Ashburton Salt Project: Environmental Review Document

K plus S Salt Australia Pty Ltd (K+S)

K04 -J11

30 May 2023

DOCUMENT CONTROL

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INVITATION TO MAKE A SUBMISSION

The Environmental Protection Authority (EPA) invites people to make a submission on the environmental review for this proposal. K plus S Salt Australia Pty Ltd (K+S) is seeking to develop and operate a green field solar salt Project (Ashburton Salt Project; Proposal) on the Western Australian coast, approximately 40km south-west of the township of Onslow, within the Shire of Ashburton (the Proposal). The Proposal includes the construction and operation of solar salt evaporation and crystallisation ponds and other associated infrastructure and activities. The Proposal has been submitted for review as required under the *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act) (EPBC Number 2016/7793).

K+S has prepared this Environmental Review Document (ERD) in accordance with the EPA's ***Procedures Manual (Part IV Divisions 1 and 2)***. The ERD is the report by the proponent on their environmental review which describes this Proposal and its likely effects on the environment. The ERD is available for a public review period of **12** weeks from **12 June 2023**, closing on **4 September 2023**. Information on the proposal from the public may assist the EPA to prepare an assessment report inwhich it will make recommendations on the proposal to the Minister for Environment.

Why write a submission?

The EPA seeks information that will inform the EPA's consideration of the likely effect of theproposal, if implemented, on the environment. This may include relevant new information that is not in the ERD, such as alternative courses of action or approaches. In preparing its assessment report for the Minister for Environment, the EPA will consider the information in submissions, the proponent's responses and other relevant information. Submissions will be treated as public documents unless provided and received in confidence, subject to the requirements of the *Freedom of Information Act 1992.*

Why not join a group?

It may be worthwhile joining a group or other groups interested in making a submission onsimilar issues. Joint submissions may help to reduce the workload for an individual or group. If you form a small group (up to 10 people) please indicate all the names of the participants. If your group is larger, please indicate how many people your submission represents.

Developing a submission

You may agree or disagree with, or comment on information in the ERD. When making comments on specific elements in the ERD:

- Clearly state your point of view and give reasons for your conclusions.
- Reference the source of your information, where applicable.
- Suggest alternatives to improve the outcomes on the environment.

What to include in your submission

Include the following in your submission to make it easier for the EPA to consider your submission:

- Your contact details – name and address.
- Date of your submission.
- Whether you want your contact details to be confidential.
- Summary of your submission, if your submission is long.
- List points so that issues raised are clear, preferably by environmental factor.
- Refer each point to the page, section and if possible, paragraph of the ERD.
- Attach any reference material, if applicable. Make sure your information is accurate.

The closing date for public submissions is: **4 September 2023**

The EPA prefers submissions to be made electronically via the EPA's Consultation Hub at https://consultation.epa.wa.gov.au.

Alternatively, submissions can be:

- posted to: Chairman, Environmental Protection Authority, Locked Bag 10, Joondalup DC WA 6919, or
- delivered to: Environmental Protection Authority, Prime House, 8 Davidson Terrace, Joondalup, WA 6027.

If you have any questions on how to make a submission, please contact the EPA Services at the Department of Water and Environmental Regulation on 6364 7000.

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APPENDIX U. GHD (2021d). Materials Characterisation Study. Prepared for K+S Salt Australia Pty Ltd.

APPENDIX V. GHD (2022) Memorandum Ashburton groundwater modelling- updated results. Prepared for K+S Salt Australia Pty Ltd.

APPENDIX W. GHD (2021c). Ashburton Solar Salt Project. Hydrogeological Investigation. Prepared for K+S Salt Australia Pty Ltd.

APPENDIX X. CyMod Systems (2022). Independent Review of Ashburton Salt Project Groundwater Modelling. Prepared for K+S Salt Australia Pty Ltd.

APPENDIX Y. CyMod Systems (2021). Ashburton Salt Project Groundwater Modelling Independent Review. Armadale: Report Prepared for K+S Salt Australia Pty Ltd.

APPENDIX Z. Archae-aus (2020). A Report of the Reconnaissance Assessment of Cultural Heritage Sites within the Ashburton Salt Project Area, Urala Station, Western Australia. Prepared for Buurabalayji Thalanyji Aboriginal Corporation (BTAC).

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7. Biota (2022d). Fauna Management Plan
8. K+S (2022). Interim Mine Closure Plan

APPENDIX CC. Preston Consulting (2023). Interim Offset Strategy.

APPENDIX DD. Pendoley Environmental (2023) Updated Artificial Light Monitoring and Modelling Report.

ENVIRONMENTAL SCOPING DOCUMENT (ESD) REQUIREMENTS

The requirements of the ESD for the Ashburton Salt Project are listed in Table 1.

Table 1: Environmental Scoping Document Requirements

Task	Required Work	Section
	Benthic Communities and Habitats	
1.	Undertake desktop review and ground-truthing of Benthic Communities and Habitats spatial extents and any temporal variations to identify and describe the different types of benthic communities and habitats and produce comprehensive mapping (at an appropriate scale) of these benthic communities/habitats within an appropriate Local Assessment Unit (LAU).	8.5, Appendix M
2.	Determine direct loss of Benthic Communities and Habitats to occur due to Project clearing and direct habitat disturbance.	8.6.2; 8.9
3.	Undertake appropriate impact assessment techniques (including groundwater, hydrodynamic marine, tidal inundation and surface water modelling where relevant) to predict indirect loss of Benthic Communities and Habitats to occur due to:	8.6.1, 8.7
a.	Changes in tidal inundation and/or hydrodynamics caused by Project infrastructure.	
b.	Changes in surface water flows, nutrient movement and sediment movement/deposition caused by Project infrastructure.	
c.	Changes in surface and ground water quality caused by the Project.	
d.	Changes in water flows or depths.	
e.	Introduction of contaminants.	
f.	Elevated turbidity due to shipping, boat movements and dredging activities.	
g.	Introduction of pests in ballast water and on vessel hulls including dredge related vessels.	8.6.5
h.	Hindering the ability to adapt to climate change induced sea level rise.	8.6.2, Appendix G
i.	Changes in creek habitat for benthic communities and protected species in relation to the seawater intake points in Urala Creek North and South.	8.6.1
4.	Identify any critical associations between important marine fauna (including sea and shore bird) and key benthic communities and habitats that are likely to be impacted (including nursery habitats) and assess, then manage impacts to those marine fauna as described under "Marine Fauna" below.	9.4.3.4
5.	Determine the likely toxicity of the bitterns to be discharged and use in combination with bitterns plume modelling to determine the potential impacts of the discharge on benthic communities and habitats. Specifically, undertake a marine biota ecotoxicology assessment of local marine indicator species for proposed marine discharges (bitterns, dredging sediment mobilisation). This assessment will:	7.5.1, 7.5.2, 7.5.3.4, 8.6.1, 9.5.2
a.	Identify appropriate local indicator species (including benthic and pelagic species, prawn larvae and juveniles, and the most vulnerable pearl oyster life stages);	7.5.1.5, 7.5.3.4
b.	Test the tolerance of indicator species to predicted bitterns discharge and turbidity (under usual operation and extreme events), with consideration given to fertilisation, embryo and larval development, growth, and chronic and acute toxicity.	7.5.1.5, 7.5.3.4
c.	Establish trigger thresholds, below which discharge concentrations may be considered safe.	7.5.1, 7.5.2
d.	Use the results of the biota ecotoxicology assessment to inform the marine hydrodynamic modelling and design process to determine the likely impact of the discharges modelled on marine biota sensitive receptors.	7.5.1, 7.5.2, 7.5.3.4, 8.6.1, 9.5.2
6.	Evaluate the combined direct and indirect impacts to Benthic Communities and Habitats, after demonstrating how the mitigation has been considered and applied. Predictions shall:	8.6.2; 8.7
a.	Align with the approaches and standards outlined in *Technical Guidance - Protection of Benthic Communities and Habitats* (EPA, 2016c) and *Technical Guidance - Environmental Impact Assessment of Marine Dredging Proposals* (EPA, 2016d);	8.2
b.	Include a description of the severity and duration of reversible impacts, and the consequences of impacts on, and risks to, biological diversity and ecological integrity at local and regional scales (with specific attention given to prawn nursery habitats);	8.7
c.	Include an estimate of the level of confidence underpinning predictions of residual impacts; and	8.9

Task	Required Work	Section
d.	Give consideration to plausible events with the potential to significantly impacting benthic communities and habitats including the introduction of marine pests, breached levee walls, hydrocarbon and other spills, and extreme episodic events (e.g., tropical lows and cyclones).	8.6.5
7.	Assess the biodiversity and functional ecological values and significance of Benthic Communities and Habitats in relation to arid-tropical mangrove communities (*Guidance Statement 1 – Protection of Tropical Arid Zone Mangroves along the Pilbara Coastline* (EPA, 2001)) and in the context of nationally important wetland WA007, Exmouth Gulf East (*A Directory of Important Wetlands in Australia* (ANCA, 1993)).	8.7
8.	Describe the proposed monitoring, management and mitigation measures to be implemented, including an assessment of their effectiveness, at the design and operations stages to demonstrate that all reasonable and practicable avoidance and mitigation measures will be taken to ensure residual impacts and risks are acceptable. Monitoring proposed should include an appropriate baseline and reference sites.	8.8
9.	Document management and monitoring measures proposed for construction, operation and closure, including defined trigger levels and adaptive management responses, to ensure residual impacts are not greater than predicted and achieve predicted outcomes/objectives.	8.8
10.	Summarise residual impacts, after considering avoidance and minimisation. Analyse these impacts to identify and detail any that are significant. If significant residual impacts remain propose appropriate offsets.	8.9
11.	Create an offsets position following application of the 'mitigation hierarchy' (avoid, minimise, rehabilitate, offset).	8.9
12.	Demonstrate and document how the EPA's objective for this factor can be met.	8.7, 8.8, 8.9
	Coastal Processes	
13.	Undertake comprehensive modelling and mapping of local marine hydrodynamics and tidal inundation (including both extreme and normal weather conditions) to allow impact assessment in the ERD.	6.4, 7.3.1, 7.4, Appendices A and G
14.	Determine direct loss of tidal and coastal zones to occur due to direct disturbance and resulting impacts to mangroves and algal mat habitats.	6.5.1, 8.6.2
15.	Determine indirect changes likely to occur to tidal and coastal zones (due to changes in hydrodynamics and tidal inundation) and resulting impacts on mangroves, algal mats and beach habitats (i.e., potential marine turtle nesting beaches).	6.5.2, 8.6.1
16.	Undertake appropriate tidal inundation modelling to predict potential spatial re-distribution of mangroves and algal mats that may occur in response to sea level rise.	8.6.2, Appendices A and G
17.	Overlay Project infrastructure within the above model in order to predict if any changes in the spatial distribution of mangroves and algal mats are likely to occur as a result of the Project layout.	8.6.2, Appendices A and G
18.	Predict the expected sea level rise over the life of the Project and assess the likely implications for the integrity and management of the proposed infrastructure. Levees / embankments will be designed in consideration of likely inundation (resulting from sea level rise and extreme episodic weather events) and allow for periodic height increases in response to settling of the embankment over time, and sea level rise.	2.3.13
19.	Describe the proposed monitoring, management and mitigation measures to be implemented, including an assessment of their effectiveness, at the design and operations stages to demonstrate that all reasonable and practicable avoidance and mitigation measures will be taken to ensure residual impacts and risks are acceptable.	6.6, 6.7
20.	Document management and monitoring measures to ensure residual impacts are not greater than predicted and achieve predicted outcomes/objectives	6.7
21.	Summarise residual impacts, after considering avoidance and minimisation. Analyse these impacts to identify and detail any that are significant. If significant residual impacts remain propose appropriate offsets.	6.8
22.	Create an offsets position following application of the 'mitigation hierarchy' (avoid, minimise, rehabilitate, offset).	6.8
23.	Demonstrate and document how the EPA's objective for this factor can be met.	6.6, 6.7, 6.8
	Marine Environmental Quality	
24.	Collection of adequate baseline data to document background marine environmental quality (including spatial and temporal variation) within the receiving marine environment.	7.4
25.	Determine potential infill volumes and maintenance dredging requirements associated with any marine dredging works. This includes the volume to be dredged, likely frequency of dredging, proposed disposal locations (which will be onshore only), and the potential impacts associated with this dispersal for the life of the Project.	2.3.8.2, 7.5.2.6
26.	Preparation of a suitable hydrodynamic model to adequately represent the existing movement of marine waters within the receiving marine environment (including both extreme and normal weather conditions).	7.3.1, Appendix A

Task	Required Work	Section
27.	Incorporate into the hydrodynamic model:	7.3.1, Appendix A
a.	The proposed discharge of bitterns and bitterns ecotoxicology assessment; and	7.5.1, 7.5.3.4
b.	The proposed intake of seawater	6.5.2.1
	Use the hydrodynamic model to predict the impacts on hydrology and water quality of the system and sensitive receptors (such as key taxa present including where relevant prawn larvae and juveniles and the most vulnerable pearl oyster life stages), including key habitats (such as prawn nursery habitats).	8.6.1, 9.5.1.1, 9.5.2
28.	Prepare a comprehensive management and monitoring plan for bitterns discharge.	7.7.2, Appendix BB
29.	Overlay the predicted sediment discharge caused by any proposed dredging, shipping, and boat movement disturbance within the above hydrodynamic model to predict the impact of turbidity on marine environmental quality and sensitive receptors (such as coral and seagrass).	7.5.2.5, 8.6.1, 9.5.1.1, 9.5.2
30.	Conduct a technical peer review of the hydrodynamic modelling and related reporting to ensure it is consistent with regulatory policies / guidance and suitable for the scale of impacts.	7.3.2, Appendix F
31.	Prepare a comprehensive management and monitoring plan for any dredging required, shipping and boat movement disturbance of sediment.	7.7.2, Appendix BB
32.	Undertake a study to predict the likely seepage from salt ponds and groundwater mobilisation into the receiving environment (including groundwater and surrounding tidal creeks/nearshore marine waters) and potential flow-on effects to surrounding ecosystems (such as mangroves and algal mats).	13.3.1, 13.5.2.2, 8.6.1, 8.6.2
33.	Identify any acid sulfate soils or sediment that could potentially be disturbed by the Project and if required, a Development Strategy (prior to any ground disturbing works) to reduce or eliminate disturbance-related impacts, and an Acid sulfate Soils Management Plan to prevent contamination of the marine environment.	12.3.6, 12.4.3.2, Appendices K and BB
34.	Undertake a Product Spillage Risk Assessment and develop an appropriate Product Spillage Management Plan.	7.5.3.5, Appendix BB
35.	Undertake a Hydrocarbon Spill Risk Assessment and develop an appropriate Hydrocarbon and Spill Management Plan.	7.5.3.5, Appendix BB
36.	Prepare an environmental quality plan (EQP) (based on the *Pilbara Coastal Water Quality Consultation Outcomes – Environmental Values and Environmental Quality Objectives)* (Department of Environment, 2006) identifying the environmental values to be protected, levels of ecological protection, key sensitive biological receptors, and water quality indicators. Baseline data acquisition and mapping will be appropriate for ongoing monitoring.	7.7.2, Appendix BB
37.	Identify other potential sources of sediment plumes (e.g., construction activity in the intertidal zone, excavation activities in the path of surface runoff) and include these in turbidity modelling and impact assessment, and in any monitoring and management plans if they are found to be significant.	7.5.3.5, Appendix BB
38.	Describe the proposed monitoring, management and mitigation measures to be implemented, including an assessment of their effectiveness, at the design and operations stages to demonstrate that all reasonable and practicable avoidance and mitigation measures will be taken to ensure residual impacts and risks are acceptable.	7.7.2, Appendix BB
39.	Document management and monitoring measures to ensure residual impacts are not greater than predicted and achieve predicted outcomes/objectives.	7.7.2, Appendix BB
40.	Summarise residual impacts, after considering avoidance and minimisation. Analyse these impacts to identify, describe and evaluate any that are significant. If significant residual impacts remain propose appropriate offsets.	7.6, 7.8
41.	Create an offset position following application of the 'mitigation hierarchy' (avoid, minimise, rehabilitate, offset).	7.8
42.	Demonstrate and document how the EPA's objective for this factor can be met.	7.6, 7.7 ,7.8
	Marine Fauna	
43.	Undertake desktop review of previous marine fauna surveys conducted in the area focusing on conservation significant species (as well as ecological 'keystone' species and species important to commercial and recreational fishers) and produce a gap analysis of further marine fauna survey work required for this Project. The gap analysis will consider the age and techniques of previous surveys and whether the distribution and abundance of listed threatened species has changed over time. Consideration will be given to:	9.4.1, Appendix N
a.	the different usage types and behaviours (e.g., foraging, calving, nursing, resting, roosting, nesting, migrating, or passing between other habitat areas), their spatial extents and locations, and the habitat characteristics that support, or facilitate these patterns of use (e.g. the availability of a particular food source, or natural darkness);	9.4.1, 9.4.3, 9.4.3.4, Appendices N and O
b.	timeframes and seasonality of fauna use, identifying periods of high and low vulnerability to impacts;	9.4.3.4

Task	Required Work	Section
c.	fauna abundances, (presented where possible in the context of local populations or management units, including the percentages of flyway populations using migratory bird 'sites' as outlined in *Significant impact guidelines for 36 migratory shorebird species (EPBC Act Policy Statement 3.21)* (Department of the Environment, Water, Heritage and the Arts, 2009); and	9.4.3, 11.4.1.3, Appendices N and O
d.	the conservation significance at local and regional scales, of the marine fauna, and their associated habitats including access routes to and between significant habitats in Exmouth Gulf and the adjacent Pilbara nearshore bioregion.	9.4.1, 9.4.3, 9.4.3.4, 9.4.9, 9.4.10, 11.4.1.3, Appendices N and O
44.	Undertake appropriate marine fauna surveys to fill gaps identified above.	9.4.1
45.	Particular focus should be on identifying elements of the Proposal that may affect conservation significant marine fauna (as well as ecological 'keystone' species and species important to commercial and recreational fishers) and demonstrating how the mitigation hierarchy has been considered and applied in generating predictions of the severity, extent and duration of both direct and indirect impacts associated with planned construction and operational activities, as well as plausible unplanned scenarios (e.g. oil spills).	9.4.1
46.	Describe and quantify the flow-on effects of altered nutrient inputs into the Gulf in relation to productivity of the ecosystem (including prawns and fish).	7.4.6, 7.5.3.1, 8.6.1, 9.5.2
47.	Undertake an analysis of:	
a.	The potential impacts on marine fauna from shipping and boating activities and identify appropriate mitigation/management measures.	9.5.1.2, 9.7.2, Appendix BB
b.	The potential impacts on marine fauna from dredging activities and identify appropriate mitigation/management measures.	9.5.2, 9.7.2, Appendix BB
48.	Undertake site and noise source specific modelling of underwater noise (including vessel operations and piling) and potential impacts on marine fauna. Modelling will take into account concurrent emission sources, as well as cumulative effects from existing emission sources, and consider the area of impact with consideration of conservation significant fauna (as well as ecological 'keystone' species and species important to commercial and recreational fishers) with known noise sensitivity (e.g., humpback whales).	9.5.2, Appendices N and BB
49.	Undertake a light study (including current baseline and predicted) to characterise the potential changes to the light environment and the implications this may have on threatened turtles.	9.5.2, Appendices N and BB
50.	Identify sources of noise and light (e.g., dock lights, jetty construction etc. and ensure appropriate mitigation/management/offset measures are in put in place.	9.5.2, Appendices N and BB
51.	Prepare a comprehensive management plan for shipping and Project related boat traffic to avoid, minimise and manage marine fauna collisions and noise/light related impacts.	9.5.1.2, Appendices N and BB
52.	Evaluate the risk of entrainment/entrapment (particularly of prawn larvae) and potential impacts on recruitment and populations. Prepare a comprehensive design and management plan for the seawater intake(s) to minimise fauna entrapment.	15.5.2.1, 9.5.1.3, 9.7.2, Appendices P and BB
53.	Undertake a Vessel Ballast Water/Hull and Construction Equipment and Materials Pest Risk Assessment and develop an appropriate Monitoring and Management Plan to avoid and minimise pest and/or disease introduction. The resulting pest management strategy will include vessel ballast water/hull and construction equipment and materials risk assessment and mitigation prior to entry of vessels into State waters in addition to introduced marine pest (IMP) monitoring and reporting, with the aim of:	9.5.2, 9.7.2, Appendices N and BB
a.	preventing the establishment and proliferation of IMPs;	9.7.2, Appendices N and BB
b.	control (and eradication) any IMP that has established and proliferated; and	9.7.2, Appendices N and BB
c.	minimising transfer of any established IMPs further within WA.	9.7.2, Appendices N and BB

Task	Required Work	Section
54.	Identify any significant marine fauna (as well as ecological 'keystone' species and species important to commercial and recreational fishers) likely to be found in the area of influence of the Proposal, including commercially important species and migratory species.	9.4.3, 15.4.3
55.	Identify any known temporal windows that represent critical periods for key environmental/life cycle events for marine fauna (e.g., Humpback Whale calving).	9.4.3.4
56.	Identify likelihood of EPBC conservation significant species (as well as ecological 'keystone' species and species important to commercial and recreational fishers) to occur within/near the proposed Project area, including:	9.4.3, 15.4.3, Appendix N
a.	Information on the abundance, distribution, ecology and habitat preferences of the listed species	9.4.3, 15.4.3, 18.3, Appendix N
b.	Information on the conservation value of each habitat type (e.g., breeding, migration, feeding, resting, inter-nesting etc.) from a local and regional perspective, including the percentage representation of each habitat type on site in relation to its local and regional extent	9.4.3, 15.4.3, 18.3, Appendix N
c.	If a population of a listed species is present on the site, its size and the importance of that population from a local and regional perspective	9.4.3, 9.4.9, 9.4.10, 18.3, Appendix N
d.	An assessment of the risk of impact to any listed threatened species as a result of Project activities	18.3, 18.6
e.	For any impact identified, appropriate mitigation/management measures to reduce the level of impact	9.7, Appendix BB
f.	Baseline information and mapping of local occurrences	9.4.3, 9.4.9
57.	Predict the residual impact/loss of marine fauna and larval life stages and assess the likely consequences in a local and regional context.	9.6, 9.8
58.	Describe the proposed monitoring, management and mitigation measures to be implemented, including an assessment of their effectiveness, at the design and operations stages to demonstrate that all reasonable and practicable avoidance and mitigation measures will be taken to ensure residual impacts and risks are acceptable.	9.7, Appendix BB
59.	Document comprehensive management and monitoring measures for construction, operations and closure, including defined trigger levels and adaptive management responses to ensure:	9.7, Appendix BB
a.	residual impacts on conservation significant marine fauna (as well as ecological 'keystone' species and species important to commercial and recreational fishers) are not greater than predicted and achieve predicted outcomes/objectives; and	9.6, 9.7, 9.8
b.	an appropriate level of preparedness to respond to impacts on marine fauna (as well as ecological 'keystone' species and species important to commercial and recreational fishers) associated with unplanned events such as hydrocarbon, salt resource or bitterns spills	9.7, Appendix BB
60.	Summarise residual impacts, after considering avoidance and minimisation. Analyse these impacts to identify and detail any that are significant. If significant residual impacts remain propose appropriate offsets.	9.6, 9.7, 9.8
61.	Create an offsets position following application of the 'mitigation hierarchy' and analyse these impacts to identify and detail any that are significant.	9.8
62.	Demonstrate and document how the EPA's objective for this factor can be met.	9.6, 9.7, 9.8
	Flora and Vegetation	
63.	Undertake appropriate vegetation surveys within proposed areas of terrestrial disturbance/clearing and areas of potential indirect impacts. Surveys are to identify and characterise flora and vegetation in accordance with EPA policy and meet the requirements of Technical Guidance – *Flora and Vegetation Surveys for Environmental Impact Assessment* (EPA, 2016i).	10.3, Appendices Q and R
64.	Conduct an appropriate analysis of vegetation communities to establish local and regional conservation significance of each vegetation community.	0, Appendices Q and R
65.	Identify conservation significant species and communities present in the survey area, clearing footprint and areas of likely indirect impact. Including, but not limited to, threatened and priority ecological communities, potential groundwater dependent ecosystems, threatened and priority flora, potentially range restricted flora and new flora species.	0, Appendices Q and R
66.	Identify elements of the Proposal which may affect vegetation and flora and provide a detailed description and analysis of the extent, severity, duration and significance of combined direct and indirect impacts associated with each phase of the Proposal.	10.5
a.	Analysis of impacts on vegetation should present the area, or mapped extent (in ha) of each vegetation unit, and the area (in ha) and proportion of each mapped vegetation unit to be impacted (directly and indirectly).	10.5

Task	Required Work	Section
b.	Analysis of impacts on conservation significant flora should include the number of plants, and the number of populations of plants, to be impacted (directly and indirectly). These numbers should also be presented as proportions of the total numbers of known plants and populations in the local area and across the species range.	10.5
67.	Identify weeds and species susceptible to Proposal impacts to assist in developing appropriate management actions.	10.4.4, 10.5.1, 10.5.2
68.	Determine the direct, indirect and cumulative impacts of the Proposal to flora and vegetation and the significance of these impacts.	10.5
69.	Describe the proposed monitoring, management and mitigation measures to be implemented, including an assessment of their effectiveness, at the design and operations stages to demonstrate that all reasonable and practicable avoidance and mitigation measures will be taken to ensure residual impacts and risks are acceptable. Note the Mitigation Hierarchy of Avoidance, Minimisation, Rehabilitation and Offsets will be addressed when considering avoidance and minimisation.	10.7, Appendix BB
70.	Conduct a review of rehabilitation experience, identify knowledge gaps and propose rehabilitation outcomes.	8.8.3.1, 10.7.3.1
71.	Document detailed management and monitoring measures including defined trigger levels and adaptive management responses to ensure residual impacts are not greater than predicted and achieve predicted outcomes/objectives.	10.7, Appendix BB
72.	Prepare a Mine Closure Plan consistent with *Statutory Guidelines for Mine Closure Plans* (DMIRS, 2020) which includes methodologies and criteria to ensure progressive rehabilitation of disturbed areas with vegetation composed of native species of local provenance.	Appendix BB
73.	Summarise residual impacts, after considering avoidance and minimisation. Analyse these impacts to identify and detail any that are significant. If significant residual impacts remain propose appropriate offsets.	10.6, 10.7, 10.8
74.	Create an offsets position following application of the 'mitigation hierarchy' (avoid, minimise, rehabilitate, offset) and analyse these impacts to identify and detail any that are significant.	10.8
75.	Demonstrate and document how the EPA's objective for this factor can be met.	10.6, 10.7, 10.8
76.	Complete the EPA Checklist for documents submitted for Environmental Impact Assessment on terrestrial biodiversity.	No longer relevant
	Terrestrial Environmental Quality	
77.	Undertake a study to predict the likely seepage of saline water from salt ponds and potential mobilisation of hypersaline groundwater into the surrounding environment and potential for soil contamination.	12.4.1, 12.4.4.1
78.	Identify any acid sulfate soils or sediment that could potentially be disturbed by the Project and if required, develop a Development Strategy (prior to any ground disturbing works) to reduce or eliminate disturbance-related impacts, and an Acid sulfate Soils Management Plan to prevent contamination of the terrestrial environment.	12.3.6, 12.3.7.1, 12.4.3.2, Appendices K and BB
79.	Undertake a Product and Bitterns Spillage Risk Assessment and develop an appropriate Product Spillage Management Plan.	12.4.3.1, 12.6.2, Appendix BB
80.	Undertake a Hydrocarbon Spill Risk Assessment and develop an appropriate Hydrocarbon and Spill Management Plan.	12.4.3.1, 12.6.2, Appendix BB
81.	Undertake a Waste Disposal Risk Assessment and develop an appropriate Waste Management Plan.	12.4.3.1, 12.6.2, Appendix BB
82.	Undertake a Dredge Spoil Disposal Risk Assessment and develop an appropriate Dredge Spoil Disposal Management Plan.	12.4.3.1, 12.6.2, Appendix BB
83.	Describe the proposed monitoring, management and mitigation measures to be implemented, including an assessment of their effectiveness, at the design and operations stages to demonstrate that all reasonable and practicable avoidance and mitigation measures will be taken to ensure residual impacts and risks are acceptable.	12.5, 12.6, 12.7, Appendix BB
84.	Document management and monitoring measures to ensure residual impacts are not greater than predicted and achieve predicted outcomes/objectives.	12.5, 12.6, 12.7
85.	Summarise residual impacts, after considering avoidance and minimisation. If significant residual impacts remain propose appropriate offsets.	12.7
86.	Demonstrate and document how the EPA's objective for this factor can be met.	12.5, 12.6, 12.7
	Terrestrial fauna	
87.	The following fauna surveys will be undertaken within proposed areas of terrestrial disturbance/clearing and areas of potential indirect impacts:	11.3

