20.

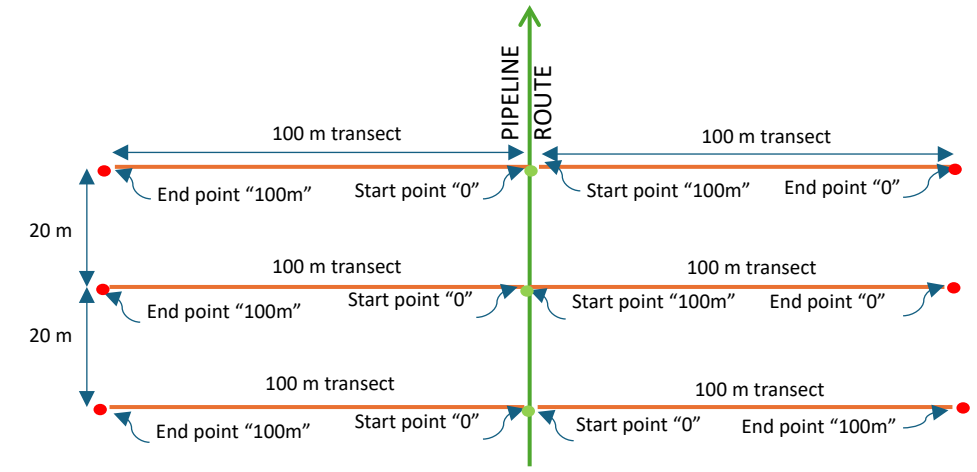


Figure 20: Diagram of distribution of survey transects at a pipeline survey site.

When line intercept transects were used to survey an AAWDCP facility (for example, the Solar Facility, Pump Stations, etc.), a three-spoked design was used as shown in Figure 21, for a better representation of the area that was surveyed.

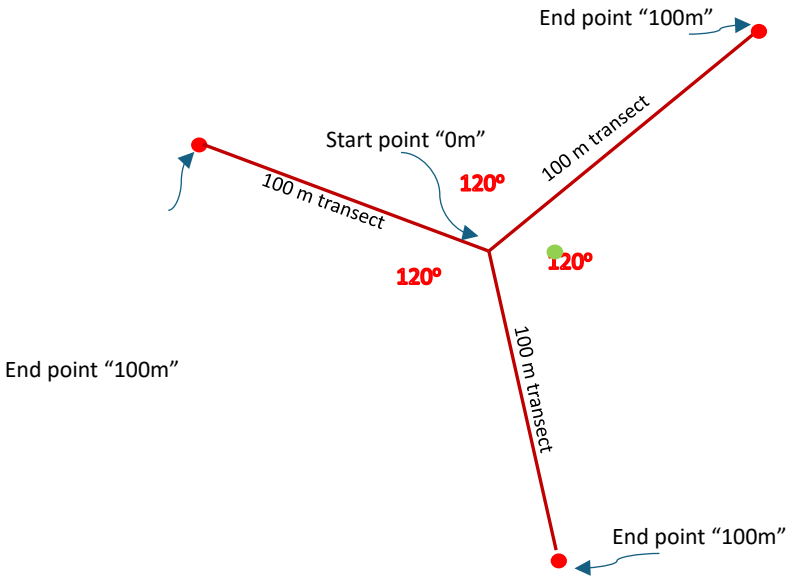


Figure 21: Three spoked line intercept transect design for measuring vegetation / habitat in an area.

Facility line transect plots took into account any obviously visible differences in vegetation or soil differences that occurred within the area boundary, and additional survey plots were established if there was obvious heterogeneity within the plot (Figure 22).



Figure 22. Three spoked line intercept transect.

4.2 Fauna Survey

4.2.1 SMALL MAMMAL TRAPPING METHOD

Sherman Traps (Figure 23) were used to trap small mammals in the study area. Traps were placed in locations where active rodent burrows were observed. Traps were baited with a mix of oat and peanut butter. Traps were placed at least one hour before sunset and collected the following morning. Trapped rodents were identified, sexed, photographed and body measurement were recorded. All trapped rodents were subsequently released in the site of collection.



Figure 23. Small mammals trapping in the field.

4.2.2 WALKING TRANSECT SURVEY METHOD

Faunal observations were made in a band, approximately 10 m on both sides of the transect in the sites (Figure 24,Figure 25). Two field biologists walked through each transect for at least 300 m. coordinates for each transect was recorded for each studied site. Observed reptiles and small mammals' burrows were photographed and recorded. In addition, night transect surveys were conducted in some selected sites for nocturnal species such as geckos and snakes. Signs of animal presence including droppings/scat, footprints, active dens/middens, were also considered. Fauna Walking Transect datasheet was filled for each visited site.



Figure 24: Field researchers conducting walking transects during daytime.



Figure 25: Field researchers conducting walking transects during nighttime.

4.2.3 CAMERA TRAP SURVEY

Five camera traps were used to target the survey of larger mammals. Deploy trail cameras for up one to days at each survey location, with the actual deployment decision made based on likelihood of observing mammals and security (theft of camera traps) concerns. Because the vegetation is sparse and usually very short traps will be easy for passers-by to see. Therefore, the decision on length of deployment is left to the local experts to decide. Each camera should be mounted on a post at a height of 30–50 cm above ground level and angled slightly downward to optimize the field of view (Figure 26). Cameras should be oriented to face north whenever feasible to minimize false triggers and avoid image overexposure from direct sunlight. Camera traps were baited with sardines.



Figure 26:Installation of camera traps.

4.2.4 BAT ROOST SURVEY

The survey was conducted in an arid region characterized by generally sparse vegetation, and a mix of natural and human-modified landscapes. Potential roosting habitats include rocky outcrops, cliffs, caves and crevices, and human structures such culverts, and abandoned buildings and mines were checked for the presence of bats. The survey was limited to areas likely to be directly impacted by AAWDCP construction activities.

5. RESULTS

5.1 Segment 1

This segment is about 14 km in length and extends from the seaport to the north at the edge of the Aqaba mountains (Figure 27). This segment is characterized by wadi systems crossing from the east to the west covered by sand and gravel.

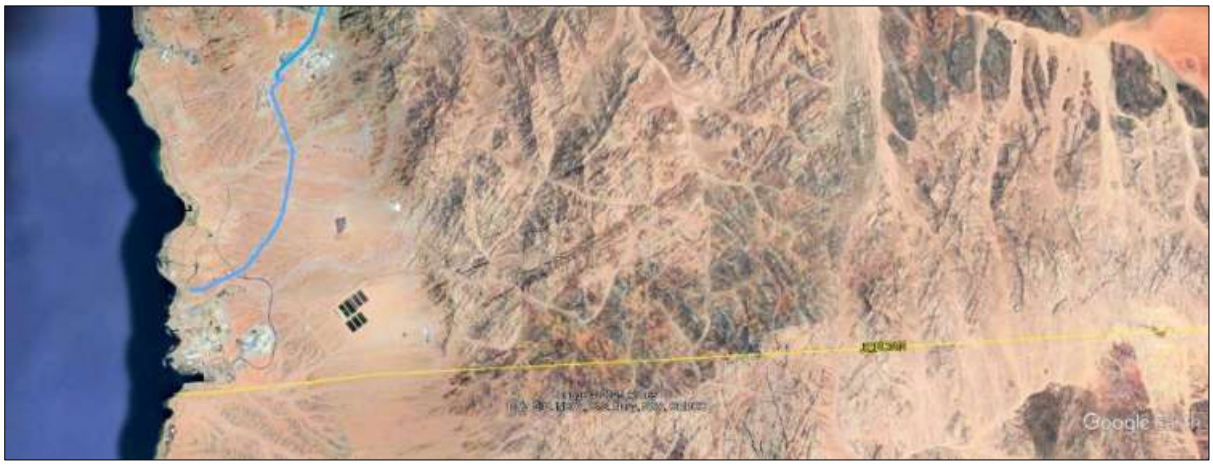


Figure 27. Outline for segment 1.

Desalination plant

This site is in close vicinity to the waterfront of the Gulf of Aqaba (Figure 28, Figure 29). Most of the block is paved with cement base, with piles of debris above. Vegetation is confined along the sides of the block with plastic garbage all over. *Prosopis juliflora* was seen in cemented area. At its most southeastern end, two large ponds that used to hold water, probably from the electric company. We were not allowed to inspect these ponds and denied entry by the manager of the electric company.



Figure 28: Landscape of the desalination plant.

Two walking transects along the block were made during 9.9.2025 as shown in Table 9. No sings of activity of reptiles or presence of small mammals were observed.

Table 9. Coordinates for two transects at the desalination plant.

Transect No.	Start		End		Length (m)
	N	E	N	E	
1	29°22'40"	34°58'06"	29°22'37"	34°58'04"	300
2	29°22'34"	34°58'03"	29°22'35"	34°58'19"	300



Figure 29. Landscape of the desalination plant. The dominant plant is *Salsola baryosma*.

FA1

This site represents a relatively deep wadi system surround by two rocky slopes from each side (Figure 30). The surface is covered medium-sized rocks that is void of vegetation. No sings of activity of reptiles or presence of small mammals were observed.



Figure 30. Landscape of FA1 location.

Flora Survey

Three line transects were made as shown in Table 10.

Table 10. Coordinates for three transects FA1 location.

Transect No.	Start		End		Length (m)
	N	E	N	E	
1	29.402830°	35.009641°	29.402718°	35.010664°	100
2	29.402649	35.009549°	29.402496°	35.010578°	100
3	29.402495°	35.009454°	29.402286°	35.010469°	100

Plant observations:

Only one plant species was recorded at this location, *Vachellia tortilis* (Vulnerable).

Fauna Survey

Two walking transects were made on 30.7.2025 as shown in Table 11.

Table 11. Coordinates for two transects FA1 location.

Transect No.	Start		End		Length (m)
	N	E	N	E	
1	29°24'11"	35°00'34"	29°24'16"	35°00'37"	300
2	29°24'10"N	35°00'33"	29°24'10"	35°00'33"	300

Reptiles observed

No reptiles were observed at this location.

Small mammals

No reptiles were observed at this location

FA2



Figure 31. Landscape of FA2 location.

Flora Survey

Six line transects were made as shown in Table 10.

Table 12. Coordinates for three transects FA2 location.

Transect No.	Start		End		Length (m)
FA2	N	E	N	E	
1	29.419187°	35.017288°°	29.419023°	35.018306°	100
2	29.419035°	35.017335°	° 29.418844°	35.018297°	100
3	29.418858°	35.017360°	29.418658°	35.018237°	100
4	29.420293°	35.016391°	29.420392°	35.015375°	100
5	29.420000°	35.016389°	29.420093°	35.015381°	100
6	29.419810°	35.016431°	29.419863°	35.015461°	100

Plant observations:

Four plant species were recorded at this location, *Salsola baryosma(Caroxylon gaetulum) Aizoon canariense, Acacia tortilis* and *Cleome droserifolia.*

FA3

This site lies between hilly areas along the truck's road. It is filled with used tires, with very scattered vegetation cover (Figure 32). No sings of activity of reptiles or presence of small mammals were observed.

The location is degraded and does not hold viable population of rodents or reptiles.



Figure 32. Landscape of FA3 location.

Flora Survey

Three line transects were made as shown in Table 13.

Table 13. Coordinates for three transects FA3 location.

Transect No. FA3	Start		End		Length (m)
	N	E	N	E	
1	29.429402°	35.015517°	29.429478°	35.014905°	100
2	29.429243°	35.015539°	29.429312°	35.014848°	100
3	29.429095°	35.015549°	29.429152°	35.014795	100

Plant observations:

Three plant species were recorded at this location, *Salsola baryosma, Ochradenus baccatus* and *Polycarpaea repens*.

Fauna Survey

One line transect was made on 30.7.2025 as shown in Table 14.

Table 14. Coordinates for one transect at FA3 location.

Transect No.	Start		End		Length (m)
	N	E	N	E	
1	29°25'07"	35°01'00"	29°25'47"	35°00'58"	300

Reptiles observed

No reptiles were observed at this location.

Small mammals

No reptiles were observed at this location.

FA4



Figure 33.Landscape of FA4 location.

Flora Survey

Three line transects were made as shown in Table 13.

Table 15. Coordinates for three transects FA3 location.

Transect No. FA4	Start		End		Length (m)
	N	E	N	E	
1	29.461038°	35.039848°	29.461421°	35.038868°	100
2	29.460833°	35.039722°	29.461250°	35.038752°	100
3	29.460660°	35.038654°	29.461038°	35.038654°	100

Plant observations:

Five plant species were recorded at this location, *Cleome droserifolia, Zilla spinosa, Anabasis setifera, Lavandula coronopifolia* and *Salsola baryosma*

FAPS1

This site is proposed as a pumping station. Very scant vegetation of Acacia was observed along the narrow wadi system that crosses the site. Small shrubs with debris and plastic and broken glass garbage were seen (Figure 34).



Figure 34: Landscape of FAPS1 location. The dominant plants are Vachellia tortilis and Zilla spinosa.

Flora Survey

Three line transects were made as shown in Table 16.

Table 16. Coordinates for three transects FAPS1 location.

Transect No.	Start		End		Length (m)
	N	E	N	E	
1	29.440577°°	35.018525°	29.443110°	35.016884°	500
2	29.440577°°	35.018525°	29.440444°	35.023652°	500
3	29.440577°°	35.018525°	29.436703°	35.015614°	500

Plant observations:

Only one plant species was recorded at this location, *Vachellia tortilis* (Vulnerable).

Fauna Survey

Two walking transects were made on 30.7.2025 as shown in Table 17.

Table 17. Coordinates for two transects at FAPS1 location.

Transect No.	Start		End		Length (m)
	N	E	N	E	
1	29°26'28"	35°01'07"	29°26'26"	35°01'01"	300
2	29°26'23"	35°01'02"	29°26'26"	35°01'05"	300

Reptiles observed

One female Aqaba agama, *Pseudotrapelus aqabensis*, was observed among the scattered medium-sized rocks along the wadi system (Figure 35). This species was originally described from Aqaba in 2012 (Melnikov et al., 2012).

Pseudotrapelus aqabensis differs from *Pseudotrapelus sinaitus* in having four well developed separated preanal pores in males and the third toe much longer than the fourth (Melnikov et al. 2012). This species by now known from Sinai, Southern Jordan and Palestine, and NW Saudi Arabia.



Figure 35. A. Adult female *Pseudotrapelus aqabensis*. B. Dorsal view of the head. C. Lateral view of the head. D. Femoral pores. E. Hind leg showing fingers.

Crecent shaped burrows similar to those of the Egyptian Spiny-tailed Lizard were also observed (Figure 36). However, we could not see any activity.



Figure 36: Suspected Egyptian Spiny-tailed Lizard burrow.

Small mammals

Four traps were installed in this site. No rodents were trapped.

5.2 Segment 2

This segment extends along the Aqaba mountains for about 17 km parallel to the ring road around Aqaba (Figure 37). It is characterized by granite mountains with interesting wadi systems. Also other infrastructures for transport trucks and others.



Figure 37. Outline for segment 2.

FA5

This site is surrounded by rocky outcrops with scattered vegetation. The side close to the road is very much disturbed by plastic garbage and old tires (Figure 38). The location does not hold any significant biodiversity in terms of reptiles or small mammals.



Figure 38. Landscape of FA5 location. The dominant plants are Hammada scoparia and Zilla spinosa.

Flora Survey

Three line transects were made as shown in Table 18.

Table 18. Coordinates for three transects FA5 location.

Transect No. FA5	Start		End		Length (m)
	N	E	N	E	
1	29.497929°	35.087727°	29.498350°	35.086770°	100
2	29.497734°	29.497734°	29.498104°	29.498104°	100
3	29.497500°	35.087500°	29.497819°	35.086516°	100

Plant observations:

Six plant species were recorded at this location, *Zilla spinosa, Ochradenus baccatus, Lavandula coronopifolia* (Near Threatened*), Hammada scoparia, Vachellia tortilis* (Vulnerable) and *Crotalaria aegyptiaca.*

Fauna Survey

One walking transect was made on 30.7.2025 as shown in Table 19.

Table 19. Coordinates for one transect at FA5 location.

Transect No.	Start		End		Length (m)
	N	E	N	E	
1	29°29'33"	35°05'16"	29°29'58"	35°05'14"	300

Reptiles observed

No reptiles were observed at this location.

Small mammals

Four traps were installed in this site. No rodents were trapped.

FA6-PS2

This site is above the road level. It consists of rubbles typically stone, brick, or other building materials. Old caravans and shades are present at the edge of the location (Figure 39). Vegetation cover is almost absent. No sings of activity of reptiles or presence of small mammals were observed.



Figure 39. Landscape of FA6-PS2 location.

Flora Survey

Three line transects were made as shown in Table 20.

Table 20. Coordinates for three transects FA6-PS2 location

Transect No. FA6-PS2	Start		End		Length (m)
	N	E	N	E	
1	29.501429°	35.094711°	29.501645°	35.094755°	100
2	29.501429°	35.094711°	29.501417°	35.094515°	100
3	29.501429°	35.094711°	29.501336°	35.094915°	100

Plant observations:

Three plant species were recorded at this location, *Ochradenus baccatus, Hammada salicornica* and *Zilla spinosa.*

Fauna Survey

Two walking transects were made on 30.7.2025 as shown in Table 21.

Table 21. Coordinates for two transects at FA6-PS2 location.

Transect No.	Start		End		Length (m)
	N	E	N	E	
1	29°30'05"	35°05'38"	29°30'04"	35°05'46"	300
2	29°30'06"	35°05'40"	29°30'26"	35°05'56"	300

Reptiles observed

No reptiles were observed at this location.

Small mammals

Four traps were installed in this site. No rodents were trapped.

5.3 Segment 3

This segment extends northwards along wadi Al Yotom parallel to the desert highway (Figure 40). It crosses wide wadi systems, reach the Wadi Rum intersection. It is about 20 km in length.



Figure 40. Outline for segment 3.

Near the dam at 29°33'07"N 35°08'23"E

A series of dams were constructed along Wadi Al Yotum that leads to Aqaba city to prevent floods during winter. This dam retained some water during the study at the biggening of August 2025 (Figure 41). We did not observe toads or reptiles around the water body. Dragonflies were common.



Figure 41. Landscape of a dam on Wadi Al Yotom.

This site was not among the sites targeted for the vegetation cover study.

Fauna Survey

A young Nubian Ibex, *Capra nubiana*, was observed in 29.3.2025 descending from the mountains to the dam for drinking water (Figure 42).



Figure 42: Nubian Ibex, *Capra nubiana*, descending from the mountains to the dam for drinking water in 29.3.2025 (Courtesy of Sameh Khtatbeh).

FA8

This location represents a rocky area surrounded by granite mountains. Few Acacia trees are present with scattered small shrubs of *Zilla spinosa* in open areas. Piles of rocks are scattered near the rocky slopes (Figure 43).



Figure 43: Landscape of FA8 location. The dominant plants are *Artemisia sieberi* and *Retama raetam*.

Flora Survey

Six line transects were made as shown in Table 22.

Table 22. Coordinates for six transects FA8 location.

Transect No.	Start		End		Length (m)
FA8	N	E	N	E	
1	29.590655°	35.164444°	29.590687°	35.165501°	100
2	29.591036°	35.164447°	29.591051°	35.165491°	100
3	29.590833°	35.164444°	29.590868°	35.165500°	100
4	29.591032°	35.163339°	29.591022°	35.162265°	100
5	29.590796°	35.163335°	29.590779°	35.162285°	100
6	29.590556°	35.163333°	29.590522°	35.162302°	100

Plant observations:

Eight plant species were recorded at this location, *Aizoon canariense, Artemisia sieberi, Launaea spinosa, Ochradenus baccatus, Retama raetam, Salsola baryosma, Zilla spinosa* and *Fagonia mollis*.

Fauna Survey

Two walking transects were made on 31.7.2025 as shown in Table 23.

Table 23. Coordinates for two transects at FA8 location.

Transect No.	Start		End		Length (m)
	N	E	N	E	
1	29°35'21"	35°09'53"	29°35'11"	35°09'46"	300
2	29°35'22"	35°09'54"	29°35'09"	35°09'43"	300

Reptiles observed

The Egyptian rock agama, *Laudakia vulgaris*, was observed in this location. One adult male siting on a rock facing a juvenile animal, and another colourful two adults on large boulders (Figure 44).

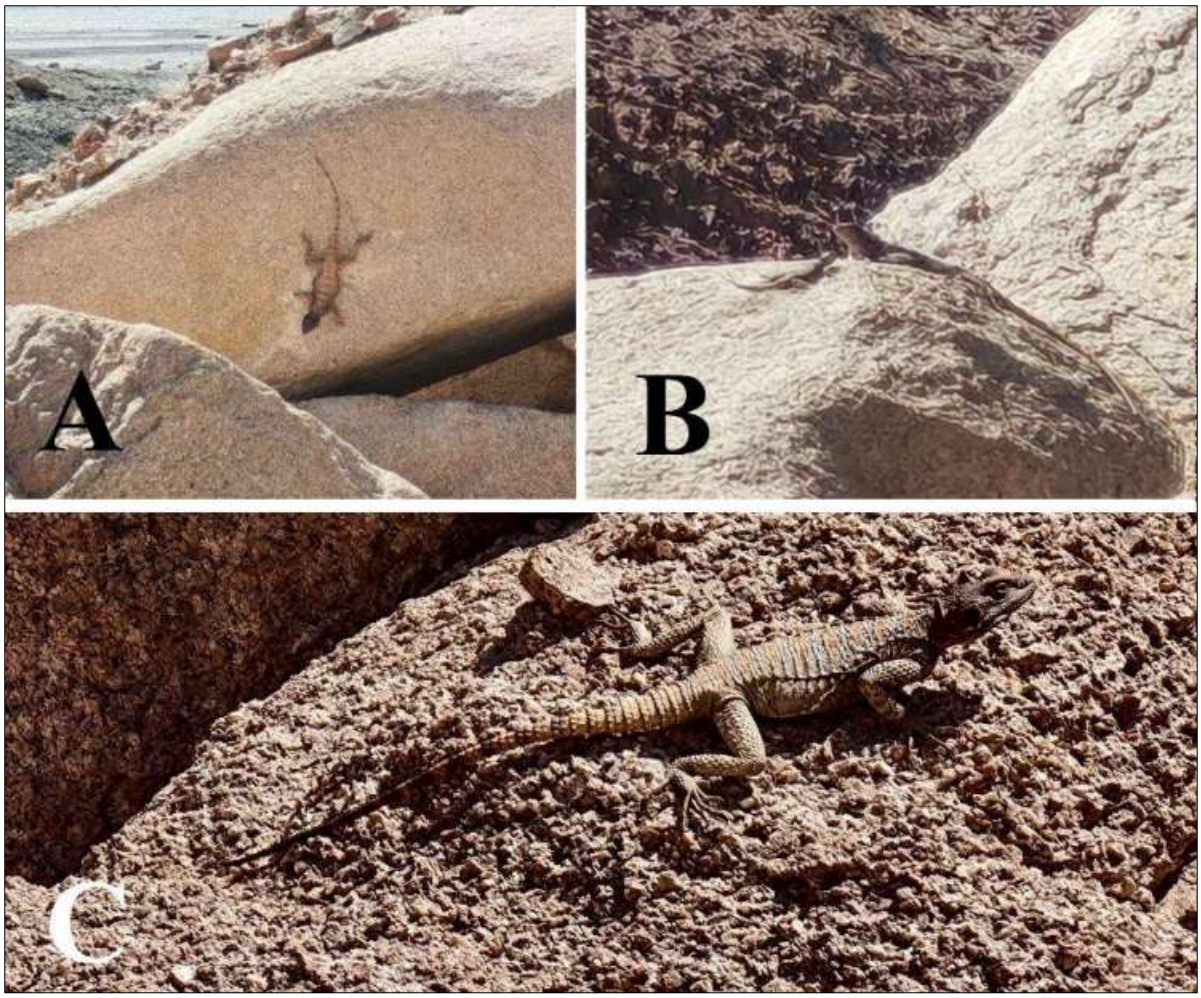


Figure 44. A. Adult Egyptian rock agama, *Laudakia vulgaris.* B. Adult and juvenile Egyptian rock agama basking on a rock. C. Large adult Egyptian rock agama, *Laudakia vulgaris*.

Small mammals

Four traps were installed near the rocky area. One Arabian spiny mouse, *Acomys dimidiatus,* was trapped (Figure 45). Tail length was 78 mm, body length 90 mm.



Figure 45. Arabian spiny mouse, *Acomys dimidiatus*.

FA9 (29°41'15"N 35°15'29"E)

This is a fenced area with remains of plastic sheets used in agriculture. The area is flat and does not offer suitable habitat for small mammals or reptiles (Figure 46).



Figure 46. Landscape of FA9 location.

Flora Survey

Three line transects were made as shown in Table 24.

Transect No. FA9	Start		End		Length (m)
	N	E	N	E	
1	29.687778°	35.258333°	29.687140°	35.259110°	100
2	29.687622°	35.258207°	29.687013°	35.259019°	100
3	29.687462°	35.258074°	29.686865°	35.258876°	100

Plant observations:

Only one plant species was recorded at this location, *Salsola baryosma.*

Fauna Survey

Reptiles observed

No reptiles were observed at this location.

Small mammals

Four traps were installed in this site. No rodents were trapped.

PS3

This location is proposed as pumping station for the pipeline. It is located on the right side of the desert highway to Aqaba before Wadi Rum intersection. It is a flat area with gravel and small rocks, and with minimum vegetation cover mixed along with plastic garbage (Figure 47).



Figure 47: Landscape of PS3 location. The dominant plant is Hammada salicornica.

Flora Survey

Six line transects were made as shown in Table 25.

Table 25. Coordinates for three transects PS3 location

Transect No.	Start		End		Length (m)
PS3	N	E	N	E	
1	29.702508°	35.268340°	29.702506°	35.269408°	100
2	29.702508	35.268340°	29.701751°	35.267792°	100
3	29.702508	35.268340°	29.703306°	35.267779°	100
4	29.703056°	35.269167°	29.702271°	35.269167°	100
5	29.703056°	35.269167°	29.702271°	35.268642°	100
6	29.703056°	35.269167°	29.703902°	35.268598°	100

Plant observations:

Two plant species were recorded at this location, *Hammada salicornica* and *Fagonia mollis.*

Fauna Survey

One line transect was made on 31.7.2025 as shown in Table 26.

Table 26. Coordinates for one transect at PS3 location.

Transect No.	Start		End		Length (m)
	N	E	N	E	
1	29°42'11"	35°16'04"	29°42'07"	35°16'09"	300

Reptiles observed

No reptiles were observed at this location.

Small mammals

Four traps were installed in this site. No rodents were trapped.

5.4 Segment 4

This segment begins from the Wadi Rum intersection with the desert highway, and extends to the east crossing the Wadi Rum formation, characterized by sand and Sandrock habitats (Figure 48). It covers a large portion of Wadi Rum PA buffer zone. It extends for about 50 km.

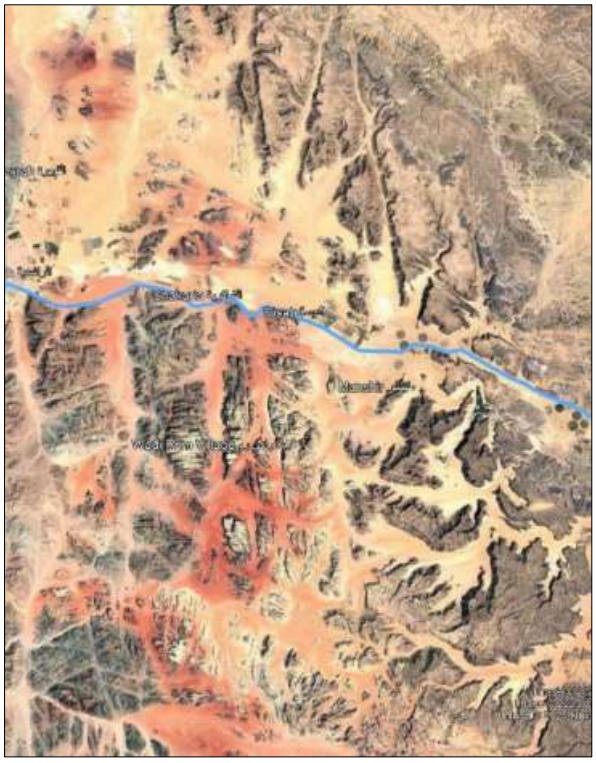


Figure 48: Outline for segment 4.

S4OHTL5

This is an open wadi system with mixed sand and gravel. In many parts it is filled with garbage (Figure 49).



Figure 49. Landscape of S4OHTL5 location. The dominant plant is *Hammada salicornica*.

Flora Survey

Three line transects were made as shown in Table 27.

Table 27. Coordinates for three transects S4OHTL5 location.

Transect No.	Start		End		Length (m)
S4-OHTL-5	N	E	N	E	
1	29.732513°	35.290940°	29.731672°	35.291302°	100
2	29.732648°	35.291077°	29.731811°	35.291420°	100
3	29.732773°	35.291231°	29.731923°	35.291567°	100

Plant observations:

Only one plant species was recorded at this location, *Hammada salicornica.*

Fauna Survey

One walking transect was made on 31.7.2025 as shown in Table 28.

Table 28. Coordinates for one transect at S4OHTL5 location.

Transect No.	Start		End		Length (m)
	N	E	N	E	
1	29°43'57"	35°17'28"	29°43'55"	35°17'31"	300

Reptiles observed

No reptiles were observed at this location.

Small mammals

No active burrows for rodents were observed at this location.

S4OHTL4

This is an open area with compacted soil, with patches of sand around shrubs (Figure 50). Vegetation is dominated by *Hammada salicornica.*



Figure 50: Landscape of S4OHTL4 location. The dominant plant is Hammada salicornica.

Flora Survey

Three line transects were made as shown in

Table 29.

Table 29. Coordinates for three transects S4OHTL4 location.

Transect No. S4-OHTL-4	Start		End		Length (m)
	N	E	N	E	
1	29.752847°	35.357604°	29.753674°	35.357991°	100
2	29.752865°	35.357400°	29.753703°	35.357757°	100
3	29.752918°	35.357201°	29.753764°	35.357547°	100

Plant observations:

Only one plant species was recorded at this location, *Hammada salicornica.*

Fauna Survey

One line transect was made on 8.8.2025 as shown in Table 30.

Table 30. Coordinates for one transect at S4OHTL4 location.

Transect No.	Start		End		Length (m)
	N	E	N	E	
1	29°45'13"	35°21'25"	29°45'10"	35°21'30"	300

Reptiles observed

Acanthodactylus boskianus was found to be common (Figure 51).

Small mammals

Active burrows for most probably *Meriones crassus* were observed (Figure 51).



Figure 51. A and B. *Acanthodactylus boskianus* observed at S4OHTL4 location.



Figure 52: Active burrows for most probably *Meriones crassus*.

S4-SPV1



Figure 53: Landscape of S4-SPV1 location

Flora Survey

Three line transects were made as shown in

Table 29.

Table 31. Coordinates for three transects S4-SPV1 location.

Transect No.	Start		End		Length (m)
S4-SPV1	N	E	N	E	
1	29.764819°	35.369220°	29.764411°	35.368331°	100
2	29.764819°	35.369220°	29.765720°	35.369283°	100
3	29.764819°	35.369220°	29.765720°	35.369283°	100

Plant observations:

Only one plant species was recorded at this location, *Hammada salicornica.*

S4-SPV2



Figure 54: Landscape of S4-SPV2 location

Flora Survey

Three line transects were made as shown in

Table 29.

Table 32. Coordinates for three transects S4-SPV2 location.

Transect No. S4-SPV2	Start		End		Length (m)
	N	E	N	E	
1	29.759126°	35.371309°	29.760028°	35.371320°	100
2	29.759126°	35.371309°	29.758667°	35.372218°	100
3	29.759126°	35.371309°	29.758691°	35.370399°	100

Plant observations:

Only one plant species was recorded at this location, *Hammada salicornica.*

S4-SPV3



Figure 55: Landscape of S4-SPV3 location

Flora Survey

Three line transects were made as shown in

Table 29.

Table 33. Coordinates for three transects S4-SPV2 location.

Transect No.	Start		End		Length (m)
S4-SPV2	N	E	N	E	
1	29.759126°	35.371309°	29.760028°	35.371320°	100
2	29.759126°	35.371309°	29.758667°	35.372218°	100
3	29.759126°	35.371309°	29.758691°	35.370399°	100

Plant observations:

Only one plant species was recorded at this location, *Hammada salicornica.*

5.5 Segment 4

This segment extends northwards along wadi Al Yotom parallel to the desert highway. It crosses wide wadi systems, reach the Wadi Rum intersection. It is about 20 km in length.

FA10

This is an open desert area with soft sand with scattered bushy vegetation (Figure 56). It is surrounded by sandstone mountains to the south. This site is not disturbed by urbanization; however, camels were observed within its boundaries.



Figure 56. Landscape of FA10 location. The dominant plant is Hammada salicornica.

Flora Survey

Six walking transects were made as shown in Table 34.

Table 34. Coordinates for six transects FA10 location.

Transect No.	Start		End		Length (m)
FA10	N	E	N	E	
1	29.697801°	29.697801°	29.696856°	35.327621°	500
2	29.697778°	35.327778°	29.693207°	35.327873°	500
3	29.697775°	35.327566°	29.696882°	35.327972°	500
4	29.698233°	35.327978°	29.699134°	35.327958°	500
5	29.698261°	35.327750°	29.699160°	35.327722°	500
6	29.698259°	35.327522°	29.699174°	35.327462°	500

Plant observations:

Only one plant species was recorded at this location, *Hammada salicornica.*

Fauna Survey

One walking transect was made on 31.7.2025 as shown in Table 35.

Table 35. Coordinates for one transect at FA10 location.

Transect No.	Start		End		Length (m)
	N	E	N	E	
1	29°41'45"	35°19'49"	29°41'45"	35°19'22"	300

Reptiles observed

Two individuals of Bosk's Fringe-fingered Lizard, *Acanthodactylus boskianus,* were observed within the transects, in addition to many tracts around shrubs and across the sandy soil (Figure 57, Table 36).