Task	Required Work	Section
a.	A desktop fauna study to inform the design of the baseline fauna surveys, place the survey results in context, and assist in evaluating the need for targeted surveys for significant species, in accordance with *Technical Guidance: Terrestrial fauna surveys* (EPA, 2016l).	11.3, Appendices O, S and T
b.	Detailed (Level 2) baseline fauna surveys in all habitats within the Development Envelopes that may be directly or indirectly impacted, and in equivalent habitats outside the Development Envelopes to provide local context. Surveys are to include terrestrial vertebrate species, avifauna, mangrove vertebrate fauna assemblages, terrestrial short range endemic (SRE) fauna, and aquatic ephemerally filled claypan associated invertebrate fauna species in accordance with *Technical Guidance: Terrestrial fauna surveys* (EPA, 2016l), *Technical Guidance: Sampling methods for terrestrial vertebrate faun*a (EPA, 2016m) and *Technical Guidance - Sampling of short range endemic invertebrate fauna* (EPA, 2016n).	11.3, Appendices O, S and T
c.	Targeted surveys for significant migratory and marine birds and their habitats in accordance with *Technical Guidance: Sampling methods for terrestrial vertebrate faun*a (EPA, 2016m) and *Industry guidelines for avoiding, assessing and mitigating impacts on EPBC Act listed migratory shorebird species* (Commonwealth of Australia, 2017a), or any other significant fauna species if the desktop study or baseline surveys identify knowledge gaps regarding significant species within the Development Envelopes.	11.3, Appendix S
88.	Undertake appropriate fauna and fauna habitat surveys within proposed areas of terrestrial disturbance/clearing and areas of potential indirect impacts. Surveys are to include terrestrial vertebrate species, migratory birds and other avifauna and short-range endemic (SRE) fauna, and aquatic, ephemerally filled claypan associated invertebrate fauna species in accordance with the requirements of Technical Guidance documents –*Terrestrial fauna surveys* (EPA, 2016l), *Sampling methods for terrestrial vertebrate faun*a (EPA, 2016m) and *Sampling of short range endemic invertebrate fauna* (EPA, 2016n).	11.3, Appendices O, S and T
89.	Identify conservation significant species and habitat present in the survey area, clearing footprint and areas of likely indirect impact.	0
90.	Identify likelihood of EPBC Act conservation significant species to occur within/near the proposed Project area, including:	0, 18.3, 18.6
a.	Information on the abundance, distribution, ecology, and habitat preferences of the listed species	0, 18.3, 18.6
b.	Information on the conservation value of each habitat type (e.g., breeding, migration, feeding, resting, inter-nesting etc.) from a local and regional perspective, including the percentage representation of each habitat type on site in relation to its local and regional extent	0, 18.3, 18.6
c.	If a population of a listed species is present on the site, its size and the importance of that population from a local and regional perspective	0,11.4.3, 11.4.4, 18.3, 18.6
d.	An assessment of the risk of impact to any listed threatened species as a result of Project activities	11.5, 18.3, 18.6
e.	For any impact identified, propose appropriate mitigation/management measures to reduce the level of impact and provide a discussion of the efficacy of these proposed mitigation/management measures	11.7, 18.3, 18.6
f.	Baseline information and maps identifying at both the site and regional levels.	11.4.3, 11.4.4
91.	Assess direct and indirect impacts on fauna within local and regional contexts, focusing on conservation significant fauna, and fauna habitats by providing a detailed description and analysis of the extent, severity, duration and significance of combined direct and indirect impacts associated with each phase of the Proposal. The description and analysis will include:	11.5
a.	Vegetation clearing and other causes of habitat loss, degradation and fragmentation;	11.5
b.	Claypan excavation and associated removal of habitat for potential short-range endemic invertebrate species;	11.5.1.1, 11.5.3
c.	Potential entrapment and collision associated with trenches, borrow pits, fences and vehicle movements;	11.5.1.2
d.	Behavioural changes and altered predator/prey relationships associated with provisioning of water and food waste, potential for increased feral access and light emissions;	11.5.2.6
e.	Exposure to toxicants and contamination, e.g. associated with spills and leaching from disturbed acid sulfate sediments	11.5.2.2
92.	Provide figures and maps showing the likely extent of loss of habitat types and the extent of habitat areas expected to recover from both direct and indirect impacts. Figures and tables should include:	11.4.3
a.	The spatial extent (in ha), and proportional loss of each habitat type to be impacted focusing on habitat types associated with conservation significant, species; and	11.5.3
b.	The abundance, or estimated abundance, of conservation significant species within areas of predicted impact as a proportion of known or estimated local populations.	11.5.3
93.	Prepare a comprehensive list of all terrestrial fauna species likely to occur in habitats to be directly or indirectly impacted.	0, Appendices O, S and T

Task	Required Work	Section
94.	Prepare comprehensive management plans for vehicle and equipment traffic to avoid collisions with fauna.	11.7.2, Appendix BB
95.	Prepare comprehensive management plans for noise, lighting and food waste impacts on fauna.	11.7.2, Appendix BB
96.	Prepare a comprehensive monitoring and management plan to address introduced animals.	11.7.2, Appendix BB
97.	Describe the proposed monitoring, management and mitigation measures including defined trigger levels and adaptive management responses to be implemented, including an assessment of their effectiveness, at the design and operations stages to demonstrate that all reasonable and practicable avoidance and mitigation measures will be taken to ensure residual impacts and risks are acceptable.	11.6, 11.7, 11.8, Appendix BB
98.	Document management and monitoring measures proposed, including defined trigger levels and adaptive management responses to ensure residual impacts are not greater than predicted and achieve predicted outcomes/objectives.	11.6, 11.7, 11.8
99.	Summarise residual impacts, after considering avoidance and minimisation and analyse these impacts to identify and detail any that are significant. If significant residual impacts remain propose appropriate offsets.	11.6, 11.7, 11.8
100.	If relevant, create an offsets position following application of the mitigation hierarchy.	11.7.4
101.	Demonstrate and document how the EPA’s objective for this factor can be met	11.6, 11.7, 11.8,
	Hydrological Processes	
102.	Undertake comprehensive modelling of hydrology and nutrient flows in the Project area (including both extreme storm events/cyclone events and average weather conditions) to investigate, document, illustrate and map existing surface water flow regime and nutrient pathways that support important environmental values of this system.	7.4.6, 13.3.1, 13.4, Appendices B, E, J, V and W
103.	Conduct a technical peer review of the hydrology and nutrient flow modelling and related reporting to ensure that it is consistent with regulatory policies / guidance and suitable for the scale of impacts.	12.4.2, Appendices F, X and Y
104.	Optimise design of the Project layout so that environmentally detrimental changes in surface water flows, tidal inundation, water compensation, other hydrological processes, and nutrient pathways/inputs are avoided and/or minimised.	6.5.2.3, 6.7, 13.5.2, 13.7
105.	Undertake groundwater modelling to investigate and define the existing groundwater regime and predict potential groundwater related impacts of the Project.	13.3.1, 13.4
106.	Identify possible bore locations, abstraction volumes and predict impacts of proposed groundwater abstraction.	13.4.11, 13.4.12
107.	Conduct a technical peer review of the groundwater modelling and related reporting to ensure that it is consistent with regulatory policies / guidance and suitable for the scale of impacts.	13.3.2, Appendices X and Y
108.	Undertake a study to predict direct and indirect impacts on all hydrological processes, and their associated consequences for biota and wetland values. Use the results of this study to develop and implement design and management measures as necessary to avoid and minimise impacts on groundwater quality and potential flow-on effects to the surrounding environment.	13.5.2.2, Appendices V and W
109.	Describe the proposed monitoring, management and mitigation measures to be implemented, including an assessment of their effectiveness, at the design and operations stages to demonstrate that all reasonable and practicable avoidance and mitigation measures will be taken to ensure residual impacts and risks are acceptable.	13.6, 13.7, 13.8, Appendix BB
110.	Document comprehensive management and monitoring measures including defined trigger levels and adaptive management responses to ensure residual impacts are not greater than predicted and achieve predicted outcomes/objectives.	13.7, Appendix BB
111.	Summarise residual impacts, after considering avoidance and minimisation. Analyse these impacts to identify and detail any that are significant. If significant residual impacts remain propose appropriate offsets.	13.6, 13.7, 13.8
112.	Create an offsets position following application of the 'mitigation hierarchy' and analyse these impacts to identify and detail any that are significant.	13.8
113.	Demonstrate and document how the EPA’s objective for this factor can be met.	13.6, 13.7, 13.8
	Inland Waters Environmental Quality	
114.	Conduct baseline studies of inland water quality for an appropriate buffer of the Development Envelopes for relevant parameters using appropriate methodologies. Parameters to include relevant baseline water quality measures and potential pollutants.	7.4.6, 13.3.1, 13.4, Appendices B, E, J, V and W

Task	Required Work	Section
115.	Identify any acid sulfate soils or sediment that could potentially be disturbed by the Project and if required, a Development Strategy (prior to any ground disturbing works) to reduce or eliminate disturbance-related impacts, and an Acid Sulfate Soils Management Plan to prevent contamination of the inland waters and environment.	12.3.6, 12.3.7.1, 12.4.3.2, 14.5.1.2, Appendices K and BB
116.	Identify any Naturally Occurring Radioactive Materials (NORMs) that could potentially be disturbed by the Project and if required, a Development Strategy (prior to any ground disturbing works) to reduce or eliminate disturbance-related impacts, and a NORMs Management Plan to prevent contamination of the inland waters and environment.	0, 14.7.2, 12.4.4.2, 14.5.1.1, Appendix I
117.	Undertake a comprehensive study of potential impacts to inland groundwater and surface water quality from Proposal implementation.	14.5, Appendices K, U, V and W
118.	Design Project infrastructure and manage activities so that potential for contamination of inland groundwater and surface water is avoided and minimised.	14.7, Appendix BB
119.	Describe the proposed monitoring, management and mitigation measures to be implemented, including an assessment of their effectiveness, at the design and operations stages to demonstrate that all reasonable and practicable avoidance and mitigation measures will be taken to ensure residual impacts and risks are acceptable.	14.6, 14.7, 14.8, Appendix BB
120.	Document management and monitoring measures to ensure residual impacts are not greater than predicted and achieve predicted outcomes/objectives.	14.6, 14.7, 14.8, Appendix BB
121.	Summarise residual impacts, after considering avoidance and minimisation. If significant residual impacts remain propose appropriate offsets.	14.8
122.	Demonstrate and document how the EPA's objective for this factor can be met.	14.8
	Social Surroundings	
123.	Undertake appropriate cultural heritage (archaeological and ethnographic) surveys for the Ashburton Salt Project.	15.3, Appendix Z
124.	Undertake design of all Project infrastructure and activities so that disturbance of cultural sites is avoided where possible.	15.5.1, 15.7.1, 15.7.2, Appendix BB
125.	In the event that disturbing a cultural heritage site is unavoidable, consult with Aboriginal stakeholders and obtain all relevant approvals under the *Aboriginal Heritage Act 1972*, prior to undertaking the disturbance.	15.7.1, 15.7.2, Appendix BB
126.	Ensure all responsibilities and requirements under the *Aboriginal Heritage Act 1972* are met.	15.7.1, 15.7.2, Appendix BB
127.	Describe the proposed monitoring, management and mitigation measures to be implemented, including an assessment of their effectiveness, at the design and operations stages to demonstrate that all reasonable and practicable avoidance and mitigation measures will be taken to ensure residual impacts and risks are acceptable.	15.6, 0, 15.8, Appendix BB
128.	Document management and monitoring measures to ensure residual impacts are not greater than predicted and achieve predicted outcomes/objectives.	15.6, 0, 15.8, Appendix BB
129.	Summarise residual impacts, after considering avoidance and minimisation. If significant residual impacts remain propose appropriate offsets.	15.8
130.	Demonstrate and document how the EPA's objective for this factor can be met.	15.6, 0, 15.8

EXECUTIVE SUMMARY

PROPOSAL DESCRIPTION

K plus S is an international resources company with headquarters in Germany and is considering through its Australian entity K+S Salt Australia Pty. Ltd. (K+S), the possibility of developing and operating a green field solar salt Project (the proposed Ashburton Salt Project; Proposal) on the Western Australian coast, approximately 40 km south-west of the township of Onslow, within the Shire of Ashburton (Figure 1). K+S proposes to construct and operate a 4.7 million tonne per annum (Mtpa) solar salt farm. Land Tenure proposed includes a Mining Tenement under the *Mining Act, 1978*, Port Tenure vested in Pilbara Ports Authority and a Public Road under the *Land Administration Act 1997* (Figure 2).

The key characteristics of the Proposal are set out below in Table 2 and Table 3. The development envelope and layout of the Proposal are provided in Figure 3.

Table 2: Summary of the Proposal

Proposal title	**Ashburton Salt Project**
Proponent name	**K plus S Salt Australia Pty Ltd**
Short description	It is proposed to construct and operate a solar salt project approximately 40 km south-west of Onslow, WA. The proposal includes the construction of solar salt evaporation and crystallisation ponds and associated infrastructure/activities (seawater intake pumps/channel/pipeline(s); seawater concentration ponds and salt crystallisation ponds; internal site roads; onsite diesel fuelled back-up/standby electricity generation and reticulation; fuel storage sites; a jetty and product loading facilities; a salt wash plant and associated ponds; salt stockpiles and conveyors; onsite buildings such as offices, storage, workshops and possibly accommodation; sewage treatment facilities and landfill; water management/monitoring bore(s); helipad; desalination plant; equipment parking and laydown areas; bitterns discharge infrastructure which includes a channel, dilution pond, pipeline and diffuser; drainage diversion/s and levees; access roads; a service corridor; borrow pit areas for rock, clay and other construction materials; and dredging and land based dredge spoil disposal.

Table 3: Location and proposed extent of physical and operational elements

Element	**Location**	**Proposed extent authorised**
Physical elements		
Evaporation & crystallisation ponds	Figure 3	Clearing of no more than 10,397 ha within a 20,990 ha Ashburton Salt Project Development Envelope.
Support infrastructure	Figure 3	Clearing of no more than 1,596 ha within a 20,990 ha Ashburton Salt Project Development Envelope. This includes: • seawater intake pumps/channel/pipeline(s); • internal site roads; • onsite diesel fuelled back-up/standby electricity generation and reticulation; • fuel storage sites; • a jetty and product loading facilities; • dredging; • land based dredge spoil disposal; • a salt wash plant and associated ponds; • salt stockpiles and conveyors; • onsite buildings such as offices, storage, workshops and accommodation; • sewage treatment facilities; • landfill; • water management/monitoring bore(s); • equipment parking and laydown areas; • bitterns discharge infrastructure which includes a channel, dilution pond, pipeline and diffuser;

Element	Location	Proposed extent authorised
		• drainage diversion(s) and levees; • borrow pits; • helipad; and • desalination plant.
Access/haul roads (including road upgrades and river crossing/bridge)	Figure 3	Clearing of no more than 155 ha within a 20,990 ha Ashburton Salt Project Development Envelope (77 ha for main access road and 78 ha for internal site access roads)
Operational elements		
Seawater intake	Figure 3	Seawater intake of no more than 250 GL per annum
Wastewater (bitterns)	Figure 3	Marine discharge of no more than 20 GL per annum (consisting of no more than 10 GL per annum bitterns diluted with seawater at a ratio of approximately 1 to 1)

PRELIMINARY KEY ENVIRONMENTAL FACTORS

The receiving environment has been carefully considered and investigated in detail through 26 scientific technical studies and which are appended to this ERD as summarised in Table 4. Based on the preliminary findings of these technical studies, the Proposal has been iteratively re-designed to minimise impacts to the environment. Proposed disturbance is localised and proportionally small. Important processes have been maintained and impacts avoided and minimised so that local and regional environmental values are protected. Several management plans are also proposed - Table 4, Appendix BB (K+S, 2021). It is considered that the EPA objectives for each relevant Environmental Factor have been met and residual impacts of the Proposal to the environment are low.

Table 5 summarises potential impacts, proposed mitigation and predicted outcomes for all environmental factors relevant to the Proposal.

Table 4: ERD Supporting Appendices

Report	Reference	Appendix
Marine and Coastal Assessment and Modelling	Water Technology, 2022b	A
Surface Water Assessment and Modelling	Water Technology, 2022a	B
Marine, Coastal and Surface Water Data Collection	Water Technology, 2021a	C
Marine, Coastal and Surface Water Existing Environment	Water Technology, 2021b	D
Surface Water Assessment and Modelling	Water Technology, 2021c	E
Peer Review of Coastal, Surface Water and Nutrient Pathway Modelling	DHI, 2021	F
Ashburton Salt Response to Sea Level Rise	Seashore Engineering, 2021	G
Ashburton Salt Projection of Future Habitat Area	Seashore Engineering, 2022	H
Memorandum Seawater Intake Assessment	Water Technology, 2018	I
Nutrient Pathway Assessment and Modelling	Water Technology, 2021d	J
Acid Sulfate Soil and Sediment Study	GHD, 2021a	K
Technical Memorandum - Phase 2 Ecotoxicology Assessment.	AECOM, 2022c	L
Assessment of Benthic Communities and Habitats	AECOM, 2022a	M
Marine Fauna Impact Assessment	AECOM, 2022b	N
Migratory Shorebird Assessment	Biota, 2022c	O
Prawn Assessments	Water Technology, 2022c	P
Detailed Vegetation and Flora Survey	Biota, 2022a	Q
Targeted Flora Survey 2022	Biota, 2022e	R
Level 2 Seasonal Fauna Survey	Biota, 2022b	S

Report	Reference	Appendix
Claypan Ephemeral Fauna Desktop Review	Biota, 2021	T
Materials Characterisation Study	GHD, 2021d	U
Memorandum Ashburton groundwater modelling- updated results.	GHD, 2022	V
Hydrogeological Investigation	GHD, 2021c	W
Independent Review of Ashburton Salt Project Groundwater Modelling	CyMod Systems, 2022	X
Ashburton Salt Project Groundwater Modelling Independent Review	CyMod Systems, 2021	Y
A Report of the Reconnaissance Assessment of Cultural Heritage Sites within the Ashburton Salt Project Area, Urala Station, Western Australia	Archae-aus, 2020	Z
Meeting Notes: Heritage and Culture Committee - K+S Social Surrounds Discussion	BTAC, 2021b	AA
Environmental Management Plans	Various	BB
Interim Offset Strategy.	Preston Consulting, 2023	CC
Updated Artificial Light Monitoring and Modelling Report.	Pendoley Environmental (2023)	DD

Table 5: Summary of Potential Impacts, Proposed Mitigation and Predicted Outcomes

Coastal Processes

Objective

To maintain the geophysical processes that shape coastal morphology so that the environmental values of the coast are protected.

Policy and guidance

- Environmental Factor Guideline: Coastal Process (EPA, 2016a).
- Statement of Planning Policy No. 2.6: State Coastal Planning Policy (WAPC, 2013).
- A Directory of Important Wetlands in Australia (ANCA, 1993).
- WA Environmental Offsets Policy (Government of Western Australia, 2011).
- WA Environmental Offsets Guidelines (Government of Western Australia, 2014).

Potential impacts

Cumulative Impacts:

- Cumulative disturbance is relatively minor with proportional loss locally and regionally for each important coastal feature estimated at less than 0.3%:

Coastal Features	Direct Impact (ha)	Indirect Impact (ha)	Cumulative Impact (ha)	Local Area (Jetty to Tent Point) (ha)	East Exmouth Gulf Region (ha)	Proportional Loss Locally (%)	Proportional Loss Regionally (%)
Mangroves	3.94	0.34	4.28	2,185	11,742	0.2%	0.04%
Algal Mats	12.74	3.94	16.68	5,384	11,617	0.31%	0.14%
Transitional Mudflats	17.81	-	17.81	4,020	20,747	0.44%	0.09%
Intertidal Mudflats (Total of Above Habitats)	34.49	4.55	38.77	11,589	44,106	0.33%	0.09%
Tidal Creek	0.54	-	0.54	503	2,710	0.11%	0.02%
Barrier Dune	0.17	-	0.17	1,787 (Jetty to tent Point)	2,059	0.01%	0.008%
TOTAL	35.2	4.55	39.48	13,879	48,875	0.28%	0.08%

Indirect Impacts:

- The presence of the pile-supported jetty is predicted to have negligible influence on the marine hydrodynamic regime or coastal morphology of the area due to the transmissive nature of the structure design (Water Technology, 2022b).
- Conservative modelling has predicted only minor and localised changes to fluvial morphology in Urala Creek South due to the seawater intake. Seawater intake pumping is predicted to have a negligible impact on tidal submergence time at high tide. Pumping will cease at low tide (Water Technology, 2022b).
- Due to its position largely on the supratidal salt flats, the overall development is predicted to have minimal impact on tidal inundation given it is beyond the reach of most tides. A marginal increase in inundation time (~5%) was predicted against the seaside embankment walls and over the tidal flat connecting to Urala Creek North. A very localised moderate increase in inundation time (~30%) was predicted over a small area adjacent to the seawater intake channel embankment. These predicted increases in inundation time are unlikely to impact coastal processes including overall tidal exchange or sediment deposition given they are relatively minor and localised.
- The Proposal will not impact the seashore or coastal barrier dune response to sea level rise due to distance from the Proposal.

Mitigation	Avoid: • The infrastructure necessary for the Proposal includes a seawater intake, solar evaporation ponds, crystalliser ponds and a salt export jetty. To avoid impacts on coastal processes and morphology this infrastructure has been located largely outside the intertidal areas and with a minimal footprint to avoid direct disturbance of the tidal creeks and only minimal disturbance to a barrier dune for the conveyor. • The jetty is designed as a pile support transmissive structure, which means that it does not impede water flows and therefore has minimal effects on local currents. The footprint of the piles is also too small to generate any material impact on the nearshore hydrodynamic or longshore sediment transport conditions in such a low energy environment (Water Technology, 2022b). Minimise: • The seawater intake has been positioned on the banks of Urala Creek South which has a deeper channel than Urala Creek North, thereby minimising erosion and fluvial morphology impacts due to seawater pumping. • The inlet well of the seawater intake on the banks of Urala Creek South will be positioned in the optimal location to minimise environmental impacts such as erosion and scour. Design considerations include locating the inlet well on the creek bank rather than within the creek channel to minimise hydrodynamic impacts. The proponent does not plan to pump water at low tide and the highest pumping rates will only occur in November/December which does not coincide with the extreme spring tide range. Likely impacts will be significantly below the modelled unrealistic worst-case scenario of pumping November/December intake rates during an extreme low tide (which only occur in March/April) (Water Technology, 2022b). • Ensure the jetty abutment does not extend onto the sandy beach to prevent impacts to sediment movement, • Monitor erosion and implement additional erosion prevention measures as required to prevent further erosion. In the event of significant changes in sediment supply to intertidal areas as a result of the Proposal, a Coastal Processes Monitoring and Management Plan will be prepared and implemented; and • Implement the DSDMP (Appendix BB). Rehabilitate: • At the completion of the Proposal the site will be rehabilitated to reinstate the existing environment. A MCP will be required under the *Mining Act 1978* for the majority of the Proposal and an Interim MCP is provided in Appendix BB. • Temporary disturbance of areas due to construction are limited, however construction of the conveyor embankment connecting to the jetty could expose areas of the coastal dune barrier to wind erosion. Appropriate protection measures including dune revegetation will be used to rehabilitate and protect these areas from wind erosion. • At the completion of operations, all buildings and structures will be removed from the site and the pond areas may be selectively reconnected to the existing tidal flat system. K+S preferred post end land use is to leave the evaporation ponds in situ so that they become fauna habitat for shore birds (including migratory birds which require “wetland areas” for migratory stop over rest and feeding). • Natural tidal flows will allow movement of mangrove plant and seed material which will passively revegetate the reconnected tidal areas. This will enhance the habitat values of the ponds post closure. • The effect of sea level rise will be considered during the closure planning process, and it may be possible to create a “niche” environment for mangroves and/or algal mats which may enable them to continue to exist.
Outcomes	• Residual Impact: There are not expected to be any significant residual impacts once the closure activities have been implemented.

<table>
<tr><th colspan="2">Marine Environmental Quality</th></tr>
<tr><td>Objective</td><td>To maintain the quality of water, sediment and biota so that environmental values are protected.</td></tr>
<tr><td>Policy and guidance</td><td>

Environmental Factor Guideline: Marine Environmental Quality (EPA, 2016b).
Technical Guidance - Protection of Benthic Communities and Habitats (EPA, 2016c).
Technical Guidance - Environmental Impact Assessment of Marine Dredging Proposals (EPA, 2016d).
Technical Guidance - Protecting the Quality of Western Australia's Marine Environment (EPA, 2016e).
Identification and investigation of acid sulfate soils and acidic landscapes (DER, 2015a).
Treatment and management of soil and water in acid sulfate soil landscapes (DER, 2015b).
Pilbara Coastal Water Quality Consultation Outcomes — Environmental Values and Environmental Quality Objectives, Department of Environment, Government of Western Australia, Marine Series Report No. 1 (Department of Environment, 2006).
Australian and New Zealand Guidelines for Fresh and Marine Water Quality (ANZG, 2018)
National Assessment Guidelines for Dredging (Commonwealth of Australia, 2009)
A Directory of Important Wetlands in Australia (ANCA, 1993).
WA Environmental Offsets Policy (Government of Western Australia, 2011).
WA Environmental Offsets Guidelines (Government of Western Australia, 2014).
"Appendix B: Potentially contaminating industries, activities and land uses" in Assessment and management of contaminated sites: Contaminated sites guidelines (DER, 2014).

</td></tr>
<tr><td>Potential impacts</td><td>
Direct Impact:

Predilution of bitterns and the design of the bitterns diffuser has:

Optimised the predicted dilution and mixing of bitterns with seawater on discharge.
Resulted in average, best case and worst case predicted LEPA and MEPA sizes which exceed the EPA (2016a) guideline sizes of 70 and 250 m respectively, however are predicted to be as small as reasonably can be achieved.

The small-scale two-week dredging program to remove 17,000 m^3 of sediment adjacent to the jetty has:

Been planned with onshore disposal of dredge spoil, including appropriate treatment and monitoring of decant water prior to return to the ocean.
Resulted in a predicted:

ZoHI localised immediately around the small dredging and tailwater discharge area.
ZoMi up to 1.5 km eastwards of the dredging area.
ZoI up to 4 km eastwards of the dredging area and 0.5 km either side of the tailwater discharge.

Been predicted to only cause elevated turbidity impacts for one week after the cessation of dredging.

Indirect Impacts:

The Proposal will not significantly alter nutrient pathways due to the small and infrequent nature of the predicted terrestrial reductions and no impact to marine nitrogen sources on which the Exmouth Gulf is reliant. Conservative modelling predicted the Proposal will reduce nitrogen sources as follows (Water Technology, 2021d):

A regional post-development proportional reduction in nitrogen flows into the Exmouth Gulf of 0.24% of land and ocean sources.
A local post-development proportional reduction in nitrogen flows into the Proposal catchment of 0.8% of land and ocean sources.

All potentially acid generating sediment removed through dredging will be treated on land with appropriate monitoring of decant water prior to marine disposal, in accordance with the ASSSMP (GHD, 2021b).
AECOM (2021c) conducted an ecotoxicology assessment of dredged material and bitterns, concluding that:

The dredged material is likely to present a very low risk of ecotoxicity in the marine environment, given none of the NAGD (Commonwealth of Australia, 2009) and ANZG (2018) screening criteria were exceeded in sample tests and land disposal of dredged material is proposed.