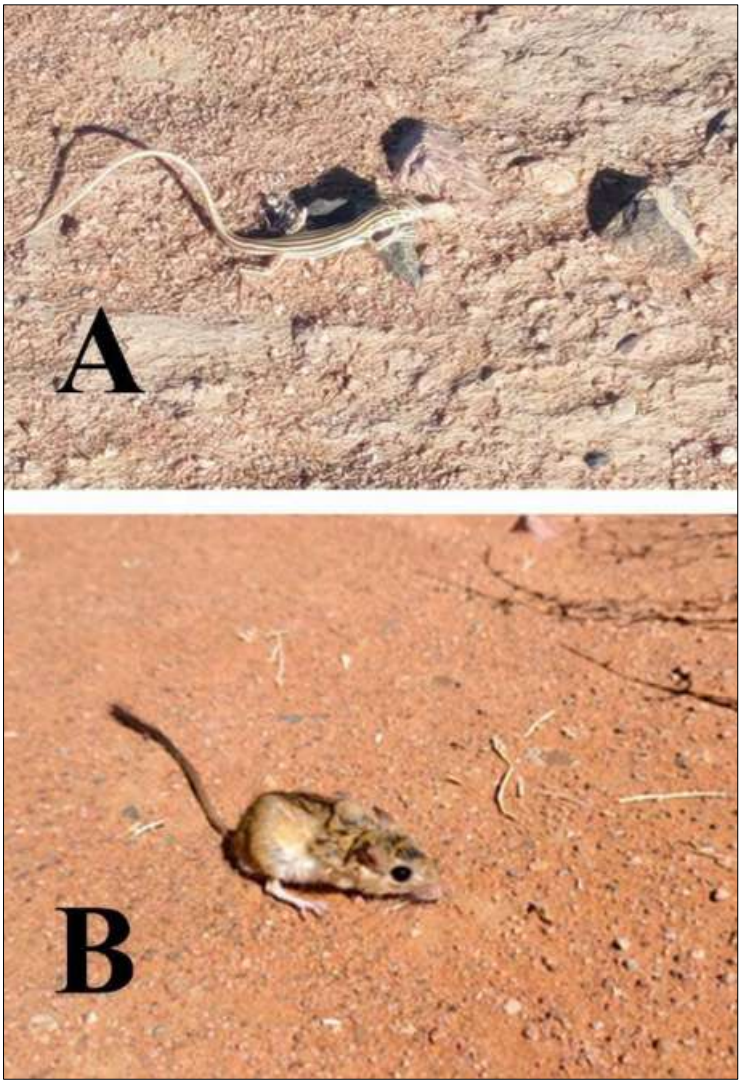


Figure 57. A. Bosk's Fringe-fingered Lizard, *Acanthodactylus boskianus*. B. Wagner's Gerbil, *Gerbillus dasyurus*.

Table 36. Reptiles and mammals species observed at RA10.

Species	Common name	No. of observed individuals
Gerbillus dasyurus	Wagner's Gerbil	1
Acanthodactylus boskianus	Bosk's Fringe-fingered Lizard	2

Small mammals trapping

A total of 6 Sherman traps were installed around burrows close to the mountains that were identified during daytime walking transects. One male Wagner's Gerbil, *Gerbillus dasyurus,*

was trapped (Figure 58). Body measurements were 130 mm for the tail length and 70 mm for body length.



Figure 58: Sherman trap at location FA10.

FA11



Figure 59: Landscape of FA11 location

Flora Survey

Three walking transects were made as shown in Table 34.

Table 37. Coordinates for six transects FA10 location.

Transect No.	Start		End		Length (m)
FA11	N	E	N	E	
1	29.700000°	35.384722°	29.704645°°	35.384481°°	500
2	29.700039°	35.384515°	29.704611°	35.384236°	500
3	29.699991°	35.384305	29.704592°	35.383938°	500

Plant observations:

Two plant species were recorded at this location, *Haloxylon salicornicum* and *Retama raetam*

Solar PV

This is a large block with a total area of about 5 km^2. It represents a depression in its centre whereas rainwater remains, forming crust after evaporation. It seems to be extensively used for agriculture as the remains of plastic sheets are scattered all over the site (Figure 60).



Figure 60. Landscape of Solar PV location. The dominant plant is *Hammada salicornica* and *Calotropis porecea*.

This site was not among the sites targeted for the vegetation cover study.

Fauna Survey

Two line transects were made on 31.7.2025 as shown in Table 38.

Table 38. Coordinates for two transects at Solar PV location.

Transect No.	Start		End		Length (m)
	N	E	N	E	
1	29°45'38"	35°21'37"	29°45'35"	35°21'52"	300
2	29°45'38"	35°21'57"	29°45'37"	35°21'40"	300

Reptiles observed

Despite the presence of lizard tracts on the soil and around bushes, we did not observe any active lizards during the survey time. Lizards inhabiting such habitat are most likely to be the Bosk's Fringe-fingered Lizard, *Acanthodactylus boskianus.*

Small mammals trapping

A total of 6 Sherman traps were installed around burrows that were identified during daytime walking transects. The burrows seem to be active; however no rodents were trapped. It is suspected that either the Fat Sand Jird, *Psammomys obesus*, or the Libyan Jird, *Meriones crassus*, may inhabit such burrows owing their size (Figure 61).



Figure 61: Sherman traps installed around active rodent's burrows. The dominant plant is *Hammada salicornica*.

5.6 Segment 5

This segment extends for about 40 km, starts around Al Masri farms to the east, then extends northward crossing mixed gravel and sand habitats (Figure 62).

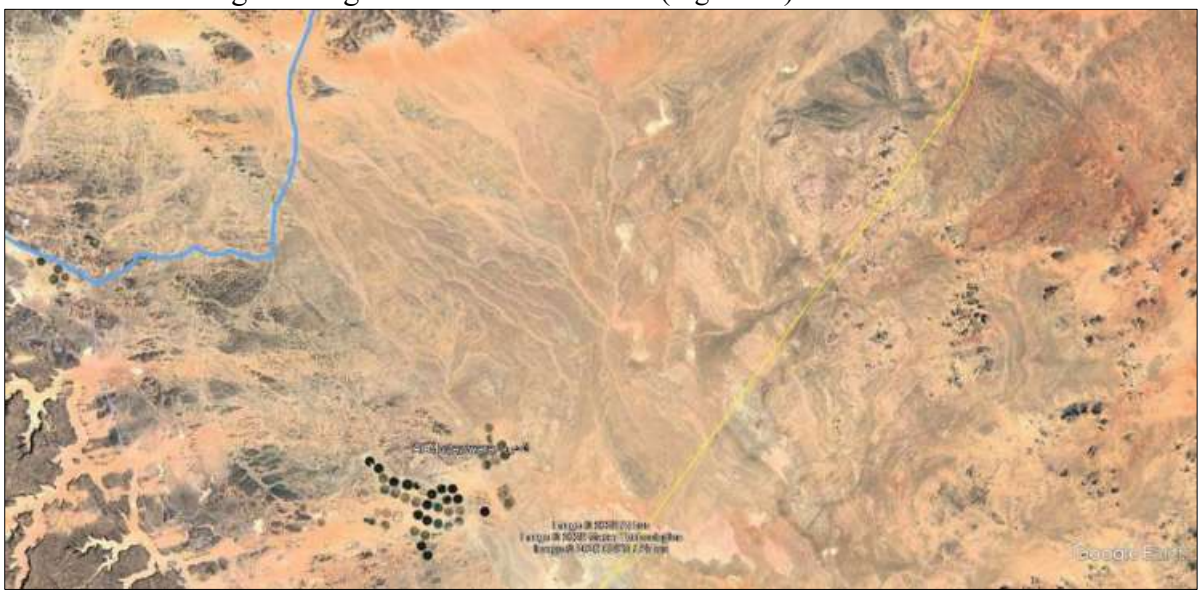


Figure 62: Outline for segment 5.

FA12 This a rocky area with a shallow wadi system with dense *Retama reteam*. The rocky area is sandstone with crevices (Figure 63).



Figure 63: Landscape of FA12 location. The dominant plant *Retama reteam*.

Flora Survey



Figure 64: Field biologist inspecting flora in a site.

Six line transects were made as shown in Table 39.

Table 39. Coordinates for three transects FA12 location.

Transect No. FA12	Start		End		Length (m)
	N	E	N	E	
1	29.677914°	35.430715°	29.678593°	35.431425°	100
2	29.678056°	35.430556°	29.678726°	35.431276°	100
3	29.678227°	35.430408°	29.678918°	35.431166°	100
4	29.677452°	35.430662°	29.675872°	29.675872°	200
5	29.677294°	35.430804°	29.675730°	35.428292°	200
6	29.677129°	35.430958°	29.675615°	35.428368°	200

Plant observations:

No vegetation

Fauna Survey

Two walking transects were made on 8.8.2025 as shown in Table 40.

Table 40. Coordinates for two transects at FA12 location.

Transect No.	Start		End		Length (m)
	N	E	N	E	
1	29°40'27"	35°25'31"	29°40'30"	35°25'34"	300
2	29°40'23"	35°25'32"	29°40'23"	35°25'44"	300

Camera trapping

A camera trap baited with sardine was installed facing the mountains area at 29°40'26"N 35°25'32"E (Figure 64). The camera trap was reset again at 8.8.2025.



Figure 65: Installing camera trap at location FA12.

The Red Fox, *Vulpes vulpes*, was the only wild carnivore to approach the trap. It was first recorded at 21:44 and kept coming back and forth until 3:33. During early morning hours, a feral dog was recoded (Figure 66).



Figure 66: Series of images captured by camera trap showing the Red Fox, *Vulpes vulpes*, and a dog.

Bat Roosts

The crevices of the rocky area around the mountains were inspected for the presence of bats. No roosts or sings of bat activity were detected.

Small mammals trapping

A total of 8 Sherman traps were installed around burrows that were identified during daytime walking transects. Only one male Bushy-tailed Jird, *Sekeetamys calurus*, was trapped near the rocky area (Figure 67). Body measurements were 160 mm for the tail length and 90 mm for body length.



Figure 67. The Bushy-tailed Jird, *Sekeetamys calurus*.

FA13A

This is an open desert with sand with bushes of the *Haloxylon persicum* (Vulnerable). Sandstone mountains surround the site to the southwest. Tracts of vehicles crosses the site from all directions (Figure 68).



Figure 68. Landscape of FA13A location. The dominant plant is Haloxylon persicum.

Flora Survey

Six line transects were made as shown in Table 41.

Table 41. Coordinates for six transects FA13A location.

Transect No.	Start		End		Length (m)
FA13A	N	E	N	E	
1	29.674991°	35.441351°	29.670533°	35.440603°	500
2	29.675000°	35.441111°	29.670485°	35.440839°	500
3	29.675001°	35.440890°	29.670461°	35.440995°	500
4	29.675278°	35.441389°	29.679912°	35.441497°	500
5	29.675302°	35.441194°	29.679904°	35.441281°	500
6	29.675314°	35.440966°	29.679998°	35.441045°	500

Plant observations:

Only one plant species was recorded at this location, *Haloxylon persicum* (Vulnerable).

Fauna Survey

One line transect was made on 1.8.2025 as shown in Table 42.

Table 42. Coordinates for one transect at FA13A location.

Transect No.	Start		End		Length (m)
	N	E	N	E	
1	29°40'25"	35°26'58"	29°40'28"	35°26'46"	300

Reptiles observed

Four individuals of Schmidt's Fringe-fingered Lizard, *Acanthodactylus schmidti,* were observed (Figure 69). This a sand dwelling species that prefers soft sand and mostly found under bushes during daytime.



Figure 69: Schmidt's Fringe-fingered Lizard, *Acanthodactylus schmidti.*

Small mammals

Abandoned burrows were observed around edges of wadi beds.

FA13B



Figure 70. Landscape of FA13B location.

Flora Survey

Three line transects were made as shown in Table 41.

Table 43. Coordinates for 3 transects FA13B location.

Transect No. FA13B	Start		End		Length (m)
	N	E	N	E	
1	29.645833°	35.520833°	29.642382°	35.517593°	500
2	29.645938°	35.520668°	29.642306°	35.517715°	500
3	29.646050°	35.520500°	29.642193°	35.517847°	500

Plant observations:

No vegetation was observed.

FA14A



Figure 71. Landscape of FA14A location.

Flora Survey

Six line transects were made as shown in Table 41.

Table 44. Coordinates for six transects FA14A location.

Transect No. FA14A	Start		End		Length (m)
	N	E	N	E	
1	29.613257°	35.568926°	29.614178°	35.563757°	500
2	29.613056°	35.568889°	29.613978°	35.563746°	500
3	29.612865°	35.568888°	29.613855°	29.613855°	500
4	29.613255°	35.569074°	29.611467°	35.573880°	500
5	29.613050°	35.569064°	29.611693°	29.611693°	500
6	29.612852°	35.569027°	29.611898°	35.574051°	500

Plant observations:

Five plant species were recorded at this location, *Salsola baryosma, Haloxylon salicornicum Suaeda maritima, Salsola tragus* and *Tamarix nilotica*

FA14B

This site is surrounded by rocky area with sand blown on its sides. It is void of vegetation. The flat side is covered by small pebbles and small-sized rocks (Figure 72). No sings of activity for reptiles were observed, and no burrows were seen within its vicinity.

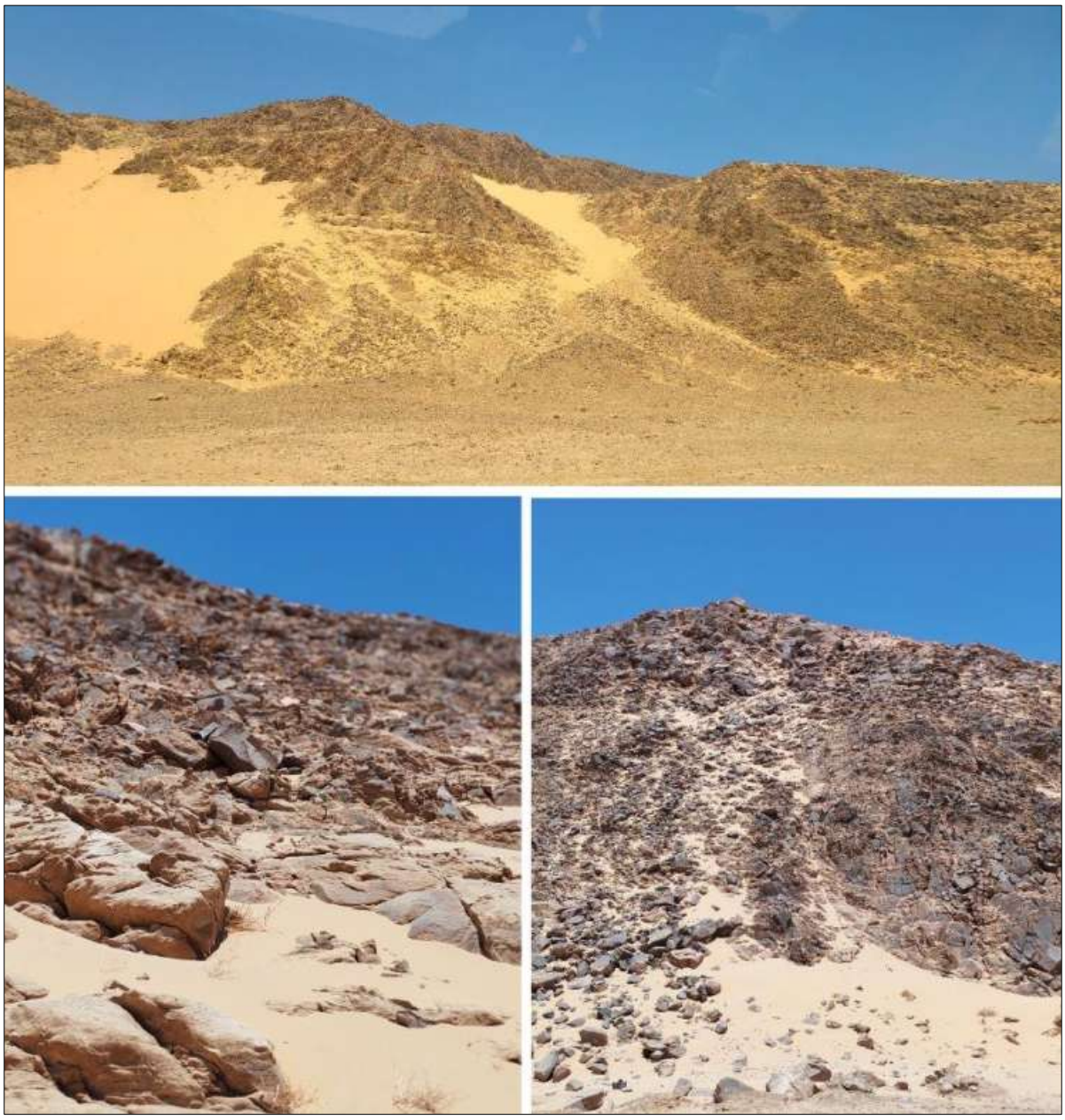


Figure 72: Landscape of FA14B location.

Flora Survey

Three line transects were made as shown in Table 41.

Table 45. Coordinates for six transects FA14B location.

Transect No.	Start		End		Length (m)
FA14B	N	E	N	E	
1	29.623104°	35.579378°	29.618719°	35.580629°	500
2	29.623056°	35.579167°	29.611467°	35.573880°	500
3	29.623006°	35.578949°	29.618755°	35.580796°	500

Plant observations:

No vegetation

Fauna Survey

One walking transect was made on 1.8.2025 as shown in Table 46.

Table 46. Coordinates for one transect at FA14B location.

Transect No.	Start		End		Length (m)
	N	E	N	E	
1	29°37'22"	35°34'34"	29°37'25"	35°34'36"	300

Reptiles observed

No reptiles were observed in this site.

Small mammals

Abandoned burrows were observed around edges of wadi beds.

FA15A (29°36'48"N 35°37'36"E)

This location represents three open artificial pools that were formed through direct input of water from Sabeeh Al Masri Farms, to provide water for sheep and camels owned by the Bedouins in the area. The pools are shallow, with lush southern cattail, *Typha elephantina*. Two large *Vachellia gerrardii* stand at the edge of the dirt road (Figure 73).



Figure 73. Landscape of wetland FA15A location. The dominant plants are *Typha elephantina, Cynodon dactylon* and *Carex pachystylis*.

Fauna Survey

Camera trap

A camera trap was placed on 8.8.2025 (29°36'46"N 35°37'32"E). On the 15th of August 2025 (Figure 74), the camera was recovered. However, it failed to record any movement for animals. This was due to the heat wave that took place on the 10th of August and lasted for over one week.

On 28.8.225, a camera trap was placed at this site. One image for the red fox, *Vulpes vulpes*, was captured at 22:57 near the open water pools (Figure 75).



Figure 74. Camera trap installed at FA15.



Figure 75. The red fox, Vulpes vulpes, photo trapped at location FA15.

Reptiles and amphibians observed

No reptiles were observed within the vicinity of the site. However, during the night survey on the 28.6.2025, the Variable Green Toad, *Bufotes sitibundus*, was observed in the open pools (Figure 76).

Small mammals

No burrows were observed.



Figure 76: The Variable Green Toad, *Bufotes sitibundus*.

Birds

Ten species of birds were observed in this location (Table 47). All recorded species are common and are not threatened.

Table 47. Birds observed at FA15.

Common name	Scientific name	Conservation status
Rock Dove	*Columba livia*	LC
Desert Lark	*Ammomanes deserti*	LC
Crested Lark	*Galerida cristata*	LC
Rock Martin	*Ptyonoprogne fuligula*	LC
Desert Wheatear	*Oenanthe deserti*	LC
Mourning Wheatear	*Oenanthe lugens*	LC
Tristram's Starling	*Onychognathus tristramii*	LC
House Sparrow	*Passer domesticus*	LC
Sinai Rosefinch	*Carpodacus synoicus*	LC
Spur-winged Lapwing	*Vanellus spinosus*	LC

FA15



Figure 77: Landscape of FA15 location.

Flora Survey

Three line transects were made as shown in

Table 49.

Table 48. Coordinates for three transects FA15 location.

Transect No.	Start		End		Length (m)
FA15	N	E	N	E	
1	29.60106	35.64068	29.601693°	35.641493°	100
2	29.601232°	35.640550°	29.601820°	35.641339°	100
3	29.601383°	35.640422°	29.601975°	35.641236°	100

Plant observations:

No vegetation was observed.

FA15A



Figure 78: Landscape of FA15A location.

Flora Survey

Three line transects were made as shown in

Table 49.



Figure 79. Field biologist inspecting flora in a site.

Table 49. Coordinates for three transects FA15A location.

Transect No. FA15	Start		End		Length (m)
	N	E	N	E	
1	29.60106	35.64068	29.601693°	35.641493°	100
2	29.601232°	35.640550°	29.601820°	35.641339°	100
3	29.601383°	35.640422°	29.601975°	35.641236°	100

Plant observations:

Seven plant species were recorded at this location, *Vachellia gerrardii* (Vulnerable), *Retama raetam, Hammada salicornica, Hammada scoparia, Typha elephantina, Cynodon dactylon* and *Carex pachystylis*

FA16

This site is close to main pipeline with sandy soil sometimes covered by gravel. The northern side is surrounded by small mountains covered by gravel (Figure 80). Flat rocky crevices are common around the edges of the mountains offering suitable habitats for Agamids. *Zilla spinosa* and the white saxaul, *Halyxlon presicum* are the most common vegetation.



Figure 80. Landscape of FA16 location. The dominant plants is *Halyxlon presicum*.

Flora Survey

Six line transects were made as shown in Table 50.



Figure 81: Field biologist inspecting flora in a site.

Table 50. Coordinates for six transects FA16 location.

Transect No. FA16	Start		End		Length (m)
	N	E	N	E	
1	29.555263°	35.695031°	29.551429°	35.692415°	500
2	29.555172°	35.695210°	29.551281°	35.692607°	500
3	29.555042°	35.695368°	29.551145°	35.692766°	500
4	29.555447°	35.695171°	29.556246°	35.695717°	100
5	29.555345°	35.695353°	29.556140°	35.695878°	100
6	29.555236°	35.695532°	29.556024°	35.696056°	100

Plant observations:

Two plant species were recorded at this location, *Hammada salicornica* and *Retama raetam*

Fauna Survey

Two walking transects were made on 1.8.2025 as shown in Table 51.

Table 51. Coordinates for two transects at FA16 location.

Transect No.	Start		End		Length (m)
	N	E	N	E	
1	29°33'13"	35°41'52"	29°33'14"	35°41'57"	300
	29°33'19"	35°41'42"	29°33'12"	35°41'58"	300

Reptiles observed

One individual of the Sinai agama, *Pseudotrapelus sinaitus,* was located under a stone (Figure 82). No other lizards were observed.



Figure 82: Sinai agama, *Pseudotrapelus sinaitus*.

Small mammals

No burrows were observed.

5.7 Segment 6

This section crosses wadi systems with the lava desert south of Al Jafr. It extends for about 110 km (Figure 83).



Figure 83: Outline for segment 6.

FA17



Figure 84: Landscape of FA17 location.

Flora Survey

Six line transects were made as shown in Table 50.

Table 52. Coordinates for 6 transects at FA17 location.

Transect No. FA17	Start		End		Length (m)
	N	E	N	E	
1	29.516340°	35.749100°	29.513507°	35.745127°	500
2	29.516224°	35.749254°	29.513352°	35.745285°	500
3	29.516103°	35.749409°	29.513189°	35.745503°	500
4	29.516670°	35.749310°	29.520087°	35.752672°	500
5	29.516786°	35.749152°	29.520238°	35.752460°	500
6	29.516903°	35.748997°	29.520365°	35.752329°	500

Plant observations:

Three plant species were recorded at this location, *Artemisia Judaica, Haloxylon salicornicum* and *Fagonia mollis*

FA20



Figure 85: Landscape of FA20 location.

Flora Survey

Three line transects were made as shown in Table 50.

Table 53. Coordinates for 3 transects at FA20 location.

Transect No.	Start		End		Length (m)
FA20	N	E	N	E	
1	29.52507	35.90660	29.525560°	35.905738°	100
2	29.524903°	35.906528°	29.525407°	35.905663°	100
3	29.524731°	35.906438°	29.525250°	35.905586°	100

Plant observations:

Three plant species were recorded at this location, *Calligonum comosum, Fagonia mollis* and *Artemisia judaica*

This site was not among the sites targeted for animal studies.

FA21

This location is situated near the manholes of Disi pipeline. Leaked water formed small pools with dense vegetation (Figure 86). Bushes of Retama *raetam.* The soil is mostly sandy with pebbles in some parts. This site is frequented by hunters, since empty cartridges were observed, along with feather of killed birds.



Figure 86: Landscape of FA21 location. The dominant plants are Phragmites australis and Cynodon dactylon.

Flora Survey

Six line transects were made as shown in Table 54.

Table 54. Coordinates for six transects FA21 location.

Transect No. FA21	Start		End		Length (m)
	N	E	N	E	
1	29.52507	35.90660	29.525560°	35.905738°	100
2	29.524903°	35.906528°	29.525407°	35.905663°	100
3	29.524731°	35.906438°	29.525250°	35.905586°	100
4	29.57064	35.93894	29.570199°	35.939850°	100
5	29.570484°	35.938845°	29.570039°	35.939760°	100
6	29.570320°	35.938736°	29.569861°	35.939645°	100

Plant observations:

Six plant species were recorded at this location, *Artemisia Judaica* (Vulnerable), *Phragmites australis, Hammada salicornica, Fagonia mollis, Cynodon dactylon* and *Retama raetam*

Fauna Survey

One walking transect was made on 1.8.2025 as shown in Table 55.

Table 55. Coordinates for two transects at FA21 location.

Transect No.	Start		End		Length (m)
	N	E	N	E	
1	29°34'14"	35°56'19"	29°34'17"	35°56'16"	300

Camera trapping

One camera trap was installed on 1 August 2025 (29°34'14"N 35°56'20"E). The camera trap was stolen when inspected on 8.8.2025. Another attempt to install a camera trap was undertaken on the 28.8.2025 (Figure 87). No animals were captured during this period.



Figure 87: Installation of a camera trap at FA21 on 1 August 2025.

Reptiles observed

Two young Arnold's Fringe-fingered Lizard, *Acanthodactylus opheodurus,* were observed in the coarse soil around vegetation (Figure 88).



Figure 88: Arnold's Fringe-fingered Lizard, *Acanthodactylus opheodurus*.

Small mammals

No evidence of active burrows for small mammals was observed.

FA22

This is a flat area with dense vegetation of *Retama raetam* and *Hammada salicornica*. The substratum is sandy with sometimes mixed with small pebbles. To the east side, remains of a tunnel-bridge of the Hijazi Railway is present (Figure 89).



Figure 89: Landscape of FA22 location. The dominant plant is *Hammada salicornica*.

Flora Survey

Six line transects were made as shown in Table 56.

Table 56. Coordinates for six transects FA22 location.

Transect No.	Start		End		Length (m)
FA22	N	E	N	E	
1	29.583947°	35.944299°	29.584078°	35.945425°	100
2	29.584125°	35.944365°	29.583874°	35.945372°	100
3	29.58431	35.94443	29.583681°	35.945266°	100
4	29.58411	35.94316	29.583541°	35.942368°	100
5	29.583928°	35.943175°	29.583356°	35.942377°	100
6	29.583742°	35.943173°	29.583170°	35.942380°	100

Plant observations:

Seven plant species were recorded at this location, *Hammada salicornica, Fagonia mollis, Heliotropium rotundifolium, Hyoscyamus muticus* (Critically Endangered), *Retama raetam, Artemisia judaica* (Vulnerable) and *Zilla spinosa*

Fauna Survey

Two walking transects were made on 1.8.2025 as shown in Table 57.

Table 57. Coordinates for two transects at FA22 location.

Transect No.	Start		End		Length (m)
	N	E	N	E	
1	29°34'14"	35°56'19"	29°34'17"	35°56'16"	300
2	29°34'22"	35°56'16"	29°35'02"	35°56'31"	300

Bat roosts

The railway tunnels were inspected for the presence of bats. No bat roosts were detected.

Reptiles observed

We found Hasselquist's Fan-footed Gecko, *Ptyodactylus hasselquistii* on the walls of the railway tunnels. Bosk's Fringe-fingered Lizard, *Acanthodactylus boskianus,* was observed under small shrubs avoiding sunlight (Figure 90).



Figure 90: A. Bosk's Fringe-fingered Lizard, *Acanthodactylus boskianus*. B. Hasselquist's Fan-footed Gecko, *Ptyodactylus hasselquistii.*

Small mammals

Few abandoned burrows were observed close to large bushes.

FA23

Narrow wadi system with *Retama raetam*. The soil is sandy, while the edges are covered by gravel and small pebbles (Figure 91).



Figure 91: Landscape of FA23 location. The dominant plant is *Artemisia monosperma*.

Flora Survey

Six line transects were made as shown in Table 58.

Table 58. Coordinates for six transects FA23 location.

Transect No. FA23	Start		End		Length (m)
	N	E	N	E	
1	29.63532	35.95650	29.634689°	35.957255°	100
2	29.635196°	35.956371°	29.634554°	35.957123°	100
3	29.635039°	35.956242°	29.634424°	35.956985°	100
4	29.63687	35.95648	29.637350°	35.955602°	100
5	29.636718°	35.956351°	29.637185°	35.955463°	100
6	29.636568°	35.956216°	29.637015°	35.955326°	100

Plant observations:

Two plant species were recorded at this location, *Artemisia monosperma* (Near Threatened) and *Pulicaria undulata.*

Fauna Survey

One walking transect was made on 1.8.2025 as shown in Table 59.

Table 59. Coordinates for one transect at FA23 location.

Transect No.	Start		End		Length (m)
	N	E	N	E	
1	29°38'510"	35°57'21"	28°39'09"	35°57'19"	300

Reptiles observed

Tracts of lizards were observed over the soft sand.

Small mammals

No active rodent burrows were observed.

RA24

A wide wadi system that extends over 500 in width located near a manhole for the Disi water pipeline. It is mostly covered by *Retama raetam.* Substratum is mostly sand with some areas covered by small rocks (Figure 92).



Figure 92: Landscape of FA24 location. The dominant plant is *Artemisia monosperma*.

This site was not among the sites targeted for the vegetation cover study.

Fauna Survey

One walking transect was made on 1.8.2025 as shown in Table 60.

Table 60. Coordinates for six transects FA23 location.

Transect No.	Start		End		Length (m)
	N	E	N	E	
1	29°39'51"	35°58'43"	28°39'58"	35°58'35"	300

Camera trap

One camera trap was installed on 6 August 2025 (29°40'10"N 35°58'34"E) at 17:40. On the 15th of August 2025, the camera was recovered. However, it failed to record any movement for animals. This was due to the heat wave that took place on the 10th of August and lasted for over one week.

On the 28th of August 2025, a camera trap was installed at this site. Images for two individuals of the red fox, *Vulpes vulpes*, and one Ethiopian hedgehog, *Paraechinus aethiopicus*, were captured at between 5:22 and 5:36 (Figure 93).



Figure 93. Two individuals of the red fox, *Vulpes vulpes*, and one Ethiopian hedgehog, *Paraechinus aethiopicus*.

Reptiles observed

Three adults *Acanthodactylus boskianus* were observed under bushes, and one young specimen was seen on the sand (Figure 94).

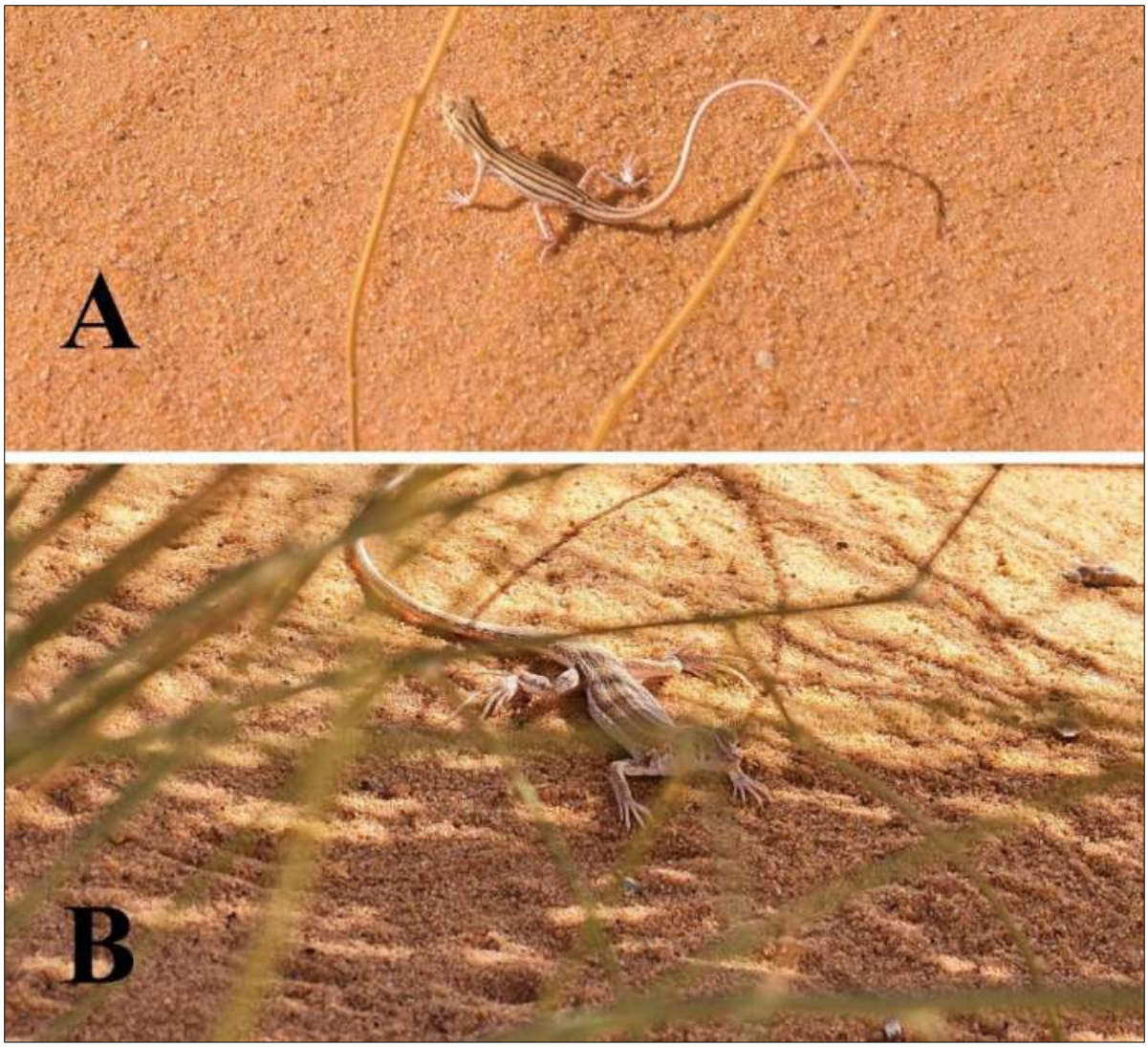


Figure 94: *Acanthodactylus boskianus* from site FA25.