</td></tr>
</table>

	○ Once the metals within the bitterns plume are diluted such that they meet the nominated 99% or 95% species protection level at the boundary of the modelled MEPA (as predicted by Water Technology, 2022b), they present very low risk of ecotoxicity or bioaccumulation in the marine environment.
Mitigation	Avoid: • A transhipping approach has been adopted for export of the salt product which avoids the need to dredge a shipping channel to the berth at the jetty. • The bitterns are being discharged to the ocean to avoid long-term large-scale storage on site which would create a risk of spillage. • The alignment of the jetty has been moved to deeper water (compared to the original proposed alignment) to minimise dredging and improve the mixing and dilution of the bitterns. • Pre-dilution of the bitterns will be undertaken prior to discharge through the specifically designed diffuser at the jetty. • All dredge spoil will be disposed of on land and tailwater will be monitored to meet required water quality criteria as listed in the ASSSMP prior to discharge to the marine environment. • Excavation spoil from the seawater intake will be contained in the seawater intake channel embankments and managed in accordance with the Acid Sulfate Soil and Sediment Management Plan (ASSSMP; GHD, 2021b), and water within the excavated material will be treated and evaporated rather than disposed of back to the waterways, minimising tidal creek water quality impact. Minimise: • The diffuser design was developed iteratively to minimise impacts on the marine environment (Water Technology, 2022b). • Pre-dilution of the bitterns using seawater before being discharged to reduce the average density of the bitterns and maximise the efficiency of initial dilution at the diffuser. • The diffuser design includes an upward discharge from part-way up the water column to further maximise initial dilution and ensure mixing occurs throughout the full water depth. • The diffuser design uses a relatively high discharge velocity and many small port diameters to achieve the desired level of mixing • Implement the following management plans: ○ Marine Environmental Quality Monitoring and Management Plan (MEQMMP; Appendix BB). The MEQMMP will be revised prior to operations to include the results of updated WET testing using Proposal-specific bitterns and local indicator species (or agreed surrogates). ○ Dredging and Sediment Management Plan (DSMP; Appendix BB). ○ Waste Management Plan (WMP; Appendix BB). ○ ASSSMP (Appendix BB). Rehabilitate: • A MCP will be required under the *Mining Act 1978* for most of the Proposal. An Interim MCP (Appendix BB) has been developed for the Proposal and will continue to evolve during the life of the Proposal. If the Proposal receives Ministerial Approval under Part IV of the EP Act as well as under the EPBC Act, the Interim MCP will be developed in more detail and submitted to the Department of Mines, Industry Regulation and Safety (DMIRS) for approval as required by the *Statutory Guidelines for MCPs under the Mining Act 1978* - DMIRS (2020b). • The bitterns discharge infrastructure will be removed from site; however, the jetty may be transferred to the ownership of another user. Alternatively, it could be decommissioned and removed. All closure options for the jetty will be discussed with relevant stakeholders as part of ongoing development of the MCP.
Outcomes	• Residual Impact: The Proposal is unlikely to result in significant residual impacts to this factor, however the predicted water quality impacts occur within marine areas that are Biologically Important Areas (BIAs) and/or critical habitat for some marine fauna species. As a result, even localised water quality impacts may contribute to significant residual impacts to BCH and marine fauna.

Benthic Communities and Habitats	
Objective	To protect benthic communities and habitats (BCH) so that biological diversity and ecological integrity are maintained.
Policy and guidance	• Environmental Factor Guideline: Benthic Communities and Habitats (EPA, 2016f). • Technical Guidance - Protection of Benthic Communities and Habitats (EPA, 2016c). • Technical Guidance - Environmental Impact Assessment of Marine Dredging Proposals (EPA, 2016d). • Technical Guidance - Protecting the Quality of Western Australia's Marine Environment (EPA, 2016e). • Guidance Statement 1 – Protection of Tropical Arid Zone Mangroves along the Pilbara Coastline (EPA, 2001). • Pilbara Coastal Water Quality Consultation Outcomes — Environmental Values and Environmental Quality Objectives, Department of Environment, Government of Western Australia, Marine Series Report No. 1 (Department of Environment, 2006). • Australian and New Zealand Guidelines for Fresh and Marine Water Quality (ANZG, 2018) • National Assessment Guidelines for Dredging (Commonwealth of Australia, 2009) • A Directory of Important Wetlands in Australia (ANCA, 1993). • WA Environmental Offsets Policy (Government of Western Australia, 2011). • WA Environmental Offsets Guidelines (Government of Western Australia, 2014) "Appendix B: Potentially contaminating industries, activities and land uses" in Assessment and management of contaminated sites: Contaminated sites guidelines (DER, 2014). • Barging and transhipment operations will be carried out under a Works Approval and Environmental Licence issued under Part 5 of the Part IV of EP Act.
Potential impacts	Direct Impact: ○ Localised, proportionally small direct disturbance will occur due to clearing, earthworks and pond filling including approximately 36 ha of intertidal BCH and 2.6 ha of subtidal BCH. Indirect Impact: • Localised, proportionally very small indirect disturbance will occur from saline seepage, salt crusting, a minor creek blockage, dredging sediment discharge and bitterns discharge. These processes are predicted to affect (AECOM, 2022a): ○ 5.52 ha of intertidal BCH including 0.34 ha of mangrove and 0.24 ha of a tidal sub-creek affected by blockage and 3.94 ha of algal mats and 0.09 ha of Samphire affected by saline groundwater seepage. ○ 223.77 ha of subtidal BCH including 217 ha of soft sediment (potential seagrass habitat), 0.18 ha of macroalgae and 2.2 ha of macroalgae and sparse coral habitat within the bitterns Low Environmental Protection Area (LEPA) and 4.39 ha of macroalgae within the dredging Zone of High Influence (ZoHI). Cumulative Impact:

Intertidal BCH	Direct Loss (ha)	Indirect Loss (ha)	Cumulative Loss (ha)	LAU (ha)	East Exmouth Gulf (ha)	% LAU	% East Exmouth Gulf
Mangroves	3.94	0.34	4.28	540	11,742	0.79%	0.04%
Transitional Mud Flats	17.81	-	17.81	1,980	20,747	0.44%	0.09%
Algal Mats	12.74	3.94	16.68	3,350	11,617	0.50%	0.14%
Samphire	36.36	-	36.36	459	2,141	7.88%	1.70%
Sandy Beaches	0.99	-	0.99	127.5	1,040	0.78%	0.10%
Tidal Creeks	0.30	0.24	0.54	297	2,710	0.18%	0.02%
Total	*71.14*	*5.52*	76.66	*6,754*	*49,557*	*1.14%*	*0.15%*
Subtidal BCH	**Direct Loss (ha)**	**Indirect Loss (ha)**	**Cumulative Loss (ha)**	**LAU (ha)**	**Study Area (ha)**	**% LAU**	**% Study Area**
Soft Sediment	2.3	217	219.3	4,674	8,968	0.08%	2.45%
Macroalgae	0.22	4.57	4.79	82	147	5.62%	3.26%
Macroalgae & Sparse Coral	0.1	2.2	2.3	244	325	0.04%	0.71%
Total	*2.62*	*223.77*	*226.39*	*5,000*	*9,438*	*0.17%*	*2.40%*

	West Pilbara Regional Assessment: • Estimated cumulative proportional losses for the West Pilbara considering historical and projected future losses from other developments is very small. For the West Pilbara Region, the development is predicted to increase mangrove loss by 0.02%, algal mat loss by 0.06% and samphire loss by 0.5% (AECOM, 2022a). Response to Sea Level Rise: • The natural loss of mangroves and algal mats from the Eastern Exmouth Gulf is predicted to occur progressively after approximately 50 years due to sea level rise with or without the Proposal in place (Seashore Engineering, 2021). • The Ashburton Salt Proposal is uniquely positioned to consider the creation of ongoing habitat for algal mat, mangroves and associated fauna as a part of Proposal closure, by converting the ponds into a functioning wetland system which could provide a niche for BCH survival longer than otherwise anticipated, by providing physical protection from the effects of sea level rise behind rock armoured embankments.
Mitigation	Avoid: • Eight iterations of the pond design were undertaken to minimise the footprint. Alignment of the western boundary of concentration ponds was moved further east to minimise direct loss of algal mats and provide a setback from mangroves areas (>800 m) to avoid seepage-related impacts to mangroves and longer-term impacts related to salinity increases. As a result, the spatial extent of mangrove and algal mat loss from the Proposal is less than that from other WA existing and proposed solar salt projects, and from other major infrastructure projects constructed within similar settings on the Pilbara coast. • Detailed analysis of seawater intake options and locations was undertaken reducing the seawater intake locations from two (Urala Creek North and South), to only one (Urala Creek South). • Detailed analysis of dredging options and spoil disposal was undertaken. Transhipment is proposed with low draft barges to avoid the need for dredging a long shipping channel to deeper water (avoiding significant disturbance of the seafloor via dredging). The dredged berthing pocket is proposed in a location away from sensitive benthic habitats (such as coral reefs) thereby avoiding impacts to sensitive habitats. • There is no requirement for disposal of dredged material at sea avoiding much larger impacts to subtidal BCH from elevated turbidity. • There is no requirement for dredged material to be used for coastal land reclamation avoiding potential impacts to intertidal BCH through direct disturbance or sedimentation. • It is proposed that bitterns will be discharged via a diffuser positioned such that the mixing zone is in an area of existing high disturbance (dredged berthing pocket) and away from sensitive benthic habitats (coral reef and seagrass) thereby avoiding impacts to sensitive habitats. • Throughout the salt production process, no chemicals will be added at any stage of the process avoiding ecotoxicity risk for BCH. Minimise: • Appropriate culverts and drainage diversions were designed to minimise impacts to tidal and surface water flows and nutrient pathways, therefore minimising related impacts to intertidal habitats. • Conduct detailed analysis of bitterns disposal options. • The area and volume of sediment to be dredged is minimised to 0.7 ha and 17,000 m^3, minimising impacts to subtidal habitats. • Modelling predicts that the localised plumes of elevated turbidity will not persist for more than a week following cessation of the dredging activity (Water Technology, 2022b), minimising duration of impact to subtidal habitats and associated marine fauna. • Obtain and comply with the appropriate approvals. • Implement the Introduced Marine Pest Monitoring and Management Plan (IMPMMP; Appendix BB). • Implement the DSMP (Appendix BB). • Implement the MEQMMP (Appendix BB). • A Mangrove, Samphire and Algal Mat Management Plan (MSAMMP) will be developed and implemented that integrates the monitoring of mangrove, samphire and algal mat health/status with the monitoring of shallow groundwater conditions (including salinity), and mapping showing Project-related

	changes in habitat distribution. This management plan is currently being developed with the intention for this plan to be assessed later in the assessment or as a condition of approval (if approved). • Undertake appropriate monitoring measures to minimise residual groundwater impacts to BCH. • Given the annual variability of seagrass extent, conduct baseline seagrass surveys at least 12 months prior to any disturbance within the marine environment, annually during construction, and ongoing monitoring to be determined pending the results of the baseline surveys. The monitoring will be used to inform appropriate management measures if seagrass is identified within potential impact zones; • Develop and implement an Oil Spill Response Plan. This Plan will be developed in consultation with PPA. • Implement appropriate controls to minimise the risk of hydrocarbon spills. • Implement appropriate controls to minimise the risk of impact from unintentional brine pipeline spills. • Ensure product infrastructure wash down water is captured and not released to the surrounding environment. • Monitor erosion and install erosion protection (i.e., rock armouring and dune vegetation) if required. Rehabilitate: • A MCP will be required under the *Mining Act 1978* for most of the Proposal. An Interim MCP (Appendix BB) has been developed for the Proposal and will continue to evolve during the life of the Proposal. If the Proposal receives Ministerial Approval under Part IV of the EP Act as well as under the EPBC Act, the Interim MCP will be developed in more detail and submitted to DMIRS for approval as required by the *Statutory Guidelines for MCPs under the Mining Act 1978* - DMIRS (2020b). • The natural loss of mangroves and algal mat after approximately 50 years, due to sea level rise is predicted occur with or without the Proposal in place (Seashore Engineering, 2021). However, the Proposal is uniquely positioned to consider the creation of ongoing habitat for algal mat and mangroves as a part of Proposal closure and this will be explored as part of closure planning for the site. The effect of sea level rise will be considered during the closure planning process, and it may be possible to create a "niche" environment for mangroves and/or algal mats which may enable them to continue to exist beyond the currently anticipated timeframe of sea level rise induced mangrove/algal mat loss, by providing physical protection from the effects of sea level rise behind rock armoured embankments. • At the completion of operations, all buildings and structures on land will be removed from the site and the pond areas may be selectively reconnected to the existing tidal flat system. The bitterns discharge infrastructure will be removed from site; however, the jetty may be transferred to the ownership of another user. Alternatively, it could be decommissioned and removed. If ponds are to be reconnected, the MCP will establish which embankments to breach that will enable inwards tidal movement bringing sediments and allowing tidal channels to expand naturally. Natural tidal flows will allow movement of mangrove propagules (seeds) which will passively revegetate the reconnected tidal areas. This will enhance the habitat values of the ponds to BCH and fauna post closure. The effect of sea level rise will be considered during the closure planning process.

Outcomes	Residual Impact: the loss of BCH is considered unlikely to be significant from a broader biological diversity and ecological integrity perspective, this loss of BCH is considered to be significant given it occurs within BIAs or is considered critical habitat for several significant marine fauna species. The Proposal is therefore predicted to result in the following residual impacts that are considered significant, as reflected in the Marine Fauna and Terrestrial Fauna sections:
	• The loss of up to 226.2 ha of nearshore BCH, which may be utilised by species such as turtles, dugong, green sawfish and other elasmobranchs;
	• The loss of the following BCH which may be utilised by Migratory Shorebirds:
	    • 0.99 ha of Sandy Beaches BCH;
	    • 4.28 ha of Mangroves BCH, which may also be utilised by green turtle juveniles;
	    • 17.81 ha of Transitional Mudflat BCH;
	    • 16.68 ha of Algal Mats BCH.
	• The loss of 0.54 ha of tidal creek BCH, which may be utilised by green sawfish and green turtle juveniles.
	Offsets are proposed to counterbalance these significant residual impacts (refer to Section 17).

	Based on the above the Proposal is expected to be able to meet the EPA's objective for this factor. The implementation of the proposed mitigation and offsets are expected to minimise and counterbalance any significant residual impacts to BCH.

Marine Fauna	
Objective	To protect marine fauna so that biological diversity and ecological integrity are maintained.
Policy and guidance	• *A Directory of Important Wetlands in Australia* (ANCA, 1993). • *Approved Commonwealth Conservation Advice on Pristis clavata (Dwarf sawfish)*(TSSC, 2009a) • *Approved Conservation Advice for Aipysurus apraefrontalis (Short-nosed Sea Snake)* (DSEWPaC, 2011a). • *Approved Conservation Advice for Dermochelys coriacea (Leatherback Turtle)* (DSEWPaC, 2008). • *Approved Conservation Advice for Megaptera novaeangliae (humpback whale)* (TSSC, 2015b) • *Approved Conservation Advice for Pristis zijsron (Green Sawfish)* (TSSC, 2008) • *Australian and New Zealand Guidelines for Fresh and Marine Water Quality* (ANZG, 2018) • *Australian Ballast Water Management Requirements* (DAWR, 2017). • *Biofouling Biosecurity Policy* (Department of Fisheries, 2017a). • *Commonwealth Listing Advice on* Aipysurus apraefrontalis *(Short-nosed Seasnake)* (TSSC, 2011b). • *Commonwealth Listing Advice on Pristis* clavate *(Dwarf Sawfish)*. (TSSC, 2009b). • *Conservation Advice Rhincodon typus whale shark* (TSSC, 2015d). • *Conservation Management Plan for the Blue Whale - A Recovery Plan under the Environment Protection and Biodiversity Conservation Act 1999* (Commonwealth of Australia, 2015). • *Environmental Assessment Guideline 5 – Protecting Marine Turtles from Light Impacts* (EPA, 2010). • *Environmental Factor Guideline: Marine Fauna* (EPA, 2016g). • *EPBC Act Environmental Offsets Policy* (Commonwealth of Australia, 2012). • *EPBC Act Policy Statement 2.1 - Interaction between offshore seismic exploration and whales: Industry guidelines (DOEWHA, 2008).* • *Light Pollution Guidelines: National Light Pollution Guidelines for Wildlife Including Marine Turtles, Seabirds and Migratory Shorebirds (DotEE, 2020).* • *Marine Bioregional Plan for the North-West Marine Region* (DSEWPaC, 2012). • *National Assessment Guidelines for Dredging* (Commonwealth of Australia, 2009) • *National Strategy for Mitigating Vessel Strike of Marine Mega-fauna* (DotEE, 2017b) • *Recovery Plan for Marine Turtles in Australia* (Commonwealth of Australia, 2017b) • *Recovery Plan for the Grey Nurse Shark* (*Carcharias taurus*) (Department of Environment, 2014) • *Sawfish and River Sharks Multispecies Recovery Plan* (DotE, 2015a) • *Significant impact guidelines for 36 migratory shorebird species (EPBC Act Policy Statement 3.21) (*DEWHA, 2009a) • *Technical Guidance - Environmental Impact Assessment of Marine Dredging Proposals* (EPA, 2016d). • *Threat abatement plan for predation by feral cats* (DotE, 2015b). • *Threat abatement plan for predation by the European red fox* (DEWHA, 2008c). • *Threat abatement plan for predation, habitat degradation, competition and disease transmission by feral pigs (Sus scrofa)* (DEE, 2017). • *Threat Abatement Plan for the Impacts of Marine Debris on Vertebrate Marine Life* (DEWHA, 2009b) • *Threat Abatement Plan for the impacts of marine debris on the vertebrate wildlife of Australia's coasts and oceans (DEE, 2018)*. • *Vessel Check: Biofouling Risk Assessment Tool* (Department of Fisheries, 2017b). • *WA Environmental Offsets Guidelines* (Government of Western Australia, 2014).

	• *WA Environmental Offsets Policy* (Government of Western Australia, 2011).
Potential impacts	Direct Impact:

Direct Impact:

- It is unlikely that habitat loss resulting from construction and operation of the Proposal (0.4% or less of Exmouth Gulf habitat) will impact the biological diversity and ecological integrity of marine fauna populations and their habitats. However, given the area intersects with several BIAs and critical habitat areas for marine fauna the predicted habitat loss may be considered significant. As such, any habitat loss or associated disturbances in these areas have the potential to negatively impact critical habitat.

Habitat	**Significant Marine Fauna**	**Cumulative Loss (ha)**	**% of LAUs**	**% of Tubridgi to Tent Pt**	**% of East Exmouth Gulf**
Mangroves	Juvenile green turtles	4.28	0.2%	0.12%	0.04%
Tidal Creeks	Green sawfish, Juvenile green turtles	0.54	0.11%	0.06%	0.02%
Soft sediment (nearshore), macroalgae, sparse coral	Turtles, dugong, green sawfish, other elasmobranchs	226.4	4.7% of soft sediment, 5.8% macroalgae, 0.9% macroalgae / sparse coral	2.2%	0.4%
Sandy beach	Turtles (nesting)	0.99	0.7%	0.33%	0.1%
Offshore waters	Humpback whales, dolphins, turtles, elasmobranchs	0	0%	0%	0%
TOTAL		**232.21**			

- The increase in shipping traffic may impact marine fauna, however, the transhipment vessel will be restricted to a maximum speed of 9 knots in the navigation channel. With the implementation of additional mitigation measures and implementation of the Marine Fauna Management Plan (MFMP; Biota, 2022d), impacts due to vessel movements associated with the Proposal are expected to be low.
- The seawater intake will include a screened rock armoured inlet well excavated into the creek bank to reduce the risk of entrapment of floating debris and large fauna. The downward facing intake pipes within the intake well will also be screened. USEPA (2014) recommendations screen water velocity of less than 0.15 metres per second (m/s), for protection of 96% of motile species (concluded from fish swim speeds). The intake pumps mean water velocity has been calculated to operate at 0.11 m/s indicating screen velocity less than 0.15 m/s should be readily achievable (Vortex Australia, 2020).
- Underwater sound modelling was undertaken to determine the distance from activities that marine fauna may experience a temporary reduction in hearing sensitivity (Temporary Threshold Shift - TTS) or permanent reduction in hearing sensitivity (Permanent Threshold Shift - PTS). Soft start procedures will allow marine fauna to move away from the noise source before such thresholds are reached. Piling operations will additionally be undertaken outside key ecological windows for humpback whales (in particular the southern migration September to November) and turtle mating and nesting season (October to January) (AECOM, 2022b and Pendoley Environmental, 2020).

Indirect Impacts:

- The proposed dredging is a relatively small dredging activity which is estimated to take two weeks to complete and produce relatively small, localised and temporary elevated turbidity plumes unlikely to significantly impact marine fauna.
- The risk to Marine Fauna from the bitterns discharge water quality is considered low given the likely avoidance of the area (AECOM, 2022a) and the low risk of bioaccumulation of metals (AECOM, 2022c).Given the relatively low magnitude of light spill from the Proposal, in comparison to the light from other sources, it is considered that the Proposal will not contribute significantly to the overall light climate in the region, and therefore will not raise the risk of significant impacts upon marine fauna (from light spill) to a substantially greater degree than presently exists in the region (AECOM, 2022a and Talis, 2021).

	• The nutrient pathway modelling (Water Technology, 2021d) indicates that the nutrient-related changes are small in proportion to the total estimated nutrient flows into the local catchment and the Exmouth Gulf with impacts to primary and secondary productivity and Marine Fauna unlikely to occur (AECOM, 2022a). • With appropriate mitigation measures in place, Proposal hydrocarbon spills are unlikely to significantly impact marine fauna. • With appropriate mitigation measures in place and the government regulations surrounding Introduced Marine Pests (IMP), the Proposal is unlikely to increase IMP.
Mitigation	Avoid: • Detailed analysis of seawater intake options and locations reducing the seawater intake locations from two (Urala Creek North and South), to only one (Urala Creek South). • Detailed analysis of dredging options and spoil disposal was undertaken. Transhipment is proposed with low draft barges to avoid the need for dredging a long shipping channel to deeper water (avoiding significant disturbance of the seafloor via dredging). The dredged berthing pocket is proposed in a location away from sensitive benthic habitats (such as coral reefs) thereby avoiding impacts to sensitive habitats and associated marine fauna. • There is no requirement for disposal of dredged material at sea avoiding much larger impacts to subtidal marine fauna from elevated turbidity. • It is proposed that bitterns will be discharged via a diffuser positioned such that the mixing zone overlaps with an area of existing high disturbance (dredged berthing pocket) and away from sensitive benthic habitats (coral reef), minimising impacts to sensitive habitats and associated marine fauna. • Throughout the salt production process, no chemicals will be added at any stage of the process avoiding ecotoxicity and bioaccumulation risks to marine fauna. • Uphold noise management zone distances for marine mammals and turtles to avoid the onset of injury and adverse behavioural effects. Minimise: • Implementing appropriate engineering design and project management measures. • Engineering design of the seawater intake pumps mitigate any potential impacts on marine fauna. • Minimise the risk of fatal vessel strikes to marine fauna by implementing appropriate controls. • Minimise potential dredging and piling noise impacts to marine fauna by implementing appropriate controls. • Obtain and comply with a Works Approval and Licence under Part V of the EP Act for solar salt manufacturing (which will include the bitterns disposal) and bulk material loading. These approvals will manage the pollution risks to marine fauna associated with bitterns disposal, product spills and other emissions associated with the process and loading facilities. • Implement the MFMP (Appendix BB). • Implement the DSMP. The DSMP has been provided in Appendix BB and includes a comprehensive set of management actions and environmental performance measures related to marine fauna. • Implement the IMPMMP (Appendix BB). • Implement the MEQMMP (Appendix BB). • Review lighting requirements during detailed design to ensure light spill impacts are minimised. Rehabilitate: • At the completion of the Proposal the site will be rehabilitated to reinstate the Marine Fauna. An Interim MCP (Appendix BB) for the Proposal has been developed and will continue to evolve during the life of the Proposal. If the Proposal receives Ministerial Approval under Part IV of the EP Act as well as under the EPBC Act, the Interim MCP will be developed in more detail and submitted to DMIRS for approval as required by the *Statutory Guidelines for MCPs under the Mining Act 1978* - DMIRS (2020b). • K+S preferred post closure land use is to leave the evaporation ponds in situ so that they become a “wetland” habitat for mangroves, algal mats and associated fauna (including migratory birds which require “wetland areas” for migratory stop over). This will also likely create habitat opportunities for marine fauna.

	• At the completion of operations, all buildings and structures on land will be removed from the site and the pond areas may be selectively reconnected to the existing tidal flat system. If ponds are to be reconnected, the MCP will establish which bunds to breach that will enable inwards tidal movement bringing sediments and allowing tidal channels to expand naturally. Natural tidal flows will allow movement of mangrove propagules (seeds) which will passively revegetate the reconnected tidal areas. This will enhance the habitat values of the ponds to marine fauna post closure. • The bitterns discharge infrastructure will be removed from site; however, the jetty may be transferred to the ownership of another user. Alternatively, it could be decommissioned and removed.
Outcomes	• Residual Impact: K+S has incorporated extensive avoidance and minimisation measures into the Proposal design and operational processes. A key measure was to focus the disturbance footprint further inland on the unvegetated Supratidal salt flats, which has resulted in only a small proportion of the total Proposal footprint occurring within marine fauna habitat. With the implementation of these measures the Proposal will result in the loss of 232.2 ha of marine fauna habitat. This loss of marine fauna habitat is considered to be significant for several significant marine fauna species, particularly when assessed in context with other indirect Proposal impacts. As a summary, the Proposal is therefore predicted to result in the following residual impacts that are considered significant: ○ The loss of up to 226.2 ha of nearshore BCH, which may be utilised by species such as turtles, dugong, green sawfish and other elasmobranchs; ○ The loss of 4.28 ha of mangroves, which may be utilised by green turtle juveniles; ○ The loss of 0.54 ha of tidal creek, which may be utilised by green sawfish and green turtle juveniles; ○ Significant fauna behavioural responses associated with noise, light, water quality and sedimentation; and ○ Potential injury or death associated with the seawater intake, dredging or vessel strike. Offsets are proposed to counterbalance these significant residual impacts.

Flora and Vegetation	
Objective	To protect flora and vegetation so that biological diversity and ecological integrity are maintained.
Policy and guidance	• Environmental Factor Guideline: Flora and Vegetation (EPA, 2016h). • Technical Guidance – Flora and Vegetation Surveys for Environmental Impact Assessment (EPA, 2016i). • Checklist for documents submitted for EIA of proposals that have the potential to significantly impact on Sea and Land factors (EPA, 2016j). • Environmental Protection Bulletin 20 - Protection of naturally vegetated areas through planning and development (EPA, 2013). • Guidance Statement 6 – Rehabilitation of Terrestrial Ecosystems (EPA, 2006). • Statutory Guidelines for MCPs (DMIRS, 2020). • A Directory of Important Wetlands in Australia (ANCA, 1993). • WA Environmental Offsets Policy (Government of Western Australia, 2011). • WA Environmental Offsets Guidelines (Government of Western Australia, 2014). • *National Recovery Plan for Olearia macdonnellensis, Minuria tridens (Minnie Daisy) and Actinotus schwarzii (Desert Flannel Flower).* Department of Natural Resources, Environment, The Arts and Sport, Northern Territory. Available from: http://www.environment.gov.au/resource/national-recovery-plan-olearia-macdonnellensis-minuria-tridens-minnie-daisy-and-actinotus. In effect under the EPBC Act from 13-Nov-2009 (Nano & Pavey, 2008). “Appendix B: Potentially contaminating industries, activities and land uses” in *Assessment and management of contaminated sites: Contaminated sites guidelines* (DER, 2014). • *EPBC Act Environmental Offsets Policy* (Commonwealth of Australia, 2012).
Potential impacts	Cumulative Impact:

- The Proposal will result in direct disturbance (clearing and pond filling) of approximately 1,265 ha of vegetation in mostly very good to excellent condition. This represents approximately 5% of the vegetation within the study area.
- It is predicted that saline seepage and salt crusting will impact 121 ha of vegetation in mostly very good to excellent condition. This represents approximately 0.5% of the vegetation within the study area. No significant flora records occur within the areas of predicted saline seepage or salt crusting
- The Proposal will result in direct and indirect impacts to 1,386 of native vegetation. Of this, at least 333 ha of this vegetation is in Degraded – Poor condition. The remaining 1,053 ha is currently in Good – Excellent condition.

Biota 2022a Vegetation Survey						
Unit Code	Brief Description	Direct Impact (ha)	Indirect Impact (ha)	Cumulative Impact (ha)	Total in Study Area (ha)	% Study Area
B1	Spinifex grassland	-	-	-	16	0.00%
S1	Samphire S1	4.07	-	4.07	414	0.98%
S2	Samphire S2	33.94	0.64	34.58	153	22.59%
S3	Samphire S3	117.94	1.64	119.58	1,150	10.39%
S4	Saline low shrubland/grassland S4	12.83	-	12.83	1,722	0.75%
S5	Saline tall shrubland/grassland S5	-	-	-	15	0.00%
C1	Eucalyptus victrix low woodland C1	0.81	-	0.81	11	7.54%
C2	Eucalyptus victrix low woodland C2	8.34	-	8.34	681	1.22%
C3	Acacia tall shrubland C3	15.48	-	15.48	1,447	1.07%
C4	Acacia tall shrubland C4	0.01	-	0.01	351	0.00%
P1	Acacia tall shrubland P1	682.09	12.77	694.86	8,535	8.14%
P2	Acacia tall shrubland P2	362.67	101.38	464.05	3,526	13.16%
P3	Acacia tall shrubland P3	-	-	-	622	0.00%
P4	Acacia tall shrubland P4	16.51	3.60	20.11	2,801	0.72%
D1	Acacia low open woodland D1	-	-	-	645	0.00%
D2	Acacia low open woodland D1	0.19	-	0.19	340	0.06%
D3	Grevillea, Hakea, Acacia tall open shrubland D3	9.65	1.26	10.91	564	1.94%
D4	Grevillea, Hakea, Acacia tall open shrubland D4	-	-	-	355	0.00%
Total	*Vegetated Areas*	1,264.53	121.29	1385.82	23,346	5.94%
Beard et. al 2013 Pre-European Vegetation Mapping						
Unit Code	Brief Description	Direct Impact (ha)	Indirect Impact (ha)	Total Impacted (ha)	East Exmouth Gulf (ha)	% East Exmouth Gulf
117	Hummock grassland Triodia spp.	1.57	-	1.57	6143	0.03%
589	Short bunchgrass savanna	1,689.73	104.20	1,793.93	78305	2.29%
670	Hummock grassland with scattered shrubs/mallee	451.09	5.91	457.00	119387	0.38%
Total	*Vegetated Areas*	*2,142.39*	*110.11*	*2,252.50*	*203,835*	*1.11%*

- *Minuria tridens*, *Stackhousia clementii* and *Triumfetta echinate* were identified as having a high proportion of their records within the Biota (2022) Study Area within the Development Envelopes. No indirect impacts to significant flora are predicted.
- The vegetation communities to be disturbed are not considered threatened with over 90% of their original extent remaining (Table 74) (Beard et al, 2013). At a local scale all of the vegetation units will have more than 77% of their local extent remaining after the implementation of the Proposal. Therefore, is it unlikely that vegetation loss resulting from the Proposal will impact the biological diversity and ecological integrity of vegetation locally or regionally.

Mitigation

Avoid:

- Impact to vegetation and flora have been avoided by placing most of the Proposal disturbance (salt ponds) on the salt flats which are devoid of vegetation.
- K+S intends to avoid significant flora species records of *Minuria tridens* (with 50 m buffer), *Stackhousia clementii*, and *Triumfetta echinate* during the detailed design of the Proposal.

	• The location of sterile *Tecticornia* species will also be avoided if the single sterile *Tecticornia* species recorded within the development envelope cannot be identified and confirmed that it is not restricted to the development envelope. Minimise: • Reducing the size of the salt ponds has minimised groundwater seepage and salt crust impacts and therefore minimised these effects on vegetation to localised areas. • Design of surface water mitigation measures via modelling (culverts and drainage diversions) (Water Technology, 2021c) has minimised the interruption of surface water flows and will maintain required environmental flows to vegetation surrounding the embankments. • Implement industry best-practice management measures for flora and vegetation. • Obtain and comply with the appropriate approvals. • Avoid any new records of Threatened or Priority Flora identified where practicable. • Consider the *Minuria tridens* record location in the Proposal design as it progresses to ensure as much surrounding habitat is maintained as practicable. • Minimise clearing within P1 and P2 Acacia shrublands vegetation types which may provide habitat for the EPBC Threatened Flora *Minuria tridens*. • Maintain as large a buffer as practicable around significant flora species in order to maintain suitable surrounding habitat. • Monitor the potential changes to tidal inundation regimes. This monitoring will be conducted to verify the model and associated indirect impact assessments. • Design and construct concentrator and crystalliser ponds to be safe and stable according to DMIRS requirements. • Implement appropriate controls to further reduce the risk of impact from unintentional brine pipeline spills. Rehabilitate: • At the completion of the Proposal the site will be rehabilitated to reinstate the flora and vegetation. A MCP will be required under the *Mining Act 1978* for the majority of the Proposal. At the completion of construction all temporary disturbance areas (which may include temporary laydown areas and the fringes of linear infrastructure corridors) will be rehabilitated as outlined within MCP submitted to DMIRS for approval as required by the *Statutory Guidelines for MCPs under the Mining Act 1978* - DMIRS (2020b). An Interim MCP (Appendix BB) for the Proposal has been developed and will continue to evolve during the life of the Proposal. • At the completion of operations, all buildings and structures on land will be removed from the site and rehabilitation of terrestrial vegetation will occur in disturbance area which are unaffected by sea level rise. • Selection of locally endemic native species will ensure that only species which are present locally are used in rehabilitation activities and the aim will be to establish a self-sustaining ecosystem with similar biological diversity and ecological integrity to that which existed prior to Proposal implementation.
Outcomes	Residual Impact: • K+S has incorporated extensive avoidance and minimisation measures into the Proposal design and operational processes. A key measure was to focus the disturbance footprint on the unvegetated Supratidal salt flats, which has resulted in only a small proportion of the total Proposal footprint requiring vegetation disturbance. The Proposal will result in direct and indirect impacts to 1,386 of native vegetation, however at least 333 ha of this vegetation is in Degraded – Poor condition. • The Proposal has also been designed to ensure that impacts to vegetation types are kept to a low percentage of the local extent (all <23%). The Proposal is however predicted to result in the following residual impacts that are considered significant: • Up to 1,053 ha of Good to Excellent quality vegetation, which includes potential habitat for significant flora. • Offsets are proposed to counterbalance these significant residual impacts. • The Proposal includes additional large areas of ponds that contain salts or brine and as such rehabilitation may be impeded for some time post-closure, although the majority of areas affected are salt pans that do not support vegetation. The Proposal is a long-life Proposal with an infinite resource (seawater and solar energy) and therefore closure of the ponds may not occur this century, so consideration of altered ocean hydrodynamics and climate change will be necessary

Terrestrial Fauna	
Objective	To protect terrestrial fauna so that biological diversity and ecological integrity are maintained.
Policy and guidance	• Significant impact guidelines for 36 migratory shorebird species (EPBC Act Policy Statement 3.21) (DEWHA, 2009a). • Survey Guidelines for Australia's Threatened Bats (DEWHA, 2010). • Survey Guidelines for Australia's Threatened Birds (DSEWPaC, 2011b). • Survey Guidelines for Australia's Threatened Mammals (DSEWPaC, 2011c). • Survey Guidelines for Australia's Threatened Reptiles (DSEWPaC, 2011d). • Environmental Factor Guideline: Terrestrial Fauna (EPA, 2016k). • Technical Guidance: Terrestrial fauna surveys (EPA, 2016l). • Technical Guidance: Sampling methods for terrestrial vertebrate fauna (EPA, 2016m). • Technical Guidance - Sampling of short range endemic invertebrate fauna (EPA, 2016n). • Industry guidelines for avoiding, assessing and mitigating impacts on EPBC Act listed migratory shorebird species (DotEE, 2017a). • National Recovery Plan for the Northern Quoll *Dasyurus hallucatus* (Hill & Ward, 2010). • Approved Conservation Advice for *Calidris ferruginea* (Curlew Sandpiper) (TSSC, 2015a). • Approved Conservation Advice for *Limosa lapponica baueri* (Bar-tailed godwit (western Alaskan)) (TSSC, 2016e). • Approved Conservation Advice for *Limosa lapponica menzbieri* (Bar-tailed godwit (northern Siberian)) (TSSC, 2016f). • Approved Conservation Advice for *Numenius madagascariensis* (Eastern Curlew) (TSSC, 2015c). • Commonwealth Conservation Advice on *Sternula nereis* (Fairy Tern) (TSSC, 2011a). • Approved Conservation Advice for *Calidris tenuirostris* (Great knot) (TSSC, 2016b). • Approved Conservation Advice for *Calidris canutus* (Red knot) (TSSC, 2016a). • Approved Conservation Advice for *Charadrius leschenaultii* (Greater sand plover) (TSSC, 2016c). • Approved Conservation Advice for *Charadrius mongolus* (Lesser sand plover) (TSSC, 2016d). • Threat Abatement Plan for Predation by the European Red Fox (DEWHA, 2008c). • Threat abatement plan for predation by feral cats (DotE, 2015b). • Wildlife Conservation Plan for Migratory Shorebirds (DotE, 2015c). • Threat abatement plan for the biological effects, including lethal toxic ingestion, caused by cane toads (DSEWPaC, 2011e). • *Threat Abatement Plan for the incidental catch (or bycatch) of seabirds during oceanic longline fishing operations (Commonwealth of Australia, 2018)*. • Approved Conservation Advice for *Liasis olivaceus barroni* (Olive Python – Pilbara subspecies), (DEWHA, 2008b). • Light Pollution Guidelines: National Light Pollution Guidelines for Wildlife Including Marine Turtles, Seabirds and Migratory Shorebirds (DotEE, 2020). • Listing Advice on Northern quoll (*Dasyurus hallucatus*) (TSSC, 2005) • WA Environmental Offsets Policy (Government of Western Australia, 2011). • WA Environmental Offsets Guidelines (Government of Western Australia, 2014). • "Appendix B: Potentially contaminating industries, activities and land uses" in Assessment and management of contaminated sites: Contaminated sites guidelines (DER, 2014). • EPBC Act Environmental Offsets Policy (Commonwealth of Australia, 2012).

Potential impacts

Direct Impacts

- Vehicle and equipment strike resulting in direct mortality is likely to be rare given:
  - Vehicle speed limits will be enforced.
  - There will be minimal vehicle traffic between ponds, jetty and coastal corridors, therefore risk of vehicle strike on fauna will be relatively low.
  - Direct disturbance of significant fauna habitats such as mangroves, bare intertidal / transitional mudflats, sandy beaches and isolated mainland remnant "islands" have been minimised, with the majority of the disturbance (88.6%) occurring on unvegetated Supratidal salt flats, which provide minimal fauna habitat value.
  - The Ashburton River crossing will be designed to allow fauna to pass underneath, minimising the likelihood of fauna crossing the road.
- Entrapment and collision associated with trenches, borrow pits and fences is considered unlikely given no trenches are required, borrow pit clearing will be commenced slowly in one direction allowing fauna to escape clearing activities and fencing will not be installed until the completion of construction and only around the administration and processing complex. The concentrator and crystalliser ponds will have low embankments with shallow walls and therefore any fauna that enter the ponds are expected to be able to climb out.
- There is evidence of power lines presenting a collision risk for birds, with shorebirds at Rottnest Island having been observed colliding with overhead powerlines between Salt Lake foraging areas (Birds Australia 2010; Stevenson 2011). Power supply is to be provided by a third-party and does not form part of this Proposal, however the power line route will be inland from key shorebird habitats and therefore it is likely that shorebirds would only cross the power line route on rare occasions.

Indirect Impacts

- The Proposal does not provide any significant vectors for increases in introduced fauna species; the accommodation camp will be relatively small, and there are no other Proposal activities that would either attract introduced fauna species or aid their survival in the area.
- Seepage from the ponds is not expected to impact fauna habitat as only small amounts of seepage is predicted, and the groundwater is already hypersaline. Pipelines will utilise industry-standard materials to minimise the chance of leaks, and ponds have been designed with adequate freeboard and overflow features to minimise the risk of unplanned overflows and wall breaches.
- Construction of the Proposal will result in relatively low levels of noise as most of the works will be conducted in narrow strips on soft mudflats (for the pond walls). Minimal night works are expected during pond construction given the difficult terrain.
- Waste will be minimised by adopting the hierarchy of waste controls; avoid, minimise, re-use, recycle and safe disposal. Food wastes will be stored in bins that are not easily accessible to fauna and disposed of appropriately at the onsite landfill, which will be licenced under Part V of the EP Act.
- It is likely that the Proposal if constructed will provide important new habitat for migratory shorebirds within the ponds.

Cumulative Impact:

- Predicted cumulative impact to significant fauna habitat is proportionally small, representing 4.27% of such habitat locally and 0.66% regionally. Both direct disturbance and Indirect impacts of saline groundwater seepage and salt crusting have been included in the cumulative impacts below.

Significant Fauna Habitat	Direct Impact (ha)	Indirect Impact (ha)	Cumulative Impact (ha)	Local (ha)	Region (ha)	% of Local	% of Region
Mangroves: Northern Coastal Free-tailed Bat (Abundance Moderate), Roosting migratory birds (Abundance Low)	4.23	0.34	4.57	3,724	11,742	0.12%	0.04%
Transitional mudflat: Foraging migratory birds (Abundance High)	17.78	-	17.78	7,990	20,747	0.22%	0.09%
Sandy beaches: Roosting migratory birds (Abundance High)	0.99	-	0.99	298	1,040	0.33%	0.10%
Ashburton riparian zone: Olive Python and Northern Quoll (Abundance Low)	0.53	-	0.53	266	580	0.20%	0.09%
Plains along the Ashburton River: Foraging Northern Quoll (Abundance Low)	67.00	-	67.00	19,583	181,427	0.34%	0.04%

Hinterland sand/clay plain: Short-tailed Mouse (Abundance Low – Moderate)	610.19	116.85	727.04			3.71%	0.40%
Isolated mainland remnant islands: Mygalomorph Spiders (Abundance Low – Moderate)	751.05	25.24	776.29	5,715	11,478	13.58%	6.76%
Algal mats: Foraging migratory birds (when inundated - abundance unknown)	12.77	3.92	16.69	6,199	11,617	0.27%	0.14%
Freshwater claypans: Invertebrates (Abundance High After Flood), Foraging migratory birds (when inundated - abundance unknown)	65.30	3.91	69.21	1,416	23,614	4.89%	0.29%
Total	1,517.07	146.34	1,663.41	38,992	250,628	4.27%	0.66%

- It is noted that direct and indirect impacts to important habitat for listed fauna species is considered significant. These impacts are summarised below:
  - Northern Coastal Free-tailed Bat (Priority 1) – 4.57 ha of Mangroves habitat;
  - Migratory Sea / Shorebirds (including Threatened Sea / Shorebirds) – 109.24 ha of known and potential habitat, including:
    - 0.99 ha of Sandy Beaches habitat;
    - 4.57 ha of Mangroves habitat;
    - 17.78 ha of Transitional Mudflat habitat;
    - 16.69 ha of Algal Mats habitat;
    - 69.21 ha of Freshwater Claypan habitat;
  - Pilbara Olive Python – 0.53 ha of River bank / creekline / drainage habitat on the Ashburton River;
  - Northern Quoll – 0.53 ha of River bank / creekline / drainage habitat on the Ashburton River and 67.00 ha of surrounding foraging habitat;
- Hinterland sand/clay plain habitats utilised by the Short-tailed Mouse (Priority 4) (low – moderate abundance) are widespread and the Proposal is predicted to impact only 3.7% of the local extent of this habitat.
- Habitat for terrestrial SRE species (Isolated mainland remnant islands) are also widespread (5,715 ha local extent). Only one potential terrestrial SRE species was recorded within the development envelope. This species was also recorded outside the development envelope, which demonstrates that its local extent extends beyond the development envelope.
- Aquatic invertebrate habitats (Freshwater claypans habitat) are also widespread, and the Proposal is predicted to impact 4.9% of the local extent of these habitats. K+S acknowledges however that the claypans have not been extensively surveyed when inundated, and therefore there remains the potential for a species to be restricted to a portion of habitat that is intended to be disturbed. To avoid this risk K+S will undertake additional surveys within claypan areas when they are inundated prior to construction to confirm that there are no species restricted to the proposed disturbance areas.

Mitigation

Avoid:

- Impacts to fauna habitat have been avoided by placing most of the Proposal disturbance (salt ponds) on the bare salt flats which are devoid of vegetation and other valuable habitat features.
- K+S will ensure that the Proposal avoids the local loss of any aquatic invertebrate species. K+S will commission additional aquatic invertebrate surveys of freshwater claypan habitat that intersects with proposed disturbance areas. These surveys will be conducted prior to construction during a period of inundation to ensure they obtain adequate results. If any aquatic invertebrate species are recorded as being restricted to only the proposed disturbance areas, then the freshwater claypan habitat(s) where the species was recorded will be avoided and alternate borrow sources will be found.

Minimise:

- Implement industry best-practice management measures for fauna:
- Obtain and comply with the appropriate approvals.
- Develop and implement the WMP (Appendix BB)
- Develop and implement a BCH health monitoring program. The monitoring is to be conducted over the life of the Proposal. If indirect impacts are noted to have occurred then investigate potential corrective actions, such as alterations of tidal or freshwater inundation flows;

	• Verify inundation modelling results after construction to ensure potential indirect impacts to coastal habitats is within predicted outcomes. • Conduct annual migratory shorebird surveys within the study area. The annual surveys will be conducted in a similar manner to the targeted survey conducted by Biota (2022) and will provide information regarding long-term changes in the numbers, species and distributions of migratory shorebirds utilising the study area; • Record the usage of the concentrator and crystalliser ponds by fauna species. Incorporate these areas into the annual migratory shorebird survey if shorebird species are noted to utilise the ponds; • Record any fauna entrapment within the ponds as an incident and review whether additional egress mechanisms should be installed; • Concentrator and crystalliser ponds will be designed and constructed to be safe and stable according to DMIRS requirements; • Appropriate controls will be used to further reduce the risk of impact from unintentional brine pipeline spills. • Implement the Fauna Management Plan provided in Appendix BB. Rehabilitate: • At the completion of the Proposal the site will be rehabilitated to reinstate the terrestrial fauna. A MCP will be required under the *Mining Act 1978* for most of the Proposal. At the completion of construction all temporary disturbance areas (which may include temporary laydown areas and the fringes of linear infrastructure corridors) will be rehabilitated as outlined within MCP submitted to DMIRS for approval as required by the *Statutory Guidelines for MCPs under the Mining Act 1978* - DMIRS (2020b). • At the completion of operations, all buildings and structures on land will be removed from the site and rehabilitation of terrestrial vegetation will occur in disturbance area which are unaffected by sea level rise. • Selection of locally endemic native species will ensure that only species which are present locally are used in rehabilitation activities and the aim will be to establish a self-sustaining ecosystem with similar biological diversity and ecological integrity to that which existed prior to Proposal implementation. • An Interim MCP has been developed for the Proposal and will continue to evolve during the life of the Proposal. If the Proposal receives Ministerial Approval under Part IV of the EP Act as well as under the EPBC Act, the MCP will be developed in more detail and submitted to DMIRS for approval as required by the *Statutory Guidelines for MCPs under the Mining Act 1978* - DMIRS (2020b).

Outcomes	Residual Impact:
	• The Proposal is predicted to result in the following residual impacts that are considered significant:
	  ○ 109.24 ha of confirmed and potential habitat for Migratory Shorebirds (including several Threatened species), including:
	    ▪ 0.99 ha of Sandy Beaches habitat;
	    ▪ 4.57 ha of Mangroves habitat (which also provides habitat for the Northern Coastal Free-tailed Bat (Priority 1);
	    ▪ 17.78 ha of Transitional Mudflat habitat;
	    ▪ 16.69 ha of Algal Mats habitat;
	    ▪ 69.21 ha of Freshwater Claypan habitat;
	  ○ 0.53 ha of River bank / creekline / drainage habitat on the Ashburton River that provides potential habitat for the Pilbara Olive Python and Northern Quoll
	  ○ 67.00 ha of surrounding Northern Quoll foraging habitat.

<table>
<tr><th colspan="2">Terrestrial Environmental Quality</th></tr>
<tr><td>Objective</td><td>To maintain the quality of land and soils so that environmental values are protected.</td></tr>
<tr><td>Policy and guidance</td><td>

Environmental Factor Guideline: Terrestrial Environmental Quality (EPA, 2016o).
Acid Sulfate Soil Guideline Series: Identification and investigation of acid sulfate soils and acidic landscapes (DER, 2015a)
Acid Sulfate Soil Guideline Series: Treatment and management of soils and water in acid sulfate soil landscapes (DER, 2015b)
National Acid Sulfate Soils Guidance (Water Quality Australia, 2018)
Draft Guidance: Materials Characterisation Baseline Data Requirements for Mining Proposals (DMP, 2016).

</td></tr>
<tr><td>Potential impacts</td><td>
Direct Impacts

Potential contaminants could include salt product, bitterns, hydrocarbons and general site wastes. With appropriate mitigation these impacts should not occur. Therefore, the approach for this development is that spills and contamination are avoided and if they occur accidentally, they will be managed through appropriate planning and management measures.
Sulfidic material was encountered on site within the supratidal flats, creek mudflats and lower lying regions of the Proposal area as well as the berthing pocket dredging location (GHD, 2021a).
A number of infrastructure areas requiring excavation will require acid sulfate soils/sediment (ASSS) treatment as outlined below (GHD, 2021a)

<table>
<tr><th>Infrastructure</th><th>Treatment Required</th></tr>
<tr><td>Jetty Berthing Pocket</td><td>Marine sediment sampling indicates likely to be acid generating. Will be contained and treated in land disposal area.</td></tr>
<tr><td>Borrow Pit 3 & 4 and Drainage Diversions</td><td>Likely to be acid generating at depth, however surface soils may have completed previous oxidation and leaching cycles resulting in lower risk. Further sampling will be conducted to confirm prior to excavation.</td></tr>
<tr><td>Pond External Walls</td><td>Materials will require confirmatory testing to ascertain acid generating potential prior to re-use.</td></tr>
<tr><td>Seawater Intake Inlet Well</td><td>Creek sediment sampling indicates likely to be acid generating. Will be contained and treated within intake channel, which will not be connected to the marine environment.</td></tr>
</table>

An ASSSMP has been developed for the Proposal – Appendix BB (GHD, 2021b).

Indirect Impacts

The effects of saline seepage and salt crust to terrestrial vegetation and BCH are localised and proportionally small with these processes impacting: (AECOM, 2022a) (Biota, 2022a) (Biota, 2022b):

3.92 ha of algal mat (0.03% of algal mat of East Exmouth Gulf).
2.28 ha of samphire (0.06% of local samphire).
119 ha of acacia shrubland/woodland (0.7% of similar vegetation in the study area)
3.91 ha of claypan (0.017% of claypan of East Exmouth Gulf).

Naturally occurring geochemical and physical soil properties which may have environmental or employee health impacts and will be managed and assessed under other regulatory processes (DMIRS, 2020a) (DMIRS, 2020b) (DMP, 2012).

</td></tr>
<tr><td>Mitigation</td><td>
Avoid:

Detailed analysis of seawater intake options and locations was undertaken reducing the seawater intake locations from two (Urala Creek North and South), to only one (Urala Creek South), reducing disturbance of potentially acid forming mudflat areas.
Throughout the salt production process, no chemicals will be added at any stage of the process avoiding the spillage of chemical additives.
The majority of the disturbance associated with infrastructure will be located within the elevated regions of the site. Typically, these higher elevated areas are between 5 and 10 m Australian Height Datum (AHD) and consist of calcareous materials such as calcarenite gravel, coral and shell fragments and present a low risk of oxidation during disturbance and have significant natural buffering ability.
Borrow pits 1 and 2 are located in elevated areas and do not present a risk of ASS disturbance.
No excavation will be required for the seawater intake channel. Its embankment will be built on top of mudflat areas, avoiding the disturbance of ASS.
All access roads will be constructed on built-up embankments of imported material and therefore require no excavation or a risk of ASS disturbance.

</td></tr>
</table>

	• The conveyor system will be constructed on a built-up embankment with culverts located underneath to convey surface water flows. The embankment will be constructed on top of the natural ground surface and composed of imported material - there will be no excavation required for the conveyor or the culverts which avoids potential disturbance of ASS. Minimise: • The area and volume of sediment to be dredged was minimised to 0.7 ha and 17,000 m^3 minimising associated ASS risks. • Dredged spoil will be disposed of onshore. • The excavation of the seawater intake inlet well, will be managed in accordance with the ASSMP (GHD, 2021b) so that spoil is contained and treated with no discharge of decant water: • Further testing for ASS will be undertaken in the following proposed excavation areas to confirm acid generation potential and if acid generating potential exists, spoil will be managed in accordance with the ASSSMP. • Appropriate erosion protection will be implemented in the location of coastal dune disturbance (geological unit Qs) at the site of the conveyor and jetty, such as rock armouring and dune revegetation. • Further testing of materials (soils/borrow) will be undertaken prior to disturbance of the geological units and appropriate management plans developed for any potential impacts (to be approved by DMIRS under other regulatory processes). • A range of management plans will be developed to prevent, mitigate and remediate accidental spills or inappropriate waste disposal. • To manage any disturbance of sulfidic material within the supratidal salt flats, mudflats, lower lying ground and dredging area and ensure appropriate management of spoil from these areas, an ASSSMP has been developed – Appendix BB (GHD, 2021b). • Implement the DSMP (Appendix BB). • Implement the MEQMMP (Appendix BB). • Implement the WMP (Appendix BB). • Management plans and measures to manage naturally occurring properties of materials which may affect the environment, workforce health or rehabilitation as required under the appropriate approvals. Rehabilitate: • At the completion of operations, all buildings and structures on land will be removed from the site. • Selection of topsoil and suitable growth media for rehabilitation activities will take into consideration susceptibility to erosion (i.e., piping and dispersion) and other factors that may be prohibitive to plant growth such as high salinity as measured through EC/TDS and toxicity (e.g., AASS, PASS and heavy metal toxicity typically under acidic conditions) (GHD, 2021b) (GHD, 2021d). • Soils suitable for rehabilitation activities have been identified (GHD, 2021d). • All potential sources of ongoing contamination (bitterns, bitterns pond, crystallisers, salt stockpiles) will be removed and rehabilitated. • An Interim MCP has been developed for the Proposal and will continue to evolve during the life of the Proposal. If the Proposal receives Ministerial Approval under Part IV of the EP Act as well as under the EPBC Act, the MCP will be developed in more detail and submitted to DMIRS for approval as required by the *Statutory Guidelines for MCPs under the Mining Act 1978* - DMIRS (2020b).
Outcomes	Residual Impact: With the implementation of mitigation, K+S considers that the Proposal is able to be implemented without any significant residual impacts to this factor.

Hydrological Processes	
Objective	To maintain the hydrological regimes of groundwater and surface water so that environmental values are protected.
Policy and guidance	• Environmental Factor Guideline: Hydrological Processes (EPA, 2016q). • Australian groundwater modelling guidelines (Waterlines Report Series No. 82) (Barnett et al., 2012). • Operational Policy 5.12 - Hydrogeological reporting associated with a groundwater well licence (DoW, 2009). • Rights in Water and Irrigation Act 1914. • Western Australia water in mining guideline (Water licensing delivery report series: Report No. 12) (DoW, 2013). • A Directory of Important Wetlands in Australia (ANCA, 1993). • WA Environmental Offsets Policy (Government of Western Australia, 2011). • WA Environmental Offsets Guidelines (Government of Western Australia, 2014).

Potential impacts	Direct Impact:
	• The Proposal will create direct disturbance of 11,990 ha (~120 square kilometres (km^2)) of land predominantly on the supratidal salt flats which will excise a proportionally small area of the local and Ashburton River catchments (1.7% of the local catchment and 0.2% of the Ashburton River Catchment).
	Indirect Impacts:
	• The proposed development will locally alter minor surface water flows; however, these impacts are mitigated by locating Proposal infrastructure outside major flow paths and implementing mitigation strategies, which include culverts, levees and drainage diversion channels (Water Technology, 2021c).
	• The effects of the Proposal on radial groundwater movement, water logging and seepage are localised to the immediate vicinity of the pond infrastructure (GHD, 2021c). Impacts to the surrounding environment are predicted to be localised and proportionally small as summarised below:
	  ○ No impact to mangroves.
	  ○ 3.92 ha of algal mat (0.03% of algal mat of East Exmouth Gulf).
	  ○ 2.28 ha of samphire (0.06% of local samphire).
	  ○ 119 ha of acacia shrubland/woodland (0.7% of similar vegetation in the study area)
	  ○ 3.91 ha of claypan (0.017% of claypan of East Exmouth Gulf).