Small mammals

Burrows of different rodents were observed.

FA25



Figure 95: Landscape of FA25 location.

Flora Survey

Six line transects were made as shown in Table 58.

Table 61. Coordinates for six transects FA25 location.

Transect No. RA25	Start		End		Length (m)
	N	E	N	E	
1	29.66548	35.97981	29.665482°	35.980848°	100
2	29.665303°	35.979751°	29.665294°	35.980802°	100
3	29.665124°	35.979696°	29.665118°	35.980744°	100
4	29.66548	35.97981	29.665482°	35.980848°	100
5	29.665303°	35.979751°	29.665294°	35.980802°	100
6	29.665124°	35.979696°	29.665118°	35.980744°	100

Plant observations:

Three plant species were recorded at this location, *Artemisia monosperma, Zilla spinosa* and *Citrullus colocynthis*

This site was not among the sites targeted for animal studies.

FA26



Figure 96: Landscape of FA26 location..

Three line transects were made as shown in Table 58.

Table 62. Coordinates for six transects FA26 location.

Transect No. RA26	Start		End		Length (m)
	N	E	N	E	
1	29.68489	35.99305	29.684892°	35.993573°	100
2	29.684734°	35.992925°	29.684734°	35.993442°	100
3	29.684585°	35.992801°	29.684589°	35.993327°	100

Plant observations:

Only one plant species was recorded at this location, *Hammada salicornica.*

This site was not among the sites targeted for animal studies.

FA27

This location is close to a pumping station for Disi Water Pipeline. It represents a wadi system with dense cover of *Tamarix nilotica,* with a water leak in its centre (Figure 97).



Figure 97: Landscape of FA27 location. The dominant plant is Tamarix nilotica.

Flora Survey

Three line transects were made as shown in Table 63.

Table 63. Coordinates for three transects FA27 location.

Transect No.	Start		End		Length (m)
FA27	N	E	N	E	
1	29.68944	35.99391	29.689672°	35.994929°	100
2	29.689651°	35.993882°	29.689884°	35.994893°	100
3	29.689848°	35.993894°	29.690080°	35.994897°	100

Plant observations:

Four plant species were recorded at this location, *Phragmites australis, Tamarix nilotica, Tamarix aphylla* and *Fagonia mollis.*

Fauna Survey

Two line transects were made on 6.8.2025 as shown in Table 64. A night survey was conducted on the 18th of August 2025.

Table 64. Coordinates for one transect at FA27 location.

Transect No.	Start		End		Length (m)
	N	E	N	E	
1	29°41'22"	35°59'37"	29°41'20"	35°59'41"	300
2	29°41'22"	35°59'38"	29°41'19"	35°59'40"	300

Reptiles observed

One adult *Sinai agama, Pseudotrapelus sinaitus,* was observed under rocks during daytime (Figure 98). Night survey yielded the observation of the Fan footed Gecko, *Ptyodactylus hasselquistii*, hidden in a crevice of the presser release manhole (Fig. 98).



Figure 98. Reptiles observed at FA27. A. *Pseudotrapelus sinaitus. B. Ptyodactylus hasselquistii*.

Mammals observed

During the night survey on the 18th of August 2025, we encountered a red fox, *Vulpes vulpes* near the pumping station.

FA29

This is a small wadi covered by stones and very few shrubs. The edges are covered by compact soil (Figure 99).



Figure 99. Landscape of FA29 location. The dominant plant is *Zilla spinosa*.

This site was not among the sites targeted for the vegetation cover study.

Fauna Survey

Two line transects were made on 6.8.2025 as shown in Table 65. A night survey was conducted on the 18th of August 2025.

Table 65. Coordinates for one transect at FA29 location.

Transect No.	Start		End		Length (m)
	N	E	N	E	
1	29°43'10"	35°58'47"	29°43'11"	35°58'50"	300
2	29°43'08"	35°58'48"	29°43'07"	35°58'43"	300

Reptiles observed

No reptiles were observed. Only tracts of lizards were observed.

During the night survey, we observed the fan-footed Gecko, *Ptyodactylus hasselquistii* and Jordan short-fingered gecko, *Stenodactylus grandiceps* close to this site (Figure 100).

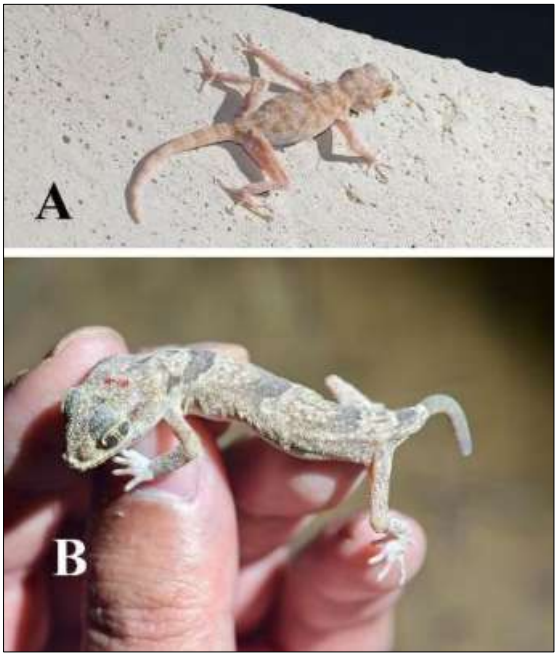


Figure 100. A. The fan-footed Gecko, *Ptyodactylus hasselquistii.* B. Jordan short-fingered gecko, *Stenodactylus grandiceps.*

Small mammals

No active burrows were observed.

FA30

This location is a relatively wide wadi system with *Retama raetam* and *Zilla spinosa.* The soil is compact and hard with scattered piles of rocks (Figure 101).



Figure 101: Landscape of FA30 location. The dominant plant is *Zilla spinosa*.

Flora Survey

Six line transects were made as shown in Table 66.

Table 66. Coordinates for six transects FA30 location.

Transect No. FA30	Start		End		Length (m)
	N	E	N	E	
1	29.719540°	35.979026°	29.719122°	35.978114°	100
2	29.719386°	35.979153°	29.718948°	35.978242°	100
3	29.71922	35.97926	29.718768°	35.978326°	100
4	29.71964	35.97987	29.720216°	35.980677°	100
5	29.719805°	35.979744°	29.720394°	35.980545°	100
6	29.719975°	35.979611°	29.720563°	35.980423°	100

Plant observations:

Four plant species were recorded at this location, *Zilla spinosa, Pulicaria undulata, Artemisia sieberi* and *Astragalus spinosus.*

Fauna Survey

Two line transects were made on 6.8.2025 as shown in Table 67. A night survey was conducted on the 18th of August 2025.

Table 67. Coordinates for one transect at FA30 location.

Transect No.	Start		End		Length (m)
	N	E	N	E	
1	29°44'42"	35°58'27"	29°44'46"	35°58'23"	300
	29°44'42"	35°58'28"	29°44'46"	35°58'43"	300

Reptiles observed

No reptiles were observed.

Small mammals

No active burrows were observed.

FA30B



Figure 102: Landscape of FA30B location.

Flora Survey

Three line transects were made as shown in Table 66.

Table 68. Coordinates for six transects FA30B location.

Transect No. FA30B	Start		End		Length (m)
	N	E	N	E	
1	30.56257	36.12095	30.562102°	36.121850°	100
2	30.56257	36.12095	30.562103°	36.120020°	100
3	30.56257	36.12095	30.563484°	36.120943°	100

Plant observations:

No vegetation

This site was not among the sites targeted for animal studies.

FA32

This wadi system holds the most dense stands of *Vachellia gerrardii* of various hights that some reaches up to 4m in hight. Few *Retama raetam* were observed. The substratum is compacted with few areas with sand (Figure 103).



Figure 103: Landscape of FA32 location. The dominant plants are Vachellia gerrardii and Retama raetam.

Flora Survey

Six line transects were made as shown in Table 67.

Table 69. Coordinates for six transects FA32 location.

Transect No. FA32	Start		End		Length (m)
	N	E	N	E	
1	29.80734	35.97446	29.807333°	35.975465°	100
2	29.807530°	35.974465°	29.807542°	35.975518°	100
3	29.807727°	35.974472°	29.807755°	35.975516°	100
4	29.807719°	35.974112°	29.807740°	35.973052°	100
5	29.807521°	35.974111°	29.807524°	35.973047°	100
6	29.807315°	35.974090°	29.807323°	35.973034°	100

Plant observations:

Three plant species were recorded at this location, *Zilla spinosa, Retama raetam* and *Vachellia gerrardii* (Vulnerable).

Fauna Survey

Two line transects were made on 8.8.2025 as shown in Table 70. A night survey was conducted on the 18th of August 2025.

Table 70. Coordinates for one transect at FA32 location.

Transect No.	Start		End		Length (m)
	N	E	N	E	
1	29°48'28"	35°57'27"	29°48'28"	35°58'30"	300
2	29°48'28"	35°57'27"	29°48'25"	35°58'28"	300

Reptiles observed

Acanthodactylus boskianus was observed (Figure 104).



Figure 104. *Acanthodactylus boskianus* observed at RA32.

During night survey, we observed Jordan short-fingered gecko, *Stenodactylus grandiceps*, on the ground (Figure 105).



Figure 105: Jordan short-fingered gecko, *Stenodactylus grandiceps.*

Small mammals

Burrows of different rodents were observed. Six traps were installed in this site, and no rodents were trapped on the following day.

FA33

This wadi system is opposite to location FA32. Few *Vachellia gerrardii* are scattered within this wadi, however, *Retama raetam* is common in the eastern side. Substratum is sandy in some parts, but mainly rocky on the sides. Small bushes of *Zilla spinosa* are scattered within the eastern part of the wadi (Figure 106).



Figure 106: Landscape of FA33 location. The dominant plants are Vachellia gerrardii and Retama raetam.

This site was not among the sites targeted for the vegetation cover study.

Fauna Survey

Two walking transects were made during 9 August 2025 Table 71.

Table 71. Coordinates for two transects at FA33 location.

Transect No.	Start		End		Length (m)
	N	E	N	E	
1	29°52'55"	35°59'38"	29°52'59"	35°59'45"	300
2	29°52'55"	35°59'36"	29°52'54"	35°59'31"	300

Reptiles observed

No reptiles were observed within this location, however, very close to it we observed a young Egyptian spiny-tailed lizard, *Uromastyx aegyptia*, at 29°50'19"N 35°58'48"E.

Small mammals

No burrows for rodents were observed.

FA35

This is a narrow wadi system surround by the north with a rocky cliff. Few *Vachellia gerrardii* and *Retama raetam* were observed within the wadi system. Part of the wadi is sandy, while the edges are covered by gravel and medium-sized rocks (Figure 107).



Figure 107: Landscape of FA35 location. The dominant plants are Vachellia gerrardii and Retama raetam.

Flora Survey

Six line transects were made as shown in Table 72.

Table 72. Coordinates for six transects FA35 location.

Transect No. FA35	Start		End		Length (m)
	N	E	N	E	
1	29.819889°	35.975379°	29.819906°	35.976447°	100
2	29.819648°	35.975378°	29.819667°	35.976448°	100
3	29.819410°	35.975367°	29.819419°	35.976426°	100
4	29.819244°	35.974027°	29.819292°	35.972974°	100
5	29.819032°	35.974031°	29.819086°	35.972992°	100
6	29.818827°	35.974004°	29.818841°	35.972948°	100

Plant observations:

Four plant species were recorded at this location, *Vachellia gerrardii,* (Vulnerable). *Zilla spinosa, Pulicaria undulata* and *Astragalus spinosus.*

Fauna Survey

One walking transect was made during 8 August 2025 (Table 73).

Table 73. Coordinates for one transect at FA35 location.

Transect No.	Start		End		Length (m)
	N	E	N	E	
1	29°49'12"	35°58'31"	29°49'09"	35°58'25"	300

Camera trapping

A camera trap was installed on the 8th of August 2025. Upon inspection on the following day, the camera was stolen (Fig. 108).

Reptiles observed

No reptiles were observed.

Small mammals

Six Sherman trap were installed on the 8th of August 2025. Upon inspection on the following day, all the traps were stolen (Figure 108).



Figure 108: Location for the installed camera trap and the Sherman traps at RA35 location.

FA36

This is a wide wadi system with few *Vachellia gerrardii* and *Retama raetam*. Most of the wadi is covered by gravel and medium-sized rocks (Figure 109). Evidence of grazing on *Vachellia gerrardii* was noted.



Figure 109: Landscape of FA36 location. The dominant plants are Vachellia gerrardii and Zilla spinosa.

Flora Survey

Six line transects were made as shown in Table 74.

Table 74. Coordinates for six transects FA36 location.

Transect No. RA36	Start		End		Length (m)
	N	E	N	E	
1	29.80734	35.97446	29.807333°	35.975465°	100
2	29.807530°	35.974465°	29.807542°	35.975518°	100
3	29.807727°	35.974472°	29.807755°	35.975516°	100
4	29.807719°	35.974112°	29.807740°	35.973052°	100
5	29.807521°	35.974111°	29.807524°	35.973047°	100
6	29.807315°	35.974090°	29.807323°	35.973034°	100

Plant observations:

Four plant species were recorded at this location, *Zilla spinosa, Vachellia gerrardii,* (Vulnerable). *Pulicaria undulata* and *Retama raetam.*

Fauna Survey

Two walking transects were made during 9 August 2025 (Table 75).

Table 75. Coordinates for two transects at RA36 location.

Transect No.	Start		End		Length (m)
	N	E	N	E	
1	29°50'11"	35°58'42"	29°50'06"	35°58'49"	300
2	29°50'11"	35°58'43"	29°50'08"	35°58'37"	300

Reptiles observed

No reptiles were observed.

Small mammals

No active burrows were observed.

FA37

This site is located along a shallow wadi system that runs parallel to a pressure release manhole for the Disi Water Pipeline. There is a water leakage with minimum amount of water making a small pool that does not exceed 30 cm long. Shepherds along with their sheep frequent the site. Bermuda grass, *Cynodon dactylon*, grows around the small water pool, while the wadi is dominated by *Zilla spinosa.* The substratum is a mix of compacted sand and rocks (Figure 110).



Figure 110: Landscape of FA37 location. The dominant plant is Zilla spinosa.

Flora Survey

Six line transects were made as shown in Table 76.

Table 76. Coordinates for six transects FA37 location.

Transect No. FA37	Start		End		Length (m)
	N	E	N	E	
1	29.874420°	35.991790°	29.874391°	35.992827°	100
2	29.874593°	35.991848°	29.874583°	35.992886°	100
3	29.874766°	35.991908°	29.874762°	35.992950°	100
4	29.874919°	35.991359°	29.874936°	35.990311°	100
5	29.874756°	35.991286°	29.874785°	35.990264°	100
6	29.874580°	35.991210°	29.874590°	35.990174°	100

Plant observations:

Eight plant species were recorded at this location, *Pulicaria undulata, Kickxia aegyptiaca, Fagonia mollis, Vachellia gerrardii* (Vulnerable), *Zilla spinosa, Farsetia aegyptiaca, Asteriscus graveolens* and *Fagonia bruguieri.*

Fauna Survey

One walking transect was made at this site during 9.9.2025 as shown in Table 77.

Table 77. Coordinates for one transect at FA37 location.

Transect No.	Start		End		Length (m)
	N	E	N	E	
1	29°52'26"	35°59'28"	29°52'30"	35°59'34"	300

Reptiles observed

No reptiles were observed.

Small mammals

Large active burrows were observed, perhaps for *Meriones crassus.*

FA38

This site is a wadi system with relative abundance of *Vachellia gerrardii* of various hight. Evidence of grazing was observed owing the presence of small trees. Substratum is compacted soil with gravel, with small shrubs of *Zilla spinosa* (Figure 111).

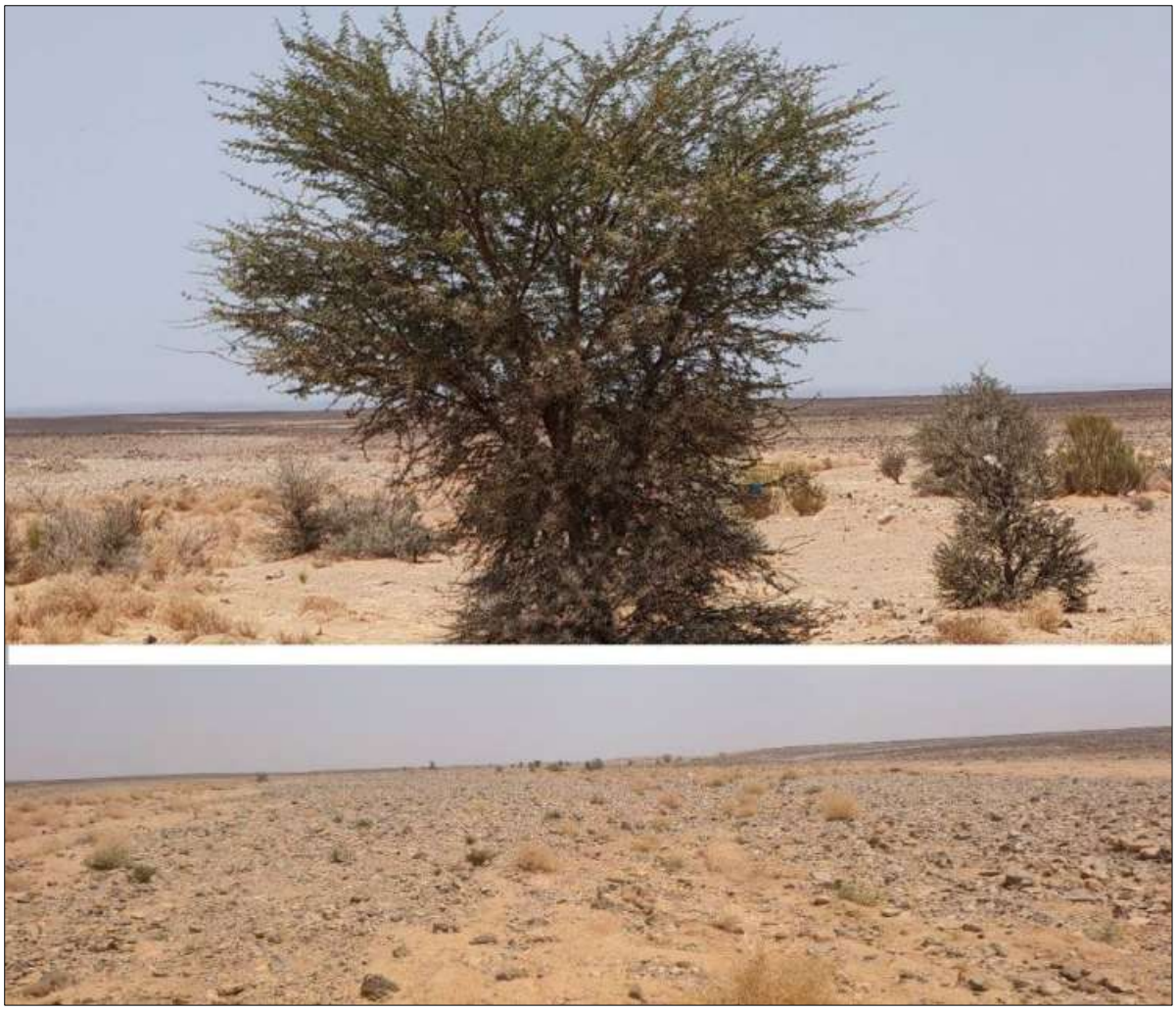


Figure 111: Landscape of FA38 location. The dominant plants are Vachellia gerrardii and Zilla spinosa.

Flora Survey

Six line transects were made as shown in Table 78.

Table 78. Coordinates for six transects FA38 location.

Transect No.	Start		End		Length (m)
FA38	N	E	N	E	
1	29.883290°	35.994530°	29.883277°	35.995581°	100
2	29.883475°	35.994578°	29.883469°	35.995622°	100
3	29.883647°	35.994623°	29.883667°	35.995672°	100
4	29.883713°	35.994277°	29.883751°	35.993230°	100
5	29.883529°	35.994234°	29.883577°	35.993197°	100
6	29.883350°	35.994190°	29.883367°	35.993163°	100

Plant observations:

Five plant species were recorded at this location, *Peganum harmala, Asteriscus graveolens, Retama raetam, Zilla spinosa* and *Pulicaria undulata.*

Fauna Survey

Two walking transects were made at this site during 9.9.2025 as shown in

Table 79.

Table 79. Coordinates for two transects at RA38 location.

Transect No.	Start		End		Length (m)
	N	E	N	E	
1	29°52'54"	35°59'38"	29°52'55"	35°59'45"	300
2	29°52'59"	35°59'45"	29°52'55"	35°59'36"	300

Reptiles observed

A single *Acanthodactylus boskianus* was observed.

Small mammals

No active burrows were observed in this site.

FA39

This site represents a wadi system dominated by *Retama raetam* and *Zilla spinosa*. few *Vachellia gerrardii* is very not common. It is mostly covered by gravel and small rocks (Figure 112).



Figure 112: Landscape of FA39 location. The dominant plants are Retama raetam and Zilla spinosa.

Flora Survey

Six line transects were made as shown in Table 80.

Table 80. Coordinates for six transects FA39 location.

Transect No. FA39	Start		End		Length (m)
	N	E	N	E	
1	29.919770°	36.002840°	29.919708°	36.003893°	100
2	29.919929°	36.002894°	29.919898°	36.003933°	100
3	29.920114°	36.002953°	29.920100°	36.003986°	100
4	29.920292°	36.002580°	29.920301°	36.001545°	100
5	29.920115°	36.002540°	29.920121°	36.001501°	100
6	29.919940°	36.002500°	29.919949°	36.001454°	100

Plant observations:

Five plant species were recorded at this location, *Vachellia gerrardii* (Vulnerable), *Zilla spinosa, Achillea fragrantissima, Fagonia bruguieri* and *Retama raetam.*

Fauna Survey

Two walking transects were made at this site during 9.9.2025 as shown in Table 81.

Table 81. Coordinates for two transects at FA39 location.

Transect No.	Start		End		Length (m)
	N	E	N	E	
1	29°55'08"	36°00'04"	29°55'12"	36°00'05"	300
2	29°55'13"	36°00'07"	29°55'18"	36°00'04"	

Reptiles observed

No reptiles observed in this site.

Small mammals

Burrows were observed under *Retama raetam*.

FA40

This site is located along a wadi system that runs parallel to a pressure release manhole for the Disi Water Pipeline. That wadi is dominated by *Retama raetam* and *Zilla spinosa,* with few *Vachellia gerrardii.* The substratum is a mix of sand and small rocks (Figure 113).



Figure 113: Landscape of RA40 location. The dominant plants are *Retama raetam* and *Zilla spinosa*.

Flora Survey

Six line transects were made as shown in Table 82.

Table 82. Coordinates for six transects FA40 location.

Transect No.	Start		End		Length (m)
FA40	N	E	N	E	
1	29.927650°	36.004550°	29.927607°	36.005596°	100
2	29.927836°	36.004596°	29.927794°	36.005637°	100
3	29.928008°	36.004639°	29.928004°	36.005694°	100
4	29.928025°	36.004485°	29.928027°	36.003453°	100
5	29.927847°	36.004443°	29.927893°	36.003408°	100
6	29.927670°	36.004400°	29.927713°	36.003358°	100

Plant observations:

Six plant species were recorded at this location, *Zilla spinosa, Achillea fragrantissima, Vachellia gerrardii* (Vulnerable), *Retama raetam, Hammada scoparia* and *Fagonia bruguieri.*

Fauna Survey

Two walking transects were made at this site during 9.8.2025 as shown in Table 83.

Table 83. Coordinates for two transects at FA40 location.

Transect No.	Start		End		Length (m)
	N	E	N	E	
1	29°55'39"	36°00'16"	29°55'37"	36°00'13"	300
2	29°55'39"	36°00'13"	29°55'47"	36°00'22"	300

Reptiles observed

Tracts of lizards were observed across the sandy part of the site, however, we did not observed any lizard due to the high temperature that day that reached 43° C. On the 16th of August 2025, we revisited the site and observed 12 *Acanthodactylus boskianus*.

Small mammals

No active burrows were observed in this site.

FA41

This is a wadi system with large bushes of *Retama raetam* and *Zilla spinosa,* with few *Vachellia gerrardii.* The substratum is a mix of sand and small rocks (Figure 114).



Figure 114: Landscape of FA41 location. The dominant plants are Retama raetam and Zilla spinosa.

Flora Survey

Six line transects were made as shown in Table 84.

Table 84. Coordinates for six transects FA41 location.

Transect No.	Start		End		Length (m)
FA41	N	E	N	E	
1	29.936280°	36.006620°	29.936276°	36.007665°	100
2	29.936459°	36.006673°	29.936450°	36.007708°	100

3	29.936645°	36.006727°	29.936598°	36.007764°	100
4	29.936697°	36.006337°	29.936726°	36.005301°	100
5	29.936523°	36.006283°	29.936538°	36.005246°	100
6	29.936340°	36.006230°	29.936371°	36.005194°	100

Plant observations:

Six plant species were recorded at this location, *Zilla spinosa, Vachellia gerrardii* (Vulnerable), *Hammada scoparia, Retama raetam, Fagonia bruguieri* and *Achillea fragrantissima*

Fauna Survey

Two walking transects were made at this site during 16.8.2025 as shown in Table 85.

Table 85. Coordinates for two transects at FA41 location.

Transect No.	Start		End		Length (m)
	N	E	N	E	
1	29°56'10"	36°00'23"	29°56'10"	36°00'31"	300
2	29°56'10"	36°00'23"	29°56'08"	36°00'20"	300

Reptiles observed

A total of 9 *Acanthodactylus boskianus* were observed across the walking transects. Near this site at (29°56'46"N 36°00'31"E), we located three males of the Northern Arabian Plain Agama, *Trapelus agnetae.* They were basking around noontime with ambient temperature of 37^0 C (Figure 115).



Figure 115: A, B. and D. *Acanthodactylus boskianus*. C. *Trapelus agnetae.*

Small mammals

Burrows for most probably the Sundevall's jird, *Meriones crassus* were observed.

FA42

Shallow wadi with few *Vachellia gerrardii* and *Retama raetam.* There is a water leakage near the pressure release manhole forming a small water pool dominated by *Typha elephantina Typha elephantina*and very dense *Zilla spinosa.* The substratum is a mix of sand and rocks (Figure 116).

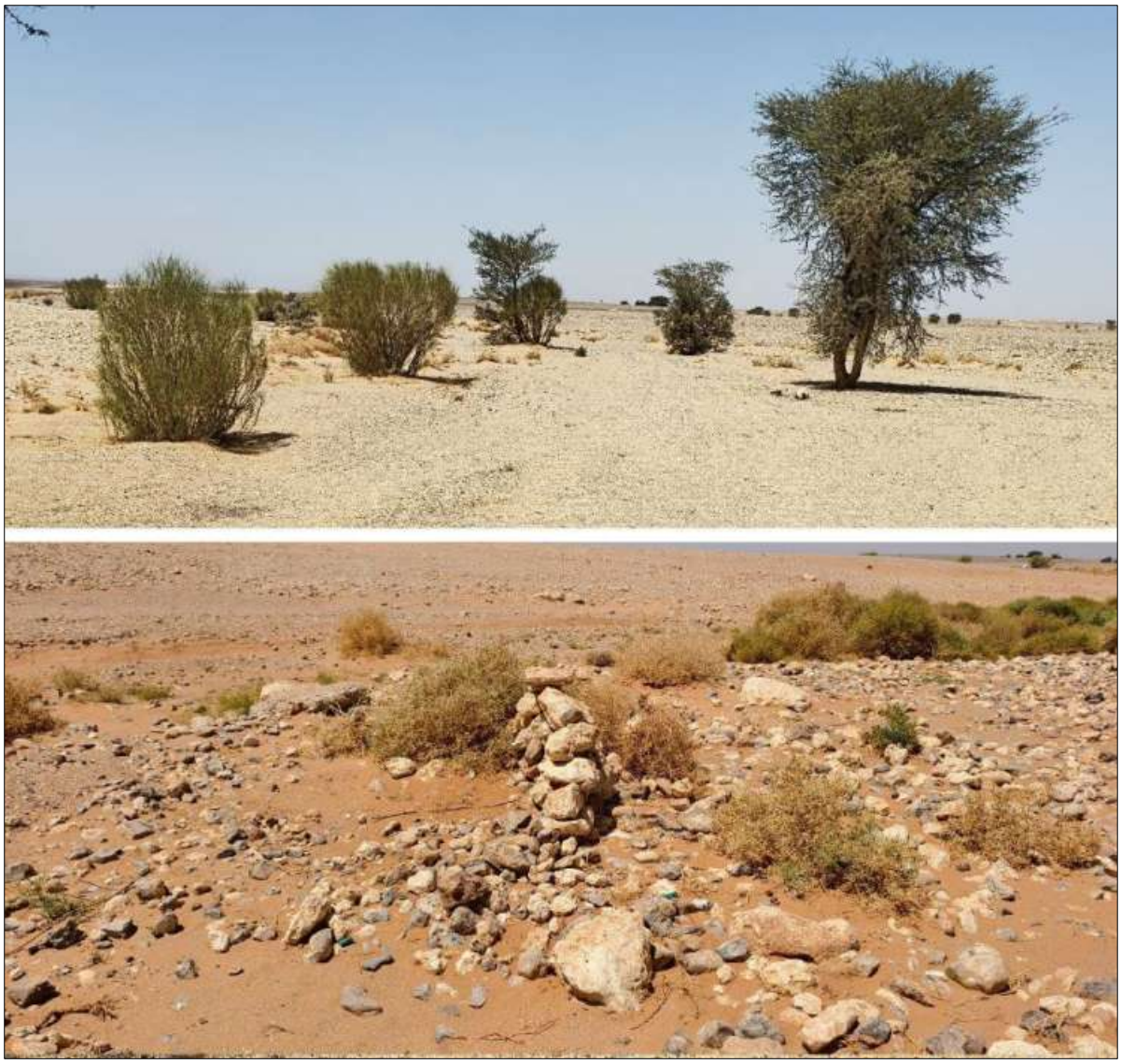


Figure 116: Landscape of FA42 location. The dominant plants are *Retama raetam, Vachellia gerrardii* and *Zilla spinosa.*

Flora Survey

Six line transects were made as shown in Table 86.

Table 86. Coordinates for six transects FA42 location.

Transect No. FA42	Start		End		Length (m)
	N	E	N	E	
1	29.954057°	36.010643°	29.954035°	36.011687°	100
2	29.954230°	36.010682°	29.954218°	36.011720°	100
3	29.954410°	36.010720°	29.954378°	36.011775°	100
4	29.954430°	36.010500°	29.954463°	36.009455°	100
5	29.954251°	36.010458°	29.954262°	36.009422°	100
6	29.954076°	36.010418°	29.954077°	36.009377°	100

Plant observations:

Six plant species were recorded at this location, *Pulicaria undulata, Achillea fragrantissima, Zilla spinosa, Cynodon dactylon, Phragmites australis, Peganum harmala, Vachellia gerrardii* (Vulnerable)*, Fagonia bruguieri* and *Hammada scoparia.*

Fauna Survey

Two walking transects were made at this site during 16.8.2025 as shown in Table 87.

Table 87. Coordinates for two transects at FA42 location.

Transect No.	Start		End		Length (m)
	N	E	N	E	
1	29°57'14"	36°00'37"	29°57'11"	36°00'45"	300
2	29°57'15"	36°00'37"	29°57'14"	36°00'33"	300

Birds observed

Reed warbler, *Acrocephalus scirpaceus*, Sinai Rosefinch, *Carpodacus synoicus*, Collared Dove, *Streptopelia decaocta* and Crested Lark, *Galerida cristata*, were observed within the site close to the water pool.

Reptiles observed

A total of 3 *Acanthodactylus boskianus* were observed across the walking transects (Figure 117).



Figure 117: *Acanthodactylus boskianus* observed at site FA42.

Small mammals
No burrows were observed.

FA43
This is a wide wadi system with very few *Vachellia gerrardii* and *Retama raetam.* The wadi is dominated by *Zilla spinosa.* Also, scattered Bitter Apple, *Citrullus colocynthis* and the Giant Milkweed, *Calotropis procera* are present. The substratum is gravel with patches of sand (Figure 118).



Figure 118: Landscape of FA43 location. The dominant plant is Zilla spinosa.

Flora Survey
Six line transects were made as shown in Table 88.

Table 88. Coordinates for six transects FA43 location.

Transect No.	Start		End		Length (m)
FA43	N	E	N	E	
1	29.968410°	36.013900°	29.968396°	36.014969°	100
2	29.968593°	36.013942°	29.968575°	36.014988°	100
3	29.968765°	36.013986°	29.968755°	36.015035°	100
4	29.968862°	36.013591°	29.968887°	36.012548°	100
5	29.968684°	36.013548°	29.968705°	36.012520°	100
6	29.968500°	36.013510°	29.968510°	36.012476°	100

Plant observations:
Three plant species were recorded at this location, *Stipagrostis plumosa, Zilla spinosa* and *Citrullus colocynthis.*

Fauna Survey
One walking transect was made at this site during 16.8.2025 as shown in Table 89.

Table 89. Coordinates for one transect at FA43 location.

Transect No.	Start		End		Length (m)
	N	E	N	E	
1	29°58'06"	36°00'49"	29°58'09"	36°00'57"	300

Reptiles observed

Tracts of the Desert Monitor, *Varanus griseus*, were observed across the sand in the site (Figure 119), along with tracts of small lizards.



Figure 119: Tracts of the Desert Monitor, *Varanus griseus*.

Small mammals

Burrows for most probably the Sundevall's jird, *Meriones crassus* were observed (Figure 120).



Figure 120: Burrows of *Meriones crassus.*

FA44

This is a wide wadi system dominated by *Zilla spinosa.* The very far eastern end with relatively dense *Vachellia gerrardii* and *Retama raetam* (Figure 121).



Figure 121: Landscape of FA44 location. The dominant plant is Zilla spinosa.

Flora Survey

Six line transects were made as shown in Table 90.

Table 90. Coordinates for six transects FA44 location.

Transect No. FA44	Start		End		Length (m)
	N	E	N	E	
1	29.981150°	36.016680°	29.981134°	36.017733°	100
2	29.981331°	36.016725°	29.981323°	36.017781°	100
3	29.981505°	36.016769°	29.981485°	36.017809°	100
4	29.981613°	36.016476°	29.981610°	36.015428°	100
5	29.981424°	36.016434°	29.981407°	36.015383°	100
6	29.981250°	36.016400°	29.981259°	36.015360°	100

Plant observations:

Five plant species were recorded at this location, *Zilla spinosa, Pulicaria undulata, Peganum harmala, Achillea fragrantissima* and *Vachellia gerrardii* (Vulnerable).

Fauna Survey

One walking transect was made at this site during 16.8.2025 as shown in Table 91.

Table 91. Coordinates for one transect at RA44 location.

Transect No.	Start		End		Length (m)
	N	E	N	E	
1	29°58'53"	36°0100"	29°58'54"	36°00'58"	300

Reptiles observed

A total of 4 *Acanthodactylus boskianus* were observed across the walking transects (Figure 122).



Figure 122: Acanthodactylus boskianus observed in location FA44.

Small mammals

No burrows were observed.

FA45 (29°59'58"N 36°01'15"E)

This is location represents hammada type that is covered by black chert of variable sizes. It is void of vegetation cover (Figure 123).



Figure 123: Landscape of FA45 location.

Flora Survey

Six line transects were made as shown in Table 92.

Table 92. Coordinates for six transects FA45 location.

Transect No.	Start		End		Length (m)
FA45	N	E	N	E	
1	29.998700°	36.020890°	29.998693°	36.021942°	100
2	29.998877°	36.020934°	29.998859°	36.021984°	100
3	29.999054°	36.020978°	29.999040°	36.022016°	100
4	29.999093°	36.020525°	29.999106°	36.019489°	100

5	29.998911°	36.020487°	29.998929°	36.019444°	100
6	29.998733°	36.020446°	29.998772°	36.019388°	100

Plant observations:

No flora was observed.

Fauna Survey

One walking transect was made at this site during 16.8.2025 as shown in Table 93.

Table 93. Coordinates for one transect at FA45 location.

Transect No.	Start		End		Length (m)
	N	E	N	E	
1	29°59'58"	36°01'15"	29°59'57.80"	36° 1'22.78"	150

Reptiles observed

No reptiles were observed.

Small mammals

No burrows were observed.

FA46

This is a hammad type with little vegetation cover (Figure 124).



Figure 124: Landscape of FA46 location. The dominant plant is *Zilla spinosa*.

Flora Survey

Six line transects were made as shown in Table 94.

Table 94. Coordinates for six transects RA46 location.

Transect No. RA46	Start		End		Length (m)
	N	E	N	E	
1	30.015125°	36.024540°	30.015115°	36.025591°	100
2	30.015306°	36.024580°	30.015297°	36.025627°	100
3	30.015481°	36.024620°	30.015483°	36.025672°	100
4	30.015538°	36.024257°	30.015578°	36.023223°	100
5	30.015361°	36.024221°	30.015382°	36.023181°	100
6	30.015169°	36.024180°	30.015172°	36.023142°	100

Plant observations:

Only one plant species was recorded at this location, *Zilla spinosa.*

Fauna Survey

Two walking transects were made at this site during 16.8.2025 as shown in Table 95.

Table 95. Coordinates for two transects at FA46 location.

Transect No.	Start		End		Length (m)
	N	E	N	E	
1	30°00'56"	36°01'28"	30°00'52"	36°01'26"	300
	30°00'56"	36°01'28"	30°00'58"	36°01'34"	300

Reptiles observed

One male of the Northern Arabian Plain Agama, *Trapelus agnetae,* was observed basking on a rock.

Small mammals

No burrows were observed.

FA46A

There is a water leakage near the pressure release manhole forming a small water pool dominated by *Typha elephantina* and *Zilla spinosa* (Figure 125). Part of the reeds is burned. Also, scattered Bitter Apple, *Citrullus colocynthis* are common around the site.



Figure 125: Landscape of FA46A location. The dominant plants are *Typha elephantina* and *Phragmites australis.*

Flora Survey

Six line transects were made as shown in Table 96.

Table 96. Coordinates for six transects FA46A location.

Transect No. FA46A	Start		End		Length (m)
	N	E	N	E	
1	30.021680°	36.026040°	30.021678°	36.027083°	100
2	30.021860°	36.026071°	30.021837°	36.027122°	100
3	30.022041°	36.026105°	30.022037°	36.027150°	100
4	30.022237°	36.025687°	30.022310°	36.024655°	100
5	0	36.025648°	30.022072°	36.024612°	100
6	30.021870°	36.025610°	30.021878°	36.024579°	100

Plant observations:

Four plant species were recorded at this location, *Zilla spinosa, Asteriscus graveolens, Fagonia bruguieri* and *Phragmites australis.*

Fauna Survey

One walking transect was made at this site during 16.8.2025 as shown in Table 97.

Table 97. Coordinates for one transect at FA46A location.

Transect No.	Start		End		Length (m)
	N	E	N	E	
1	30°01'18"	36°01'33"	30° 1'19.08"	36° 1'37.02"	300

Reptiles observed

Acanthodactylus boskianus was observed (Figure 126).



Figure 126: Acanthodactylus boskianus observed in FA46A location.

Small mammals

No burrows were observed.

FA47

There is a water leakage near the pressure release manhole forming a small water pool dominated by *Typha elephantina* (Figure 127).



Figure 127: Landscape of FA47 location. The dominant plants are *Typha elephantina* and *Phragmites australis*.

This site was not among the sites targeted for the vegetation cover study.

Fauna Survey

One walking transect was made at this site during 16.8.2025 as shown in Table 98.

Table 98. Coordinates for one transect at FA47 location.

Transect No.	Start		End		Length (m)
	N	E	N	E	
1	30°01'57"	36°01'42"	30°01'56"	36°01'44"	300

Reptiles observed

A lizard of the genus *Acanthodactylus* was observed (Figure 128).



Figure 128: *Acanthodactylus* sp. The dominant plant is *Pulicaria undulata*.

Small mammals

Burrows for Gerbils were observed.

FA48

There is a water leakage near the pressure release manhole forming a small water pool dominated by *Typha elephantina* and *Zilla spinosa.* Also, scattered bushes of *Pulicaria undulata* are common around the site (Figure 129).



Figure 129: Landscape of FA48 location. The dominant plants are *Zilla spinosa* and *Pulicaria undulata*.

Flora Survey

Six line transects were made as shown in Table 99.

Table 99. Coordinates for six transects FA48 location.

Transect No. FA48	Start		End		Length (m)
	N	E	N	E	
1	30.046070°	36.031540°	30.046056°	36.032579°	100
2	30.046247°	36.031572°	30.046247°	36.032622°	100
3	30.046428°	36.031608°	30.046418°	36.032645°	100
4	30.046536°	36.031201°	30.046541°	36.030165°	100
5	30.046364°	36.031167°	30.046377°	36.030140°	100
6	30.046180°	36.031140°	30.046196°	36.030092°	100

Plant observations:

Two plant species were recorded at this location, *Zilla spinosa* and *Pulicaria undulata.*

Fauna Survey

One walking transect was made at this site during 16.8.2025 as shown in Table 100.

Table 100. Coordinates for one transect at FA48 location.

Transect No.	Start		End		Length (m)
	N	E	N	E	
1	30°02'46"	36°01'53"	30°02'44"	36°01'57"	300

Reptiles observed

One male of the Northern Arabian Plain Agama, *Trapelus agnetae,* was observed basking on the ground (Figure 130).



Figure 130: The Northern Arabian Plain Agama, *Trapelus agnetae.*

Small mammals.

No active burrows were observed.

FA50

This location is covered by chert with minimum vegetation cover (Figure 131). Along its sides, rock piles of various sizes were observed.



Figure 131: Landscape of FA50 location.

This site was not among the sites targeted for the vegetation cover study.

Fauna Survey

One walking transect was conducted (Table 101).

Table 101. Coordinates for one transect at RA50 location.

Transect No.	Start		End		Length (m)
	N	E	N	E	
1	30°03'03"	36°02'03"	30°03'26"	36°01'54"	300

Reptiles observed

Three species of agamids were observed in and around this site. Most notably, the Egyptian Spiny-tailed Lizard, *Uromastyx aegyptia*, a species that is listed as vulnerable according to the IUCN Redlist. The other agamids include the Northern Arabian Plain Agama, *Trapelus agnetae* and the Sinia Agama, *Pseudotrapelus sinaitus* (Figure 132).



Figure 132. A. *Uromastyx aegyptia*. *B. Trapelus agnetae* male. *C. Trapelus agnetae* female. *D. Pseudotrapelus sinaitus* male. *E. Pseudotrapelus sinaitus* female.

FA51

This is an open desert with chert covered by a thin layer of sand. *Zilla spinosa* dominates the site (Figure 133).



Figure 133: Landscape of FA51 location.

Flora Survey

Six line transects were made as shown in Table 102.

Table 102. Coordinates for six transects FA51 location.

Transect No.	Start		End		Length (m)
FA51	N	E	N	E	
1	30.064650°	36.035830°	30.064638°	36.036866°	100
2	30.064829°	36.035866°	30.064826°	36.036905°	100
3	30.065002°	36.035901°	30.065001°	36.036944°	100
4	30.065068°	36.035547°	30.065073°	36.034512°	100
5	30.064898°	36.035510°	30.064895°	36.034473°	100
6	30.06471	36.03547	30.064710°	36.035470°	100

Plant observations:

Only one plant species was recorded at this location, *Zilla spinosa.*

Fauna Survey

One walking transect was made at this site during 16.8.2025 as shown in Table 103.

Table 103. Coordinates for one transect at FA51 location.

Transect No.	Start		End		Length (m)
	N	E	N	E	
1	30°03'57"	36°02'09"	30°03'57"	36°02'13"	300

Reptiles observed

Tracts of the Desert Monitor, *Varanus griseus*, were observed across the sand in the site (Figure 134), along with tracts of small lizards.

Small mammals

Burrows for most probably the Sundevall's jird, *Meriones crassus* were observed.



Figure 134: A. Tracts of the Desert Monitor, *Varanus griseus*. B-D. *Meriones crassus* burrows. The dominant plant is *Zilla spinosa.*

FA51B



Figure 135: Landscape of FA51B location.

Flora Survey

Six line transects were made as shown in Table 102.

Table 104. Coordinates for six transects FA51B location.

Transect No.	Start		End		Length (m)
FA51B	N	E	N	E	
1	30.066990°	36.036420°	30.066947°	36.037467°	100
2	30.067170°	36.036468°	30.067174°	36.037506°	100
3	30.067348°	36.036509°	30.067351°	36.037548°	100
4	30.067439°	36.036064°	30.067447°	36.035025°	100
5	30.067260°	36.036029°	30.067253°	36.034988°	100
6	30.067080°	36.035990°	30.067089°	36.034947°	100

Plant observations:

Only one plant species was recorded at this location, *Zilla spinosa.*

This site was not among the sites targeted for animal studies.

FA52

A wide wadi system with compact soil and gravel around the edges. Vegetation is mostly *Zilla spinosa* (Figure 136).

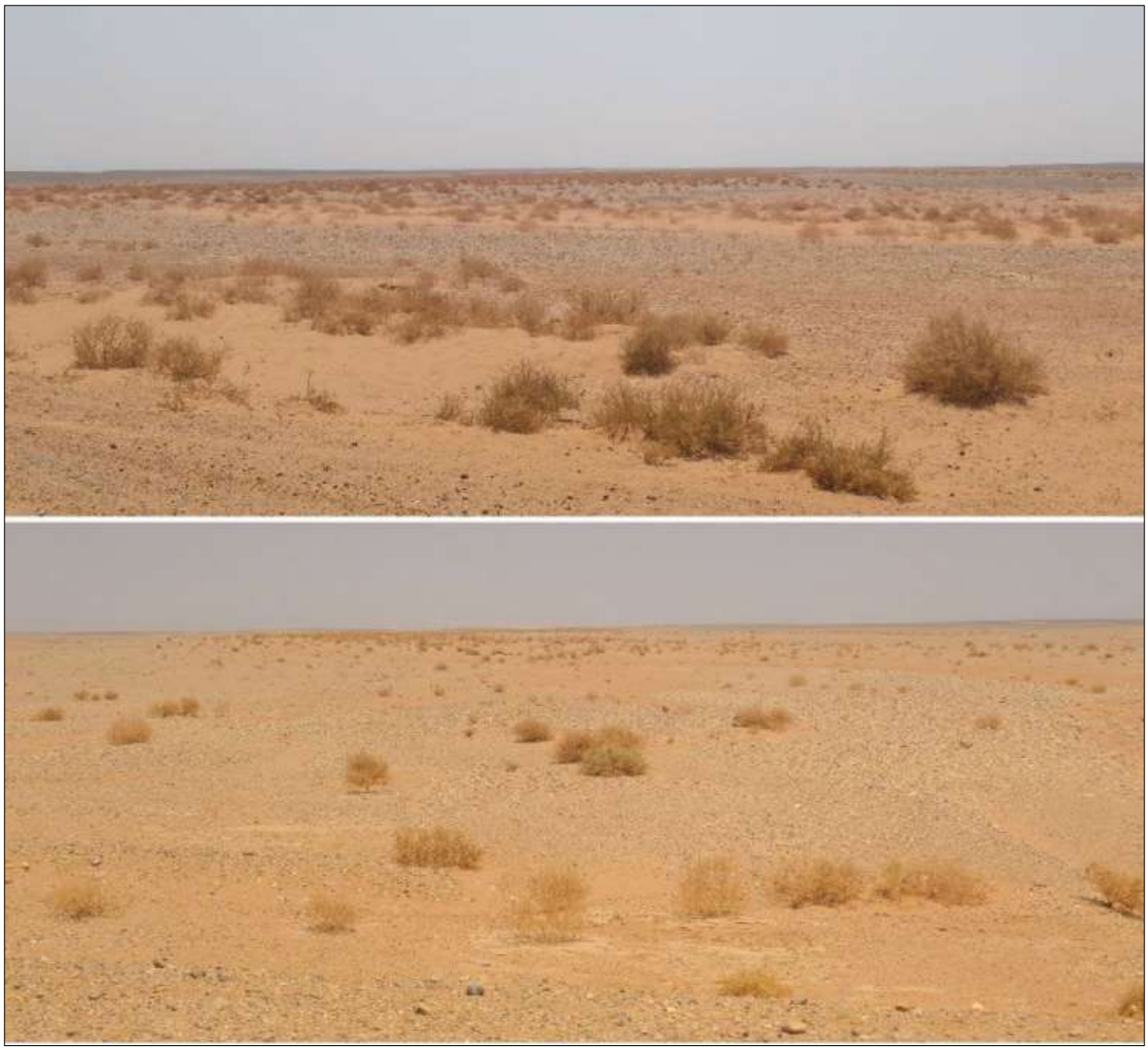


Figure 136: Landscape of FA52 location. The dominant plant is Zilla spinosa

This site was not among the sites targeted for the vegetation cover study.

Fauna Survey

Two walking transects were made at this site during 16.8.2025 as shown in Table 105.

Table 105. Coordinates for two transects at FA52 location.

Transect No.	Start		End		Length (m)
	N	E	N	E	
1	30°05'17"	36°02'27"	30°05'30"	36°02'26"	300
2	30°05'32"	36°02'31"	30°05'22"	36°02'34"	300

Reptiles observed

One male of the Northern Arabian Plain Agama, *Trapelus agnetae,* was observed basking on a shrub of *Zilla spinosa* (Figure 137).



Figure 137: The Northern Arabian Plain Agama, *Trapelus agnetae*, basking on *Zilla spinosa*.

Small mammals

A dead Ethiopian Hedgehog, *Paraechinus aethiopicus*, was observed.

FA53

This site is located near a pressure releasing manhole. Leaked water caused growth of *Typha* and greenery around the manhole including *Pulicaria undulata* (Figure 138). Also, *Zilla spinosa* and *Citrullus colocynthis* are around the hammad part of the site.



Figure 138: Landscape of FA53 location. The dominant plants are Cynodon dactylon and Pulicaria undulata.

Flora Survey

Six line transects were made as shown in Table 106.

Table 106. Coordinates for six transects FA53 location.

Transect No. FA53	Start		End		Length (m)
	N	E	N	E	
1	30.175870°	36.058950°	30.175862°	36.059992°	100
2	30.176054°	36.058983°	30.176022°	36.060025°	100
3	30.176232°	36.059017°	30.176248°	36.060060°	100
4	30.176287°	36.058544°	30.176299°	36.057495°	100
5	30.176099°	36.058494°	30.176130°	36.057456°	100
6	30.175930°	36.058450°	30.175956°	36.057403°	100

Plant observations:

Five plant species was recorded at this location, *Pulicaria undulata, Peganum harmala, Hyoscyamus muticus* (Critically Endangered), *Zilla spinosa* and *Cynodon dactylon.*

Fauna Survey

Two walking transects were made at this site during 17.8.2025 as shown in Table 107.

Table 107. Coordinates for two transects at FA53 location.

Transect No.	Start		End		Length (m)
	N	E	N	E	
1	30°10'30"	36°03'31"	30°10'33"	36°03'35"	300
2	30°10'34"	36°03'31"	30°10'33"	36°03'35"	300

Reptiles observed

Two active burrows of *Uromastyx aegyptia* were observed close to the hammada. Also, *Acanthodactylus boskianus* was observed.

Small mammals

No active burrows were observed.

FA54

This is a narrow wadi system crossing hammad desert. It is located near a pressure release manhole. The wadi is covered by wind-blown sand with small rocks, while the hammad is covered by chert (Figure 139). Vegetation is dominated by *Zilla spinosa* and *Hammada scorporia.*



Figure 139: Landscape of FA54 location. The dominant plant is *Hammada scorporia*.
This site was not among the sites targeted for the vegetation cover study.

Fauna Survey

One walking transect was made at this site during 17.8.2025 as shown in Table 108.

Table 108. Coordinates for one transect at FA54 location.

Transect No.	Start		End		Length (m)
	N	E	N	E	
1	30°10'53"	36°03'34"	30°11'00"	36°03'39"	300

Reptiles observed

2 individuals of *Acanthodactylus boskianus* were observed (Figure 140).



Figure 140: Acanthodactylus boskianus at location FA54.

Small mammals

No active burrows were observed.

FA55

A wadi system intercepted by a small water leak from a pressure release manhole. The soil is compacted with few sandy areas covered with *Zilla spinosa* (Figure 141).



Figure 141: Landscape of FA55 location. The dominant plant is Hammada scorporia.

Flora Survey

Three line transects were made as shown in Table 109.

Table 109. Coordinates for three transects FA55 location.

Transect No.	Start		End		Length (m)
FA55	N	E	N	E	
1	30.217930°	36.067121°	30.217935°	36.068162°	100
2	30.218113°	36.067153°	30.218095°	36.068192°	100
3	30.218291°	36.067187°	30.218264°	36.068234°	100

Plant observations:

Two plant species were recorded at this location, *Pulicaria undulata* and *Zilla spinosa.*

Fauna Survey

One walking transect was made at this site during 17.8.2025 as shown in Table 110.

Table 110. Coordinates for one transect at FA55 location.

Transect No.	Start		End		Length (m)
	N	E	N	E	
1	30°13'04"	36°04'01"	30°13'07"	36°04'04"	300

Reptiles observed
2 individuals of *Acanthodactylus boskianus* were observed (Figure 142).

Small mammals
No burrows were observed at this site.



Figure 142: Observed Acanthodactylus boskianus at FA55 location.

FA56

This location is situated around a pressure release manhole. Locals destroyed the manhole whereas water is leaking forming small pools. Small growth of *Typha* along *Xainthium spinosum* around the pools. The location is very much disturbed with plastic garbage (Figure 143).



Figure 143: Landscape of FA56 location. The dominant plant is Xainthium spinosum.

This site was not among the sites targeted for the vegetation cover study.

Fauna Survey

One walking transect was made at this site during 17.8.2025 as shown in Table 111.

Table 111. Coordinates for one transect at FA56 location.

Transect No.	Start		End		Length (m)
	N	E	N	E	
1	30°20'08"	36°05'56"	30°20'11"	36°05'59"	300

Amphibians and reptiles observed

Few individuals of *Acanthodactylus boskianus* were observed and a high number of the Variable Green Toad, *Bufotes sitibundus* were observed in the water and on rocks (Figure 144).

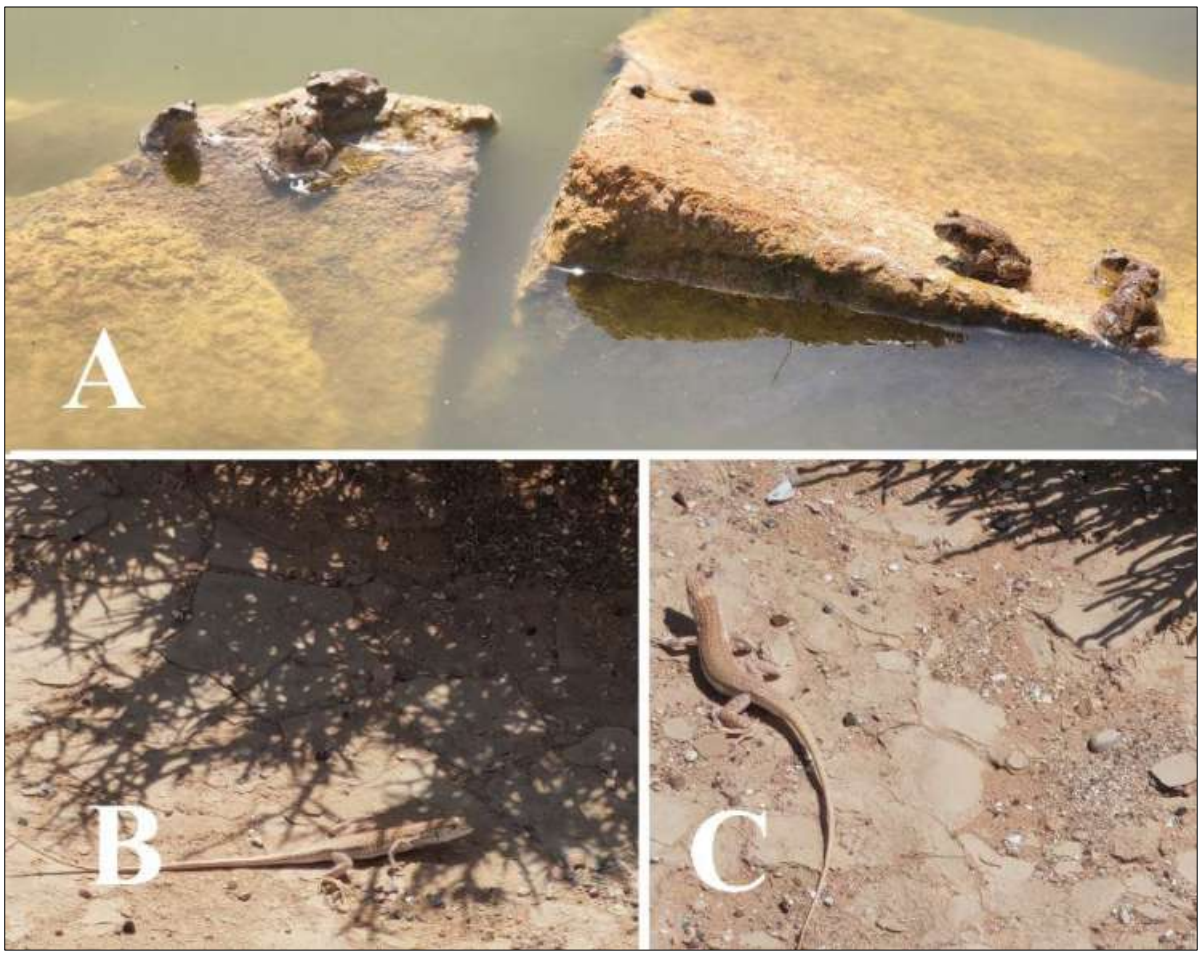


Figure 144:Variable Green Toad, *Bufotes sitibundus*. B and C. *Acanthodactylus boskianus.*

Small mammals

No active burrows were observed.

FA57

This is an open area, the right side shows evidence of previous agricultural activities, while the left side is dominated by bushes of *Zilla spinosa* among others (Figure 145).



Figure 145: Landscape of FA57 location. The dominant plant is *Zilla spinosa*.

This site was not among the sites targeted for the vegetation cover study.

Fauna Survey

One walking transect was made on the 17th of August 2025 (Table 112).

Table 112. Coordinates for one transect at FA57 location.

Transect No.	Start		End		Length (m)
	N	E	N	E	
1	30°22'58"	36°06'30"	30°22'56"	36°06'28"	300

Reptiles observed

No reptiles were observed.

Small mammals

No rodent burrows were observed. Locals indicated the presence of foxes.

FA58

This site is considered as hammada habitat with mixed chert and gravel (Figure 146). Vegetation consists of *Diplotaxis acris, Zilla spinosa* and *Achillea fragrantissima*.



Figure 146: Landscape of FA58 location. The dominant plant is *Zilla spinosa*.

This site was not among the sites targeted for the vegetation cover study.

Fauna Survey

Two walking transects were made on the 17th of August 2025 (Table 113).

Table 113. Coordinates for one transect at FA58 location.

Transect No.	Start		End		Length (m)
	N	E	N	E	
1	30°25'04"	36°06'44"	30°24'59"	36°06'44"	300
	30°25'02"	36°06'46"	30°25'02"	36°06'55"	300

Reptiles observed

Two species of reptiles were observed, *Acanthodactylus boskianus*, and a female *Trapelus agnetae* (Figure 147).

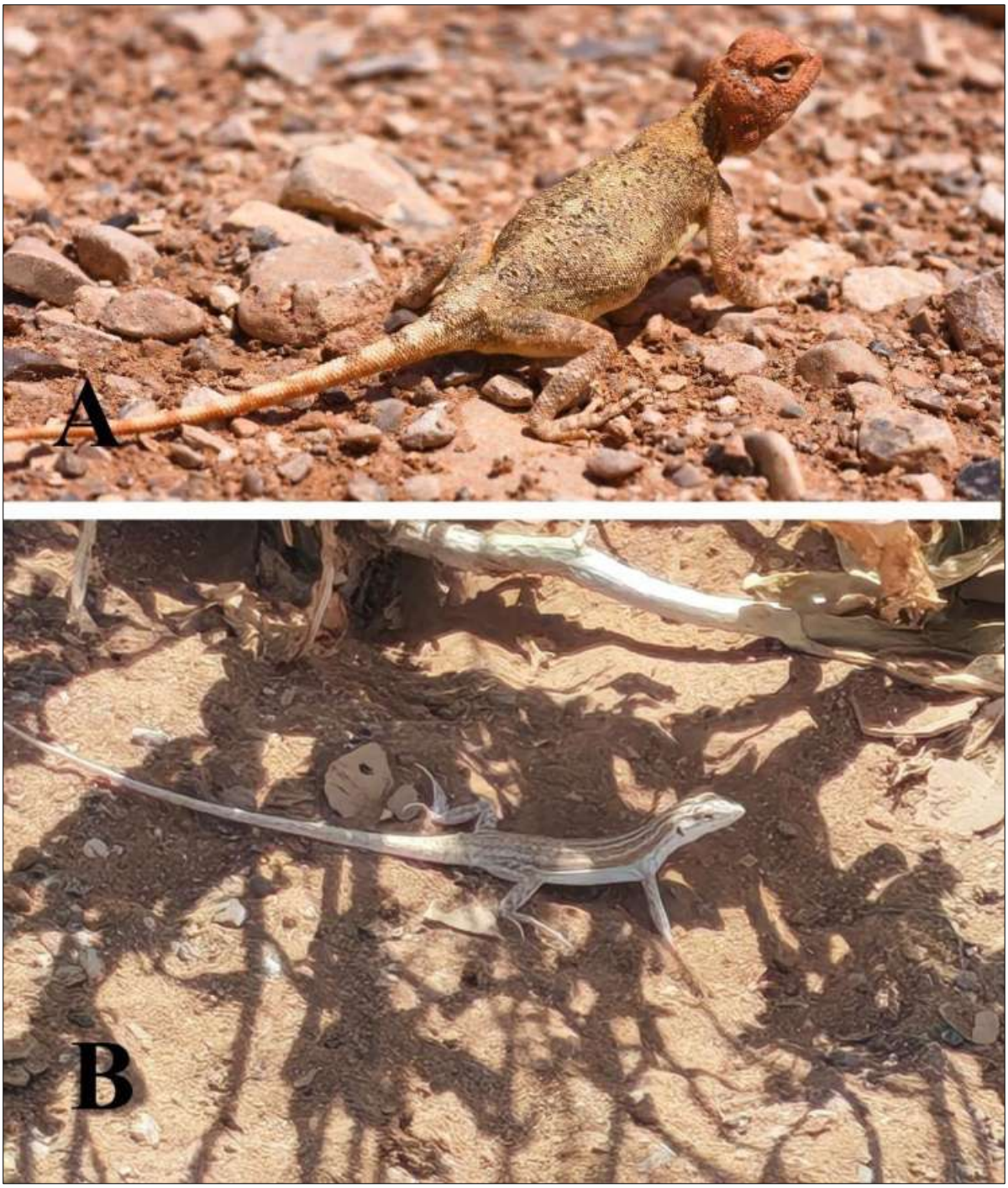


Figure 147: A. Female *Trapelus agnetae*. B. *Acanthodactylus boskianus*.

Small mammals

No burrows were observed at this site.

FA59

This site is considered as hammada habitat with covered by small chert (Figure 148). Very few Desert Wallflower, *Diplotaxis acris,* was seen. Evidence of previous excavations was observed.



Figure 148: Landscape of FA59 location.

This site was not among the sites targeted for the vegetation cover study.

Fauna Survey

One walking transect was made on the 17th of August 2025 (Table 114).

Table 114. Coordinates for one transect at FA59 location.

Transect No.	Start		End		Length (m)
	N	E	N	E	
1	30°30'13"	36°06'59"	30°30'13"	36°06'57"	300

Reptiles observed

No reptiles were observed at this location.

Small mammals

No burrows were observed at this site.

FA60

This site is considered as hammada habitat with covered by chert (Figure 149). Cleared areas around the road hosts relatively dense Desert Wallflower, *Diplotaxis acris.*



Figure 149: Landscape of FA60 location.

This site was not among the sites targeted for the vegetation cover study.

Fauna Survey

One walking transect was made on the 17th of August 2025 (Table 115).

Table 115. Coordinates for one transect at FA60 location.

Transect No.	Start		End		Length (m)
	N	E	N	E	
1	30°31'45"	36°06'56"	30°31'46"	36°07'00"	300

Reptiles observed

A male Northern Arabian Plain Agama, *Trapelus agnetae,* was observed on the ground (Figure 150).



Figure 150: A male Northern Arabian Plain Agama, *Trapelus agnetae*, was observed on the ground.

Small mammals

No burrows were observed at this site.

FAPS4

This is an arid area void of vegetation. It is located opposite to Disi Pipeline Pumping Station. It is filled with debris resulted from previous excavation (Figure 151).



Figure 151: Landscape of FAPS4 location.

This site was not among the sites targeted for the vegetation cover study.

Fauna Survey

One walking transect was made on the 17th of August 2025 (Table 116).

Table 116. Coordinates for two transects at FAPS4 location.

Transect No.	Start		End		Length (m)
	N	E	N	E	
1	30°33'46"	36°07'18"	30°33'43"	36°07'15"	300

Reptiles observed

No reptiles were seen at this location.

Small mammals

No burrows were observed at this site.

5.8 Segment 7

This segment begins when the pipeline intersects with the desert highway near Jurf Al Daweesh, extending northwards to Daba'a area and Queen Alia airport. The habitat is mostly flat desert covered with gravel and flint. Its total length is about 115 km (Figure 152).



Figure 152: Outline for segment 7.

FA61



Figure 153: Landscape of FA61 location.

Flora Survey

Six line transects were made as shown in Table 109.

Table 117. Coordinates for three transects FA61 location.

Transect No.	Start		End		Length (m)
FA61	N	E	N	E	
1	30.561560°	36.121680°	30.561529°	36.122733°	100
2	30.561739°	36.121704°	30.561708°	36.122762°	100

3	30.561919°	36.121728°	30.561899°	36.122796°	100
4	30.561871°	36.121096°	30.561872°	36.120045°	100
5	30.561696°	36.121092°	30.561731°	36.120039°	100
6	30.561510°	36.121090°	30.561520°	36.120041°	100

Plant observations:

Three plant species were recorded at this location, *Tamarix nilotica, Diplotaxis harra* and *Anabasis articulata.*

This site was not among the sites targeted for animal studies.

FA62



Figure 154: Landscape of FA62 location.

Flora Survey

Six line transects were made as shown in Table 109.

Table 118. Coordinates for three transects FA62 location.

Transect No. FA62	Start		End		Length (m)
	N	E	N	E	
1	30.591403°	36.087415°	30.592145°	36.088022°	100
2	30.591513°	36.087246°	30.592284°	36.087800°	100
3	30.591619°	36.087084°	30.592408°	36.087628°	100
4	30.591427°	36.086783°	30.590983°	36.085883°	100
5	30.591324°	36.086953°	30.590878°	36.086037°	100
6	30.591220°	36.087130°	30.590799°	36.086198°	100

Plant observations:

Two plant species were recorded at this location, *Tamarix nilotica* and *Diplotaxis harra*

This site was not among the sites targeted for animal studies.

FA63



Figure 155: Landscape of FA63 location.

Flora Survey

Six line transects were made as shown in Table 109.

Table 119. Coordinates for three transects FA63 location.

Transect No. FA63	Start		End		Length (m)
	N	E	N	E	
1	30.661640°	36.011960°	30.662286°	36.012720°	100
2	30.661783°	36.011830°	30.662412°	36.012590°	100
3	30.661926°	36.011702°	30.662549°	36.012452°	100
4	30.661773°	36.011389°	30.661331°	36.010484°	100
5	30.661622°	36.011502°	30.661200°	36.010575°	100
6	30.661470°	36.011620°	30.661034°	36.010706°	100

Plant observations:

Only one species was recorded at this location, *Anabasis articulata.*

This site was not among the sites targeted for animal studies.