Mitigation	Avoid: • The Proposal has been positioned to prevent interference with the major flow paths of Yannarie and Ashburton Rivers and thereby maintain the connectivity of the salt flats and the coast. • Eight iterations of the pond design have been undertaken to minimise the footprint. Alignment of the western boundary of concentration ponds was moved further east to avoid groundwater seepage and salinity related impacts to mangroves. Minimise: The following strategies have been adopted to minimise hydrological impacts: • Locate key infrastructure areas outside the 2% Annual Exceedance Probability (AEP) (~1 in 50 year average recurrence interval (ARI)) flood zone where possible. • Divert flows around key infrastructure areas that intersect flow paths. • Divert flows back onto natural flow paths. • Ensure full conveyance of 10% AEP surface water flows under the main access road into site. • Ensure surface water flows into downstream receptors are not impeded by proposed infrastructure. • Protect infrastructure that falls outside of direct flow paths, but which is within the 2% AEP flood zone. • Culvert locations and sizes were identified for the main access road and conveyor embankment to maintain flow connectivity.

	• Drainage diversions were also designed to remove floodwaters from the salt flats Eastern Basin, along a series of salt flat basins to maintain connectivity with the salt flats.
	• Two management plans are planned to be developed at the final design stage. Given the limited scale of impacts to surface water and groundwater K+S considers that these management plans are not critical to the initial assessment phase of the Proposal and were not required by the ESD. A description of these plans is provided below:
	  ○ To ensure the surface water strategies are adequately implemented at the final design stage a detailed Surface Water Management Plan (SWMP) will be developed prior to construction. The SWMP will be completed following detailed design to ensure all measures to minimise impacts to surface water flow have been implemented.
	  ○ A Groundwater Monitoring and Management Plan (GWMMP) will be implemented to ensure that groundwater seepage and mounding impacts are monitored and managed to ensure they do not exceed the extent predicted in this ERD.
	Rehabilitate:
	• At the completion of the Proposal the site will be rehabilitated to reinstate hydrological processes.
	• At the completion of operations, all buildings and structures on land will be removed from the site and the pond areas may be selectively reconnected to the existing tidal flat system. K+S preferred post closure land use is to leave the evaporation ponds in situ so that they become fauna habitat for shore birds (including migratory birds which require "wetland areas" for migratory stop over).
	• Consideration will be given to the removal of specific culverts, levees and diversion channels as required to reconnect the groundwater and surface water hydrological regime in areas modified by the Proposal.
	• An Interim MCP has been developed for the Proposal and will continue to evolve during the life of the Proposal. If the Proposal receives Ministerial Approval under Part IV of the EP Act as well as under the EPBC Act, the MCP will be developed in more detail and submitted to DMIRS for approval as required by the *Statutory Guidelines for MCPs under the Mining Act 1978* - DMIRS (2020b).

Outcomes	Residual Impact: Detailed technical assessments have developed a comprehensive understanding of the hydrological processes both regionally and locally including surface flow and groundwater systems and the potential impacts associated with the Proposal were found to be localised in the vicinity of the Proposal and proportionally small on a regional basis. While impacts were deemed to not be extensive during modelling, monitoring and management plans will be developed at the detailed design phase to ensure impacts are within modelled predictions and to inform management measures. Given the minor nature of the direct and indirect impacts from the development on hydrological processes the residual impacts to this factor are not considered to be significant

Inland Waters Environmental Quality	
Objective	To maintain the quality of groundwater and surface water so that environmental values are protected.
Policy and guidance	• Environmental Factor Guideline: Inland Waters Environmental Quality (EPA, 2016p). • Environmental Factor Guideline: Hydrological Processes (EPA, 2016q). • Acid Sulfate Soil Guideline Series: Identification and investigation of acid sulfate soils and acidic landscapes (DER, 2015a) • Acid Sulfate Soil Guideline Series: Treatment and management of soils and water in acid sulfate soil landscapes (DER, 2015b) • Australian and New Zealand Guidelines for Fresh and Marine Water Quality (ANZG, 2018) • Australian groundwater modelling guidelines (Waterlines Report Series No. 82) (Barnett et al., 2012). • Rights in Water and Irrigation Act 1914. • State Water Quality Management Strategy No. 6: Implementation Framework for Western Australia for the Australian and New Zealand Guidelines for Fresh and Marine Water Quality and Water Quality Monitoring and Reporting (Guidelines Nos. 4 & 7: National Water Quality Management Strategy) (Report No. SWQ 6) (Government of Western Australia, 2004). • Western Australia water in mining guideline (Water licensing delivery report series: Report No. 12) (DoW, 2013).

	• "Appendix B: Potentially contaminating industries, activities and land uses" in Assessment and management of contaminated sites: Contaminated sites guidelines (DER, 2014).

Potential impacts	Direct Impact:
	• A range of management plans will be developed to prevent, mitigate and remediate accidental spills or inappropriate waste disposal.
	• To manage any disturbance of sulfidic material within the supratidal salt flats, mudflats, lower lying ground and dredging area and ensure appropriate management of spoil from these areas, an ASSSMP has been developed – Appendix BB (GHD, 2021b).
	• Erosion, scouring or disturbance of sodic and/or dispersive soils could cause increased turbidity and sediment loading of surface waters. Appropriate engineering controls will be applied to prevent erosion and scour including geofabric, rock armouring and revegetation. Appropriate management of sodic/dispersive soils will occur during construction and operations and approval sought under other regulatory processes requiring materials characterisation and management (DMIRS, 2020a) (DMIRS, 2020b).
	Indirect Impacts:
	• Highly conservative modelling predicted a local post-development proportional reduction in nitrogen flows into the Proposal catchment of 0.8% of land and ocean sources and unlikely to impact surrounding ecosystems (Water Technology, 2021d).
	• Tidal inundation modelling outputs show that, due to the alignment of salt pond outer levees being located well landward (> 800 m) of the mangrove zone there is not expected to be any significant modifications to tidal flows, therefore the tidally moderated salinity levels within shallow groundwater beneath the mangroves is expected to be unaffected by the Proposal (Water Technology, 2022b) (AECOM, 2022a).
	• Modelling indicates that the halo of increased salinity groundwater propagating radially from the ponds, is unlikely to reach most of the mangrove zone which is >800 m from the salt ponds. Any increase in salinity that does occur below the minor tidal sub-creeks which are closest to the salt ponds, will be likely effectively moderated by tidal flushing resulting in fresher layer of tidal water occurring in the shallow groundwater tapped by the mangrove roots (AECOM, 2022a) (GHD, 2021c)
	• The effects of groundwater seepage (surface expression) are localised to the immediate vicinity of the pond. Saline seepage and salt crust will have no credible impact to salt flat areas which already have a thick salt crust. The impacts of groundwater seepage and associated salt crusting to other habitats are proportionally small and localised with the following areas predicted to be affected (AECOM, 2022a) (Biota, 2022a) (Biota, 2022b):
	  ○ 3.92 ha of algal mat (0.03% of algal mat of East Exmouth Gulf).
	  ○ 2.28 ha of samphire (0.06% of local samphire).
	  ○ 119 ha of acacia shrubland/woodland (0.7% of similar vegetation in the study area)
	  ○ 3.91 ha of claypan (0.017% of claypan of East Exmouth Gulf).

Mitigation	Avoid: • Eight iterations of the pond design have been undertaken to minimise the footprint. Alignment of the western boundary of concentration ponds was moved further east to avoid seepage and salinity related impacts to mangroves. • The Proposal is located largely in the supratidal zone, resulting in minimal interference of tidal inundation which plays an important role in moderating shallow groundwater salinity important for mangroves. • A range of measures to avoid impacts related to acid sulphate soils and sediment within the ASSSMP. Minimise: • Surface water engineering mitigation measures (culverts and drainage diversions) have been designed to maintain connectivity of the local and regional surface water flow paths, thereby minimising impacts to overland nutrient pathways. • Appropriate engineering controls will be applied to prevent erosion and scour including geofabric, rock armouring and revegetation. • The area and volume of sediment to be dredged was minimised to 0.7 ha and 17,000 m^3 minimising ASS risks associated with the onshore disposal of dredge spoil. • Dredged spoil will be disposed of onshore.

	• The excavation of the seawater intake inlet well, will be managed in accordance with the ASSSMP (GHD, 2021b; Appendix BB) so that spoil is contained and treated with no discharge of decant water. • Further testing for ASS will be undertaken in the following proposed excavation areas to confirm acid generation potential and if acid generating potential exists, spoil will be managed in accordance with the ASSSMP. • Appropriate erosion protection will be implemented in the location of coastal dune disturbance (geological unit Qs) at the site of the conveyor and jetty, such as rock armouring and dune revegetation. • Further testing of materials (soils/borrow) will be undertaken prior to disturbance of the geological units and appropriate management plans developed for any potential impacts (to be approved by DMIRS under other regulatory processes). • Detailed management strategies will be developed to prevent, mitigate and remediate accidental spills or inappropriate waste disposal. • To manage any disturbance of sulfidic material within the supratidal salt flats, mudflats, lower lying ground and dredging area and ensure appropriate management of spoil from these areas, an ASSSMP has been developed – Appendix BB (GHD, 2021b). • Implement the DSMP (Appendix BB). • Implement the MEQMMP (Appendix BB) which encompasses both marine and intertidal areas. • Implement the WMP (Appendix BB). • Management plans and measures to manage naturally occurring properties of materials which may affect the environment, workforce health or rehabilitation as required under the appropriate Approvals. Rehabilitate: • At the completion of the Proposal the site will be rehabilitated to reinstate the inland waters environmental quality. • At the completion of operations, all buildings and structures on land will be removed from the site and the pond areas may be selectively reconnected to the existing tidal flat system. • Consideration will be given to the removal of specific culverts, levees and diversion channels as required to reconnect the groundwater and surface water in areas modified by the Proposal. All potential sources of ongoing contamination (bitterns, bitterns' pond, crystallisers, salt stockpiles) will be removed and rehabilitated. • An Interim MCP has been developed for the Proposal and will continue to evolve during the life of the Proposal. If the Proposal receives Ministerial Approval under Part IV of the EP Act as well as under the EPBC Act, the MCP will be developed in more detail and submitted to DMIRS for approval as required by the *Statutory Guidelines for MCPs under the Mining Act 1978* - DMIRS (2020b).
Outcomes	Residual Impact: The Proposal does not include any direct / intentional impacts to inland waters environmental quality, however without appropriate mitigation the Proposal may result in the disturbance of ASS and spillages of product, brine, waste or hydrocarbons that could impact this factor. With the implementation of mitigation, K+S considers that the Proposal is able to be implemented without any significant residual impacts to this factor.

Social Surroundings	
Objective	To protect social surroundings from significant harm.
Policy and guidance	• Environmental Factor Guideline: Social Surroundings (EPA, 2016r). • Guidance Statement 41 – Assessment of Aboriginal Heritage (EPA, 2004). • Aboriginal Heritage - Due Diligence Guidelines (Version 3.0) (DAA and DPC, 2013). • *Aboriginal Heritage Act 1972* (WA) (AH Act) and *Aboriginal Cultural Heritage Act 2021* (WA) (ACH Act).
Potential impacts	Direct Impacts • The proposed disturbance of areas which may contain Aboriginal heritage sites (Archae-aus, 2020) is proportionally small in the study area (5.24% of high likelihood areas and 0.34% of medium likelihood areas).

	• Whilst Aboriginal heritage sites will be disturbed, consultation will occur with the Thalanyji people and their representative BTAC on minimising and mitigating the impacts of disturbance as far as practicable. Appropriate approvals to undertake disturbance will be sought under AH Act or ACH Act.
	• Disturbance of habitats with cultural associations for Thalanyji people (BTAC, 2021b) is proportionally small in relation to surrounding similar habitats as follows:
	    o Mangroves: 4.57 ha (0.85% locally and 0.04% regionally).
	    o Transitional Mudflats 17.78 ha (0.9% locally and 0.09% regionally).
	    o Beaches: 0.99 ha (0.78% locally and 0.1% regionally).
	    o Tidal Creeks: 0.56 ha (0.19% locally and 0.02% regionally).
	    o Subtidal Habitat: 8.68 ha (0.17% locally and 0.008% regionally).
	• No disturbance of European heritage sites will occur.
	Indirect Impacts:
	• The area of habitat within the seawater intake area of influence (including both the nearshore habitat and creek habitat) (Water Technology, 2018) is proportionally low compared to the entire nursery habitat of the EGPMF (approximately 0.39% of the nursery area). On this basis it is unlikely that a significant proportion of the prawn population available for commercial harvest will be removed by the seawater intake.
	• Jetty construction, bitterns discharge, dredging, underwater sound, artificial lighting and alteration of nutrient pathways are considered unlikely to significantly impact the prawn fisheries given their limited interface with the marine environment in comparison to the large extent of the prawn fisheries.
	• K+S commissioned Water Technology to undertake an agent-based modelling (ABM) study to assess the potential impacts of the intake and outfall on prawn populations in Exmouth Gulf. This study has been a collaborative effort with extensive stakeholder engagement with participants from DPIRD, MG Kallis and Murdoch University. The results of this prawn modelling exercise are intended to be provided to DPIRD as the managers of the fisheries and will be provided to the EPA to inform this assessment.
	• It is considered that the frequency of transhipper and ocean-going vessel movements will be low and unlikely to impact recreational or commercial vessel movements in the area.
	• The Proposal will not prevent access by the community to local waters by boat, except for the Port Marine Boundary which is localised and proportionally small compared to surrounding available marine waters.
	• The Proposal is not expected to impact recreation in the wider area, given its limited interface with the Exmouth Gulf and relatively low number of vessel movements.
	• Given the relatively low magnitude of light spill from the Proposal, in comparison to the light from other sources, it is considered that the Proposal will not contribute significantly to the overall light climate in the region, and therefore will not raise impacts from light spill to a substantially greater degree than presently exists.
	• The Proposal will result in minimal dust and noise during construction as most of the works will be conducted in narrow strips on soft mudflats (for the pond walls).
	• Management measures will be in place for noise and dust, and these will be further assessed during the works approval and licencing process under Part IV of the EP Act. The Proposal is located within a remote location, with the nearest sensitive receptor (Urala Homestead) approximately 8 km away. Therefore, dust, noise and visual amenity impacts to community are unlikely to be significant.

Mitigation	Avoid: • K+S will meet its obligations under the AH Act or ACH Act. • K+S will engage with BTAC for an agreed programme for the undertaking of archaeological and ethnographic surveys, which will occur prior to any ground disturbing works, to be undertaken with BTAC. • Wherever possible works will avoid disturbance of Aboriginal Heritage Sites. • Eight iterations of the pond design have been undertaken to minimise the footprint.

	• Proposal design measures have been implemented to avoid impacts to benthic habitats with cultural associations for Thalanyji people. • Disturbance of European Heritage Sites will not occur. Minimise: • BTAC and K+S are finalising a Project Agreement and Indigenous Land Use Agreement (ILUA). • Where it is not possible to avoid disturbance of Aboriginal sites, consultation will occur with the Thalanyji people on minimising disturbance and mitigating the impacts of disturbance as far as practicable and appropriate approvals to undertake disturbance will be sought under the AH Act or ACH Act. • K+S will work with the Thalanyji people and their representative BTAC on maintaining existing cultural associations with the environment during Proposal construction and operations (subject to safety requirements). • The Proposal will include defined access points across (under) the product conveyor to allow free land access to areas north of the Proposal. • The location and design of the Proposal minimises its interface with the Exmouth Gulf thereby minimising impacts to commercial fisheries and recreational users. Nevertheless, K+S will continue to liaise with commercial and recreational fishing groups to ensure impacts are minimised over the life of the Proposal. • The location and design of the Proposal minimises the social impacts of access restrictions, visual amenity, anthropogenic light pollution, noise and dust. K+S will record any complaints or incidences associated with these potential impacts and implement measures as required to minimise the likelihood or re-occurrence. Rehabilitate: • At the completion of the Proposal the site will be rehabilitated to reinstate the natural environment and pre-development social surroundings. • At the completion of operations, all buildings and structures on land will be removed from the site and the pond areas may be selectively reconnected to the existing tidal flat system. • Consultation has occurred with the Shire of Ashburton and the Thalanyji people on end land use and such consultation will continue for the life of the Proposal. • An Interim MCP has been developed for the Proposal and will continue to evolve during the life of the Proposal. If the Proposal receives Ministerial Approval under Part IV of the EP Act as well as under the EPBC Act, the MCP will be developed in more detail and submitted to DMIRS for approval as required by the *Statutory Guidelines for MCPs under the Mining Act 1978* - DMIRS (2020b).
Outcomes	Residual Impact: Given the planned ongoing consultation with the Thalanyji people regarding social surroundings it is considered likely that the Proposal can be implemented without significant residual impacts to this factor.

OFFSETS

SIGNIFICANT RESIDUAL IMPACTS

After the implementation of mitigation measures, the Proposal is predicted to have a significant residual impact on the environmental values listed in Table 6 and the MNES listed in Table 6 and Table 7.

Table 6: Summary of significant residual impacts – Part IV EP Act Environmental Values

Environmental Value	Other associated values	Residual Impacts
Nearshore BCH	Turtles, dugong, green sawfish and other elasmobranchs	Loss of up to 226.2 ha
Migratory Shorebirds	Green turtle juveniles and Northern Coastal Free-tailed Bat (Priority 1) (Mangrove BCH), turtles (Sandy Beach BCH), Exmouth Gulf East Wetland (WA007) which is listed in the Directory of Important Wetlands in Australia (EnviroWorks 2016)	Loss of: • 0.99 ha of Sandy Beaches BCH; • 4.28 ha of Mangroves BCH, which may also be utilised by green turtle juveniles; • 17.81 ha of Transitional Mudflat BCH; • 16.68 ha of Algal Mats BCH.
Tidal Creek BCH	Green sawfish and green turtle juveniles	Loss of 0.54 ha
'Good' to 'Excellent' condition native vegetation	Pilbara Olive Python and Northern Quoll	Clearing of up to **1,053** ha of good to excellent condition native vegetation, including 67 ha of foraging and dispersal habitat for Pilbara Olive Python and Northern Quoll (discussed below)
River bank / creekline / drainage habitat	Pilbara Olive Python and Northern Quoll	Disturbance of 0.53 ha

Table 7: Summary of significant residual impacts – MNES

Relevant MNES	Residual Impacts
Listed threatened species and communities (Sections 18 & 18A)	
Migratory Shorebirds	Clearing of: • Up to 0.99 ha of Sandy Beaches habitat; • Up to 4.57 ha of Mangroves habitat; • Up to 17.78 ha of Transitional Mudflat habitat; • Up to 16.69 ha of Algal Mats habitat; • Up to 69.21 ha of Freshwater Claypan habitat
Pilbara Olive Python (*Liasus olivaceaus barroni*) critical habitat	Clearing of up to 0.53 ha of Riverbank / creekline / drainage habitat on the Ashburton River
Northern Quoll (*Dasyurus hallucatus*)	Clearing of up to 0.53 ha of Riverbank / creekline / drainage habitat on the Ashburton River Clearing of up to 67 ha of surrounding foraging habitat
Marine Fauna, including elasmobranchs, Marine Turtles and marine mammals	Loss of up to 226.2 ha of nearshore BCH, 4.28 ha of Mangrove BCH and 0.54 ha of Tidal Creeks BCH Indirect impacts associated with marine noise, vessel strike, water quality (from dredging and bitterns' disposal) and unplanned pollution (i.e., spills)
Listed migratory species (Sections 20 & 20A)	
Migratory Shorebirds	Clearing of: • Up to 0.99 ha of Sandy Beaches habitat; • Up to 4.57 ha of Mangroves habitat; • Up to 17.78 ha of Transitional Mudflat habitat; • Up to 16.69 ha of Algal Mats habitat; • Up to 69.21 ha of Freshwater Claypan habitat

PROPOSED OFFSETS

Table 8 describes the measures proposed to offset the residual impacts associated with the Proposal.

Table 8: Proposed offsets

Offset	Type	Details	Relevant values / MNES
Terrestrial land management – contribution to land management for direct and indirect impacts to Pilbara Olive Python habitat and Northern Quoll supporting habitat. A minimum of 200 ha of degraded Pilbara Olive Python habitat and Northern Quoll supporting habitat in the local area is proposed to be managed to improve habitat quality.	Direct – management of existing habitat	Large areas of the study area and the Northern Quoll supporting habitat have been heavily impacted by invasive weeds and grazing. The funds will be collated with other terrestrial fund commitments discussed below to focus on improving the quality of the broader landscape, with these specific funds focused on areas of Northern Quoll and Pilbara Olive Python habitat within the local area. DBCA have identified that there may be some suitable land management programs may be established at the time of approval (if approved) that could be suitable to align with. DBCA is currently conducting research and planning for these programs. The aim is to deliver a land management project that achieves overall biodiversity conservation outcomes.	Pilbara Olive Python, Northern Quoll
Terrestrial land management – contribution to land management for direct and indirect impacts to 'Good' to 'Excellent' condition native vegetation not already offset by the measure above. A minimum of 3,200 ha of degraded vegetation in the local area is proposed to be managed to improve vegetation / habitat quality.	Direct – management of existing flora, vegetation and fauna habitat	Large areas of the study area and surrounds have been heavily impacted by invasive weeds and grazing. The funds will be collated with the terrestrial fund commitments discussed above to focus on improving the quality of the broader landscape. DBCA have identified that there may be some suitable land management programs may be established at the time of approval (if approved) that could be suitable to align with. DBCA is currently conducting research and planning for these programs. The aim is to deliver a land management project that achieves overall biodiversity conservation outcomes.	Native vegetation, fauna habitat, *Minuria tridens*
Contribution of $230,000 to a relevant scientific initiative regarding intertidal BCH on the eastern Exmouth Gulf shoreline. DBCA have noted that there are clear knowledge gaps regarding intertidal BCH on the eastern Exmouth Gulf coastline. DBCA are currently identifying research programs required for management of the marine	Indirect (research) – contribution prior to or within 12 months of the commencement of construction for the purpose of research	DBCA have noted that there are clear knowledge gaps regarding intertidal BCH on the eastern Exmouth Gulf coastline. DBCA are currently identifying research programs required for management of the marine park, there is potential for funds to be used to improve one of these research programs. The proponent shall ensure that the real funding will be maintained through	• Migratory shorebirds • Marine fauna • Mangroves • Samphire • Algal Mats • Transitional Mudflats

Offset	Type	Details	Relevant values / MNES
park, there is potential for funds to be used to improve one of these research programs. Funding will be maintained through indexation to the Perth CPI.		indexation to the Perth CPI, commencing in 2023.	
Marine (offshore) management - $1 million contribution to management of regional threats to the Eastern Exmouth Gulf area. Funding will be maintained through indexation to the Perth CPI.	Direct – management of marine waters, fauna and/or subtidal BCH	K+S is aware of plans to designate a marine park for Exmouth Gulf. It is expected that several management measures will be put in place to conserve the values of the Exmouth Gulf marine park, and K+S proposes to provide funds to either: • Extend the managed areas outside of the marine park, in areas advised by DBCA; and/or • Provide management within the marine park that is in addition to what is being undertaken by DBCA (to achieve better outcomes)	• Migratory shorebirds • Marine fauna

HOLISTIC IMPACT ASSESSMENT

The receiving environment has been carefully considered and investigated in detail. The Proposal has been iteratively re-designed to minimise impacts to the environment. Proposed disturbance is localised and proportionally small. Important processes have been maintained so that local and regional environmental values are protected. With mitigation measures it is predicted that some significant residual impacts will remain. Offsets are proposed to counterbalance these significant residual impacts and are deemed to be suitable given the limited scale of these impacts. With the implementation of these offsets, it is considered that the EPA objectives for each relevant Environmental Factor can be met.

CUMULATIVE IMPACT ASSESSMENT

In August 2020, the then WA Minister for Environment requested that the EPA provide strategic advice under Section (16e) of the EP Act on the potential cumulative impacts on the environmental, social and cultural values of Exmouth Gulf. The request for strategic advice originated from several potentially significant development proposals in the Exmouth Gulf region being referred to the EPA under Part IV of the EP Act. One of these proposals was the Proposal. A cumulative impact study was prepared by the Western Australian Marine Science Institution (WAMSI) in partnership with the EPA to assist in delivering this advice (WAMSI, 2021).

The report provided a review on the potential cumulative impacts of these projects on the environmental, social and cultural values of Exmouth Gulf. The report identified Exmouth Gulf to be a multi-use area, with various drivers and pressures across a multitude of sectors. Key values were considered across five themes (sea, land, water, air and people) within the context of the definitions under the EP Act and the EPA's framework of environmental factors and objectives (EPA, 2020b). No key values were identified to be in a state of very poor condition with most categorised in a state of good or very good condition. The EPA did, however, acknowledge that the condition of key values of the gulf are likely to continue to degrade overtime without improved coordination and management.
K+S has considered the cumulative pressures on the Exmouth Gulf in this assessment. When taking this into account K+S have determined that the combined Proposal impacts to marine fauna from habitat loss, marine

noise, shipping, dredging and bitterns disposal are considered to be significant. Management offsets are proposed to counterbalance these impacts.

K+S also noted comments provided by the EPA (EPA Report 1704) regarding cumulative impacts in their assessment of the Mardie Project. The EPA advised that:

> "All future salt proposals on the West Pilbara Coast (defined as the area from the bottom of the Exmouth gulf to Karratha) which have the potential to impact tidal samphire mudflats habitat, algal mat and mangrove habitat will need to assess potential regional and cumulative impacts to these habitats. This consideration must include assessment of the cumulative impacts with existing, approved and proposed proposals, in the context of the known extent of habitats in the Pilbara. Assessment must include both direct impacts, and consideration of changes to the ecological process such as surface water, groundwater, and tidal inundation which support intertidal habitats".

K+S has considered the EPA's advice regarding cumulative impacts and designed the Proposal to avoid and minimise impacts to the key BCH values that were noted to be at threat of cumulative impacts from salt proposals ("tidal samphire mudflats habitat, algal mat and mangrove habitat"). As a result, the Proposal has been re-designed to reduce direct and indirect impacts to algal mats, mangroves and intertidal samphires. Impacts to these BCH types are now minor in the context of the Mardie Project, with only 76.7 ha of disturbance compared to the 1,267-ha proposed for the Optimised Mardie Project (Preston Consulting, 2022a). Nevertheless, given the cumulative pressures on these BCH types, the impacts were assessed as being significant, and research offsets were proposed to counterbalance these impacts.

The Proposal has specifically targeted areas of unvegetated supratidal flats, which has limited the extent of vegetation that will need to be cleared to implement the Proposal. There are limited cumulative clearing pressures on vegetation in the surrounding area, with more than 90% of their pre-European extent remaining. Nevertheless, K+S notes that the EPA considers that the clearing of native vegetation and impacts on other associated environmental values in the Pilbara IBRA bioregion is significant where the cumulative impact may reach critical levels if not managed. While the Proposal lies just outside the Pilbara IBRA bioregion, K+S has assessed vegetation loss in a similar manner, with the loss of Good to Excellent vegetation being considered to be a significant residual impact. Offsets are proposed to counterbalance those impacts, targeting the management of weed infestations in the region.

1 INTRODUCTION

1.1 PURPOSE AND SCOPE

The Ashburton Salt Project (Proposal) is a solar salt farm being proposed by K plus S Salt Australia Pty Ltd (K+S) on salt flats approximately 40 km south-west of Onslow, in the Pilbara Region of Western Australia (WA) (Figure 1). If developed, the Proposal will produce 4.7 million tonnes per annum (mtpa) of salt by evaporating sea water using the sun and wind (a process known as solar salt farming). The salt would be sold to buyers for example in Asia for use in industrial processes and transhipping would occur directly from site from a jetty. Low-draft barges would collect salt from the jetty and transport it out to sea for loading onto seagoing vessels, avoiding the need for a shipping channel to be dredged.

This Environment Review Document (ERD) has been prepared following the *Instructions on how to prepare an Environmental Review Document* (Environmental Protection Authority (EPA), 2020a) in order to provide an environmental impact assessment (EIA) of the Proposal to EPA under section 40(2)(b) of the *Environmental Protection Act 1986* (WA) (EP Act).

The purpose of the document is to present an environmental review of the principal components of this Proposal, including a detailed EIA and description of proposed environmental management strategies for key environmental factors.