FA64

This site is located at the entrance of Al Abyad Phosphate Mining installations. It is know as Al Abyad Wadi, characterised by dense vegetation of the leafless tamarisk, *Tamarix aphylla*. Stands of the tamarisk can reach up to 3 m in hight. The soil is loamy with mixed sand at certain areas (Figure 156). During winter, this wadi is flooded with rainwater coming from the north.



Figure 156: Landscape of location FA64 The dominant plant is *Tamarix aphylla.*

Flora Survey

Three line transects were made as shown in Table .

Table 118. Coordinates for three transects FA64 location.

Transect No. FA64	Start		End		Length (m)
	N	E	N	E	
1	31.016108°	36.011641°	31.016410°	36.012626°	100
2	31.016269°	36.011594°	31.016562°	36.012569°	100
3	31.016376°	36.011528°	31.016679°	36.012576°	100

Plant observations:

Only one plant species was recorded at this location, *Anabasis articulata.*

Fauna Survey

We did not observe any species of reptiles in this site, however, rodent burrows were not very uncommon.

Table 119. Coordinates for two transects at location FA64.

Transect No.	Start		End		Length (m)
	N	E	N	E	
1	31°00'52"	36°00'58"	31°00'56"	36° 00'59"	300
2	31°00'52"	36°00'59"	31°01'01"	36°01'01"	300

FA65



Figure 157: Landscape of FA65 location.

Flora Survey

Three line transects were made as shown in Table 109.

Table 120. Coordinates for three transects FA65 location.

Transect No. FA65	Start		End		Length (m)
	N	E	N	E	
1	31.040663°	36.008580°	31.040634°	36.009639°	100
2	31.040844°	36.008585°	31.040904°	36.009620°	100
3	31.041024°	36.008569°	31.041085°	36.009677°	100

Plant observations:

Three plants species were recorded at this location, *Anabasis articulata, Atriplex leucoclada* and *Tamarix nilotica*

This site was not among the sites targeted for animal studies.

FA66

This location is close to the desert highway near Al Qatraneh. It represents a depression with a narrow wadi system with by relatively rich vegetation cover of *Anabasis articulata*. It is

relatively degraded due to off-roading by trucks and small vehicles. The western side of the site is flat with flat surface and void of vegetation (Figure 157).



Figure 157: Landscape of location FA66. The dominant plant is Anabasis articulata

Flora Survey

Three line transects were made as shown in Table 120.

Table 120. Coordinates for three transects FA66 location.

Transect No.	Start		End		Length (m)
FA66	N	E	N	E	
1	31.269036°	36.051142°	31.269173°	36.050056°	100
2	31.268864°	36.051095°	31.269074°	36.050059°	100
3	31.268691°	36.051048°	31.268866°	36.050013°	100

Plant observations:

Only one plant species was recorded at this location, *Anabasis articulata.*

Fauna Survey

Two walking transects were conduct at this location as shown in Table 121.

Table 121. Coordinates for two transects at location FA66.

Transect No.	Start		End		Length (m)
	N	E	N	E	
1	31°16'07"	36°02'59"	31°16'03"	36° 02'55"	300
2	31°16'06"	36°03'00"	31°16'01"	36°02'57"	300

Observed reptiles

Two species of reptiles were found in this location, the Snake-eyed Lizard, *Ophisops elegans,* during daytime (Figure , Table 122) and Baluch rock gecko, *Bunopus tuberculatus* at night.



Figure 159: A. The Snake-eyed Lizard, *Ophisops elegans*.

Table 122. Reptile species observed at FA68 location.

Species	Common name	No. of observed individuals
Ophisops elegans	Snake-eyed Lizard	1
Bunopus tuberculatus	Baluch rock gecko	1

Small mammals trapping

A total of 10 Sherman traps were installed around burrows that were identified during daytime walking transects. No rodents were trapped, instead the traps were triggered by black beetles of the family Tenebrionidae.

FA68A



Figure 160: Landscape of FA68A location.

Flora Survey

Three line transects were made as shown in Table 109.

Table 124. Coordinates for three transects FA68A location.

Transect No.	Start		End		Length (m)
RA68A	N	E	N	E	
1	31.298501°	36.058069°	31.298576°	36.056995°	100
2	31.298329°	36.058021°	31.298540°	36.057007°	100
3	31.298149°	36.058058°	31.298430°	36.056926°	100

Plant observations:

Five plants species were recorded at this location, *Anabasis articulata, Achillea fragrantissima, Peganum harmala, Malva parviflora* and *Hordeum marinum*

This site was not among the sites targeted for animal studies.

FA68B

This site is a flat wide open wadi system with relatively rich vegetation cover of *Anabasis articulata*. A small pumping station is located to its northern end, that sometimes leaks water to the surroundings. In areas where rainwater covers certain patches, it becomes void of vegetation (Figure).



Figure 161: Landscape of location FA68B. The dominant plant is *Anabasis articulata.*

Flora Survey

Three line transects were made as shown in Table .

Table 125. Coordinates for three transects FA68B location.

Transect No. FA68B	Start		End		Length (m)
	N	E	N	E	
1	31.298501°	36.058069°	31.298576°	36.056995°	100
2	31.298329°	36.058021°	31.298540°	36.057007°	100
3	31.298149°	36.058058°	31.298430°	36.056926°	100

Plant observations:

Five plant species were recorded at this location, *Anabasis articulata, Achillea fragrantissima, Peganum harmala, Malva parviflora* and *Hordeum marinum.*

Fauna Survey

Reptiles observed

Daytime and night-time walking transects were conducted in this site (Table). Four species of reptiles were observed including one snake species most probably Forskål sand snake, *Psammophis schokari*, the Snake-eyed Lizard, *Ophisops elegans,* during daytime, and two geckos during the night walking transects, Baluch rock gecko, *Bunopus tuberculatus* and *Hemidactylus dawudazraqi* (Figure , Table). *Ophisops elegans* and *Bunopus tuberculatus* were observed under *A. articulata* bushes, while *Hemidactylus dawudazraqi* was observed on the wall of the pumping station.

The Snake-eyed Lizard was the most common species with 6 observations.

Table 126. Coordinates for two transects at location FA68B.

Transect No.	Start		End		Length (m)
	N	E	N	E	
1	31°17'54"	36°03'31"	31°17'56"	36° 03'24"	300
2	31°17'54"	36°03'29"	31°17'54"	36°03'23"	300

Table 127. Reptile species observed at FA68B location.

Species	Common name	No. of observed individuals
Ophisops elegans	Snake-eyed Lizard	6
Snake		1
Bunopus tuberculatus	Baluch rock gecko	1
Hemidactylus dawudazraqi	Not assigned	1

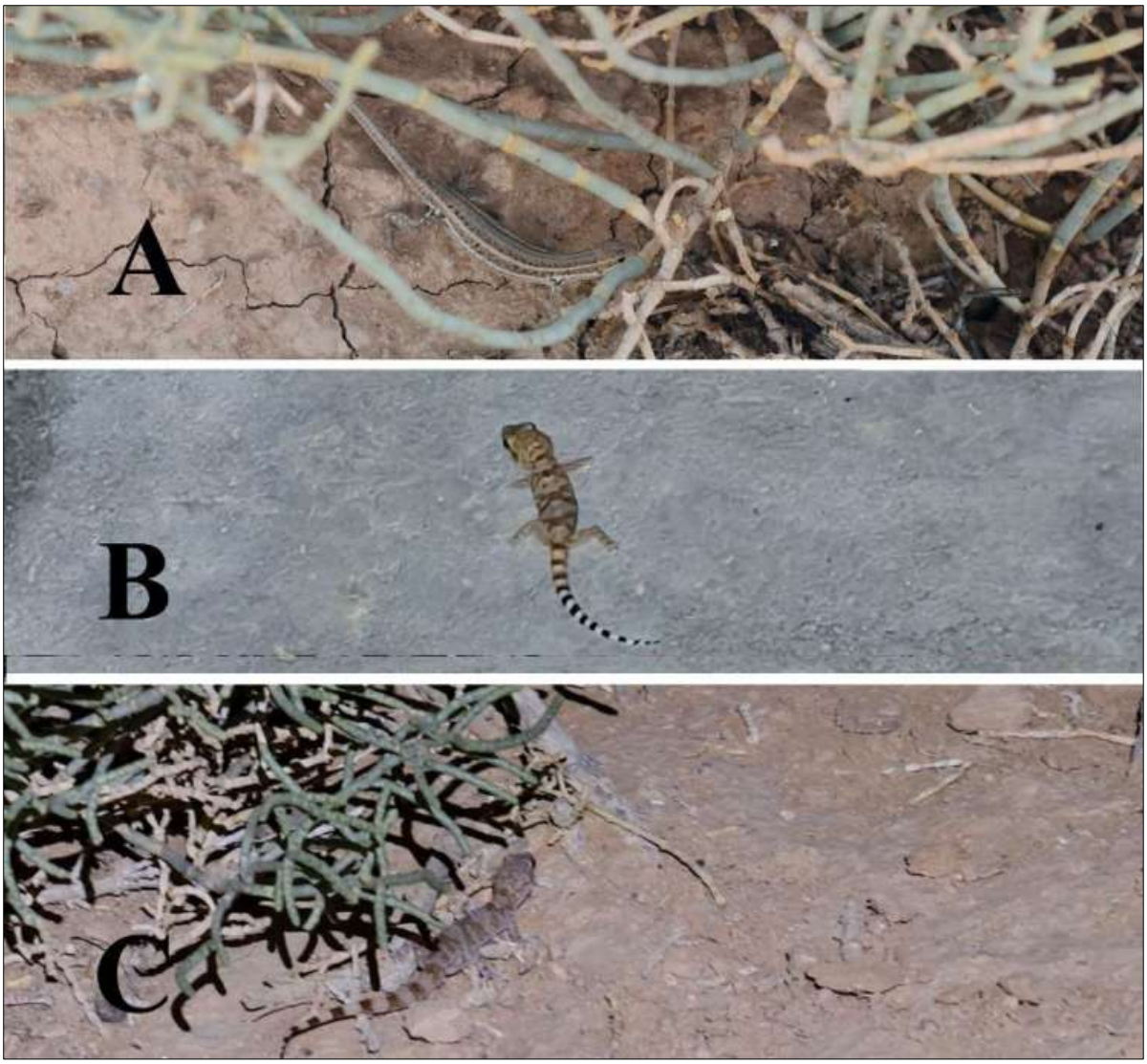


Figure 162: A. The Snake-eyed Lizard, *Ophisops elegans*. B. *Hemidactylus dawudazraqi*. C. Baluch rock gecko, *Bunopus tuberculatus*.

Small mammals trapping

A total of 10 Sherman traps were installed around burrows that were identified during daytime walking transects (Figure). No rodents were trapped, instead the traps were triggered by black beetles of the family Tenebrionidae.



Figure163: Field biologist setting traps at site FA68B.

FA69A

This site is located at the entrance of Daba'a village along the desert highway. The area is rocky with scattered *Anabasis* vegetation cover, with a slope from the west to the east. It was selected since the endemic species *Acanthodactylus ahmaddisii* was described in 2004 (Figure).



Figure 164: Landscape of location FA69A. The dominant plant is Anabasis articulata

Flora Survey

Three line transects were made as shown in Table 102.

Table 128. Coordinates for six transects FA69A location.

Transect No.	Start		End		Length (m)
FA69	N	E	N	E	
1	31.617199°	35.997851°	31.617610°	35.998791°	100
2	31.617345°	35.997782°	31.617756°	35.998743°	100
3	31.617509°	35.997724°	31.617929°	35.998643°	100

Plant observations:

Only one plant species was recorded at this location, *Anabasis articulata.*

Fauna Survey

Acanthodactylus ahmaddisii was described based on a single specimen that was previously identified as *Acanthodactylus pardalis,* that is currently housed at the Hebrew Museum (Figure 158). This species is characterized by three complete supraoculars; subocular broadly bordering the mouth; upper temporals smooth; dorsal scales small, flat, 52 across midbody; ventral plates in (presumably) 12 straight longitudinal series; three series of scales around the fingers and toes, which are not pectinate; subdigital lamellae clearly tricarinate; tail not spiny laterally; presacral vertebrae 24 (Werner, 2004).

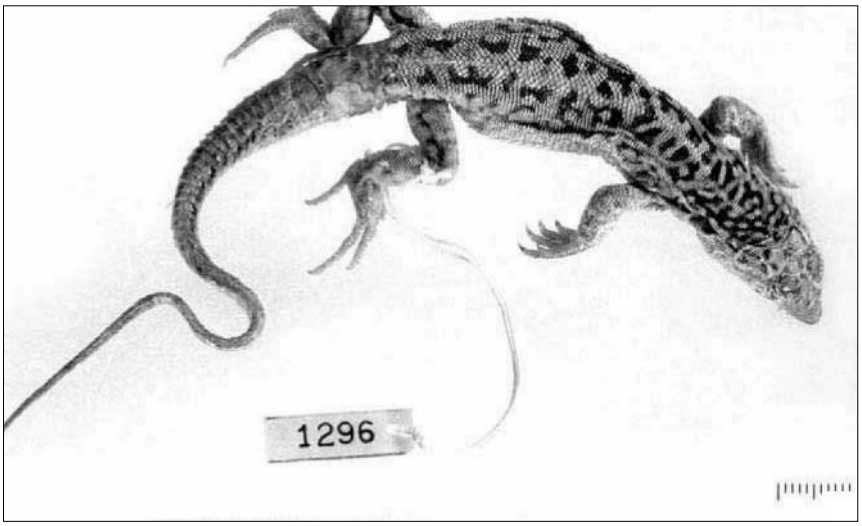


Figure 158. Holotype of *Acanthodactylus ahmaddisii* sp.n. HUJ-R 1296 male (Scale bar: 1 cm) (after Werner, 2004).

Reptiles observed

No reptiles were found at this site along a transect 300 m long (Start 31°36'59"N 35°59'53"E, End 31°37'01"N 35°59'57"E)

To ascertain the presence of *Acanthodactylus ahmaddisii* within the vicinity of this area, we conducted an extensive survey at Daba'a Rangeland Reserve (31°02'22"N, 36°00'28"E), a protected and fenced area within the boundary of Daba'a (Figure 159). We observed three species of reptiles (Table , Figure 160), whereas *Ophisops elegans* was the most common species.



Figure 159: Daba'a Rangeland Reserve

Table 129. Reptile species observed at Daba'a Rangeland Reserve.

Species	Common name	No. of observed individuals
Ophisops elegans	Snake-eyed Lizard	25
Eumeces schneiderii	Schneider's Skink	1
Pseudotrapelus sinaitus	Sinai Agama	1



Figure 160: A. The Snake-eyed Lizard, *Ophisops elegans*. B. Schneider's Skink, *Eumeces schneiderii*.

FA69B

This site represents a wadi system with *Tamarix aphylla* and *Anabasis articulata*. Vegetation cover is mostly around the edges, with fewer cover on the sides. Its width is about 32 meters and runs from east to west (Figure 161).



Figure 161: Landscape of location FA69B. The dominant plants are *Anabasis articulata* and *Pulicaria undulata.*

Flora Survey

Three line transects were made as shown in Table 102.

Table130. Coordinates for six transects FA69B location.

Transect No. FA69 B	Start		End		Length (m)
	N	E	N	E	
1	31.641559°	35.989179°	31.641563°	35.990138°	100
2	31.641693°	35.989214°	31.641716°	35.990185°	100
3	31.641863°	35.989273°	31.641877°	35.990243°	100

Plant observations:

Only one plant species was recorded at this location, *Anabasis articulata*

Fauna Survey

Two walking transects were made, whereas no reptiles were observed. A red fox, *Vulpes vulpes*, den was identified around the edge of the wadi.

Table 131. Coordinates for two transects at location FA69B.

Transect No.	Start		End		Length (m)
	N	E	N	E	
1	31°38'29"	36°00'11"	31°38'33"	36° 01'51"	300
2	31°45'18"	36° 0156"	31°45'25"	36°00'16"	300

FA70

This site is characterized by its rocky substratum, with scarce vegetation cover. Rocks of various sizes cover the area (Figure 162). The slope is gentle running from west to east.



Figure 162: Landscape of location FA70. The dominant plant is Anabasis articulata

Flora Survey

Three line transects were made as shown in Table 123.

Table 123. Coordinates for three transectsFA70 location.

Transect No. FA70	Start		End		Length (m)
	N	E	N	E	
1	31.759077°	36.026381°	31.758428°	36.025620°	100
2	31.758945°	36.026511°	31.758358°	36.025675°	100
3	31.758804°	36.026653°	31.758297°	36.025793°	100

Plant observations:

Only one plant species was recorded at this location, *Anabasis articulata.*

Fauna Survey

Three walking transects were surveyed across the site as indicated in Table 124. Two individuals of the Egyptian Rock Agama, *Laudakia vulgaris,* were observed around noontime (Figure 163, Table). This agamid basks at rocks, when disturbed it take refuge under rocks.



Figure 163: the Egyptian Rock Agama, Laudakia vulgaris, hiding under a rock.

Table 124. Coordinates for three transects at location FA70.

Transect No.	Start		End		Length (m)
	N	E	N	E	
1	31°45'23"	36° 01'33"	31°45'24"	36° 01'51"	300
2	31°45'18"	36° 0156"	31°45'25"	36°01'51"	300
3	31°45'26"	36° 01'35"	31°45'31"	36° 01'28"	300

Table 134. Coordinates for the observed *Laudakia vulgaris* at location FA70.

Species	Coordinates	
	N	E
Laudakia vulgaris	31°45'21"	36° 01'32"
Laudakia vulgaris	31°45'17"	36° 0155"

Power station (PS5)

This area is located on the most northern edge of segment 7 at 31° 46' 19"N 36° 01' 01"E. It covers a total area of 69,000 m^2. The area is flat with few scattered *Anabasis articulata* bushes in the middle. Soil is very compacted in most of the proposed site. Sign of ploughing are evident throughout the lot. Plastic sheets used previously for agricultural activities are still within the site. It is surrounded by open farmlands and greenhouses (Figure 164).



Figure 164: Location of power station (PS5).

Flora Survey

Six line transects were made as shown in Table .

Table 135. Coordinates for six transects PS5 location.

Transect No. PS5	Start		End		Length (m)
	N	E	N	E	
1	31.771049°	36.018567°	31.770389°	36.019264°	100
2	31.771049°	36.018567°	31.771899°	36.018276°	100
3	31.771049°	36.018567°	31.770525°	36.017771°	100
4	31.768123°	36.020307°	31.769009°	36.020374°	100
5	31.768123°	36.020307°	31.767464°	36.021025°	100
6	31.768123°	36.020307°	31.767652°	36.019415°	100

Plant observations:

Only one plant species was recorded at this location, *Anabasis articulata.*

Fauna Survey

Three walking transects were surveyed for the presence of reptiles and small mammals burrows as shown in Table .

Table 136. Coordinates for three transects at PS5 location.

Transect No.	Start		End		Length (m)
	N	E	N	E	
1	31°46'18.02"	36° 1'1.14"	31°46'17.18"	36° 1'11.75"	280
2	31°46'16.08"	36° 1'0.62"	31°46'15.24"	36° 1'11.73"	300
3	31°46'14.32"	36° 1'0.34"	31°46'13.48"	36° 1'11.91"	300

Walking transects yielded no reptiles or any active burrows. This mainly due to extensive disturbance of the site through previous ploughing (Figure 165).



Figure 165: Field biologist making observations in the study site.



Figure 166: Landscape of power station PS5. The dominant plant is *Anabasis articulata*.

5.9 Segment 9

This segment extends for about 18 km near Ghamadan National Park reaching the intersection with Adh Dhuhaybah Al Sharqiyah to the east. It runs parallel to the Airport highway for about 2.5 km before it diverts to the east crossing Al Yadodeh and Al Tuneeb (Figure 167).

Green houses are scattered along the rout of the proposed pipeline, with fruit and olive farms. The sides of the roads are planted with cypress, *Cupressus sempervirens*, and the Aleppo pine, *Pinus halepensis.*

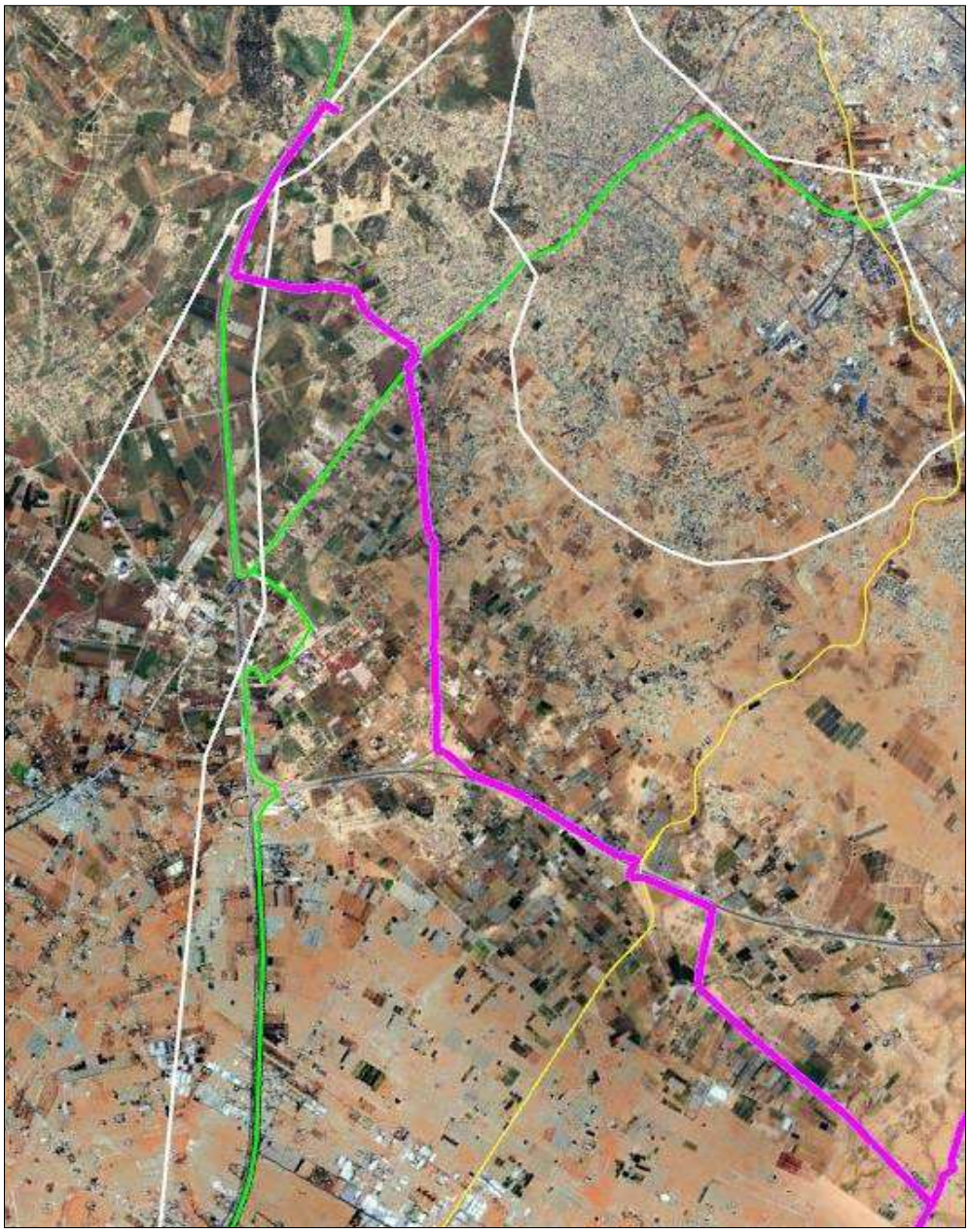


Figure 167: Arial view of Segment 9.

From a biogeographical point of view, this segment is within the Mediterranean biotope to the west, then at the edge of the Irano-Turanian biotope to the southeast. This is evident by the dense stand of Aleppo pine, *Pinus halepensis,* in Ghamadan NP and its vicinity, as well as scattered trees of Carob, *Ceratonia siliqua.* While to the southeast, *Anabasis* sp. appears as a landmark for the Irano-Turanian biotope (Figure 168).



Figure 168: A. The water reservoir at Al Mutazah Power station where the pipeline ends. B and C. Pine trees in front of Ghamadan National Park, where the pipeline will pass through.

The *terra rosa* soil is the dominant type, however, towards the southeastern part of the segment, loamy soil becomes dominant with scattered rocks of variable sizes. Mounds of the Middle Eastern blind mole rat, *Spalax ehrenbergi*, are common in uncultivated fields. Further to the southeast, open areas void of buildings were observed. Some are planted with olive trees, or with green houses for agriculture as well as sheep yards. These open lands are sometimes planted with wheat depending on the rain season (Figure 169).



Figure 169: Trees along the path of the pipeline.

The pipeline is accessible along most of its path, however, at 31°48'12.62"N 35°58'41.12"E, and the beginning of 31°47'22.32"N 36° 0'14.17"E, the pipeline diverts into agricultural areas with many green houses, whereas sometimes the green houses block the path of the road (Figure 170).



Figure 170: A. Commercial area within segment 9. .B. Olive garden close to the main road. C. Mounds of Middle Eastern blind mole rat, Spalax ehrenbergi. D. Sheep flock within open lands in the study site.

In general, this segment does not hold species of conservation significance. It is heavily urbanized with widescale of vegetables agriculture within green houses. Plastic pollution is very heavy around agricultural areas in the form of polyethylene plastic as well as plastic pipes of various sizes. In addition, irrigation pools made of plastic liners are common among the agricultural projects within most of the southeastern part of the segment (Figure 171,Figure 172).

Small mammals reported from around Ghamadan and Amman National parks include the house mouse, *Mus musculus*, Tristram Jord, *Meriones tristrami*, the Levant vole, *Microtus guentheri*, and the invasive Brown Rat, *Rattus norvegicus* (Obuch, 2018). Both *M. musculus* and *R. norvegicus* are common in urban areas and lives in close association with human habitations.



Figure 171: Arial view of the southeastern section of segment 9 showing intensive greenhouses agriculture.



Figure 172: A. The beginning of the Irano-Turanian biotope with abundance of Anabasis articulata. B. Irrigation pools with plastic lining. C. Plastic pollution in the form of pipes and plastic sheets. D. Greenhouses within the southeastern part of segment 9.

5.10 Segment 8

This segment extends for about 18 km from the town of Abu Alanda reaching Adh Dhuhaybah Al Sharqiyah village to the east. It cross Sahab and the Islamic cemetery along Mowqqar

highway, then it diverts to the southwest at Sahab interchange opposite to the Christian cemetery along Highway 45. At 31°49'10.17"N 36° 1'6.13"E, it diverts southwards reaching Adh Dhuhaybah Al Sharqiyah before it joins the fork with segment 9 (Figure 173).



Figure 173: Arial view of Segment 8.

From a biogeographical point of view, this segment is at eastern edge the Mediterranean biotope near Abu Alanda, then the Irano-Turanian biotope prevails across the entire segment. Aleppo pine, *Pinus halepensis,* as well as scattered trees of Carob, *Ceratonia siliqua,* are planted along Highway 40.

Along the right-hand side to the way to the Islamic Cemetery, stone and marble workshops are very common, throwing their stone leftover near the highway. It is a busy road for truckers to the Iraqi borders and the desert highway.

As far as small mammals, invasive species such as the House Mouse, *Mus musculus*, and the Brown Rat, *Rattus norvegicus,* are expected to occur in urban and commercial areas. However, in areas such as Adh Dhuhaybah Al Sharqiyah, the Fat Sand Rat, *Psammomys obesus,* Wagner's Gerbil, *Gerbillus dasyurus*, and the Grey Hamster, *Cricetulus migratorius,* were reported from the vicinity of Al Muwaqqar (Amr & Saliba, 1986).

Most of the path of the pipeline is very much degraded due to urbanization and presence of industrial area around the entire area (Figure 174,Figure 175).



Figure 174. A & B. End point of the pipeline at Abu Alanda Reservoir. C. Stone and marble workshops near the pipeline path. D. Commercial area in Abu Alanda. E. Planted pine trees along the highway.



Figure 175: A. Planted pine trees along the highway. B. Greenhouses along the way to Adh Dhuhaybah Al Sharqiyah. C. Residential area in Adh Dhuhaybah Al Sharqiyah.

5.11 DISI BYPASS AREA

Based on field surveys and ground truthing, it is recommended to follow the proposed bypass since it will be outside the buffer zone of Wadi Rum Protected Area (Figure 176). The bypass (Yellow line) is far from the sandstone mountains that are within the buffer zone. In addition, the proposed bypass is within already degraded areas with little biodiversity for species of conservation status.



Figure 176: Proposed Disi bypass.

5.12 CONSERVATION STATUS OF REPTILES, AMPHIBIANS AND MAMMALS ENCOUNTERED DURING THE STUDY

Fifteen species of reptiles, one amphibian and six species of mammals were reported during this survey. Of the reptiles, 14 species are listed as Least Concern in both the IUCN global and national redlist, while the Egyptian Spiny-tailed Lizard, *Uromastyx aegyptia,* is listed as Vulnerable in both lists. This species is threatened due to extensive harvesting and habitat loss within its range of distribution (Disi et al., 2014). The presence of the Variable Green Toad, *Bufotes sitibundus,* represents introduction due to human activities.

Of the six mammals, only the Nubian Ibex, *Capra nubiana,* is listed as Vulnerable and Endangered according to IUCN global and national redlist respectively. Its presence in the study area is based on an observation near the constructed dams at Wadi Al Yotum.

Scientific name	Common name	Global IUCN status	National IUCN status
Pseudotrapelus aqabensis	Aqaba Agama	NE	LC
Pseudotrapelus sinaitus	The Sinai Agama	LC	LC
Trapelus agnetae	North Arabian Plain Agama	LC	LC
Laudakia vulgaris	The Egyptian Rock Agama	LC	LC
Uromastyx aegyptia	Egyptian Spiny–tailed Lizard	NT	NT
Stenodactylus grandiceps	Jordan Short-fingered Gecko	LC	LC
Ptyodactylus hasselquistii	Hasselquist's Fan-footed Gecko	LC	LC
Bunospus tuberculatus	The Baluch Ground Gecko	LC	LC
Hemidactylus dawudazraqi	Not assigned	LC	LC
Ophisops elegans	Snake-eyed Lizard	LC	LC
Eumeces schneiderii	Schneider's Skink	LC	LC
Acanthodactylus opheodurus	Arnold's Fringe-fingered Lizard	LC	LC
Acanthodactylus schmidti	Schmidt's Fringe-toed Lizard	LC	LC
Acanthodactylus boskianus	Bosk's Fringe-toed Lizard	LC	LC
Varanus griseus	Desert Monitor	LC	LC
Bufotes sitibundus	Variable Green Toad	LC	LC
Capra nubiana	Nubian Ibex	V	EN
Acomys dimidiatus	Arabian Spiny Mouse	LC	LC
Gerbillus dasyurus	Wagner's Gerbil	LC	LC
Sekeetamys calurus	The Bushy-tailed Jird	LC	LC
Vulpes vulpes	Red Fox	LC	LC
Paraechinus aethiopicus	Ethiopian Hedgehog	LC	LC

5.13 THREATENED AND NOTEWORTHY PLANT TAXA OF SOUTHERN JORDAN (AQABA – WADI RUM – AL-JAFR)

5.13.1 Trees & Large Shrubs

1) *Vachellia* (=*Acacia*) *tortilis* — VU (Jordan)

- **Local distribution & habitat (south Jordan):** Open desert woodland on piedmonts, alluvial fans and wadi beds from Wadi Araba to Aqaba; scattered on gravelly plains and run-on zones in Rum and towards Al-Jafr. Nurse-tree role for annuals/subshrubs.
- **Key pressures:** Chronic seedling/sapling browsing (goats/camels), fuelwood cutting, off-road disturbance of recruitment microsites, declining runoff/groundwater.
- **Trends:** Mature trees persist; recruitment episodic and tied to wet years—gaps lengthening with aridification.
- **Priority actions:** Exclosures around regeneration patches; community fuel alternatives; assisted recruitment using micro-catchments; nursery production from local provenances.

2) *Vachellia* (=*Acacia*) *gerrardii*— VU (Jordan)

- **Taxonomic note:** Treated under *Vachellia gerrardii*; *subsp. negevensis* used regionally (Negev–south Jordan–NW Arabia).
- **Local distribution & habitat:** Very sparse desert acacia on wadis/piedmont fans of extreme south (Rum–Ma'an–Aqaba belt); more patchy and localized than *V. tortilis*.
- **Threats & actions:** As for *V. tortilis* but with higher fragmentation—protect known groves; prioritize seed collection & genetics to avoid genetic bottlenecks.

3) *Haloxylon persicum* — VU (Jordan)

- **Local distribution & habitat:** Late-successional dominant of stabilized dunes/ancient sands in Wadi Rum corridors and sandy tracts edging Al-Jafr; forms the saxaul "framework" with *Retama*/*Zilla*.
- **Key pressures:** Cutting for fuel, grazing/trampling of seedlings, dune destabilization and reduced establishment with drier years.
- **Actions:** Identify/zone remaining saxaul blocks; propagate drought-hardened stock; use nurse shrubs and micro-catchments in restoration.

4) *Calligonum comosum* — EN (Jordan)

- **Local distribution & habitat:** Keystone sand-binder on mobile and semi-stabilized dunes in Wadi Rum and sandy corridors toward Al-Jafr.
- **Status evidence:** Explicitly listed "Endangered at the local level" in Jordan (also cited in Fifa Nature Reserve documentation).
- **Threats:** Overgrazing of shoots, woodcutting, off-road tracks through dune fronts, sand extraction.
- **Actions:** Mark/protect dune toes and slipfaces with highest shrubs; harvest local seed for dune fixation projects; regulate off-road access.

5.13.2 Desert Shrubs & Subshrubs

5) *Artemisia judaica* — VU (Jordan)

- **Local distribution & habitat:** Common dwarf aromatic shrub of pre-desert wadis and valley floors in Wadi Araba–Aqaba and southern Badia; occurs on rocky/gravelly substrates and run-on flats.
- **Threats:** Heavy browsing close to settlements/camps; localized fuel use; track proliferation on valley floors.
- **Notes:** Ethnobotanically important; Jordanian chemotype studied (bioactive essential oil).
- **Actions:** Maintain grazing buffers on wadis; retain shrubs as nurse plants in restoration mixes.

6) *Artemisia monosperma* — NT (Jordan)

- **Local distribution & habitat:** Characteristic dwarf shrub of sand systems (mobile, stabilized) on the Rum–Araba dune belt; strong dune stabilizer.
- **Threats:** Dune disturbance by vehicles/camping; sand mining; browsing of regenerating patches.
- **Actions:** Prioritize it (with *Calligonum*/*Haloxylon*) in dune fixation schemes; protect crestlines and interdunes most used by vehicles.

7) *Cleome droserifolia* — EN (Jordan)

- **Local distribution & habitat:** Scattered on rocky/stony desert and sandy wadis; **documented from Wadi Rum/Aqaba** accessions in Jordan.
- **Threats:** Overharvesting (medicinal), browsing of new shoots, site disturbance; very patchy distribution in Jordan vs. wider regional range.
- **Notes:** National Red List categorization in Jordan is higher risk than in some neighbouring countries (e.g., DD in UAE).
- **Actions:** Map micro-populations; in-country ex situ (seed banking/micropropagation); regulate collection.

8) *Lavandula coronopifolia* — NT (Jordan)

- **Local distribution & habitat:** Rocky desert slopes and plains from Rum–Aqaba northward in arid belts; the most widespread *Lavandula* species across N. Africa–W. Asia.
- **Phenology & uses:** Often flowers early (as early as January in the region); aromatic/medicinal; Jordanian material chemically profiled.
- **Threats:** Localized collection, trampling near popular sites.
- **Actions:** Sustainable harvest protocols; protect rocky refugia and north-facing ledges.

9) *Heliotropium rotundifolium* — VU (Jordan)

- **Local distribution & habitat:** Limestone and rocky desert outcrops; present in Jordan and adjacent areas (Sinai–Negev corridor), with arid-zone distribution into the lower Jordan/Dead Sea and southward.
- **Risks/notes:** Some *Heliotropium* spp. contain pyrrolizidine alkaloids; populations can be locally sparse in extreme desert.

- **Actions:** Micro-site protection on limestone knolls; monitor small subpopulations for trends.
- **Toxic desert herb**

10) *Hyoscyamus muticus* — CR (Jordan)

- **Local distribution & habitat:** Scattered in extreme deserts and wadis; historically recorded in southern Jordan (Rum/Araba) and regionally across the Saharo-Arabian belt; extremely rare locally.
- **Threats:** Very small population size; disturbance at water points/roads; targeted collection (tropane alkaloids).
- **Actions:** Confidential location handling; rapid seed collection for banking; reinforcement trials in suitable protected microhabitats.

5.14 FLORA SPECIES RICHNESS AND PLANT COVER

Overview

The vegetation datasets from AAWDCP sites provide site-level ecological information, including species presence/abundance, species richness, Shannon–Weaver diversity index (H′), and percent vegetation cover. These metrics are widely applied in vegetation ecology (Magurran, 2004; Krebs, 2014) and are central to rangeland and restoration studies in Jordan.

Recent research by Taifour (2022) and Taifour et al. (2022) emphasizes such metrics for modelling actual vs potential vegetation types and for building the first national state-of-the-art vegetation map of Jordan, which informs conservation and restoration programmes.

Species Composition

More than 40 species were recorded across sites, reflecting desert, semi-arid, and halophytic vegetation types:

- Trees and Shrubs: *Vacehllia tortilis*, *Vacehllia gerrardii*, *Artemisia judaica*, *Retama raetam*.
- Grasses: *Stipagrostis plumosa*.
- Halophytes/xerophytes: *Anabasis articulata*, *Salsola tragus*, *Haloxylon persicum*.

Species distributions were highly variable: some (*Vacehllia tortilis*) occurred rarely, while halophytes and annual herbs dominated disturbed or saline habitats. This heterogeneity reflects the role of soil type, water availability, and grazing pressure in shaping desert communities (Noy-Meir, 1973; Zohary, 1973; Al-Eisawi, 2013; Taifour, 2022).

Species Richness

Species richness ranged from 1–2 species per site in degraded habitats to 6–7 species in more favorable conditions (Figure 177).

- Sites such as PS3-B and PS5-1 exhibited moderate richness (6–7 species).
- Many sites supported only one or two taxa, indicating fragmentation and ecological stress.

These findings align with Taifour (2022), who found richness strongly linked to environmental gradients and disturbance, and with studies on steppe and arid ecosystems in Jordan and neighboring regions (Al-Rowaily et al., 2015; Hatimi & Hegazy, 2020).

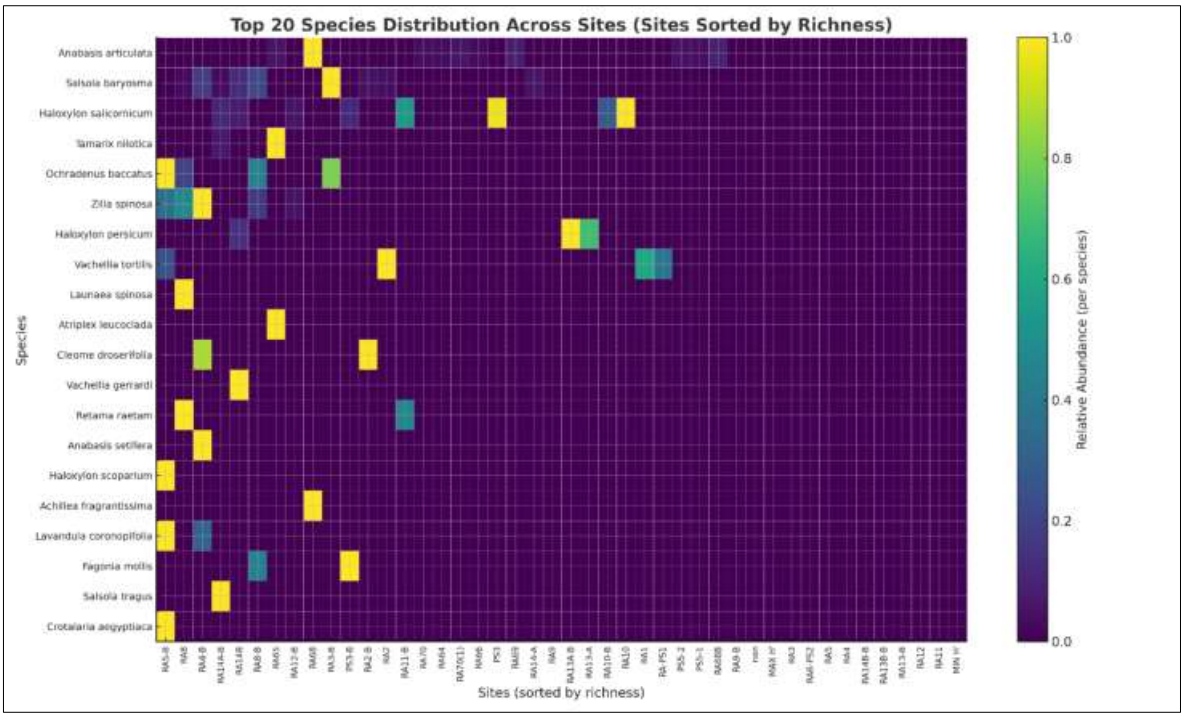


Figure 177: Species richness ranged from 1–2 species per site in degraded habitats to 6–7 species in more favorable conditions

Diversity Index (H′)

The Shannon–Weaver index values were generally very low, close to zero, reflecting dominance by few species.

- The highest value (~0.45 at PS3-B) indicates slightly greater evenness.
- Low H′ is a hallmark of degraded desert vegetation, with dominance by stress-tolerant taxa (Magurran, 2004; Omar et al., 2012; Shaltout & El-Demerdash, 2018; Taifour, 2022).

Vegetation Cover

Plant cover values were extremely low, typically <1%, with PS3 showing ~4.65%.

- Such low cover reflects aridity, overgrazing, and soil degradation, conditions well-documented in Jordan's steppe and desert (Taifour & El-Oqlah, 2017; Oran & Al-Eisawi, 2015).
- This matches national-level findings: Taifour et al. (2022) showed ~87% of Jordan is arid/semi-arid, with sparse and patchy vegetation cover.

Species Occurrence

- Stress-tolerant taxa (*Anabasis articulata, Retama raetam, Salsola tragus*) occurred sporadically.

- *Vacehllia spp.* were almost absent, confirming their rarity in degraded landscapes despite their ecological importance as keystone species for soil stabilization and fodder (Ghazanfar & Fisher, 1998; Orwa et al., 2009; Taifour, 2022).

These findings underscore both the loss of woodland elements and the need for their re-establishment in restoration projects.

Ecological Interpretation

- Degradation and Desertification: The datasets confirm degraded rangeland conditions, characterized by low richness, low diversity, and sparse cover (UNCCD, 2017; FAO, 2021).
- Dominance of Stress-Tolerant Taxa: The spread of halophytes (*Salsola*, *Anabasis*) typifies overgrazed and saline habitats (Danin, 1996; Taifour, 2022).
- Conservation Value of *Vacehllia*: Relict *Vacehllia* populations are crucial but rare. They are priority targets for restoration (Al-Eisawi, 2013; Taifour, 2022).
- Restoration Potential: Findings support urgent interventions (reseeding, controlled grazing, water harvesting) consistent with Taifour's (2022) framework of modelling potential vegetation to guide ecological recovery.

Conclusion

The integrated results from both datasets show that vegetation in the AAWDCP sites is:

- Low in richness and diversity
- Sparse in cover
- Dominated by stress-tolerant taxa

These findings are consistent with both foundational works (Al-Eisawi, 2013; Zohary, 1973) and cutting-edge research (Taifour, 2022; Taifour et al., 2022). They highlight the urgent need for ecological restoration in Jordan's arid zones, focusing on:

- Native shrub and tree reintroduction (*Vacehllia, Retama*)
- Grazing regulation
- Soil and water conservation measures
- Restoration guided by potential vegetation modelling

Such measures are critical for reversing degradation and building ecological resilience in Jordan's deserts and steppes.

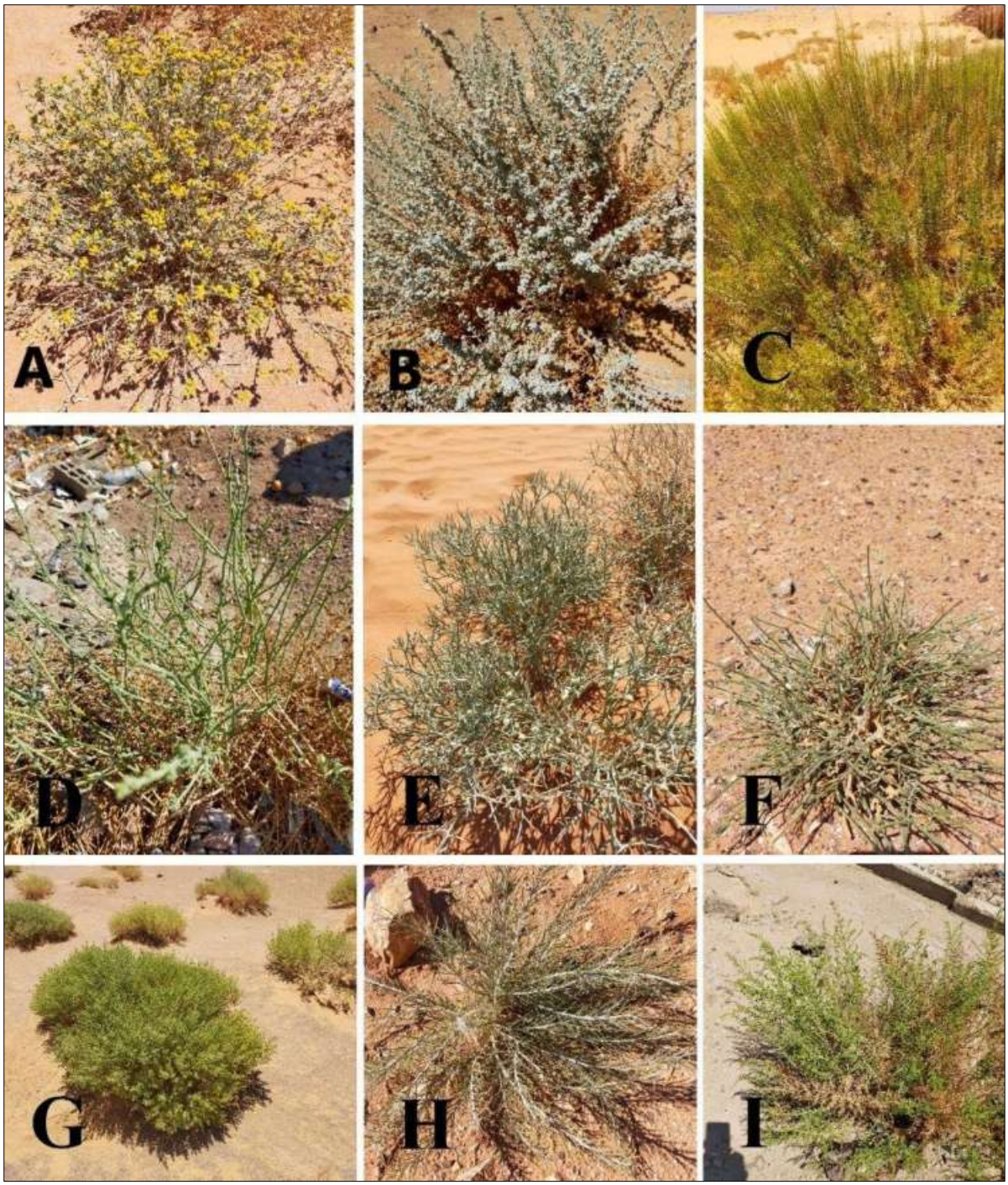


Figure 178. A. Achillea faratemnsima. B. Artemisia judaica. C. Artemisia monosperma. D. Anabasis setifera. E. Zilla spinosa. F. Anabasis articulata. G. Seidlitzia rosmarinus. H. Astragalus spinosus. I. Salsola baryosma.

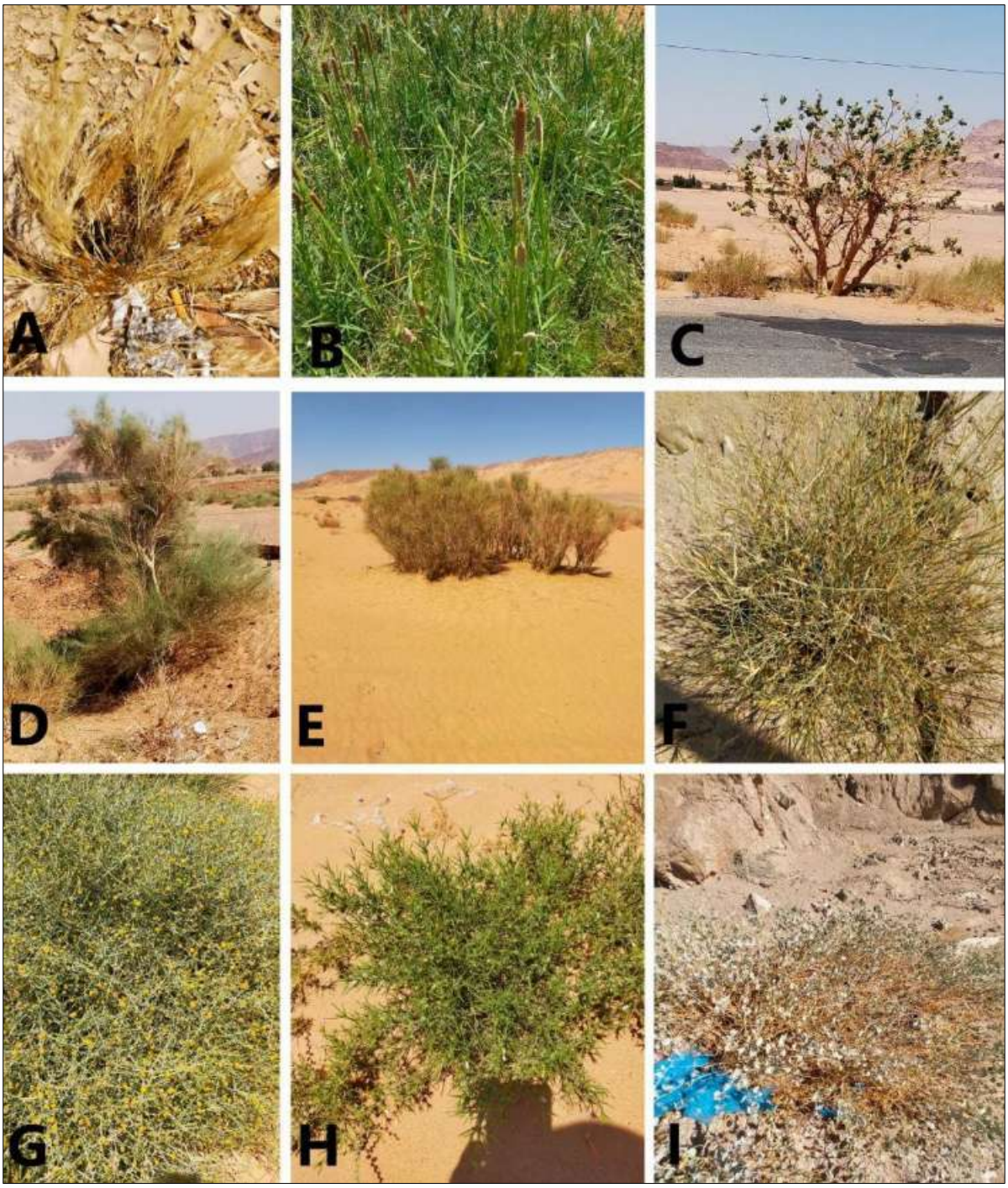


Figure 179: A. Stipellula capensis. B. Typha elephantina. C. Calotropis procera. D. Haloxylon persicum. E. Retama raetam. F. Punicum turgidum. G. Pulicaria undulata. H. Faginia mollis. I. Capparis aegyptia.

6. MITIGATION MEASURES

6.1 Fauna

We established the presence of one species, the Egyptian Spiny-tailed Lizard, *Uromastyx aegyptia*, of conservation status at the global and region levels. This species was observed in different locations along segment 6 as shown in Table 125. Care should be considered while excavating soil around these areas.

Table 125. Coordinates for observed Egyptian Spiny-tailed Lizard alive or active burrows.

Observation	N	E
Alive	30°01'18"	36°01'33"
Alive	29°50'19"	35°58'48"
Active burrows	30°10'30"	36°03'31"

It was documented that the Nubian Ibex, *Capra nubiana*, may come close to the dams constructed along Wadi Al Yotom. Workers should be warned not to shoot or cause any harm for this protected species. They may descend from the mountains of Aqaba and Wadi Rum to reach water in the dams.

6.2 Flora

While excavating along the proposed pipeline, workers should avoid both *Vachellia tortilis* and *Vachellia gerrardii* trees on both sides. Also, the workers should not cut any tree for wood for any reason. *Vachellia tortilis* communities are mainly around Aqaba mountains and Wadi Al Yotom, while *Vachellia gerrardii* stands are mostly along the second half of segment 6.

6.3 WALKING TRANSECTS -FLORA SURVEY

RA Point #	Why was the walking transect not done?
RA1	Homogeneous vegetation, hard topography
RA2	Homogeneous vegetation, hard topography
RA3	Homogeneous vegetation, hard topography
RA-PS1	Homogeneous vegetation, hard topography, industrial area
RA4	Very hard topography
RA5	Homogeneous vegetation, hard topography
RA6-PS2	Hard topography, industrial area
RA8	Homogeneous vegetation
RA9	Homogeneous vegetation
PS3	Homogeneous vegetation
RA20	Homogeneous vegetation
RA21	Homogeneous vegetation
RA22	Homogeneous vegetation
RA23	Homogeneous vegetation
RA25	Homogeneous vegetation
RA26	Hard topography
RA27	Hard topography
RA30	Homogeneous vegetation
RA30B	Homogeneous vegetation
RA31	Homogeneous vegetation
RA32	Homogeneous vegetation
RA35	Homogeneous vegetation
RA36	Homogeneous vegetation
RA37	Homogeneous vegetation
RA38	Homogeneous vegetation
RA39	Homogeneous vegetation
RA40	Homogeneous vegetation
RA41	Homogeneous vegetation
RA42	Homogeneous vegetation
RA43	Homogeneous vegetation
RA44	Homogeneous vegetation

RA45	Homogeneous vegetation
RA46	Homogeneous vegetation
RA46A	Homogeneous vegetation
RA48	Homogeneous vegetation
RA51	Homogeneous vegetation
RA51B	Homogeneous vegetation
RA53	Homogeneous vegetation
RA55	Homogeneous vegetation
RA61	Homogeneous vegetation, Hard topography
RA62	Homogeneous vegetation
RA63	Homogeneous vegetation
RA64	Homogeneous vegetation
RA65	Homogeneous vegetation
RA66	Homogeneous vegetation
RA68	Homogeneous vegetation
RA69	Homogeneous vegetation, Residential area
RA69B	Homogeneous vegetation, Residential area
RA70	Homogeneous vegetation
PS5	Homogeneous vegetation, Agricultural area
S4-SPV1	Homogeneous vegetation
S4-SPV2	Homogeneous vegetation
S4-SPV3	Homogeneous vegetation
S4-OHTL-4	Homogeneous vegetation
S4-OHTL-5	Homogeneous vegetation

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Project: Aqaba-Amman Water Desalination and Conveyance (AAWDC)

2025 Environmental and Social Impact Assessment

Appendix 6-12 Avifauna Survey

Aqaba Amman Water Desalination and Conveyance Project (AAWDCP)

Avi-Fauna Survey

Rev 01

Date	Rev	Author	Checked	Approved
7 Oct. 2025	0	TQ	L.Z.	L.Z.
12 Nov 25	1	TQ	L.Z.	L.Z.

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1. BIOGEOGRAPHICAL SETTINGS

1.1. Biogeographical Regions of Jordan

Jordan is influenced by four major biogeographic regions. Vegetation cover, soil texture, altitude and annual rain fall are among the major factors that shaped these biogeographic regions. Al-Eisawi (1985) and Disi & Amr (1998) agreed on the delineation of these four regions based on vegetation cover as well as animal distribution in Jordan. However, Taifor (2022) resented the most updated map for the biogeographical regions of Jordan that is based on vegetation map and other variables (Figure 1).

1. The Mediterranean region: This region is represented by the mountain ranges extending from the north near Irbid, to Ras Al Naqb in the south. It consists of forested vegetation with an abundance of *Juniperus phoenicea, Retama raetam*, *Pistacia atlantica, Pinus halepensis, Quercus calliprinos, Quercus coccifera* and *Quercus ithaburensis*. Open areas are characterized by high cover of the Thorny Burnet, *Sarcopoterium spinosum.* The altitude varies from 700 to 1500 m asl, with an average annual rain fall of 400-600 mm. The soil consists of several types, *terra rosa*, sandy and sandy-loamy due to erosion of the Nubian sandstone that dominates much of southern part of Jordan, (Fig. 1) and calcareous soil in the centre and north.. Irano-Turanian region: This region is represented by a narrow strip that surrounds the Mediterranean ecozone except in the far north.

2. The Irano-Turanian region extends to the north-east, joining the Syrian Desert. The vegetation is dominated by *Anabasis articulata, Artemesia herba-alba, Astragulus spinosum, Retama raetam, Urginea maritima, Ziziphus lotus, Zygophyllum dumosum* and *scattered Juniperus phoenicea* and *Pistacia atlantica* trees (Fig. 7 and 8). The altitude ranges from 400 to 700 m asl, with average annual rainfall of 50-100 mm. The layer of surface soil is very thin or absent in some instances and surface rockiness is very high.

3. Sudanian Penetration region: This region extends from the south near Aqaba along Wadi Araba reaching as far north as Dayr Alla in the Jordan Valley, then extends to south eastern Jordan around Wadi Rum, with sandstone mountains and granite mountains to the east. Acacia subtropical vegetation extends from 0 to 400 m asl, with annual precipitation of less than 50 mm. Trees of both *Acacia raddiana* and *Acacia tortilis* are common in varying densities. Other trees such as *Tamarix* spp., *Ziziphus spina-christi*, *Zygophyllum dumosum,* are also common. Shrubs including *Aanabasis articulata, Gymnocarpos decandrum, Haloxylon persicum,* and *Lycium* sp. are abundant. Soil is mostly sandy with rocky areas. Wadis are filled with alluvial materials washed from the calcareous sandstones.

Saharo-Arabian region: This is the largest biogeographical region of Jordan and covers over 70% of the total area of the country. It is located to the east bordering the Irano-Turanian region from the west and the Sudanian Penetration region from the southwest. The sand dune desert vegetation is dominated by *Haloxylon persicum, Hammada scoparia* and *Ochradenus baccatus.* Open areas and wadi beds are characterized by *Achillea fragrantissima*, *Artemisia herba-alba,* and *Astragalus* sp. Few scattered *Acacia tortilis* are also found. The soil mostly consists of gravel, sandy Hamada, saline and sandy soils. The altitude ranges from 100 m bsl to 800 m asl, with rainfall not exceeding 50 mm annually. Within this region, Azraq Oasis, stands as landmark in the middle of Jordan's east.

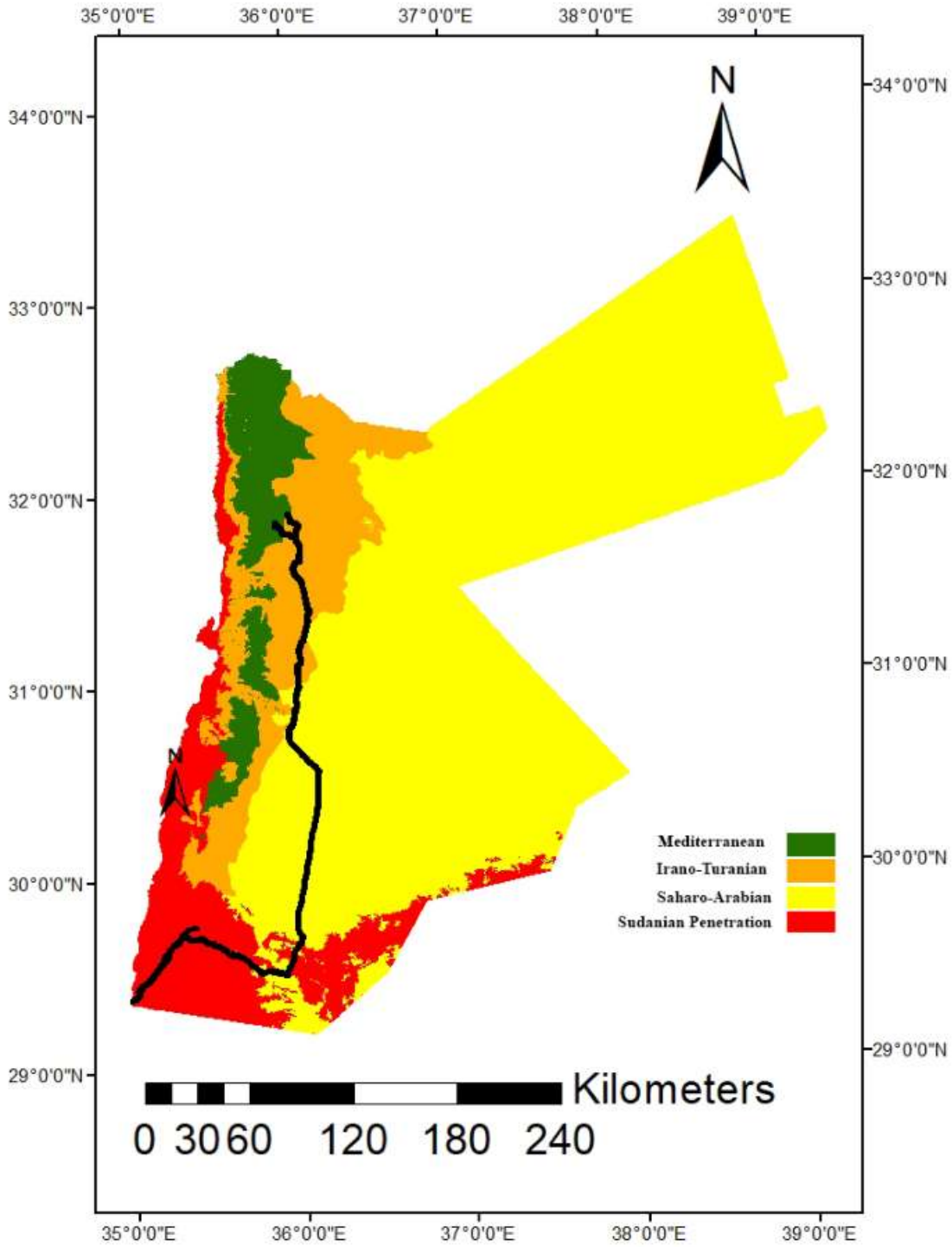


Figure 1: Biogeographical Regions of Jordan Based on Taifour et al. (2022)

Segments 1-5 are within the Sudanian Penetration region, while segment 6 is mostly within the Saharo-Arabian region. Segment 7 is associated with the Irano-Turanian region that surrounds the Mediterranean region to the east and extends along the desert high to Amman. Segment 8 is a mix of both the Mediterranean and the Irano-Turanian regions, whereas its southern end is Irano-Turanian. Segment 9 is strictly Mediterranean with *terra rossa* soil and small forests of *Pinus halepensis*.

1.2. Vegetation Types of Jordan

Vegetation types of Jordan were studied by several authors, however, the most comprehensive and applicable maps were produced by Al-Eisawi (1985) and Alberts *et al.* (2004). Both maps are similar with minor modifications. Al-Eisawi (1985) recognized 13 vegetation types; pine forests, Evergreen pine forests, deciduous oak forests, Junipers forests, Mediterranean non-forest, steppe, Hamada, saline (halophytic), tropical, sand dunes, and rocky Sudanian, water (hydrophytic) and mud flat vegetation.

Nineteen different vegetation types were identified by Alberts *et al*. (2004) including *Artemisia herba-alba* steppe, *Noaea mucronata* brush, grass land steppe, mixed steppe and Saharo-Arabian, basalt scrub, chert Hamada, sandy hamada, Acacia woodlands, *Ziziphus spina-christi* and *Balanites aegyptiacus*, weathered sand stone and granite scrub, sand dunes, aquatic and saline marshlands, slat and mud flats, *Quercus calliprinos* maquis, deciduous oak forests, *Pinus halepensis* forests, Phoenician Juniper forests, batha steppe and Mediterranean non-forest batha vegetation.

Taifour et al. (2022) Based on satellite image interpretation, proposed two maps created: an unsupervised land cover/land use map and a supervised map of present-day vegetation types, both consisting of 18 categories (Figure 2). These new maps should inform ecosystem management and conservation planning decisions in Jordan over the coming years.

Segments 1-3 are within the granite and sandstone shrubland, while segments 4 and 5 are influenced by granite and sandstone shrubland and sand dune vegetation around the northern edge of Wadi Rum. Segment 6 is mostly withing the sandy gravel hammada vegetation with *Vachellia gerrardii, Artemisia judaica*, and *Hammada scoparia.*

Segment 7 represents steppes vegetation that associated with the Irano-Turanian biogeographical region. On the other hand, segment 8 is also considered as steppes, with very little of the Garrigue and batha. Segment 9 Garrigue and batha is within the Mediterranean region that do not support forests under current physical and climatic conditions, represented by *Sarcopoterium spinosum*, among other small shrubs.

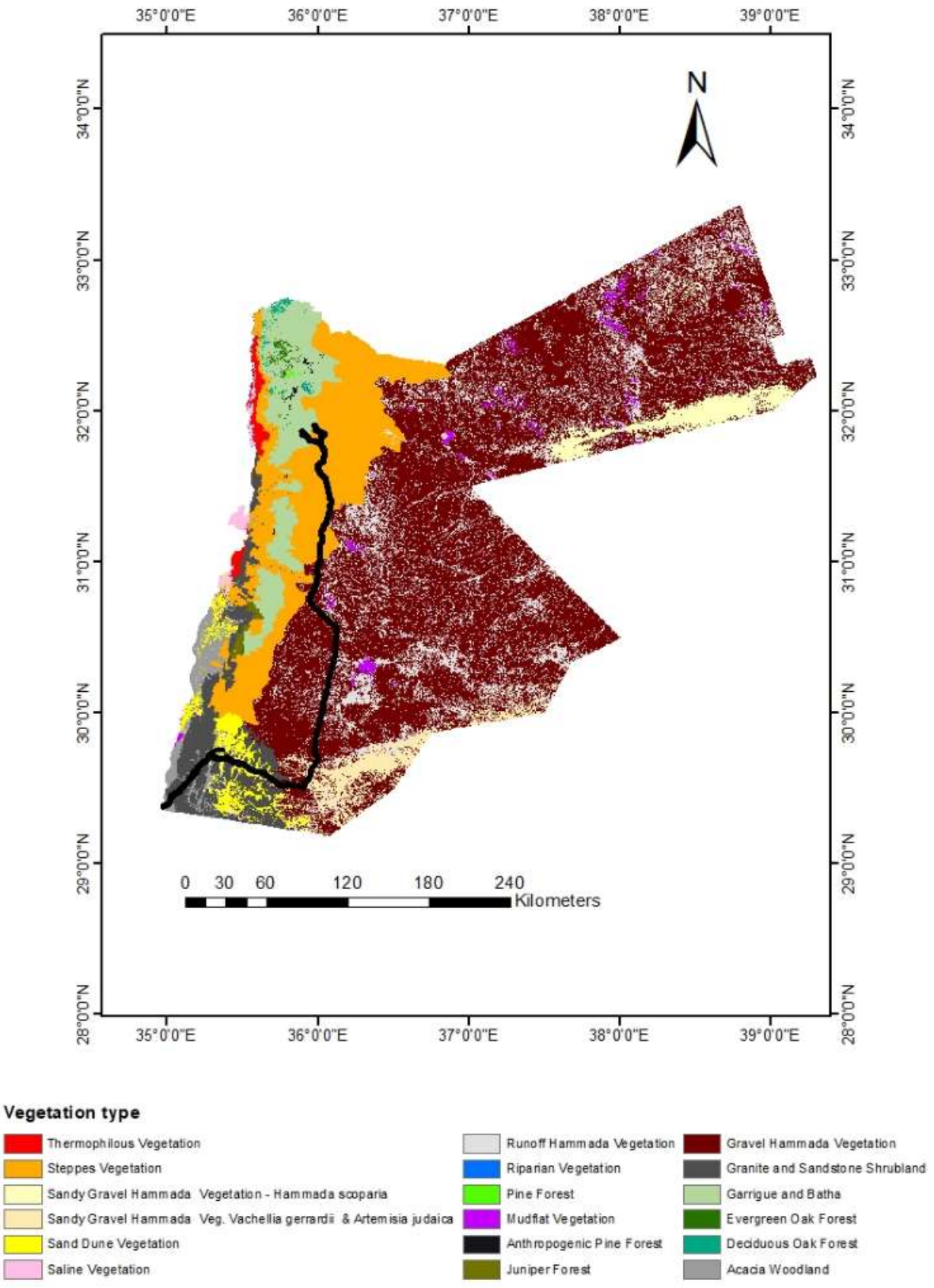


Figure 2: Vegetation Map of Jordan Based on Taifour et al. (2022)

1.3. Established Protected Areas

Twelve protected areas have been declared (Figure 3), 11 are under the supervision of the Royal Society for the Conservation of Nature, and one, Wadi Rum, is operated by Aqaba Special Economic Zone. Segments 4 and 5 are within the northern boundaries of Wadi Rum Protected area.