1.2 PROPONENT

The proponent for the Proposal is K plus S Salt Australia Pty Ltd (K+S) (ACN: 607 033 447)

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Position: Managing Director
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Perth WA 6000
Phone: 1300 653 357
Email: ashburtonsalt@k-plus-s.com

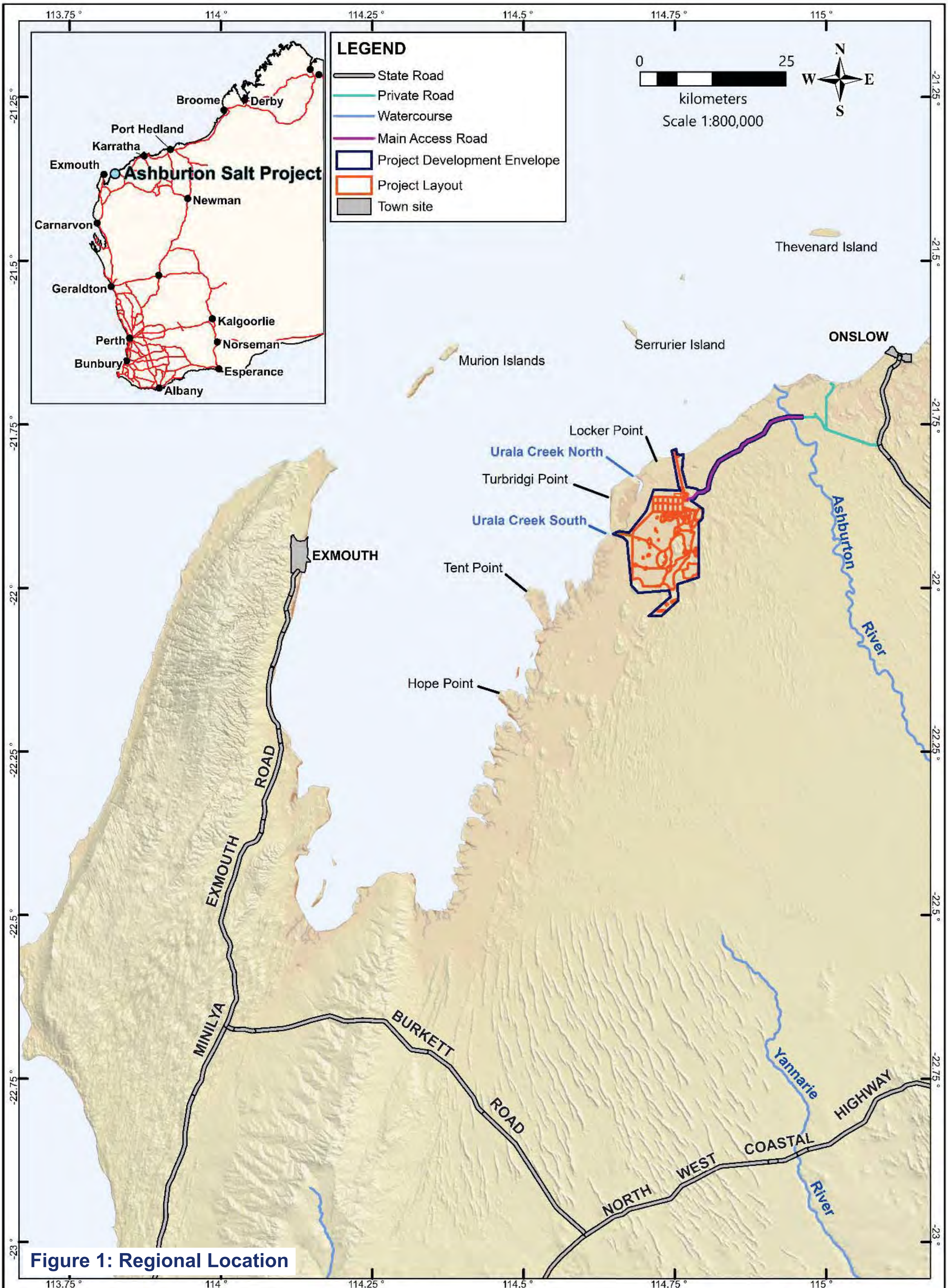


Figure 1: Regional Location

K+S	Ashburton Salt Project Location	Date: 16/08/2021 Paper: A4 P GDA94
		Data Source: 4A, 4E, 9A, 17A
		File Info: K04_J10_PER_Location_20210707.WOR

1.3 ENVIRONMENTAL IMPACT ASSESSMENT PROCESS

The EPA has determined that the Proposal is to be assessed under Part IV of EP Act. The Proposal is to be assessed by Public Environmental Review (PER) as determined by the EPA. The Public review period for the ERD will be 12 weeks.

The Australian Department of the Environment and Energy (DoEE) (now the Department of Climate Change, Energy, the Environment and Water (DCCEEW)) determined that the Proposal will be assessed under the *Environment Protection and Biodiversity Conservation Act 1999* (Cth) (EPBC Act) as a controlled action, via an accredited process.

The Proposal is not the subject of a State Agreement Act.

1.4 OTHER APPROVALS AND REGULATION

1.4.1 LAND TENURE

Three types of land tenure are proposed for this Proposal (Figure 2):

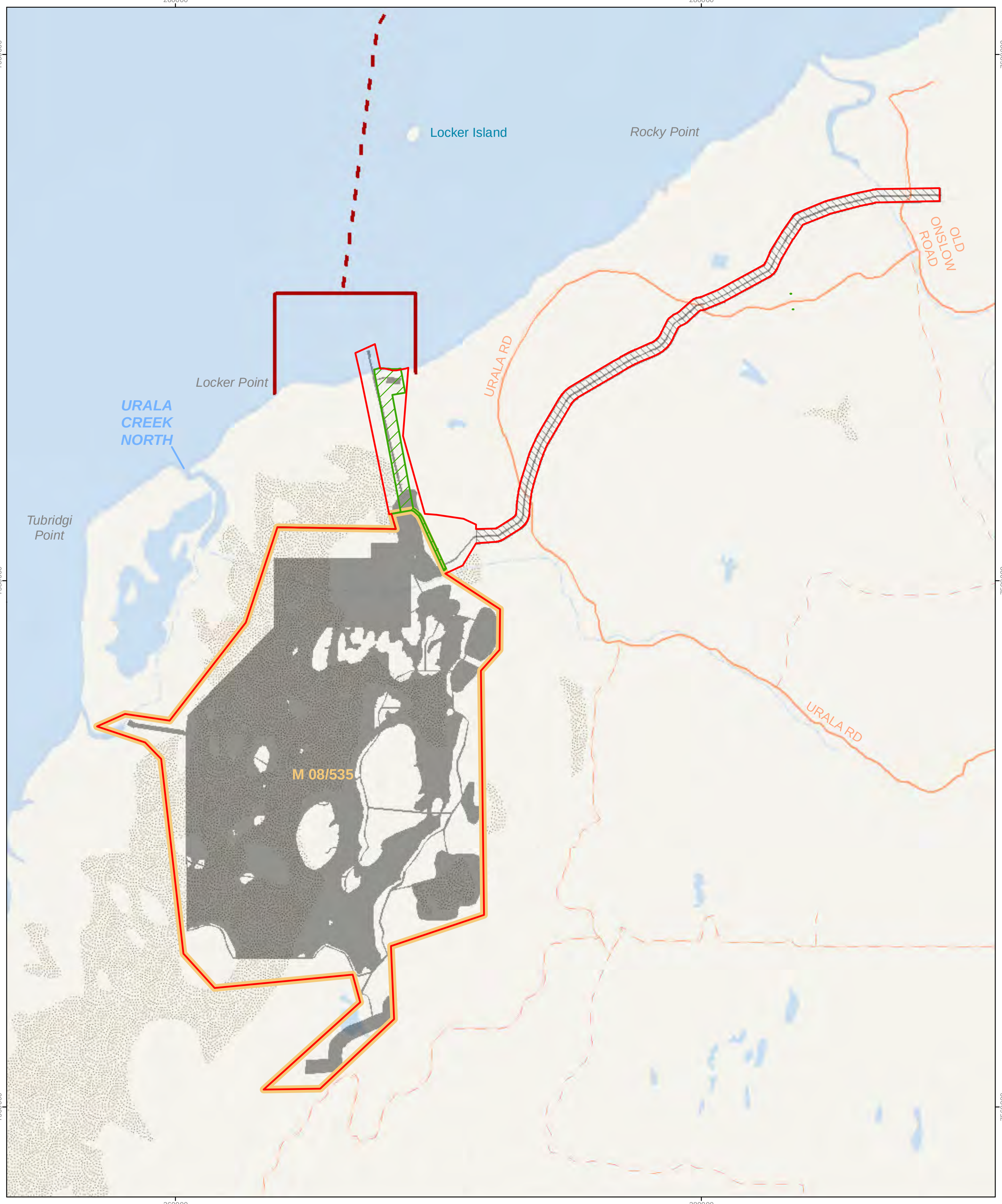
- The seawater intake, salt ponds, wash plant, stockyard and associated infrastructure will be located on a Proposed Mining Tenement under the *Mining Act 1978*.
- Infrastructure associated with the Port (conveyor, jetty, berthing pocket and dredge spoil disposal) will be within Port Tenure vested in Pilbara Ports Authority.
- The portion of the access road not covered by Mining Tenure or Port Tenure will become a Public Road under the *Land Administration Act 1997*. The road reserve will be vested in either the Shire of Ashburton or Main Roads as appropriate.

1.4.2 DECISION MAKING AUTHORITIES

The authorities listed in Table 9 have been identified as decision-making authorities (DMAs) for the Proposal.

Table 9: Decision-making Authorities

Decision-making Authority	Relevant Legislation
Minister for Mines and Petroleum.	*Mining Act 1978.*
Minister for Water.	*Rights in Water and Irrigation Act 1914.*
Minister for Lands.	*Land Administration Act 1997.*
Minister for Aboriginal Affairs.	*Aboriginal Heritage Act 1972* (WA) (AH Act); or *Aboriginal Cultural Heritage Act 2021*(WA) (ACH Act).
Chief Executive Officer, Department of Water and Environmental Regulation.	EP Act. *Environmental Protection Regulations 1987.*
Executive Director, Environment, Department of Mines, Industry Regulation and Safety.	*Mining Act 1978.*
Chief Dangerous Goods Officer, Department of Mines, Industry Regulation and Safety.	*Dangerous Goods and Safety Act 2004.*
State Mining Engineer, Department of Mines, Industry Regulation and Safety.	*Mines Safety and Inspection Act 1994.*
Chief Executive Officer, Department of Transport.	*Jetties Act 1926 (WA).*
Commissioner for Roads WA, Main Roads WA.	*Main Roads Act 1930: Road Traffic (Vehicles) Regulations 2014.*
Chief Executive Officer, Shire of Ashburton.	*Planning Development Act 2005.*



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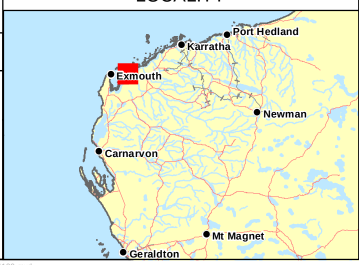
- NOTE THAT POSITION ERRORS CAN BE >5M IN SOME AREAS

LOCALITY



Legend
- Development Envelope
- Tenement M 08/535
- Indicative Port Marine Boundary
- Indicative Transhipping Route (no dredging)
- Proposed Road Reserve
- Proposed Landside Port Tenure
- Disturbance Footprint
- Minor Road
- Track

Preston Consulting

CREATED	JOB	DATE	REVISION
ENVIRONMAPS	PC2900360	8/11/2022	0

Ashburton Salt

ENVIRONMAPS Environmental Mapping Solutions t: 0406 590 006 www.environmaps.com.au

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Figure 2: Land Tenure

1.4.3 OTHER APPROVALS

Other regulatory approvals outlined in Table 10 below are required.

Table 10: Other Approvals

Proposal activities	Land tenure / access	Type of approval	Legislation regulating the activity
Construction of solar salt farm	Mining Lease	Works Approval under Part V of EP Act	EP Act (Part V). Prescribed premises category: 14 Solar salt manufacturing: premises on which salt is produced by solar evaporation.
Operation of solar salt farm	Mining Lease	Licence under Part V of EP Act	
Disturbance to Aboriginal Heritage Site	Mining Lease	Section 18 consent to disturb heritage site/s	AH Act; or ACH Act. Note: A 12 month transitional period during which the regulations, statutory guidelines and operational policies of the ACH Act will be developed. During this time the AH Act will remain in force to enable proponents to seek Section 18 consent if required.
Native Title Agreement	Mining Lease	Indigenous Land Use Agreement (ILUA).	*Native Title Act 1993*
Storage of Dangerous Goods	Mining Lease	Dangerous Goods Licence	*Dangerous Good Safety Act 2004*
Buildings	Mining Lease	Buildings Planning Approval and Building Permits	*Planning Development Act 2005*
Wastewater Treatment	Mining Lease	Application to construct or install an apparatus for the treatment of sewage	*Health Act 1911 and Health (Treatment of Sewage and Disposal of Effluent and Liquid Waste) Regulations 1974*

2 THE PROPOSAL

2.1 BACKGROUND

2.1.1 REFERRAL

In October 2016, the Proposal was referred to EPA under Part IV of EP Act. In November 2016, the EPA determined that the Proposal would require assessment via a Public Environmental Review.

The Proposal was also referred in 2016 to DCCEEW and determined to be a controlled action under EPBC Act. In early 2017 it was determined that the Proposal would be assessed under EPBC Act by the EPA as an accredited assessment.

2.1.2 ENVIRONMENTAL SCOPING DOCUMENT

An Environmental Scoping Document (ESD) outlining the requirements of the proposed EIA studies was released for public comment in September 2017. The ESD was subsequently revised taking into account public feedback in December 2017 and approved by the EPA in January 2018.

2.1.3 PROPOSAL CHANGES

2.1.3.1 JULY 2017

In July 2017, while preparing the draft ESD, K+S identified the need to include the physical elements located “outside Development Envelope” (original referral) within development envelopes and to provide some clarification on the location of support infrastructure. As a result of these discussions, K+S wish to make the following changes to the original Proposal:

- Address “outside Development Envelope” physical elements as follows:
  - Remove the haul and wet weather access roads.
  - Remove the quarry.
  - Add a “Road Development Envelope” to include the access road and borrow pits.
  - Revise the total disturbance area of the Ashburton Salt Development Envelope from 17,000 to 18,000 hectares (ha) to accommodate a potable water desalination plant and the following formerly ‘outside’ physical elements:
    - Dredging and land based dredge spoil disposal.
    - Borrow pits.
    - Airstrip and/or helipad.
- Provide an indicative location for support infrastructure within the Ashburton Salt Development Envelope.
- Provide a maximum volume of seawater to be utilised by the Proposal.

These Proposal changes were approved by the EPA under Section 43A of the EP Act in August 2017.

2.1.3.2 DECEMBER 2018

In December 2018, K+S found through its baseline monitoring program that the seawater salinity nearest to the Ashburton Salt site consistently had a higher content of salt than originally thought.

This meant that the output of salt predicted to be produced would be higher due to the saltier water. K+S revised its production estimate to 4.5 Mtpa of salt instead of 3.5 Mtpa, without any increase to Proposal footprint.

The Proposal change was approved by the EPA under Section 43A of the EP Act in December 2018.

2.1.3.3 DECEMBER 2021

In July 2021, K+S applied for a number of additional changes to the Proposal under Section 43A of the EP Act which had resulted from environmental studies and engineering design which were:

- Reduction in size from 91,677 ha to 20,990 ha and combination of Development Envelopes;
- Reduction in road disturbance footprint from 800 ha to 155 ha;
- Reduction in pond footprint from 15,000 ha to 10,397 ha and inclusion of a bitterns dilution pond;
- Increase in salt production from 4.5 Mtpa to 4.7 Mtpa;
- Deletion of the separate seawater intake points located at Urala Creek North;
- Reduction in support infrastructure disturbance footprint from 3,005 ha to 1,596 ha and refinement of layout (see points below);
- Deletion of the "Indicative Site Administration Compound" from the Proposal, with the location of the wash plant, administration and other buildings being moved closer to the ponds in areas of high ground to reduce earthworks;
- The jetty, dredged berthing pocket and wastewater pipeline diffuser location moved 2.5 km to the south-west of the previous location into deeper water;
- Locations of the landside dredge disposal area, burrow pits, and drainage diversions and protection levees within the Proposal Development Envelope defined and mapped;
- Location of a port boundary around the jetty, transhipment route and the transhipment area where ocean going vessels (OGV) would be loaded at sea defined and mapped; and
- Deletion of the airstrip from the Proposal.

The changes to the Proposal were approved by the EPA under Section 43A of the EP Act in December 2021.

2.1.3.4 APRIL 2022

In February 2022, K+S applied for vary the Proposed Action under section 156A of EPBC Act (EPBC 2016/7793). This application collated the three previous changes under Section 43A of the EP Act and was approved on 29 April 2022. The variations to the Proposed Action under Section 156A included:

- Reduction in extent of the Development Envelope and inclusion of retained physical elements previously identified as being outside the Development Envelope;
- Reduction in disturbance for the 'Evaporation and crystallisation ponds' from 15,000 ha to 10,397 ha;
- Reduction in disturbance for 'Support infrastructure' from 2,000 ha to 1,596 ha;
- Inclusion of 'Access Roads (including road upgrades and river crossing/bridge)' of 155 ha;
- Increase in salt production from 3.5 Mtpa to 4.7 Mtpa;
- Definition of port boundary and transhipment operations;
- Remove one seawater intake location option and provide a maximum volume for the seawater intake;
- Defined the location of the jetty and dredged berth pocket, Bitterns discharge, landside dredge disposal area, Borrow pits and drainage diversions and protection levees; and
- Changes to infrastructure items, including the removal of groundwater supply bores (replaced with management/ monitoring bores), replacement of the airstrip with a helipad, inclusion of a desalination plant for potable water, inclusion of drainage levees, removal of the haul road for construction materials, removal of the quarry and clarification that all dredge spoil disposal will be land-based.

2.2 JUSTIFICATION

K+S is considering the Proposal in order to participate in supplying future growth in salt demand in Asia. If developed, the Proposal will provide benefits for the local community, including:

- 364 construction jobs.
- 130 local, permanent positions once operational.
- A total impact in the local economy of $103 million a year once operational.

According to a 2022 study by ACIL Allen, the Project is expected to generate an average of 364 full time equivalent ('FTE') jobs each year during the construction phase, the majority of which will be generated in the WA economy.

The employment impact in the Pilbara region is the equivalent to between 32 and 33 average WA small businesses, demonstrating the transformative role the Proposal can play in local employment.

Once operations commence, the employment opportunities generated by the Proposal centre on the Pilbara Region, with an average 183 FTE supported. With 130 of these as direct jobs, the indirect impact of the Proposal is around 53 FTE jobs.

According to the study, the economic output impact of the Project reaches an average of $36.1 million per annum during the construction phase, rising to $233 million per annum during operations. A significant share of the output impact occurs in the Pilbara region given this is the location of the primary activities of the Proposal. During operations, the Pilbara accounts for 96% of total output from the Proposal.

The annual average economic output of the Proposal in the Pilbara region is three times larger than the region's current agriculture, forestry and fishing industry ($80.7m).

The Proposal will also:

- Increase diversification in the economy.
- Increase the use of infrastructure developed by the State Government at the Ashburton North Strategic Industrial Area (ANSIA).
- Provide additional supply of industrial salt from WA, enhancing the potential for growth in industrial processes which also use WA's offshore natural gas resources (Economic Consulting Services, 2020).

2.2.1 CONSIDERATION OF ALTERNATIVES

A range of alternatives have been considered for this Proposal as outlined in the table below.

Table 11: Consideration of Alternatives

Alternatives Considered	Details
Is the Proposal needed	Market forecasts indicate a gap in the global salt market, with a demand surplus likely in the Asian market. The Proposal will supply a significant number of local jobs and economic benefits against the backdrop of current economic difficulties.
Other technologies or options	Solar salt farming, is a proven method of sustainable salt production from seawater, using natural process such as wind, solar heat and evaporation. Other technologies for salt production are less energy efficient and require underground salt resources (salt mining).
Location options	There are very few location options available along the Western Australian coastline suitable for solar salt farming. Flat topography and specific climactic conditions are required. In addition, *Mining Act, 1978* tenure availability is required. The current location is the only suitable location available to K+S at this time.

Alternatives Considered	Details
Outgoing logistics (port) solutions	• K+S evaluated various options for an outgoing logistics solution. These options included establishing a new deep-water port for direct loading of ocean-going vessels, using shallow draft barges and/or transhipping vessels as well as the use of existing port infrastructure in the vicinity of the Proposal. • Deep-water port solutions were discarded from the process due to the negative environmental impacts associated with large-scale dredging requirements and the various impacts of ocean-going vessel traffic in or close to Exmouth Gulf. • Only one option could be viably considered for use of existing port infrastructure: the Port of Ashburton close to Onslow, at the Wheatstone liquefied natural gas (LNG) plant site. Economic analysis considered this option unfeasible. Transporting 4.7 million tons of product for more than 30 km from the Proposal to the Ashburton Port via trucks would introduce a very high operating cost to the Proposal. Alternatively, operating a conveyor system to the Ashburton Port would require less operational cost, but again render the Proposal unfeasible due to the high additional capital expenditure. • Construction of a simple trestle jetty to load a low draft transhipper is the preferred solution that combines an acceptable cost level with potential environmental impacts that are much lower than a deep-water port operation. No channel will need to be dredged, only a small berthing pocket at the jetty in which the transhipment vessel can sit in low tide. Ocean-going vessels do not need to come close to shore but will be loaded at anchoring points further out at sea.
Optimisation of the Proposal to minimise environmental impacts.	K+S has undertaken significant design optimisation to minimise environmental impacts including: • Eight iterations of the pond design to minimise footprint. • Detailed analysis of seawater intake options and locations. • Detailed analysis of bitterns disposal options and locations. • Detailed analysis of dredging options and dredge spoil disposal. • Detailed analysis of shipping methodology and options.

2.3 PROPOSAL DESCRIPTION

2.3.1 LOCATION AND KEY CHARACTERISTICS

It is proposed to construct and operate a 4.7 million tonne per annum (Mtpa) solar salt farm approximately 40 km southwest of Onslow within the Shire of Ashburton, in the West Pilbara region of WA (Figure 1). The key characteristics of the Proposal are set out in Table 13. The development envelope and layout of the Proposal are provided in Figure 3. The anticipated life of the Proposal is 50 years.

Table 12: Summary of the Proposal

Proposal title	Ashburton Salt Project
Proponent name	**K plus S Salt Australia Pty Ltd**
Short description	It is proposed to construct and operate a solar salt project approximately 40 km south-west of Onslow, WA. The proposal includes the construction of solar salt evaporation and crystallisation ponds and associated infrastructure/activities (seawater intake pumps/channel/pipeline(s); seawater concentration ponds and salt crystallisation ponds;

Proposal title	Ashburton Salt Project
	internal site roads; onsite diesel fuelled back-up/standby electricity generation and reticulation; fuel storage sites; a jetty and product loading facilities; a salt wash plant and associated ponds; salt stockpiles and conveyors; onsite buildings such as offices, storage, workshops and possibly accommodation; sewage treatment facilities and landfill; water management/monitoring bore(s); helipad; desalination plant; equipment parking and laydown areas; bitterns discharge infrastructure which includes a channel, dilution pond, pipeline and diffuser; drainage diversion/s and levees; access roads; a service corridor; borrow pit areas for rock, clay and other construction materials; and dredging and land based dredge spoil disposal.

Table 13: Location and proposed extent of physical and operational elements

Element	Location	Proposed extent authorised
Physical elements		
Evaporation & crystallisation ponds	Figure 3	Clearing of no more than 10,397 ha within a 20,990 ha Proposal Development Envelope.
Support infrastructure	Figure 3	Clearing of no more than 1,596 ha within a 20,990 ha Proposal Development Envelope. This includes: • seawater intake pumps/channel/pipeline(s); • internal site roads; • onsite diesel fuelled back-up/standby electricity generation and reticulation; • fuel storage sites; • a jetty and product loading facilities; • dredging; • land based dredge spoil disposal; • a salt wash plant and associated ponds; • salt stockpiles and conveyors; • onsite buildings such as offices, storage, workshops and accommodation; • sewage treatment facilities; • landfill; • water management/monitoring bore(s); • equipment parking and laydown areas; • bitterns discharge infrastructure which includes a channel, dilution pond, pipeline and diffuser; • drainage diversion(s) and levees; • borrow pits; • helipad; and • desalination plant.
Access / haul roads (including road upgrades and river crossing / bridge)	Figure 3	Clearing of no more than 155 ha within a 20,990 ha Proposal Development Envelope (77 ha for main access road and 78 ha for internal site access roads)
Operational elements		
Seawater intake	Figure 3	Seawater intake of no more than 250 gigalitres (GL) per annum
Wastewater (bitterns)	Figure 3	Marine discharge of no more than 20 GL per annum (consisting of no more than 10 GL per annum bitterns diluted with seawater at a ratio of approximately 1 to 1)

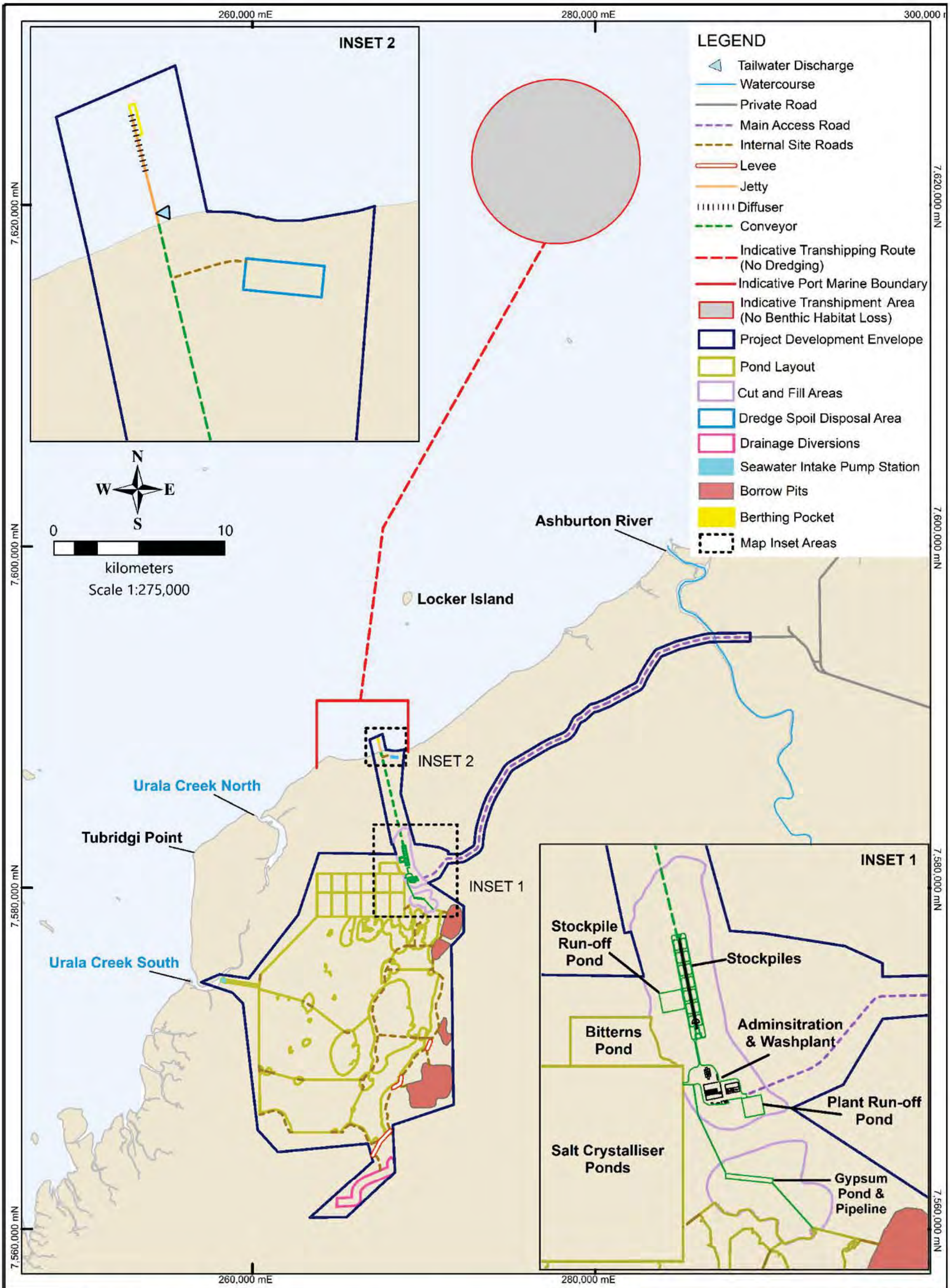

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Figure 3: Proposal Layout

2.3.2 DISTURBANCE AREAS

Proposal disturbance is predicted to occur over terrestrial, supratidal, intertidal and sub-tidal environments (Figure 4) and therefore is reported separately in various sections of this document which relate to relevant key marine, intertidal and terrestrial environmental factors. In addition, the Proposal is predicted to cause disturbance through:

- Direct impact - mechanical or physical disruption or removal; and
- Indirect impact - related flow on effects of implementing the Proposal.