Twelve protected areas have been declared (Figure 3), 11 are under the supervision of the Royal Society for the Conservation of Nature, and one, Wadi Rum, is operated by Aqaba Special Economic Zone. Segments 4 and 5 are within the northern boundaries of Wadi Rum Protected area.



Figure 3: Established Protected Areas in Jordan

1.4. Important Bird Areas

So far, 27 IBA's have been identified (Figure 4) representing a wide variety of areas including the eastern desert, Jordan Vallley northern mountains, Wadi Araba and Wadi Rum area.

Segments 4 and 5 are within the northern end of Hisma Basin-Rum. This is an isolated tract of huge, precipitous, sandstone and granite mountains, ranging up to 1754 m (Jebel Rum), separated from each other by flat sandy corridors. Main use is tourism and pastoralism.

Breeding birds include Short-toed Eagle, Verraux's Eagle (former breeder), Lanner Falcon (rare), Barbary and Sooty Falcons, Lesser Kestrel (rare), Lammergeier (former breeder), Griffon Vulture (rare), Sand Partridge, Chukar, Hume's Tawny Owl, Hooded, Mourning and White-crowned Black Wheatears, Arabian Babbler, Tristram's Grackle, Sinai Rosefinch and Trumpeter Finch. Winter visitors include Steppe Eagle, Saker (rare), Desert Warbler and Pale Rock Sparrow (rare). Imperial Eagle, Honey Buzzard, Egyptian Vulture (may breed), Crane and White Stork are uncommon autumn migrants (Jbour, 2018).



Figure 4: Important Bird Areas in Jordan including Hisma Basin-Rum IBA

Uncontrolled off-road driving is causing destruction of the sand dune habitats. Parts of this site have been declared protected, while other areas at Disi and Sahl As-Suwwan are used for intensive agricultural.

1.5. Key Biodiversity Areas

Key Biodiversity Areas are defined as the most important sites globally for species and their associated habitats. The KBA program provides a global framework for identifying, mapping, monitoring, and conserving these areas to ensure the protection of the most crucial biodiversity sites on Earth, which include rainforests, coral reefs, mountains, wetlands, deserts, grass steppes, ocean depths, and more.

Currently in Jordan, 18 key biodiversity areas have been identified (Figure 6) which align with the identified important bird areas. These areas, recognized for their importance not only for birds but also for mammals and plants, are spread across different biogeographical regions.

The pipeline crosses two key biodiversity areas, the Aqaba mountains at segment 1 and 2, and then at segment 4 and 5 in Wadi Rum area. The Aqaba mountains area is very much degraded as observed during

the survey. It is mostly used by trucks, causing considerable damage to the area by the amount of garbage resulted from old tires and oil spells. The northern part of Rum key biodiversity area is still intact, with evidence of degradation near human settlements and agricultural areas, in addition to tourism activities.



Figure 5: Key Biodiversity Areas in Jordan

2. LITERATURE REVIEW

This section is based on desktop review of existing literature, historical and current data obtained from published books, articles, reports (both published and unpublished), and online sources survey. Sources of information provided in Section 5 of this document.

The areas covered in this literature review include the following:

1. Aqaba Area (coastal region and mountains)
2. Wadi Rum Area
3. Wadi Abu Tarfah
4. Qatraneh Dam Area
5. Swaqa Dam Area
6. Amman National Park Area

The figure below shows these areas covered in this literature review in relation to the Project.

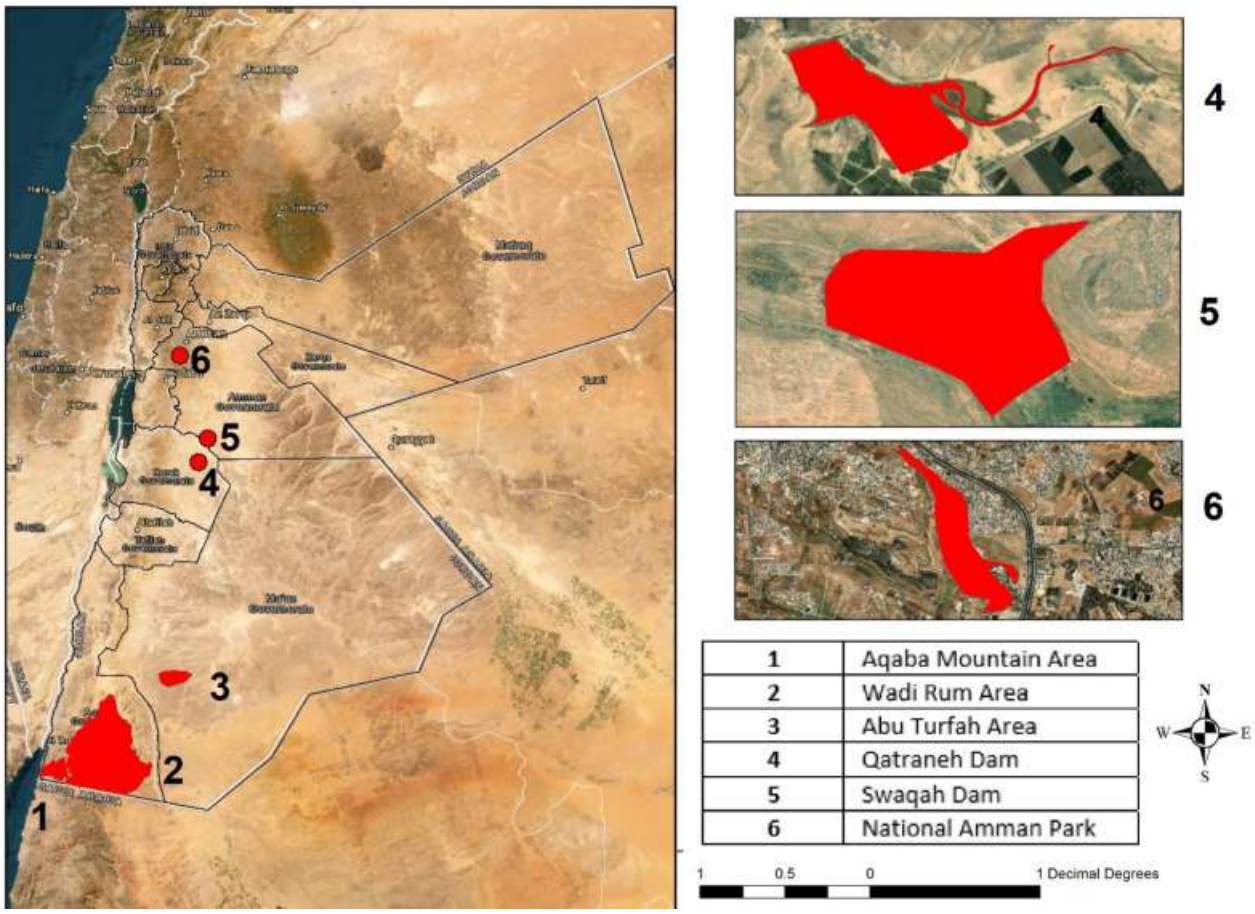


Figure 6: Areas Covered in this Avi-Fauna Literature Review in Relation to the Project

2.1. Aqaba Area (Coastal Region and Mountains)

Andrews (1995) stated that Jordan's only coastline is limited to about 26 km and alluvial fans spread from the inland mountains to the shore, which is composed mainly of rock and gravel beaches, fringed with coral reefs.

The man-made pools attracted significant numbers of waders, ducks and other birds on their migration. Raptor migration involves at least 100,000 birds per season. Important bird species include White-cheeked Tern (migrant), White-eyed Gull (non-breeding resident or visitor), Imperial Eagle (rare migrant and winter visitor), Levant Sparrow Hawk (migrant in spring; min. 10000 per season), Sooty and Lanner Falcons, Liechtenstein's Sandgrouse, Desert Owl, Hooded Wheatear, Tristram's Starling and Sinai Rosefinch (possible breeders in nearby mountains), while Arabian Babbler, and Arabian Warbler are resident in Wadi Araba north of the city.

A detailed bird baseline survey in Aqaba region was conducted by the RSCN in Spring and Autumn seasons of 2002 during March to May and September to October 2002. The RSCN survey area covered four habitats; Wadi Araba, Aqaba Mountains, coastal area and Aqaba side-wadis (RSCN 2002 a&b).

The spring survey resulted in recording 152 species, 50 species were recorded in Aqaba Mountain and wadies (

Table 1). Aqaba Mountains had the highest average number of species per square kilometer (5.6/km^2) and had good numbers of both resident and migrant species, whereas Aqaba side-wadis habitat had the lowest average (2.8/km^2) (RSCN, 2002a).

Key species include the Sooty Falcon that is listed as Vu according to the IUCN Redlist.

Table 1: List of Species Recorded by RSCN in Spring 2002 in the Aqaba Area and their Status

Common Name	Scientific Name	Status	IUCN Status
Black Kite	*Milvus migrans*	M	LC
Marsh Harrier	*Circus aeruginosus*	M	LC
Hen Harrier	*C. cyaneus*	M	LC
Steppe Buzzard	*Buteo buteo*	M	LC
Long-legged Buzzard	*B. rufinus*	R	LC
Lesser Kestrel	*Falco naumanni*	M	LC
Kestrel	*F. tinnunculus*	R	LC
Sooty Falcon	*F. concolor*	SV	VU
Sand Partridge	*Ammoperdix heyi*	R	LC
Kentish Plover	*Charadrius alexandrinus*	M	LC
Greater Sand Plover	*C. leschenaultii*	M	LC
Common Snipe	*Gallinago gallinago*	M	LC
Green Sandpiper	*Tringo ochropus*	M	LC
Arctic Skua	*Stercorarius parasiticus*	M	LC
Sooty Gull	*Larus hemprichii*	R	LC
White-eyed Gull	*L. leucophthalmus*	R	LC
Lesser Black-backed Gull	*L. fuscus*	M	LC
Yellow-legged Gull	*L. cachinnans*	M	LC
Common Tern	*Sterna hirundo*	M	LC
Rock Dove	*Columba livia*	R	LC
Collared Dove	*Streptopelia decaocto*	R	LC
Palm Dove	*S. senegalensis*	R	LC
Namaqua Dove	*Oena capensis*	M	LC
Common Swift	*Apus apus*	M	LC
Little Green Bee-eater	*Merops orientalis*	R	LC
Bee-eater	*M. apiaster*	M	LC
Hoopoe	*Upupa epops*	M	LC
Bar-tailed Lark	*Ammomanes cincturus*	R	LC
Desert Lark	*A. deserti*	R	LC
Hoopoe Lark	*Alaemon alaudipes*	R	LC
Crested Lark	*Galerida cristata*	R	LC
Swallow	*Hirundo rustica*	M	LC
Grey Wagtail	*Motacilla cinerea*	M	LC
White Wagtail	*M. alba*	M	LC
White-spectacled Bulbul	*Pycnonotus xanthopygos*	R	LC
Rufous Bush Robin	*Cercotrichas galactotes*	M	LC
Blackstart	*Cercomela melanura*	R	LC
Northern Wheatear	*Oenanthe oenanthe*	M	LC
Olivaceous Warbler	*Hippolais pallida*	M	LC
Olive-tree Warbler	*H. olivetorum*	M	LC
Lesser Whitethroat	*Sylvia curruca*	M	LC
Blackcap	*S. atricapilla*	M	LC
Palestine Sunbird	*Nectarinia osea*	R	LC
Red-backed Shrike	*Lanius collurio*	M	LC
Masked Shrike	*L. nubicus*	R	LC
Indian House Crow	*Corvus splendens*	R	LC
Tristram's Grackle	*Onychognathus tristramii*	R	LC
House Sparrow	*Passer domesticus*	R	LC

Table 2 and Table 3 list resident and migrant species recorded from Aqaba mountains.

Table 2: Resident Species Recorded by RSCN in Spring 2002 in Aqaba Mountains and Side-Wadies

Habitat	Species and number of occurrences
Aqaba mountains	Long-legged Buzzard, Rock Dove, Collared Dove, Palm Dove, Little Green Bee-eater, Bar-tailed Lark, Desert Lark, Blackstart, White -spectacled Bulbul, Palestine Sunbird, Tristram's Grackle, House Sparrow
Aqaba side-wadis	Kestrel, Rock Dove, Collared Dove, Desert Lark, Blackstart, White -spectacled Bulbul
Coastal area	Sooty Gull, White-eyed Gull, Rock Dove

Table 3: Migrant Species Recorded by RSCN in Spring in 2002 in Aqaba Mountains and Side-Wadies

Habitat	Species and number of occurrences
Aqaba mountains	Namaqua Dove, Rufous Bush Robin, Olivaceous Warbler, Olive-tree Warbler, Lesser Whitethroat, Blackcap, Red-backed Shrike, Masked Shrike
Coastal area	Kentish Plover, Greater Sand Plover, Snipe, Green Sandpiper, Arctic Skua, Lesser Black-backed Gull, Yellow-legged Gull, Caspian Tern, Common Tern, Common Swift, Hoopoe, Swallow, Grey Wagtail, White Wagtail
Aqaba side-wadis	Lesser Kestrel, Olivaceous Warbler, Lesser Whitethroat, Blackcap, Bee-eater, Swallow, Masked Shrike

The second survey in Autumn 2002 was conducted between September to October 2002 (RSCN, 2002b). A total of 154 species were recorded, 90 of these species were recorded in the Aqaba Mountains and side wadies. Unlike the spring study, this study has shown the significance of Aqaba side-wadis as suitable habitats for both migrant and resident species. This habitat had the second highest number of migrant and resident species.

Twenty-eight of the identified species are resident, sixty-one are migrant while only one species (Caspian Tern, *Sterna caspia*) was transient (present throughout the year without breeding) (Table 4).

Table 4: List of Species Recorded by RSCN in Autumn in 2002 in Aqaba Mountains and Side-Wadies

Common Name	Scientific Name	Status	IUCN status
Cory's Shearwater	*Calonectris diomedea*	M	LC
Night Heron	*Nyctocorax nycticorax*	M	LC
Grey Geron	*Ardea cinerea*	M	LC
Pintail	*Anas acuta*	M	LC
Honey Buzzard	*Pernis apivorus*	M	LC
Short-toed Eagle	*Circaetus gallicus*	M	LC
Marsh Harrier	*Circus aeruginosus*	M	LC
Sparrowhawk	*A. nisus*	M	LC
Buzzard	*Buteo buteo*	M	LC
Kestrel	*F. tinnunculus*	R	LC
Peregrine Falcon	*F. peregrinus*	M	LC
Barbary Falcon	*F. pelegrinoides*	R	LC
Chukar	*Alectoris chukar*	R	LC
Sand Partridge	*Ammoperdix heyi*	R	LC
Quail	*Coturnix coturnix*	M	LC
Corncrake	*Crex crex*	M	LC
Stone Curlew	*Burhinus oedicnemus*	M	LC
Ringed Plover	*Charadrius hiaticula*	M	LC
Kentish Plover	*C. alexandrinus*	M	LC
Greater Sand Plover	*C. leschenaultii*	M	LC

Grey Plover	*Pluvialis squatarola*	M	LC
Little Stint	*Calidris minuta*	M	LC
Dunlin	*C. alpina*	M	LC
Green Sandpiper	*Tringa ochropus*	M	LC
Wood Sandpiper	*T. glareola*	M	LC
White-eyed Gull	*Larus leucophthalmus*	R	LC
Yellow-legged Gull	*L. cachinnans*	M	LC
Caspian Tern	*Sterna caspia*	T	LC
Lichtenstein's Sandgrouse	*Pterocles lichtensteinii*	R	LC
Crowned Sandgrouse	*P. coronatus*	R	LC
Collared Dove	*Streptopelia decaocto*	R	LC
Turtle Dove	*S. turtur*	M	LC
Palm Dove	*S. senegalensis*	R	LC
Namaqua Dove	*Oena capensis*	M	LC
Swift	*Apus apus*	M	LC
Little Green Bee-eater	*Merops orientalis*	R	LC
Bee-eater	*M. apiaster*	M	LC
Roller	*Coracias garrulus*	M	LC
Hoopoe	*Upupa epops*	R	LC
Wryneck	*Jynx torquilla*	M	LC
Bar-tailed Desert Lark	*Ammomanes cincturus*	R	LC
Desert Lark	*A. deserti*	R	LC
Hoopoe Lark	*Alaemon alaudipes*	R	LC
Short-toed Lark	*Calandrella brachydactyla*	M	LC
Crested Lark	*Galerida cristata*	R	LC
Sand Martin	*Riparia riparia*	M	LC
Rock Martin	*Ptyonoprogne fuligula*	R	LC
Swallow	*Hirundo rustica*	M	LC
House Martin	*Delichon urbica*	R	LC
Tawny Pipit	*Anthus campestris*	M	LC
Yellow Wagtail	*Motacilla flava*	M	LC
White -spectacled Bulbul	*Pycnonotus xanthopygos*	R	LC
White-throated Robin	*Irania gutturalis*	M	LC
Redstart	*Phoenicurus phoenicurus*	M	LC
Blackstart	*Cercomela melanura*	R	LC
Whinchat	*Saxicola rubetra*	M	LC
Isabelline Wheatear	*Oenanthe isabellina*	M	LC
Wheatear	*O. oenanthe*	M	LC
Black-eared Wheatear	*O. hispanica*	M	LC
Desert Wheatear	*O. deserti*	R	LC
Hooded Wheatear	*O. monacha*	R	LC
White-crowned Wheatear	*O. leucopyga*	R	LC
Graceful Prinia	*Prinia gracilis*	R	LC
Scrub Warbler	*Scotocerca inquieta*	R	LC
Sedge Warbler	*Acrocephalus shoenobaenus*	M	LC
Marsh Warbler	*A. palustris*	M	LC
Olivaceous Warbler	*Hippolais pallida*	M	LC
Upcher's Warbler	*H. languida*	M	LC
Orphean Warbler	*Sylvia hortensis*	M	LC
Lesser Whitethroat	*S. curruca*	M	LC
Whitethroat	*S. communis*	M	LC
Garden Warbler	*S. borin*	M	LC

Blackcap	*S. atricapilla*	M	LC
Willow Warbler	*Phylloscopus trochillus*	M	LC
Spotted Flycatcher	*Muscicapa striata*	M	LC
Palestine Sunbird	*Nectarinia osea*	R	LC
Red-backed Shrike	*Lanius collurio*	M	LC
Lesser Grey Shrike	*L. minor*	M	LC
Southern Grey Shrike	*L. meridionalis*	R	LC
Woodchat Shrike	*L. senator*	M	LC
Masked Shrike	*L. nubicus*	M	LC
Indian House Crow	*Corvus splendens*	R	LC
Brown-necked Raven	*C. ruficollis*	R	LC
Rose-coloured Starling	*Sturnus roseus*	M	LC
House Sparrow	*Passer domesticus*	R	LC
Trumpeter Finch	*Bucanetes githagineus*	R	LC
Cinereous Bunting	*Emberiza cineracea*	M	LC
Ortolan Bunting	*E. hortulana*	M	LC
Cretzschmar's Bunting	*E. caesia*	M	LC
Black-headed Bunting	*E. melanocephala*	M	LC

Table 5 list resident species recorded from Aqaba mountains.

Table 5: Resident Species Recorded by RSCN in Autumn in Each Habitat

Habitat	Species and Number of Occurrences
Aqaba Mountains	Chukar, Sand Partridge, Collared Dove, Palm Dove, Hoopoe, Desert Lark, Rock Martin, White-spectacled Bulbul, Blackstart, Hooded Wheatear, White-crowned Black Wheatear, Scrub Warbler, Palestine Sunbird, House Sparrow
Coastal area	Barbary Falcon, White-eyed Gull, Hoopoe, Desert Lark, Crested Lark, House Sparrow
Aqaba side-wadis	Sand Partridge, Crowned Sandgrouse, Collared Dove, Palm Dove, Little Green Bee-eater, Hoopoe, Desert Lark, Crested Lark, Rock Martin, White -spectacled Bulbul, Blackstart, White-crowned Black Wheatear, Scrub Warbler, Palestine Sunbird, Brown-necked Raven

It should be noted that the globally threatened species recorded in this survey include Lesser Kestrel and Sooty Falcon.

The southern portion of the Project area overlaps the Aqaba Mountains and Coast IBA which is an important area for soaring bird migration, especially during spring.

Despite the importance of Aqaba Mountains area for avifauna, the project area is encroached by several human practices including traffic (Cargo traffic), industrial activities which lead to altering habitat and causing disturbance to the species and habitat in means of noise, dust and wastes created.

Despite the low biodiversity composition, careful considerations and management measures should be applied in the construction and operation phase.

2.2. Wadi Rum Area

Welch et al. (2000) stated that breeding birds of Wadi Rum include Short-toed Eagle, Verraux's Eagle (former breeder), Lanner Falcon (rare), Barbary and Sooty Falcons, Lesser Kestrel (rare), Lammergeier (former breeder), Griffon Vulture (rare), Sand Partridge, Chukar, Hume's Tawny Owl, Hooded, Mourning and White-crowned Black Wheatears, Arabian Babbler, Tristram's Grackle, Sinai Rosefinch and Trumpeter Finch. Winter visitors include Syrian Serin (rare) Steppe Eagle, Saker (rare), Desert Warbler and Pale Rock Sparrow (rare).

Imperial Eagle, Honey Buzzard, Egyptian Vulture (may breed), Crane and White Stork are uncommon autumn migrants.

The most comprehensive study was undertaken during June 1996 by Evans et al. (2005). They listed a total of 142 bird species within 36 families (Wadi Rum Bird Checklist 2) that were certainly recorded either during their field study or by previous observers.

Thrushes were the most diversified group (18 species), followed by warblers (18 species). Hawk-like raptors are represented by 16 species. Twelve families (Ciconlidae, Gruidae, Recurvirostridae, Burhinidae, Laridae, Meropidae, Coraciidae, Upupidae, Pycnonotidae, Timaliidae, Nectariniidae, and Oriolidae) are represented by a single species, while six families (Rallidae, Charadriidae, Caprimulgidae, Apodidae, Muscicapidae and Sturnidae) include two species each.



Figure 7: The White-Crowned Wheatear, a Common Bird for Wadi Rum

According to local status, about 30% of the birds of Wadi Rum are considered resident, with various levels of rarity (Table 6). Passage migrants constitute the highest percentage, reaching 46.5% of the total birds. The others are divided among winter and summer visitors. Accidental species such as the Namaqua Dove and the Indian-House Crow have been observed. Wallace (1988) reported the Lammergeier, *Gypaetus barbatus,* during his field studies in 1966, but it was not reported by Evans et al. (2005) and the RSCN (1999) and thus considered extinct.

Wallace (1984) listed 40 species of birds from Wadi Rum area. Other fragmentary data are included in Andrews (1995). The most comprehensive study was conducted during June 1996 by Evans et al. (2005). They listed a total of 142 bird species that were certainly recorded either during their field study or by previous observers (Table 6).

In 1999, the Royal Society for the Conservation of Nature conducted a field survey between February and May. A total of 119 species of bird were identified within the Protected Area (RSCN, 1999).

Table 6: Analysis of the Local Status of Birds Recorded in Wadi Rum Area

Local Status	No. of Species	%
Resident	42	29.7
Passage migrant	66	46.5
Winter visitor	12	8.4
Summer visitor	6	4.2
Passage migrant/ Summer visitor	6	4.2
Passage migrant/ Winter visitor	4	2.8
Summer/ Winter visitor	1	0.7
Vagrant/accidental	2	1.4
Vagrant/accidental	2	1.4
Extinct	1	0.7
Total	142	100

Conservation of Key Species in Wadi Rum

At least 10 species of conservation concern at a global or Middle Eastern level have significant populations in the study area (Table 7). This is a high concentration at the Middle Eastern level and is the main reason the proposed reserve and its environs were identified as an Important Bird Area in the Middle East context (Evans, 1994), being one of the most important sites for the conservation of birds in the region. Most of these key species are breeding birds of prey, and the main threats to them are discussed below.

Table 7: IUCN Status for Birds of Some Selected Species from Wadi Rum Area

Common Name	Species	IUCN status
Lesser Kestrel	*Falco naumanni*	LC
Corncrake	*Crex crex*	LC
Egyptian Vulture	*Neophron percnopterus*	EN
Griffon Vulture	*Gyps fulvus*	LC
Short-toed Eagle	*Circaetus gallicus*	LC
Pallid Harrier	*Circus macrourus*	NT
Golden Eagle	*Aquila chrysaetos*	LC
Verreaux's Eagle	*Aquila verreauxii*	LC
Bonelli's Eagle	*Hieraaetus fasciatus*	LC
Sooty Falcon	*Falco concolor*	NT
Lanner	*Falco biarmicus*	LC
Saker	*Falco cherrug*	EN
Striated Scops Owl	*Otus brucei*	LC
Eagle Owl	*Bubo bubo*	LC
Hume's Tawny Owl	*Strix butleri*	LC
Long-billed Pipit	*Anthus similis*	LC
Finsch's Wheatear	*Oenanthe finschii*	LC
Hooded Wheatear	*Oenanthe monacha*	LC
Upcher's Warbler	*Hippolais languida*	LC
Olive-tree Warbler	*Hippolais olivetorum*	LC
Arabian Babbler	*Turdoides squamiceps*	LC
Tristram's Grackle	*Onychognathus tristramii*	LC
Pale Rock Sparrow	*Petronia brachydactyla*	LC
Sinai Rosefinch	*Carpodacus synocus*	LC
Syrian Serin	*Serinus syriacus*	VU
Cinereous Bunting	*Emberiza cineracea*	LC
Black Stork	*Ciconia nigra*	LC
Sand Partridge	*Ammoperdix heyi*	LC
Common Crane	*Grus grus*	LC
Little Ringed Plover	*Charadrius dubius*	LC
Red-Rumped Wheatear	*Oenanthe moesta*	LC

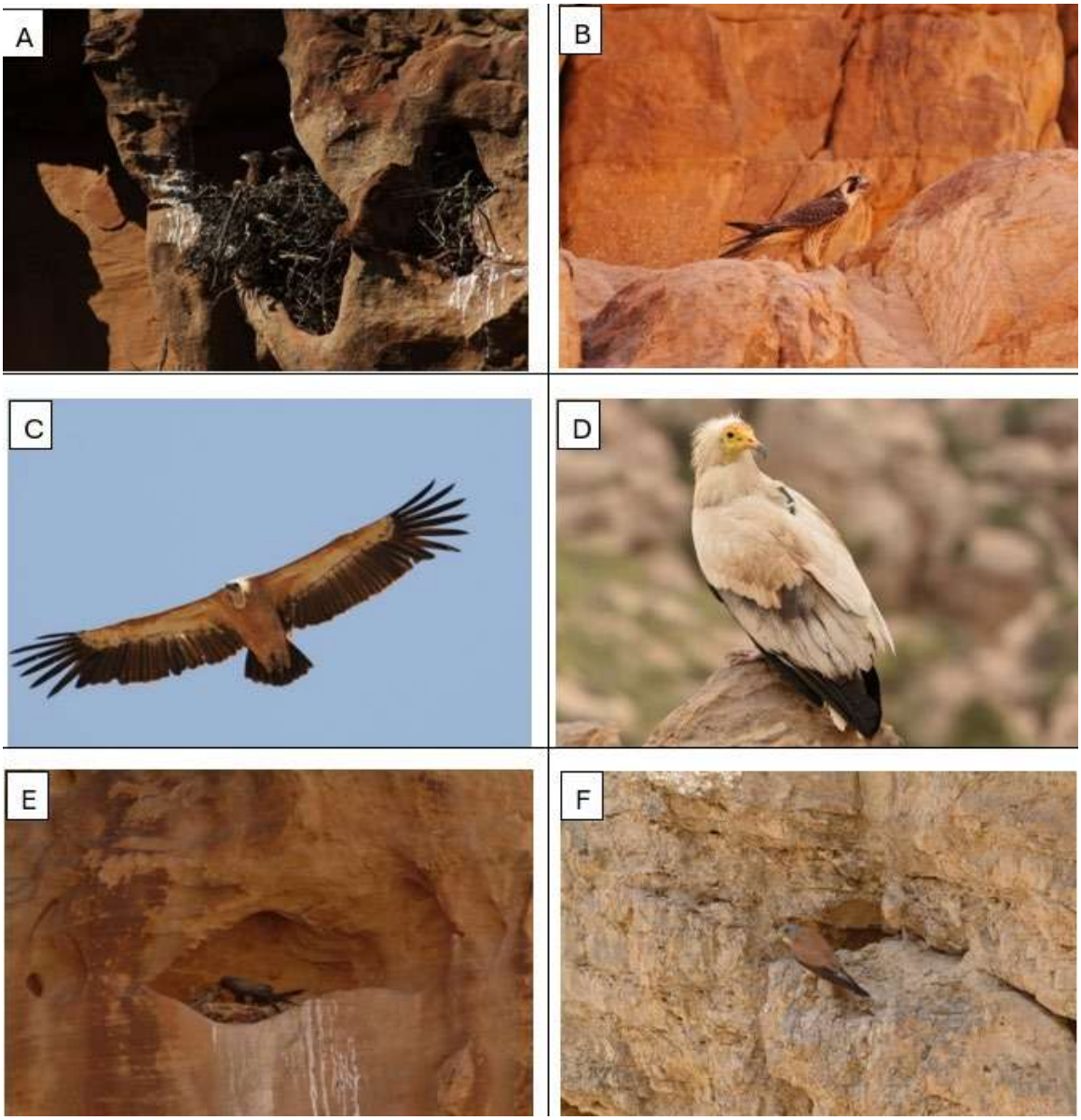


Figure 8: Representative Photos of Some Key Raptor Species in Wadi Rum. A: Bonillis Eagle, B: Peregrine Falcon, C: Griffon Vulture, D: Egyptian Vulture, E: Sooty Falcon, F: Lesser Kestrel

Table 8: Checklist of the Birds of Wadi Rum Protected Area and Environs, Southern Jordan

KEY	***CONSERVATION IMPORTANCE***
G	Globally threatened species
R	Regionally threatened species (in the Middle East)
N	Species of national conservation concern
!	Population size is significant (? denotes uncertainty)
LOCAL STATUS	
Ext	Extinct (former local status in brackets)
R	Resident
S	Summer visitor
P	Passage migrant
W	Winter visitor
?	Status uncertain
V	Vagrant/accidental
1	Common

2	Uncommon
3	Rare
BREEDING STATUS	
B	Breeding confirmed, or assumed with 100% certainty
b	Probably breeds
?	Possibly breeds

English Common Name	Family and Scientific name	Conservation importance	Local status	Breeding status
Herons and Egrets	**Ardeidae**			
Little Bittern	*Lxobrychus minutus*	.	P3	.
Squacco Heron	*Ardeola ralloides*	.	S3	?
Cattle Egret	*Bubulcus ibis*	.	S3	?
Little Egret	*Egretta garzetta*	.	P3	.
Storks	**Ciconlidae**			
Black Stork	*Ciconia nigra*	N	P3	.
Wildfowl	**Anatidae**			
Wigeon	*Anas penelope*	.	P3	.
Garganey	*Anas querquedula*	.	P3	.
Shoveler	*Anas clypeata*	.	P3	.
Hawk-type Raptors	**Accipitridae**			
Black Kite	*Milvus migrans*	.	P2	.
Lammergeier	*Gypaetus barbatus*	R	Ext(R3)	(B)
Egyptian Vulture	*Neophron percnopterus*	R!	S2,P2	b
Griffon Vulture	*Gyps fulvus*	R!	R3	b
Short-toed Eagle	*Circaetus gallicus*	R	S3	B
Marsh Harrier	*Circus aeruginosus*	.	P2	.
Pallid Harrier	*Circus macrourus*	R	P3,W3	.
Common Buzzard	*Buteo buteo*	.	P1	.
Long-legged Buzzard	*Buteo rufinus*	.	R1	B
Steppe Eagle	*Aquila nipalensis*	.	P1	.
Imperial Eagle	*Aquila heliaca*	G!	P3	.
Golden Eagle	*Aquila chrysaetos*	R	R3?	?
Verreaux's Eagle	*Aquila verreauxii*	R!	R3	B
Booted Eagle	*Hieraaetus pennatus*	.	P2	.
Booted Eagle	*Hieraaetus pennatus*	.	P3	.
Bonelli's Eagle	*Hieraaetus fasciatus*	R!	R3	b
Falcons	**Falconidae**			
Lesser Kestrel	*Falco naumanni*	G	P3,S3	?
Common Kestrel	*Falco tinnunculus*	.	R1	B
Sooty Falcon	*Falco concolor*	R!	S2	B
Lanner	*Falco biarmicus*	R(!?)	R3	?
Saker	*Falco cherrug*	R(!?)	P3,W3?	.
Barbary Falcon	*Falco pelegrinoides*	.	R2	B
Partridges	**Phasianidae**			
Chukar	*Alectoris chukar*	.	R2	B
Sand Partridge	*Ammoperdix heyi*	N	R1	B
Quail	*Coturnix coturnix*	.	P2,S3?	?
Rails	**Rallidae**			
Corncrake	*Crex crex*	G	P3	.
Moorhen	*Gallinula chloropus*	.	S3,W3?	b
Cranes	**Gruidae**			
Common Crane	*Grus grus*	N	W3	.
Stilts	**Recurvirostridae**			
Black-winged Stilt	*Himantopus himantopus*	.	P3	.