To place the overall Proposal disturbance in context, a consolidated summary of predicted disturbance over the four local environment types (terrestrial, supratidal, intertidal and subtidal - Figure 4) is provided below in Table 14. Each predicted disturbance is discussed in greater detail under relevant sections of this document related to key environmental factors. The overall Proposal direct and indirect disturbance footprint is shown in Figure 5. Disturbance to important ecological habitats such as mangroves and algal mats has been minimised by placing most of the Proposal on the supratidal salt flats which are devoid of vegetation and have limited habitat value.

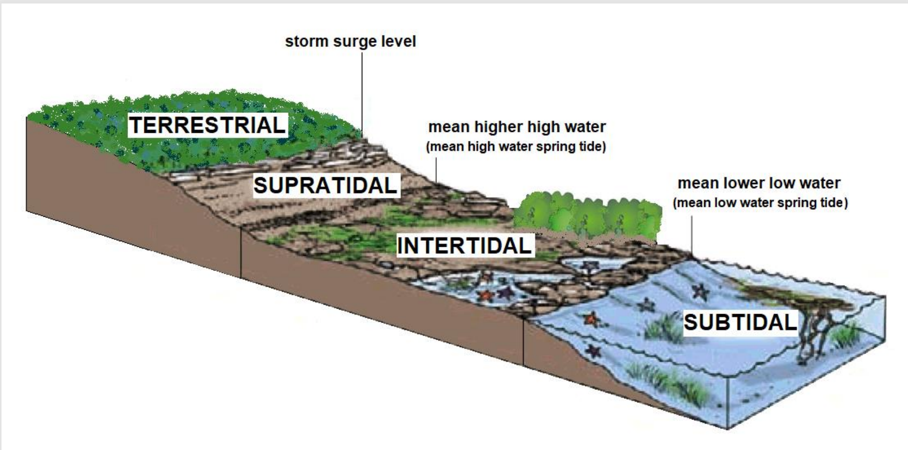
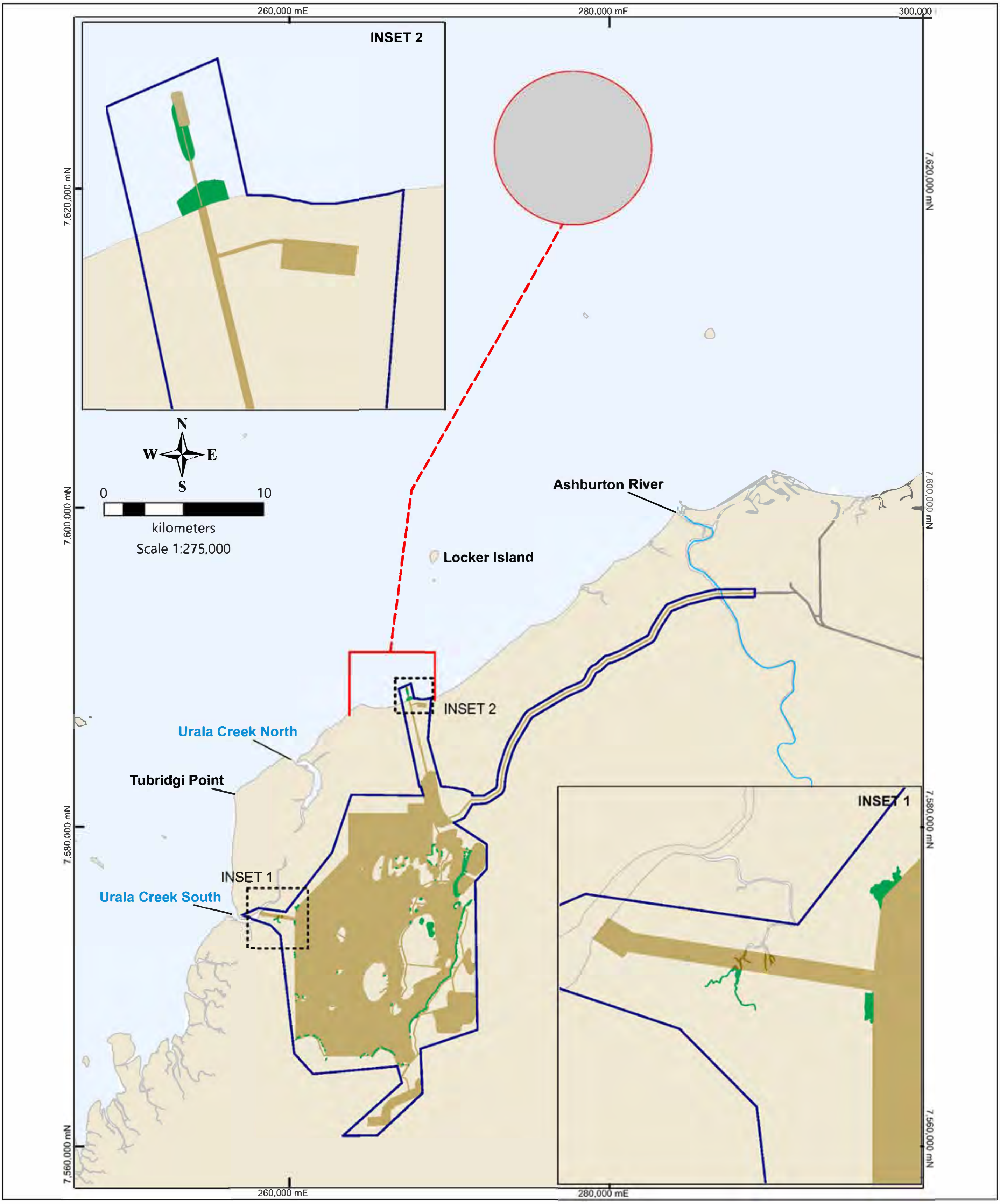


Figure 4: Local Environment Types

Table 14: Summary of Proposal Disturbance

Environ	**Habitat Type** Note 1	**Direct Impact (ha)**	**Indirect Impact (ha)**	**Cumulative Impact (ha)**	**Total in Study Area (ha)**	**Regional (ha)** Note 2	**% of Study Area**	**% of Regional**
Terrestrial	Vegetation	1,108.56	118.99	1,227.55	23,680	251,602	5.18%	0.49%
	Bare Dune	-	-	-	423	2,059	0.00%	0.00%
	Claypan	65.31	3.91	69.22	1,416	23,614	4.89%	0.29%
Supratidal	Samphire	155.95	2.28	158.23	1,717	3,903	9.22%	4.05%
	Bare Salt Flat	10,613.76	20.19	10,633.95	26,665	92,990	39.88%	11.44%
Intertidal	Mangrove	4.23	0.34	4.57	3,724	11,742	0.12%	0.04%
	Algal Mat	12.77	3.92	16.69	6,199	11,612	0.27%	0.14%
	Transitional Mudflat	17.78	-	17.78	7,987	20,660	0.22%	0.09%
	Beach	0.99	-	0.99	298	1,040	0.33%	0.10%
	Tidal Creek	0.30	0.26	0.56	899	2,710	0.06%	0.02%
	Cleared Areas	10.11	-	10.11	106	No Data	9.55%	No Data
Subtidal	Soft Sediment	2.30	1.67	3.97	8,966		0.04%	
	Macroalgae	0.22	4.39	4.61	147	112,500	3.14%	0.008%
	Macroalgae & Sparse Coral	0.10	-	0.10	325		0.03%	
Total Including Bare Salt Flat		*11,992.38*	*155.95*	*12,148.33*	*82,552*	*534,432*	*14.72%*	*2.27%*
Total Excluding Bare Salt Flat		*1,378.62*	*135.76*	*1,514.38*	*55,887*	*441,442*	*2.70%*	*0.34%*

Table Note 1: Regional subtidal habitat has been estimated as a spatial area 5 km from coast along 225 km of coastline from Ashburton River to North-West Cape. All other regional habitat has been determined for Eastern Exmouth Gulf from studies within this ERD or publicly available data.



ENVIRONMAPS Environmental Mapping Solutions t: 0406 590 006 www.environmaps.com.au

Preston Consulting

CREATED	JOB	DATE	REVISION
ENVIRONMAPS	PC2900360	30/05/2022	0

Ashburton Salt

Figure 5: Disturbance Footprint

0 5 10 km N

- NOTE THAT POSITION ERRORS CAN BE >5M IN SOME AREAS

LOCALITY

LEGEND
- Watercourse
- Private Road
- Indicative Transhipping Route (No Dredging)
- Port Marine Boundary
- Indicative Transhippment Area (No Benthic Habitat Loss)
- Project Development Envelope
- Indirect Disturbance
- Direct Disturbance
- Map Inset Areas

2.3.3 KEY COMPONENTS

The Proposal includes the following key components:

- a seawater intake (comprising an intake sump, pipelines, pumps and channel)
- concentration and crystallisation ponds
- salt wash plant
- stockpiles and conveyors
- bitterns discharge infrastructure (including a dilution pond, pipeline and diffuser)
- jetty and product loading infrastructure
- access road and internal site roads
- borrow pits for extraction of clay and other construction materials
- drainage diversions
- dredging and onshore placement of dredged material
- buildings such as offices, storage and workshops
- sewage treatment
- water monitoring bores
- small desalination plant
- electricity and natural gas distribution
- equipment parking and laydown areas
- fuel storage and a refuelling station
- helipad.

2.3.4 SOLAR SALT FARMING PROCESS

A process flow diagram, summarising the salt farming process is provided as Figure 11 below. Further details regarding each step of the process are provided in the Sections below.

2.3.4.1 SEAWATER INTAKE

General

The location of the seawater intake in Urala Creek South is shown in Figure 3 and Figure 14. The Seawater Intake initiates the salt production process by extracting and pumping seawater directly from Urala Creek South from Pump Station (PS-01) into a seawater intake channel and feeds the seawater directly into the first Salt Concentration Pond (CP1) for the Proposal. The maximum annual intake is estimated to be 250 GL. The peak intake is required in October to December when evaporation rates are highest with an estimated monthly intake during the peak months of 29 GL per month. This includes all seawater required for the evaporation ponds, wash plant and bitterns dilution water (approximately one part bitterns is expected to be diluted with one part seawater before being combined with the washwater and discharged from the diffuser).

The components of the Seawater Intake facility comprise of a Seawater Pump Station (PS-01) structure that is built on and around the seawater intake channel levee embankments, which are constructed from earthworks and protected with armoured rock revetments. The intake pumps directly feed seawater into pipelines which extend through the existing embankments into precast concrete outlet risers, which are seated on the existing prepared foundations within the intake channel (Figure 12 and Figure 13). To ensure adequate capacity and help reduce flow velocities and pumping of seawater into the intake channel, a localised excavated Seawater Intake Basin is provided within Urala Creek South around the Pump Station (PS-01). The typical configuration of the Seawater Intake is shown within Figure 6 and Figure 7. The details and construction approach of the Seawater Intake components are summarised within the sections below.

Seawater Intake Pump Station PS-01

The Seawater Intake Pump Station PS-01 comprises of five (5) 355kW Flowserve axial flow pumps, each with a flow rate capacity of 13,400 m^3 / hr to extract seawater from Urala Creek South via a series of intake risers. As shown in Figure 8, the intake riser is located behind seven (7) x 5.3m wide x 7.4m deep Johnson Screens that function to help modify the water flow creating a uniform, low-velocity flow to ensure the flow velocity will meet the environmental limitations. The screens also reduce the intake of debris while protecting aquatic life with the typical square mesh size of 83mm x 83mm adopted to provide an economical and fit for the purpose screen to mitigate entrainment and entrapment of marine turtles and fauna into the intake pipes. The intake has been designed to maximise capacity whilst restricting the creek flow velocity (not exceeding 0.15 metres per second (m/s), in line with USEPA recommendations for protection of 96% of motile species concluded from fish swim speeds (USEPA, 2014)) to mitigate the risk of scouring and impact on fauna near the intake.

Seawater from the intake risers is transferred to the adjoining DN1050 carbon steel outlet pipes and discharged into the Seawater Intake Channel. The discharge ends of the pipes are encased within concrete thrust blocks for stability, and the channel base at the outlet is lined with rock armour to minimise scouring from the seawater discharge.

The capacity of the Seawater Intake Pumps is governed by the process mass balance design and the available tide times for which pumping could be undertaken. Vertical turbine pumps were selected to accommodate the required pump station design level to mitigate flood conditions. Power to the pump station is distributed by a switchroom and substation kiosk located within the laydown and facilities area adjacent to the pump stations entrance. In all cases, the construction methodology will utilise prefabricated components, as much as possible, to minimise the Matters of National Environmental Significance (MNES) impact and ensure disturbance is limited to the footprint of the intake pump station structure itself.

Given that the pump columns submersion depth must be kept to a minimum, the pump availability is heavily influenced by the tides. Based on local submersion curves, a pump utilisation of approximately 75% will be achievable. This increases the required flow rate per pump during the available pumping times. All five (5) pumps will be operated in parallel throughout the year at peak duty during the summer months, with the provision to be shut down during low use periods to reduced duties.

A dedicated standby pump has not been incorporated into the seawater intake pump station, as the requirement for all five (5) pumps to operate simultaneously occurs only during the peak months. For the remainder of the year, at least one pump will be available to operate as a standby.

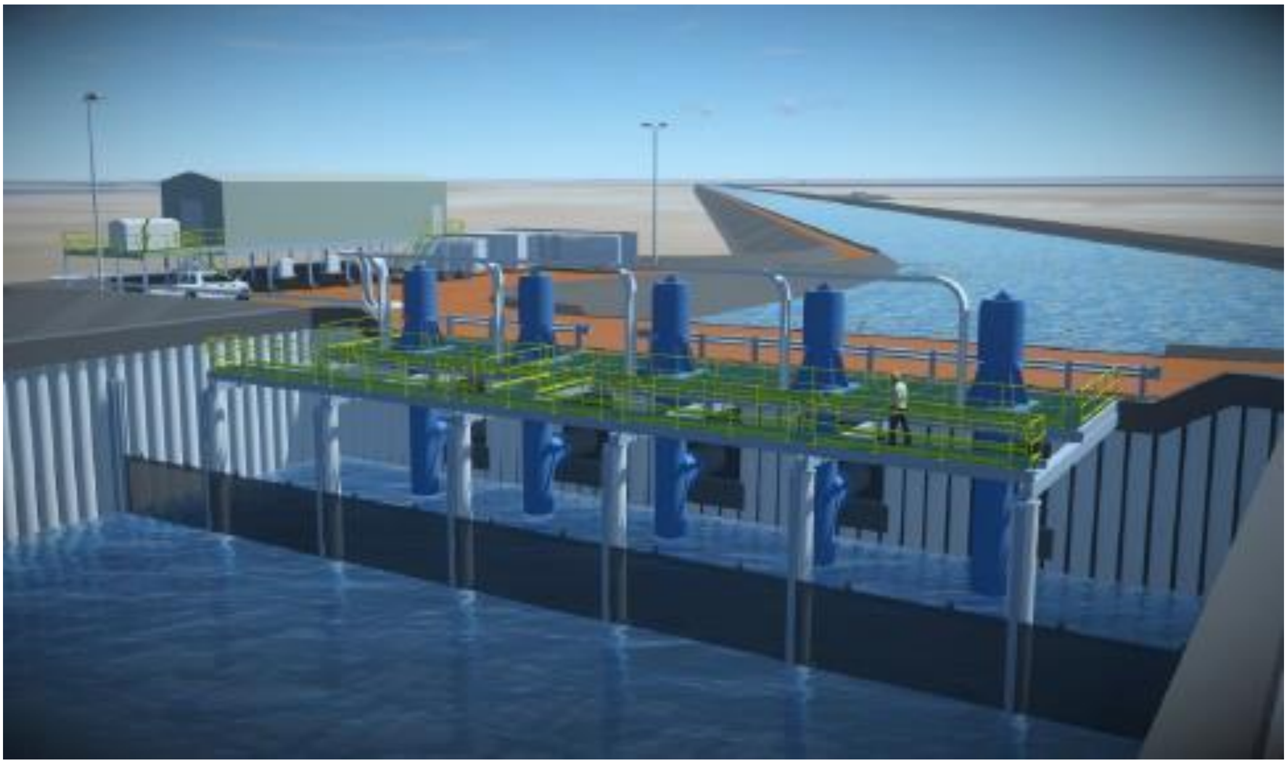


Figure 6: Sea Water Intake, Pump Station (PS-01) and Intake Channel – 3D Model

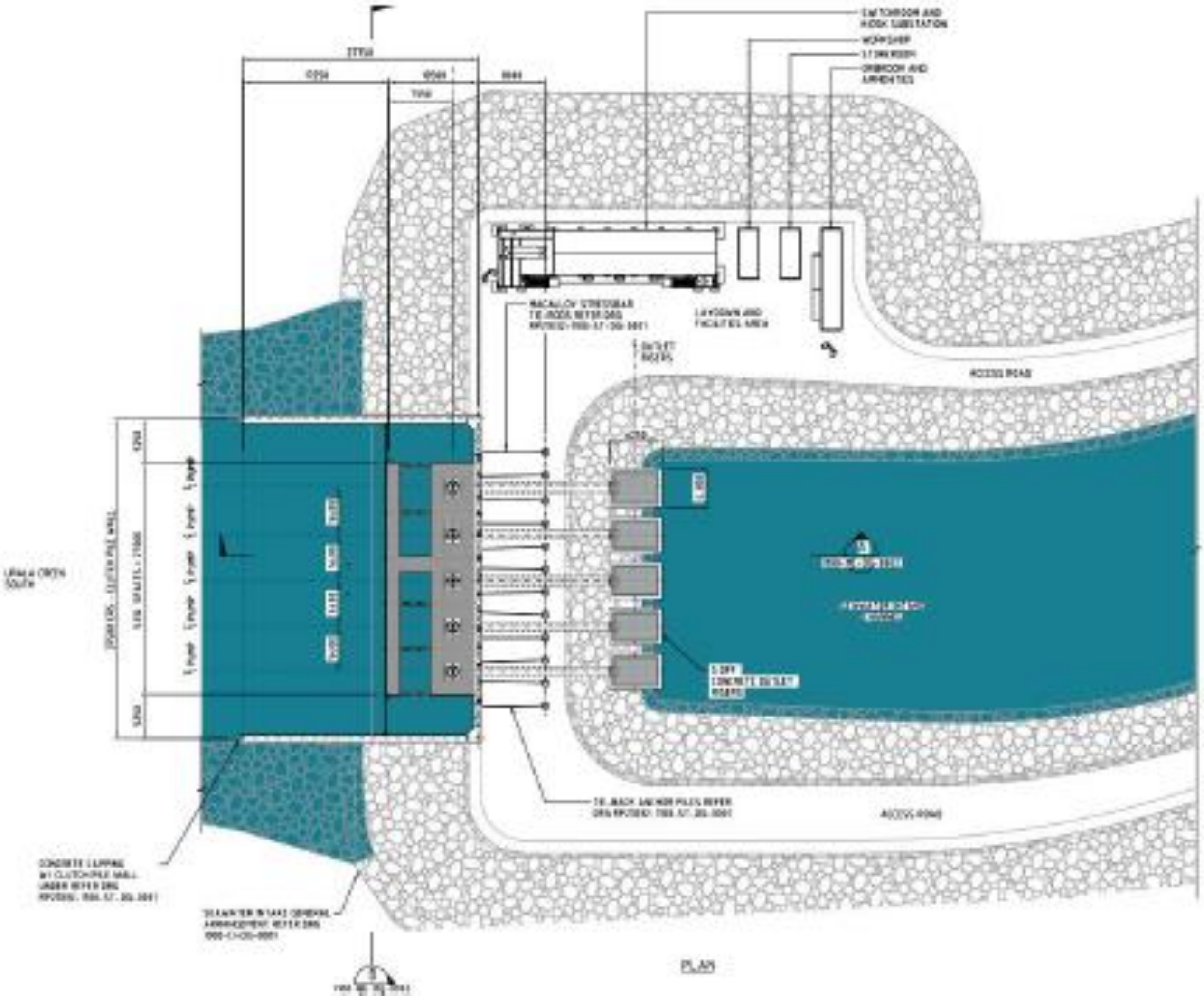


Figure 7: Sea Water Intake, Pump Station (PS-01) and Intake Channel – Plan Arrangement

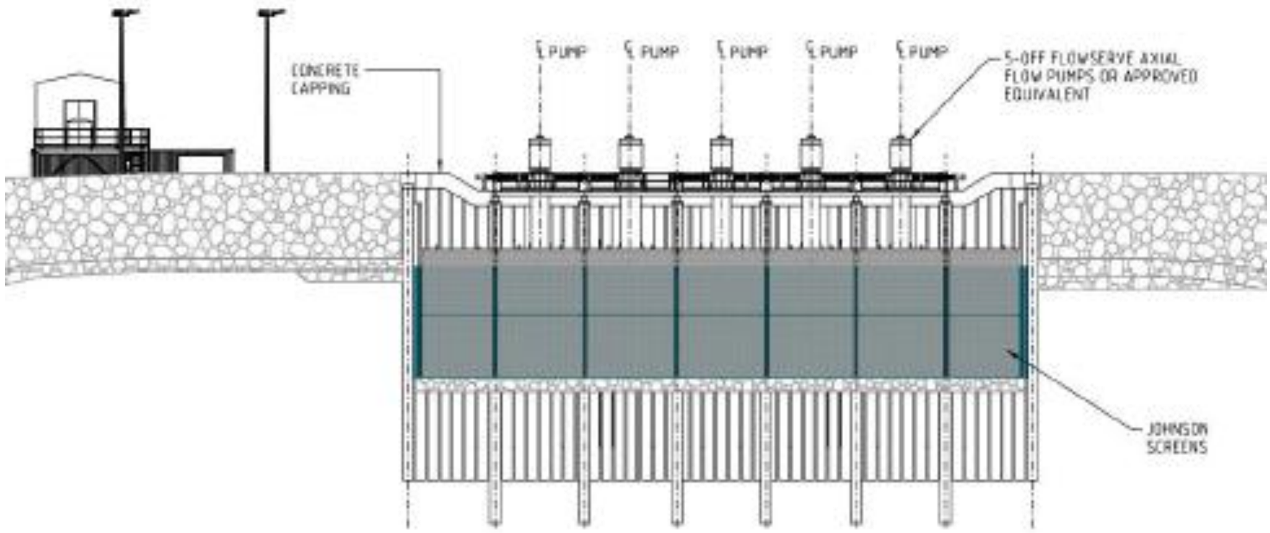


Figure 8: Sea Water Intake, Pump Station (PS-01) and Intake Channel – Plan Arrangement

Seawater Intake Basin and Platform Structure

The Seawater Intake inlet is located at Urala Creek South and comprises of a 37.5 metres (m) wide basin pocket to be excavated to a depth to accommodate seawater extraction by the Seawater Intake Pump Station PS-01. Spoil will be contained within the embankments of the intake channel and managed in accordance with the Acid Sulfate Soil and Sediment Management Plan (ASSSMP) (GHD, 2021b), and any water within the spoil will be retained on land and evaporated, with no discharges to waterways.The base of the basin pocket will be protected from scour with rock armour as shown in Figure 9. The earth retaining structure forming the inlet comprises of a clutched pile wall constructed with driven 610x12.7 millimetres (mm) steel tubes. The wall will be laterally stabilised with steel stress bars secured to driven anchor piles and capped with in-situ reinforced concrete beams to support the steel platform above. The installation of the retaining structure will be undertaken from an earthworks pad to minimise the MNES impact and ensure minimal disturbance across the broader creek during the construction phase.

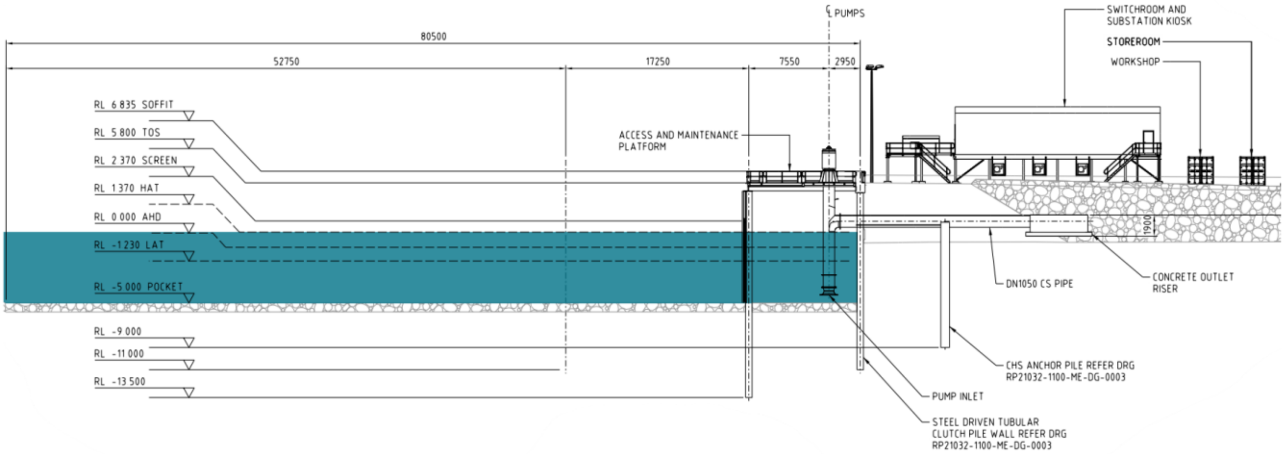


Figure 9: Sea Water Intake Basin and Structure Section View

Seawater Intake Basin and Structure Section View

The steel platform structure, approximately 26.5 m long x 11 m wide, has been designed to support Pump Station PS-01 axial flow pumps, intake riser and Johnsons Screens. The seaside end of the steel structure will be supported by steel tubular piles (ϕ813x15.88mm CHS), inclusive of pile shoes and welded guide frames to secure the Johnson Screens. Due to the site locations highly corrosive environment, the platform design has incorporated Fibre Reinforced Plastic (FRP) grating and replaceable steel handrailing to enable access for inspections and maintenance. All piling works will be installed with plant that will sit within the existing permanent footprint to ensure that the impact on surrounding MNES will be minimised and meet the environmental regulations required for the Proposal.

Seawater Intake Channel

The Seawater Intake Channel is orientated in the East-West direction and comprises of two (2) levees forming a 30m wide earthworks channel. The primary function of the intake channel is to facilitate seawater transfer between Pump Station PS-01 and Concentration Pond CP1. The channel also functions as a seawater storage facility when pumps are unable to extract seawater at the required operational rate during low tides. As shown within Figure 10 below, the alignment of the channel was selected based upon the existing site topography and to minimise the levee lengths and impact on the surrounding environment.

The 2.2km long levees comprise of low permeability fill with the batter slopes protected by rock armour. The rock armour and channel levee heights have been designed to accommodate the storm surge condition outlined within the Proposal Basis of Design Report. A 3.5m wide access road is located on the north and south channel levees. Geogrid and geofabric have been incorporated in the levee design to form a pioneering layer at the base, which will improve the stability of the levees and enable construction equipment to safely operate and access the site.

A laydown and facilities area are located immediately north of the entry point to Pump Station PS-01. The area has been sized to accommodate the equipment required for personnel to operate the pump station. The facility includes a switch room, kiosk substation, workshop, storeroom, crib and amenities room, and sufficient area for service vehicle parking.

As outlined within the Proposal geotechnical reports, the Seawater Intake channel levees are located on soft clay layers which will consolidate due to progressive construction activities and long-term settlement. The Feasibility Study design has allowed for this consolidation by including additional earthworks quantities and will ensure that there will be minimal impact on MNES during the construction phase and in service which will be limited to the permanent footprint of the channel.