Thick-knees	**Burhinidae**			
Stone-curlew	*Burhinus oedicnemus*	.	P3	.
Plovers	**Charadriidae**			
Little Ringed Plover	*Charadrius dubius*	N	S3	B
Spur-winged Plover	*Hoplopterus spinosus*	.	P3	.
Sandpipers	**Tringidae**			
Common Snipe	*Gallinago gallnago*	.	P3	.
Greenshank	*Tringa nebularia*	.	P3	.
Green Sandpiper	*Tringa ochropus*	.	P3	.
Wood Sandpiper	*Tringa glareola*	.	P3	.
Common Sandpiper	*Actitis hypoleucos*	.	P3	.
Gulls and Terns	**Laridae**			
Black-headed Gull	*Larus ridibundus*	.	P3	.
Pigeons and Doves	Columbidae			
Rock Dove	*Columba livia*	.	R1	B
Eurasian Collared Dove	*Streptopelia decaocto*	.	R2	B
Turtle Dove	*Streptopelia turtur*	.	S1	B
Palm Dove	*Streptopelia senegalensis*	.	R1	B
Namaqua Dove	*Oena capensis*	.	V	.
Typical Owls	**Strigidae**			
Striated Scops Owl	*Otus brucei*	R	P3	.
Eagle Owl	*Bubo bubo*	R!	R3	B
Little Owl	*Athene noctua*	.	R1	B
Hume's Tawny Owl	*Strix butleri*	R!	R3	B
Night Jars	**Caprimulgidae**			
European Nightjar	*Caprimulgus europaeus*	.	P3	.
Egyptian Nightjar	*Caprimulgus aegyptiacus*	.	P3,S3?	?
Swifts	**Apodidae**			
Common Swift	*Apus apus*	.	P2	.
Pallid Swift	*Apus pallidus*	.	P2,S2	?
Bee-Eaters	**Meropidae**			
European Bee-eater	*Merops apiaster*	.	P1,S3	?
Rollers	**Coraciidae**			
European Roller	*Coracias garrulus*	.	P3	.
Hoopoes	**Upupidae**			
Hoopoe	*Upupa epops*	.	P2,S2	b
Larks	**Alaudidae**			
Bar-tailed Desert Lark	*Ammomanes cincturus*	.	R2	b
Desert Lark	*Ammomanes deserti*	.	R1	B
Hoopoe Lark	*Alaemon alaudipes*	.	W2	.
Lesser Short-toed Lark	*Calandrella rufescens*	.	R2	b
Crested Lark	*Galerida cristata*	.	R1	B
Temminck's Horned Lark	*Eremophila bilopha*	.	R3?	
Martins and Swallows	**Hirundinidae**			
Sand Martin	*Riparia riparia*	.	P2	.
Pale Crag Martin	*Ptyonoprogne fuligula*	.	R1	B
Crag Martin	*Ptyonoprogne rupestris*	.	P3	
Barn Swallow	*Hirundo rustica*	.	P1	.
Red-rumped Swallow	*Hirundo daurica*	.	P	.
House Martin	*Delichon urbica*	.	P2	.
Pipits and Wagtails	**Motacillidae**			
Long-billed Pipit	*Anthus similis*	R	R3?	?
Tree Pipit	*Anthus trivialis*	.	P2	.
Red-throated Pipit	*Anthus cervinus*	.	P3	.

Yellow Wagtail	*Motacilla flava*	.	P2	.
Grey Wagtail	*Motaacilla cinerea*	.	W2	.
White Wagtail	*Motacilla alba*	.	W2,P2	.
Bulbuls	**Pycnonotidae**			
White -spectacled Bulbul	*Pycnonotus xanthopygos*	.	R2	B
Thrushes	**Turdidae**			
Rufous Bush Robin	*Cercotrichas galactotes*	.	S2,P2	B
Thrush Nightingale	*Luscinia luscinia*	.	P1	.
Black Redstart	*Phoenicurus ochruros*	.	W1	.
Common Redstart	*Phoenicurus phoenicurus*	.	P1	.
Blackstart	*Cercomela melanura*	.	R3	b
Whinchat	*Saxicola rubetra*	.	P2	.
Isabelline Wheatear	*Oenanthe isabellina*	.	P1,W3?	.
Common Wheatear	*Oenanthe oenanthe*	.	P2	.
Black-Eared Wheatear	*Oenanthe hispanica*	.	P2	.
Desert Wheatear	*Oenanthe deserti*	.	R2	B
Finsch's Wheatear	*Oenanthe finschii*	R	W3	.
Red-Rumped Wheatear	*Oenanthe moesta*	N(!?)	R3?	?
Mourning Wheatear	*Oenanthe lugens*	.	R1	B
Hooded Wheatear	*Oenanthe monacha*	R!	R2	B
White-crowned Black Wheatear	*Oenanthe leucopyga*	.	R1	B
Rock Thrush	*Monticola saxatilis*	.	P1	.
Blue Rock Thrush	*Monticola solitarius*	.	W2	.
Song Thrush	*Turdus philomelos*	.	W2	.
Warblers	**Sylviidae**			
Scrub Warbler	*Scotocerca inquieta*	.	R1	B
River Warbler	*Locustella fluviatilis*	.	P3	.
Reed Warbler	*Acrocephalus scirpaceus*	.	S2,P2	b
Olivaceous Warbler	*Hippolais pallida*	.	P1	.
Upcher's Warbler	*Hippolais languida*	R	P2	.
Olive-tree Warbler	*Hippolais olivetorum*	R	P3	.
Subalpine Warbler	*Sylvia cantillans*	.	P2	.
Desert Warbler	*Sylvia nana*	.	W	.
Orphean Warbler	*Sylvia hortensis*	.	P1	.
Barred Warbler	*Sylvia nisoria*	.	P2	.
Lesser Whitethroat	*Sylvia curruca*	.	P1	.
Whitethroat	*Sylvia communis*	.	P2	.
Garden Warbler	*Sylvia borin*	.	P2	.
Blackcap	*Sylvia atricapilla*	.	P1	.
Chiffchaff	*Phylloscopus collybita*	.	P2	.
Willow Warbler	*Phylloscopus trochilus*	.	P2	.
Wood Warbler	*Phylloscopus sibilatrix*	.	P2	.
Flycatchers	Muscicapidae			
Spotted Flycatcher	*Muscicapa striata*	.	P2	.
Semi-collared Flycatcher	*Ficedula semitorquata*	.	P2	.
Babblers	**Timaliidae**			
Arabian Babbler	*Turdoides squamiceps*	R	R3	b
Sunbirds	**Nectariniidae**			
Orange-tufted Sunbird	*Nectarinia osea*	.	R2	b
Orioles	**Oriolidae**			
Golden Oriole	*Oriolus oriolus*	.	P3	.
Shrikes	**Laniidae**			
Isabelline Shrike	*Lanius isabellinus*	.	P3	.

Red-Backed Shrike	*Lanius collurio*	.	P1	.
Great Grey Shrike	*Lanius excubitor*	.	W2	.
Woodchat Shrike	*Lanius senator*	.	P2	.
Masked Shrike	*Lanius nubicus*	.	P1	.
Crows	**Corvidae**			
Indian-House Crow	*Corvus splendens*	.	V	.
Brown-necked Raven	*Corvus ruficollis*	.	R1	B
Fan-tailed Raven	*Corvus rhipidurus*	.	R2	b
Starlings	**Sturnidae**			
Tristram's Grackle	*Onychognathus tristramii*	R	R1	B
European Starling	*Sturnus vulgaris*	.	W3	.
Sparrows	**Passeridae**			
House Sparrow	*Passer domesticus*	.	R1	B
Spanish Sparrow	*Passer hispaniolensis*	.	R1	B
Pale Rock Sparrow	*Petronia brachydactyla*	R	P3	.
Finches	**Fringillidae**			
Chaffinch	*Fringilla coelebs*	.	W2	.
Goldfinch	*Carduelis carduelis*	.	R2	B
Linnet	*Carduelis cannabina*	.	W3	.
Desert Finch	*Rhodospiza obsoleta*	.	R2	B
Trumpeter Finch	*Bucanetes githagineus*	.	R2	b
Sinai Rosefinch	*Carpodacus synocus*	R!	R1	B
Buntings	**Emberizidae**			
House Bunting	*Emberiza striolata*	.	R	B
Cinereous Bunting	*Emberiza cineracea*	R	P3	.
Ortolan Bunting	*Emberiza hortulana*	.	P1	.
Black-headed Bunting	*Emberiza melanocephala*	.	P2	.

Finally, it is important to highlight that despite the importance of Wadi Rum Area for avifauna, the project area is encroached by several human practices including tourism, agricultural activities which leaded to altering habitat. Moreover, the presence of a network of roads and off-roads facilitated heavy traffic of vehicles, which is causing disturbance to the species and habitat in means of noise, dust and wastes created. The pipeline does not reach the core of the protected area; it is just passing outside the boundaries of the buffer area.

In addition, grazing pressure was very noticed especially with the weak vegetation cover. Human pressure was proved as a mean of biodiversity loss and was documented appropriately (van der Wal et al. 2008).

Despite the low biodiversity composition, careful considerations and management measures should be applied in the construction and operation phase.

2.3. Wadi Abu Tarfah

A report published by the RSCN (RSCN, 2000) highlighted the importance of Wadi Abu Tarfah as a national important bird area. The area is part of El-Jafr Basin, is a low-relief flat, hammada desert plateau intersected by flat, shallow wadis extending to Qa' El-Jafr to the north (RSCN, 2000) (Figure 9).

The avifauna of the area is very similar to the Eastern Desert with Cream-coloured Courser, Hoopoe Lark, Temmink's Lark, Deseret Wheatear, Scrub Warbler and Trumpeter Finch. Long-legged Buzzard and Brown-necked Raven also found.

Breeding birds in Wadi Abu Tarfah include several species of larks, Red-rumped Wheatears, Trumpeter Finch and Scrub Warbler. Migrants include several passerine species that rest in the wadi vegetation; Steppe Eagle,

Steppe Buzzard and Honey Buzzard pass over in autumn. Houbara Bustard and Lanner Falcon are reported by the locals to be occasionally present from autumn to spring.

Based on that, the site is considered as a very important breeding area of Red-rumped Wheatear, *Oenanthe moesta* (Regional Endangered) which has highly restricted distribution, primarily found in Jordan's transitional arid steppe habitats at elevations between 800 to 1600 m above sea level.

The area qualifies as a sensitive area and requires investigation during the 2026 survey. Careful consideration and appropriate mitigation measures should be incorporated during both the construction and operation phases to minimise adverse effects.



Figure 9: Wadi Abu Tarfah Location



Figure 10: Red-rumped Wheatear (Female)

2.4. Qatraneh Dam

Qatraneh Dam is located on the western edge of the Eastern Desert near Qatraneh village (36 3460907N, 787685E). The dam is located about 28 km east of Karak and 75 km south of Amman, Karak Governorate (Figure 11). Farmers, in and around Qatraneh, pump water from this dam for irrigation. Bedouin tents were always noticed settling around the dam and they definitely use its water for their daily needs and livestock.

Vegetation is composed of scattered shrubs of *Artemisia sieberi* and *Helianthemum lippii*. The dam is located 1.3 km east from the route of the pipeline.

There is no documented information about bird species recorded in the site except for the data of the counts of bird census study conducted by RSCN over the past 15 years. It includes about 32 species. (Table 9). All recorded species are not listed in the IUCN redlist.

(RSCN, unpublished data-Waterbirds census). Species recorded in the site included Black-necked Grebe (*Podiceps nigricollis*), Grey Heron (*Ardea cinerea*), Spoonbill (*Platalea leucorodia*), Black-winged Stilt (*Himantopus himantopus*), Avocet (*Recurvirostra avosetta*), Little Ringed Plover (*Charadrius dubius*), Ringed Plover (*C. hiaticula*), Kentish Plover (*C. alexandrinus*), Lapwing (*Vanellus vanellus*), Little Stint (*Calidris minuta*), Dunlin (*C. alpina*), Ruff (*Philomachus pugnax*), Redshank (*Tringa totanus*), Greenshank (*T. nebularia*), Green Sandpiper (*T. ochropus*), Wood Sandpiper (*T. glareola*), Common Sandpiper (*Actitis hypoleucos*) and Black-headed Gull (*Larus ridibundus*).



Figure 11: Qatraneh Dam Location

Table 9: List of Species in Al-Qatraneh Dam

Species	Scientific Name	Status	IUCN status
Northern Pintail	*Anas acuta*	PM	LC
Shoveler	*Anas clypeata*	PM/WV	LC
Teal	*Anas crecca*	PM/WV	LC
allard	*Anas platyrhynchos*	WV	LC
Black-headed Gull	*Larus ridibundus*	PM/WV	LC
Redshank	*Tringa totanus*	PM/WV	LC
Lapwing	*Vanellus vanellus*	PM/WV	LC
Dunlin	*Calidris alpina*	PM/WV	LC
Little Stint	*Calidris minuta*	PM/WV	LC
Kentish Plover	*Charadrius alexandrinus*	SB/ PM/WV	LC
Ruff	*Philomachus pugnax*	PM/WV	LC
Wood Sandpiper	*Tringa glareola*	PM	LC
Garganey	*Anas querquedula*	PM	LC
Grey Heron	*Ardea cinerea*	R/PM	LC

Little Ringed Plover	*Charadrius dubius*	SB/PM	LC
Common Snipe	*Gallinago gallinago*	PM/WV	LC
Spoonbill	*Platalea leucorodia*	PM	LC
Black-necked Grebe	*Podiceps nigricollis*	PM/WV	LC
Avocet	*Recurvirostra avosetta*	SB/PM	LC
Greenshank	*Tringa nebularia*	PM	LC
Green Sandpiper	*Tringa ochropus*	PM/WV	LC
Wigeon	*Anas penelope*	PM/WV	LC
Ringed Plover	*Charadrius hiaticula*	PM/WV	LC
Coot	*Fulica atra*	R/PM/WV	LC
Black-winged Stilt	*Himantopus himantopus*	SB/PM	LC
Cattle Egret	*Bubulcus ibis*	R/PM	LC
Tufted Duck	*Aythya fuligula*	PM/WV	LC
Ruddy Shelduck	*Tadorna ferruginea*	V	LC
Shelduck	*Tadorna tadorna*	PM/WV	LC
Spur-winged Plover	*Hoplopterus spinosus*	R	LC
Pochard	*Aythya ferina*	PM/WV	LC
Water Pipit	*Anthus spinoletta*	WV	LC

2.5. Swaqa Dam

This dam is located to the western side of the Desert Highway. It is around 60 km south of Amman and 37 km east of Karak (36 3474915N, 792929E) (Figure 12). It is located 500 m to the west of the pipeline. When full, the total surface area reaches a bit more than 0.1km2. The water in the dam is mainly used for livestock. Vegetation is limited to Chenopod shrubs that are scattered along the main wadi and very few around the dam body.



Figure 12: Swaqa Dam Location

Only available data from the bird census counts conducted by RSCN from 2001-2003 (RSCN, unpublished data-Waterbirds census). A total of 23 species were recorded during this period (Table 10).

Table 10: Summary of Species Records in the Counts in Swaqa Dam

Species	Scientific Name	Status	IUCN status
Shelduck	*Tadorna tadorna*	PM/WV	LC
Wigeon	*Anas penelope*	PM/WV	LC
Teal	*Anas crecca*	PM/WV	LC
Garganey	*Anas querquedula*	PM	LC
Mallard	*Anas platyrhynchos*	WV	LC
Northern Pintail	*Anas acuta*	PM	LC
Shoveler	*Anas clypeata*	PM/WV	LC
Pochard	*Aythya ferina*	PM/WV	LC
Common Snipe	*Gallinago gallinago*	PM/WV	LC
Night Heron	*Nycticorax nycticorax*	SB/PM	LC
Purple heron	*Ardea purpurea*	SB/PM	LC
Cattle Egret	*Bubulcus ibis*	R/PM	LC
Little Egret	*Egretta garzetta*	R/PM	LC
Great White Egret	*Egretta alba*	PM/WV	LC
Avocet	*Recurvirostra avosetta*	SB/PM	LC
Little Ringed Plover	*Charadrius dubius*	SB/PM	LC
Kentish Plover	*Charadrius alexandrinus*	SB/ PM/WV	LC
Spur-winged Lapwing	*Hoplopterus spinosus*	R	LC
Lapwing	*Vanellus vanellus*	PM/WV	LC
Little Stint	*Calidris minuta*	PM/WV	LC
Ruff	*Philomachus pugnax*	PM/WV	LC
Greenshank	*Tringa nebularia*	PM	LC
Green Sandpiper	*Tringa ochropus*	PM/WV	LC

2.6. Amman National Park

Amman National Park is a recreational park, situated west of the Desert Highway, some 13 km south of Amman's 7th circle. Pine trees were planted in the 1960s make up park itself, and some olive orchards are close to pine forest (Andrews, 1995).

The breeding birds recorded from this area include Hobby, Chukar, Collared Dove, Turtle Dove, Little Owl, Hoopoe, Clandra Lark, Short-toed Lark, Crested Lark, White-spectacled Bulbul, Blackbird, Olivaceous Warbler, Sardinian Warbler, Great Tit, Greenfinch, Black-headed Bunting (Andrews, 1995).

On May 2018, the RSCN confirmed the breeding of Upcher's Warbler and Black-headed Bunting in the olive orchards located adjacent to the pine forests.



Figure 13: Amman National Park Location

3. AVI-FAUNA FIELD SURVEY IN ROCKFILL DAMS (SPRING 2025)

The local Avifauna expert conducted a rapid terrestrial bird survey during the spring season (10 April–5 May 2025) to document the diversity and distribution of bird species within terrestrial ecosystems in Rockfills along the proposed AAWDCP pipeline route (segment 3). The survey only covered rockfill areas which considered attractive habitats for birds. The survey aimed to identify migratory species utilising the artificial dams as stopover sites.

Given the limited timeframe in late of migration and breeding season and prevailing dry conditions, a total of six prioritised Rockfills with good accessibility, established road networks, and representative habitat diversity were covered in the survey (Figure 14). Efforts focused on the southern section of the project, particularly the rockfill dams with available water bodies between Aqaba and Wadi Rum (Segment 3) (Figure 14).

Rockfills sites was surveyed using a combination of transect walks and fixed-point observations designed to document both resident and migratory bird species to produce a comprehensive species checklist, alongside information on bird behaviour, including foraging and migratory movements.

The results of this survey added to the current dataset, which includes observations from migration periods. The focus was on identifying nest presence, and habitat preferences. These findings will help determine the ecological importance of the dam systems as year-round or seasonal breeding habitats and will contribute to the final analysis of avian diversity and habitat value.

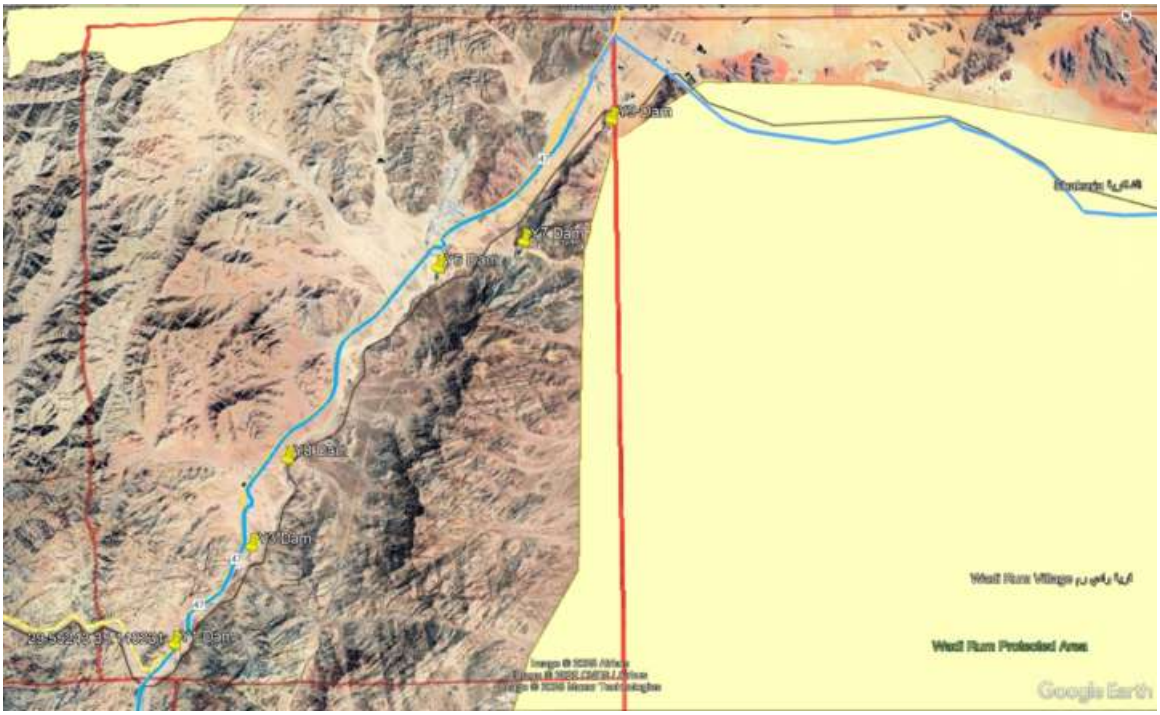


Figure 14: Rockfill Dams Locations in Segment 3

Three field visits conducted which recorded a total of 20 bird species from the six dams (Table 11). The survey placed particular emphasis on migratory species, with observations timed to coincide with the breeding season and seasonal use of temporary water bodies.

Observations also documented varying levels of anthropogenic pressure across particularly Dam Y6, showed signs of intensive human activity, including fishing, livestock grazing, and litter accumulation—factors that may directly influence avian habitat quality and species presence.

Generally, the project risk on biodiversity is negligible and would have minimal effects on Avifauna composition in Rockfills sites. This is attributed to severe degradation of the sites due to several reasons including anthropogenic pressure, low annual rainfall rate, grazing and poor soil compositions, which does not support the presence of vegetation communities.

Table 11: List of Birds Species Recorded from Six Rockfill Dams in Segment 3

Species	Scientific Name	Status	IUCN status[i]
Spur-winged Plover	*Hoplopterus spinosus*	R	LC
Black-winged Stilt	*Himantopus himantopus*	SB/PM	LC
Little Egret	*Egretta garzetta*	R/PM	LC
Mallard	*Anas platyrhynchos*	WV	LC
Grey Heron	*Ardea cinerea*	R/PM	LC
White-crowned Wheatear	*Oenanthe leucopyga*	R	LC
Desert Lark	*Ammomanes deserti*	R	LC
Blackstart	*Cercomela melanura*	R	LC
Sand Partridge	*Ammoperdix heyi*	R	LC
Arabian Bee-eater	*Merops cyanophrys*	R	LC
Palestine Sunbird	*Nectarinia osea*	R	LC
Rock Martin	*Ptyonoprogne fuligula*	R	LC
Little Grebe	*Tachybaptus ruficollis*	WV	LC
Scrub Warbler	*Scotocerca inquieta*	R	LC
White Spectacled Bulbul	*Pycnonotus xanthopygos*	R	LC
Brown-necked Raven	*Corvus ruficollis*	R	LC

Little Stint	*Calidris minuta*	PM/WV	LC
Green Sandpiper	*Tringa ochropus*	PM/WV	LC
Collared Dove	*Streptopelia decaocto*	R	LC
Great Grey Shrike	*Lanius excubitor*	WV	LC

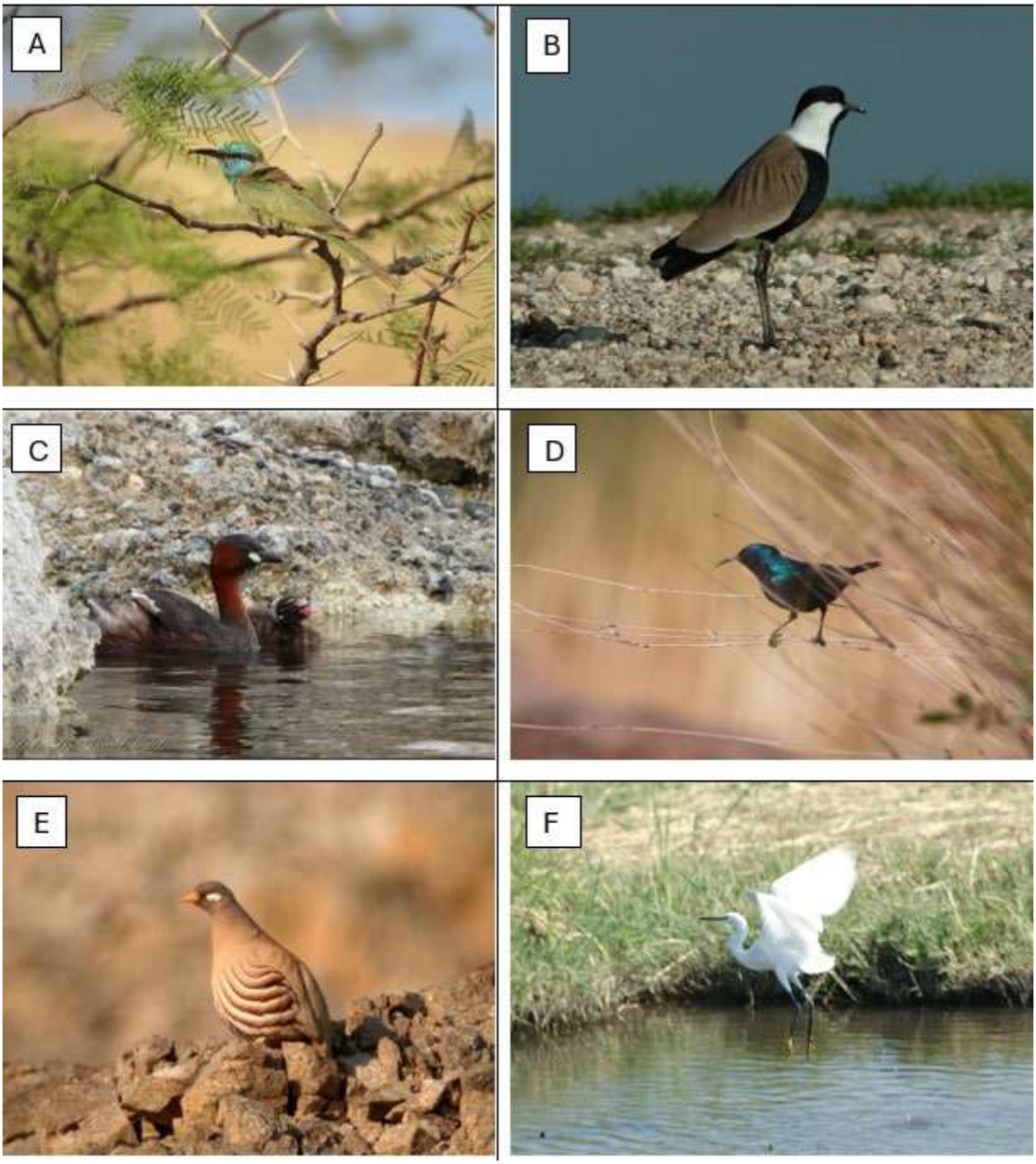


Figure 15: Representative of Some Key Birds Species in Rockfill Dams. A: Arabian Bee-eater, B: Spur-winged Lapwing, C: Little Grebe, D: Palestine Sunbird, E: Sand Partridge, F: Little Egret

3.1. Y1 Dam

A total of Six bird species recorded in Y1 including five resident and only one winter visitor species (see Table 12).



Figure 16: Dam Y1 in the Southern Part of Segment 3

Table 12: List of Bird Species Recorded in Dam Y1

Species	Scientific Name	Status	IUCN status [ii]
White-spectacled Bulbul	*Pycnonotus xanthopygos*	R	LC
Rock Martin	*Ptyonoprogne fuligula*	R	LC
Desert Lark	*Ammomanes deserti*	R	LC
Brown-necked Raven	*Corvus ruficollis*	R	LC
Great Grey Shrike	*Lanius excubitor*	WV	LC
Desert Lark	*Ammomanes deserti*	R	LC

No significant species of conservation concern were recorded in the area. The results indicate that no threatened or rare species were observed within the study area.

3.2. Y3 Dam

A total of Eight resident bird species recorded in Y3 Dam (see Table 13).



Figure 17: Dam Y3 in the Middle Part of Segment 3

Table 13: List of Bird Species Recorded in Dam Y3

Species	Scientific Name	Status	IUCN status[iii]
White-spectacled Bulbul	*Pycnonotus xanthopygos*	R	LC
Collared Dove	*Streptopelia decaocto*	R	LC
Arabian Bee-eater	*Merops cyanophrys*	R	LC
Rock Martin	*Ptyonoprogne fuligula*	R	LC
White-crowned Wheatear	*Oenanthe leucopyga*	R	LC
Desert Lark	*Ammomanes deserti*	R	LC
Brown-necked Raven	*Corvus ruficollis*	R	LC
Blacstart	*Cercomela melanura*	R	LC

3.3. Y8 Dam

A total of 10 bird species recorded in Y8 Dam area, including two winter visitor bird species, see Table 14.



Figure 18: Dam Y6 in the Middle Part of Segment 3

Table 14: List of Bird Species Recorded in Dam Y6

Species	Scientific Name	Status	IUCN status[iv]
White-spectacled Bulbul	*Pycnonotus xanthopygos*	R	LC
Sand Partridge	*Ammoperdix heyi*	R	LC
Arabian Bee-eater	*Merops cyanophrys*	R	LC
Palestine Sunbird	*Nectarinia osea*	R	LC
Rock Martin	*Ptyonoprogne fuligula*	R	LC
White-crowned Wheatear	*Oenanthe leucopyga*	R	LC
Desert Lark	*Ammomanes deserti*	R	LC
Brown-necked Raven	*Corvus ruficollis*	R	LC
Little Stint	*Calidris minuta*	PM/WV	LC
Green Sandpiper	*Tringa ochropus*	PM/WV	LC

3.4. Y6 Dam

A total of 10 bird species recorded in Y6 Dam, with only one winter visitor species (Table 15). Observations also documented varying levels of anthropogenic pressure across particularly Dam Y6, showed signs of intensive human activity, including fishing, livestock grazing, and litter accumulation—factors that may directly influence avian habitat quality and species presence.



Figure 19: Dam Y6 in Northern Part of Segment 3

Table 15: List of Bird Species Recorded in Dam Y6

Species	Scientific Name	Status	IUCN status[v]
Blackstart	*Cercomela melanura*	R	LC
Sand Partridge	*Ammoperdix heyi*	R	LC
Arabian Bee-eater	*Merops cyanophrys*	R	LC
Palestine Sunbird	*Nectarinia osea*	R	LC
Rock Martin	*Ptyonoprogne fuligula*	R	LC
White-crowned Wheatear	*Oenanthe leucopyga*	R	LC
Desert Lark	*Ammomanes deserti*	R	LC
Spur-winged Plover	*Hoplopterus spinosus*	R	LC
Little Grebe	*Tachybaptus ruficollis*	WV	LC
Scrub Warbler	*Scotocerca inquieta*	R	LC

3.5. Y7 Dam

A total of Eight resident bird species recorded in dam Y7 (Table 16).



Figure 20: Dam Y7 in Northern Part of Segment 3

Table 16: List of Bird Species Recorded in Y7 Dam

Species	Scientific Name	Status	IUCN status[vi]
Blackstart	*Cercomela melanura*	R	LC
Sand Partridge	*Ammoperdix heyi*	R	LC
Arabian Bee-eater	*Merops cyanophrys*	R	LC
Palestine Sunbird	*Nectarinia osea*	R	LC
Rock Martin	*Ptyonoprogne fuligula*	R	LC
White-crowned Wheatear	*Oenanthe leucopyga*	R	LC
Desert Lark	*Ammomanes deserti*	R	LC
Spur-winged Plover	*Hoplopterus spinosus*	R	LC

3.6. Y9 Dam

A total of seven bird species recorded from the dam, including waterfowl species and summer breeding species like Black-winged Stilt (Table 17).



Figure 21: Dam Y9 in Northern Part of Segment 3

Table 17: List of Bird Species Recorded in Dam Y9

Species	Scientific Name	Status	IUCN status[vii]
Spur-winged Plover	*Hoplopterus spinosus*	R	LC
Black-winged Stilt	*Himantopus himantopus*	SB/PM	LC
Little Egret	*Egretta garzetta*	R/PM	LC
Mallard	*Anas platyrhynchos*	WV	LC
Grey Heron	*Ardea cinerea*	R/PM	LC
White-crowned Wheatear	*Oenanthe leucopyga*	R	LC
Desert Lark	*Ammomanes deserti*	R	LC

4. WADI SYSTEM WITH A SMALL WATER POOL RECORDED DURING THE BIODIVERSITY SURVEY

FA15A (29°36'48"N 35°37'36"E) is a location found by Fauna team during the biodiversity survey for the Project, this location represents three open artificial pools that were formed through direct input of water from large commercial agricultural farms in Wadi Rum, to provide water for sheep and camels owned by the Bedouins in the area (Figure 22 and Figure 23). Sparse vegetation, including shrubs and dwarf shrubs, has established around these pools due to the localised increase in soil moisture.

The pools are shallow, with lush southern cattail, *Typha elephantina*. Two large *Vachellia gerrardii* stand at the edge of the dirt road.

These sites exhibit signs of disturbance caused by human activities, particularly by local Bedouin communities who have intentionally modified the areas to provide water for livestock, mainly sheep and camels. Despite these anthropogenic alterations, the presence of water attracts a variety of resident and migratory bird species that utilise the pools as drinking sites. However, the habitat conditions are not suitable for breeding activities, as the disturbance levels and limited vegetation cover do not provide adequate nesting opportunities.



Figure 22: Location of the Small Pool



Figure 23: Landscape of Small Wetland (FA15A). The Dominant Plants are *Typha Elephantina, Cynodon Dactylon and Carex Pachystylis*

Ten species of birds were observed in this location (Table 18). All recorded species are common and are not threatened.

Table 18. Birds Observed at FA15

Common name	Scientific name	Conservation status
Rock Dove	*Columba livia*	LC
Desert Lark	*Ammomanes deserti*	LC
Crested Lark	*Galerida cristata*	LC
Rock Martin	*Ptyonoprogne fuligula*	LC
Desert Wheatear	*Oenanthe deserti*	LC
Mourning Wheatear	*Oenanthe lugens*	LC
Tristram's Starling	*Onychognathus tristramii*	LC
House Sparrow	*Passer domesticus*	LC
Sinai Rosefinch	*Carpodacus synoicus*	LC
Spur-winged Lapwing	*Vanellus spinosus*	LC

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