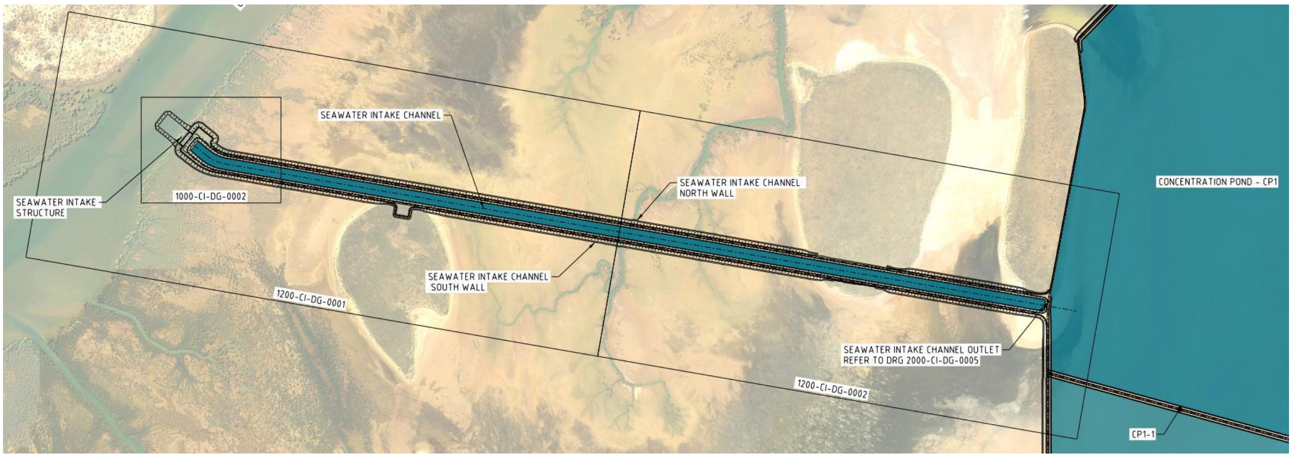


Figure 10: Sea Water Intake Channel

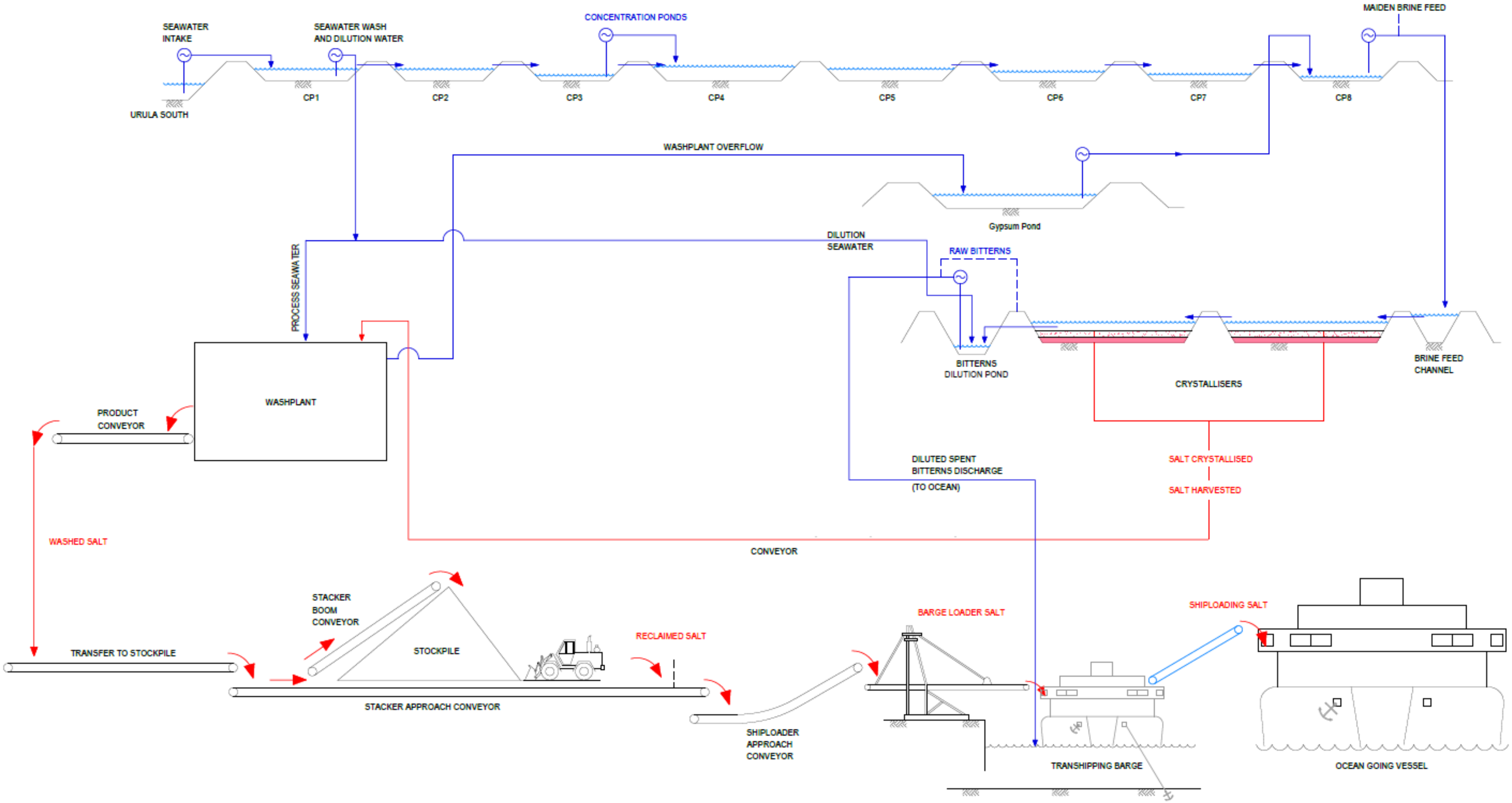


Figure 11: Solar Salt Farming Process Flow Diagram

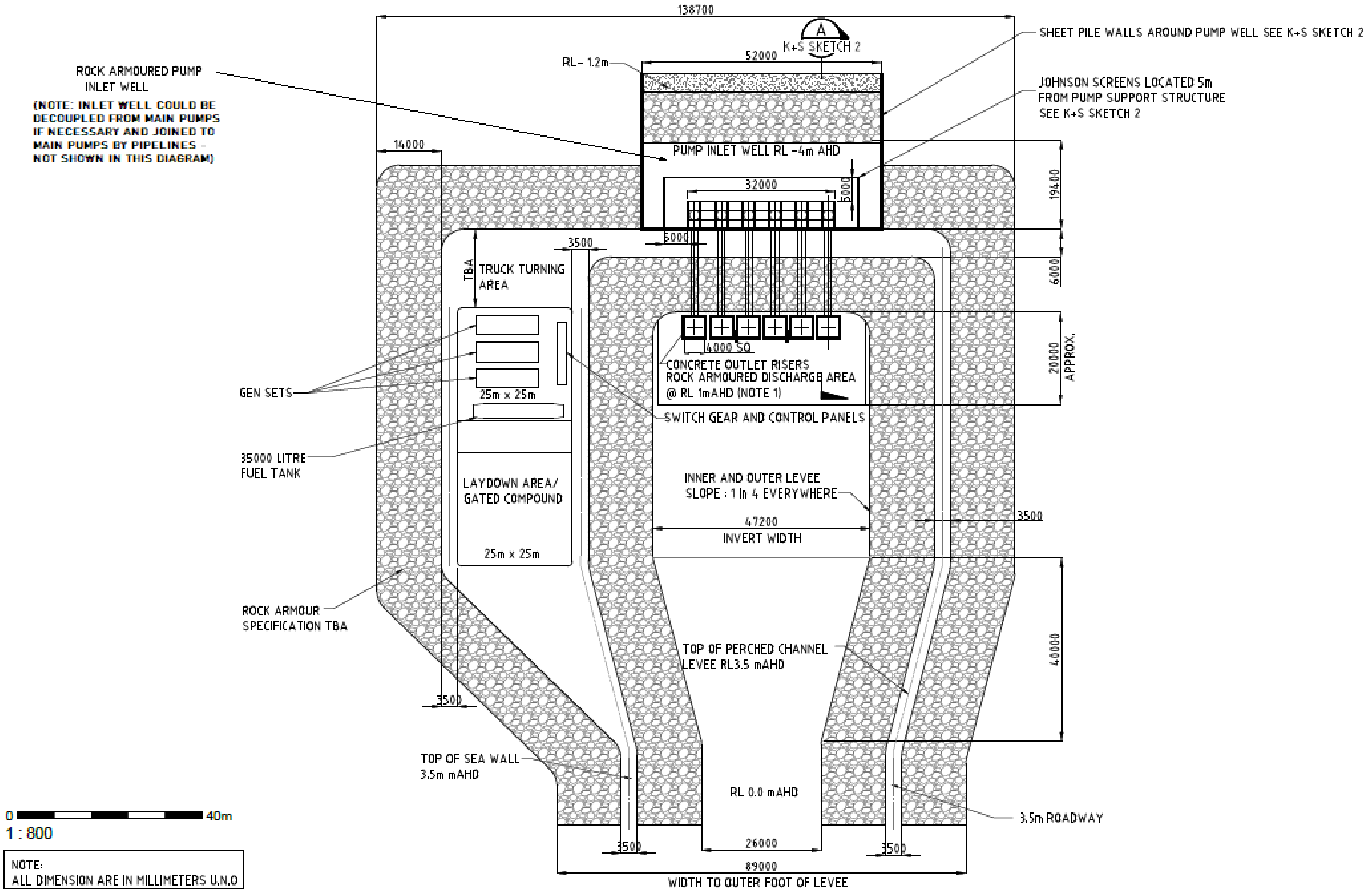


Figure 12: Seawater Intake Layout

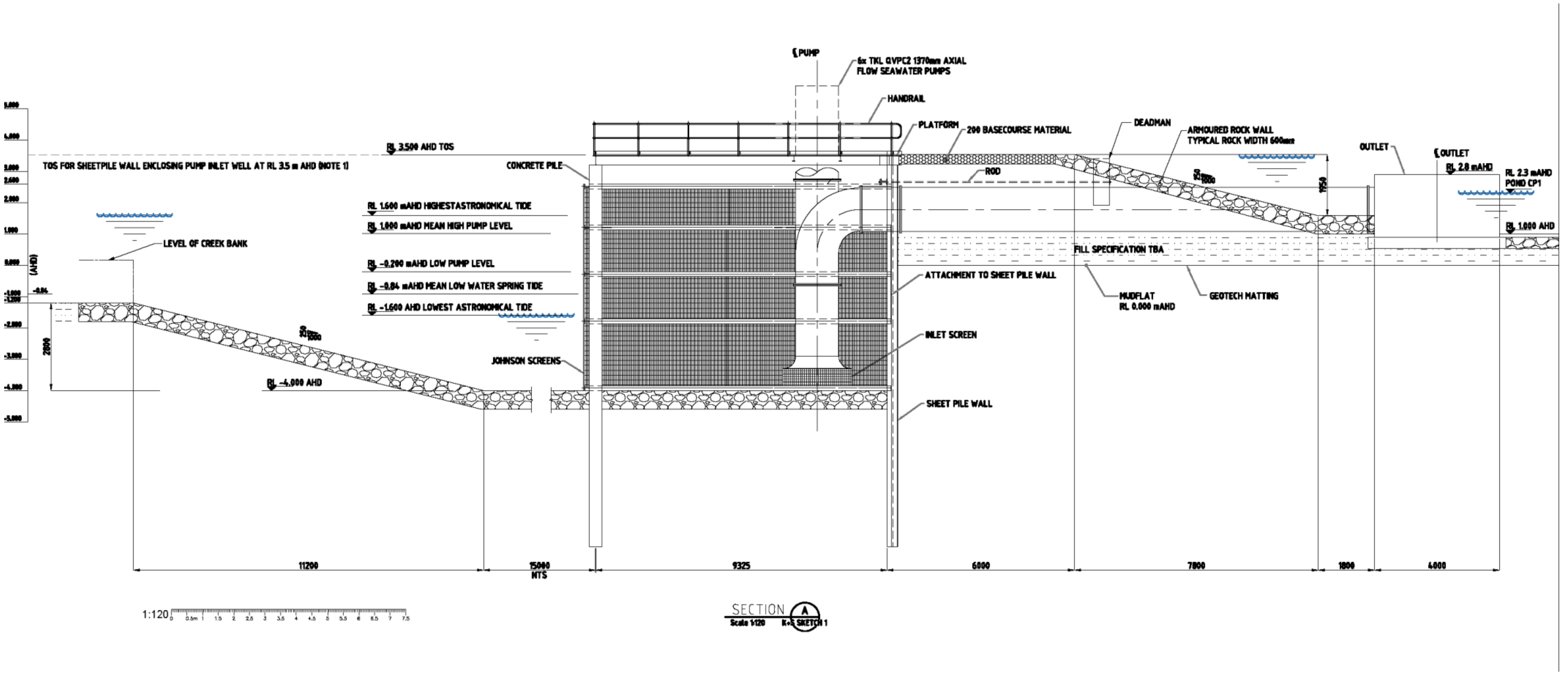


Figure 13: Seawater Intake Pump Station

2.3.4.2 SEAWATER EVAPORATION (SALT CONCENTRATION)

Evaporation Ponds

Seawater will be pumped from Urala Creek South via a channel into a series of eight evaporation (salt concentration) ponds (Figure 14 – Ponds CP1 to CP8). The design area is proposed to extend approximately 8,800 ha with perimeter embankments consisting of the following scope of work components:

- Salt concentration ponds with Seawalls (SW), Internal Walls (CP) and External Land Walls (LND) comprising of low permeability earthworks, rock protection and 3.5m wide internal access roads. The length of embankment segments totals approximately 34km.
- Brine transfer High-density polyethylene (HDPE) culverts between salt concentration ponds. The scope includes excavation, placement, backfill of culverts, and a provision for flow gates and maintenance access structures. A summary of the culvert requirements for the salt concentration ponds are listed as follows:
    - Concentration Ponds CP1 to CP2 - Ten (10) x DN1000 Culverts
    - Concentration Ponds CP2 to CP3 - Six (6) x DN1200 Culverts
    - Concentration Ponds CP4 to CP5 - Two (2) x DN1000 Culverts
    - Concentration Ponds CP5 to CP6 - Two (2) x DN1000 Culverts
    - Concentration Ponds CP6 to CP7 - Three (3) x DN900 Culverts
    - Concentration Ponds CP7 to CP8 - Five (5) x DN630 Culverts
- Brine Pump Station PS-02 comprising of four (4) axial flow pumps and associated fittings to transfer brine between salt concentration ponds CP3 and CP4. The pump station is supported by reinforced concrete pad footings and includes a provision for concrete stairs with steel handrails to enable access for future pump maintenance.

As seawater passes through the pond system, water is evaporated via solar energy, thereby producing a progressively denser brine with an increasing concentration of dissolved salts. Calcium salts precipitate out of the brine at an early stage, initially as calcium carbonate, then as calcium sulfate (as gypsum). As the calcium salts settle to the pond floors, they increase pond floor impermeability. At the final evaporation pond outlet (CP8) the brine will be saturated with sodium chloride. At this point, ~85% of the gypsum will have been removed.

A 25-year design life has been adopted for the pond wall levees, allowing for several future provisions of wall upgrades (if required) to accommodate potential future storm intensity / frequency increases over the nominated design life. A rock armouring system provides protection for a range of storm events, with the ability to extend the height of the pond wall levee embankments in the future to cater for potential changes in climatic and extreme design conditions. The two primary extreme (cyclonic) average recurrence interval (ARI) design events that have been considered for the pond wall levee embankment design include both the 1 in 50 year ARI and 1 in 100 year ARI design (cyclonic) events that was extracted from the synthetic cyclone modelling work contained within the Marine and Coastal Assessment and Modelling Report (Water Technology, 2022b).

The modelling considered future Sea Level Rise (SLR) of 400mm and assessed the storm surge and wave impact at the locations across the pond wall levees, enabling a risk-based approach to be adopted for the final design criteria. The 1 in 50 year ARI extreme (cyclonic) design event was adopted as the basis for setting the minimum height of the pond wall levee embankments, with an exceedance probability of 39.65%, providing design immunity (no overtopping) to cater for a combination of storm surge and wave run up with consideration for SLR. The 1 in 100-year extreme (cyclonic) design event was adopted for survivability with the rock armouring designed on both the seaward and leeward side to withstand overtopping without major failure and an exceedance probability of 22.21%.

Within the detailed design phase, a more elaborate and detailed coastal inundation and surface water modelling analysis will be undertaken, in conjunction with variability in storm intensity within the synthetic cyclone modelling, to understand any adjustments that may need to be made to the original construction of the pond wall levee embankment design heights and design provisions.

Gravity Flows and Pumping Stations

The location, layout and sizes of the evaporation (salt concentration) ponds (Figure 14) have been designed to take advantage of the natural topography (where possible), to enable gravity fed flows between ponds, thus reducing the number of pumping stations as much as possible. Gravity fed flow will occur between the ponds, except between pond CP3 and pond CP4 where a pump station, located at the embankment between the ponds, will pump brine up from pond CP3 into pond CP4 to provide the hydraulic head necessary to allow gravity fed flow through remaining ponds CP4 to CP8. The still pond operating depth of water in the ponds will range from 0.8 to 1.3 m and sufficient freeboard has been allowed to accommodate a 1 in 50 year rainfall event. The pond fill heights have been determined through modelling (Water Technology, 2021c) taking into account both seawater intake volumes and predicted rainfall, so that the fill height of each pond is progressively smaller, which facilitates the gravity flow from one pond to the next (except for CP4 and CP5 which have a pump station between them) (Table 15).

Table 15: Pond Fill Heights

Pond	Maximum Water level (m Australian Height Datum (AHD)) (pond fill depth plus predicted rainfall)
CP1	2.50
CP2	2.30
CP3	2.10
CP4	2.45
CP5	2.35
CP6	2.25
CP7	2.15
CP8	2.05

Evaporation Pond Embankments

The internal and external pond embankment design is shown in Figure 16. It comprises rock armouring, clay fill and a trafficable surface on the top of the embankment. Protection against pond over topping in flood surge conditions (due to extreme wave conditions) has been incorporated into the design specifications. Pond embankment heights were calculated based upon the maximum modelled (Water Technology, 2021c):

- Storm surge levels and combined wave height over the coastal foreshore reserve to the west of the Proposal site for external impacts on the west-facing seawalls – based upon a 1 in 50-year storm event.
- Inland flood mapping for the external impact on the remaining seawalls – based upon a 1 in 50-year flooding event.
- Wind set up and fetch generated within the seawater concentration ponds - based upon a 1 in 50-year event.

The maximum embankment height will be 4.5 m above ground level (on external embankments that will be higher than internal embankments separating the ponds).

Brine Transfer Structures

The scope of work for the Brine Transfer Structures comprises of the maiden brine transfer structures including the following civil, structural, and mechanical components:

- Maiden Brine Transfer Pump Station PS-03 comprising of four (4) axial flow pumps to transfer brine between Salt Concentration Pond CP8 to the Maiden Brine Feed Channel.
- Maiden brine transfer structures comprising of four (4) x DN630 HDPE culverts at six (6) locations along Embankment CR5 to facilitate gravity transfer between the Maiden Brine Channel and Salt Crystalliser Ponds. Each culvert includes a provision for flow gates and access structures to enable future inspection and maintenance.

- Seawater Storage Pond Pump Station PS-04 comprising of three (3) pumps to transfer process seawater to the Salt Wash Plant and the Bitterns Discharge Channel for flushing purposes.
- Concentrated brine transfer structures comprising of ten (10) x DN630 HDPE culverts at six (6) locations along Embankment CI1 to facilitate gravity transfer from the south Salt Crystalliser Ponds (A1-F1) to the north Salt Crystalliser Ponds (A2-2). Each culvert includes a provision for flow gates and access structures to enable future inspection and maintenance.

Leaks or spillages of hypersaline brine

Due to the overall development being positioned largely on the supratidal salt flats, if a sufficiently large spill or leak of brine from the ponds or pipelines was to occur, it is predicted to have minimal impacts. Supratidal salt flats experience infrequent inundation due to seasonal spring tides, storm surge or rainfall. High surface temperatures and evaporation rates lead to hypersaline groundwater and the crystallisation of salt in surface sediments. The extreme conditions result in salt flats being devoid of marine or intertidal biota (no vegetation, algae or invertebrate fauna) and hence this habitat is not considered to support any benthic communities (AECOM, 2022a).

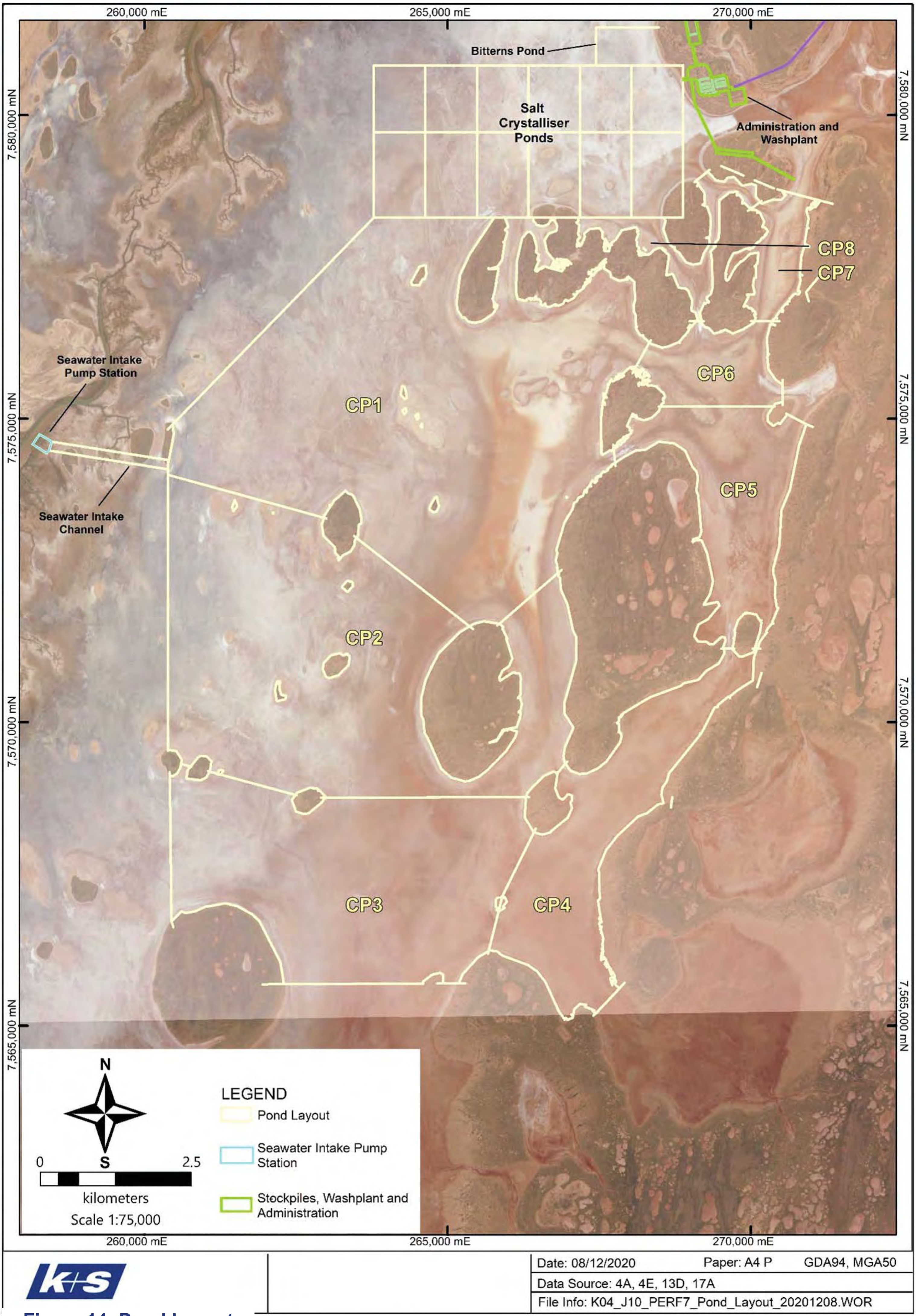
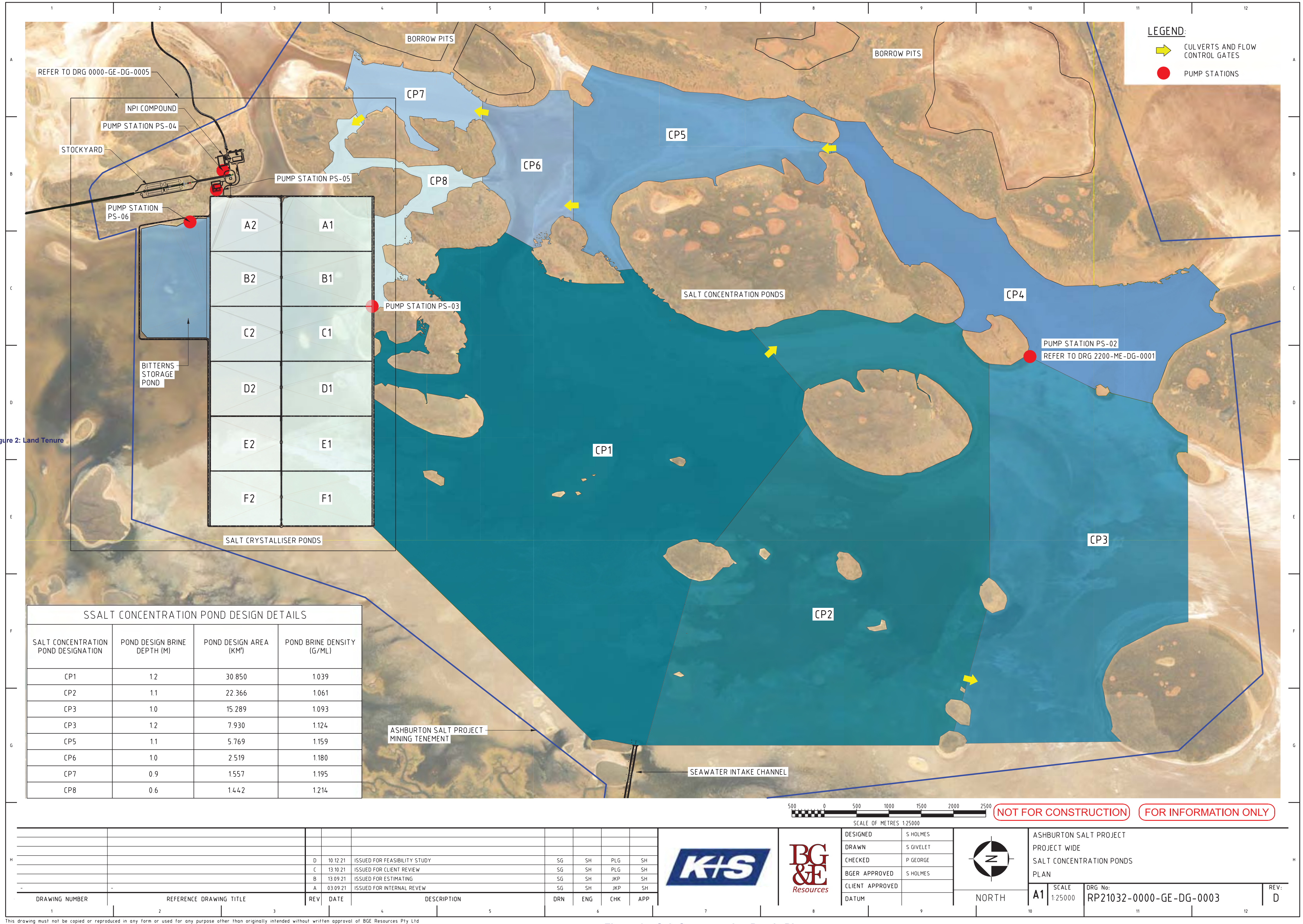


Figure 14: Pond Layout



SSALT CONCENTRATION POND DESIGN DETAILS

SALT CONCENTRATION POND DESIGNATION	POND DESIGN BRINE DEPTH (M)	POND DESIGN AREA (KM²)	POND BRINE DENSITY (G/ML)
CP1	1.2	30.850	1.039
CP2	1.1	22.366	1.061
CP3	1.0	15.289	1.093
CP3	1.2	7.930	1.124
CP5	1.1	5.769	1.159
CP6	1.0	2.519	1.180
CP7	0.9	1.557	1.195
CP8	0.6	1.442	1.214

Figure 15: Salt Concentration Ponds Plan

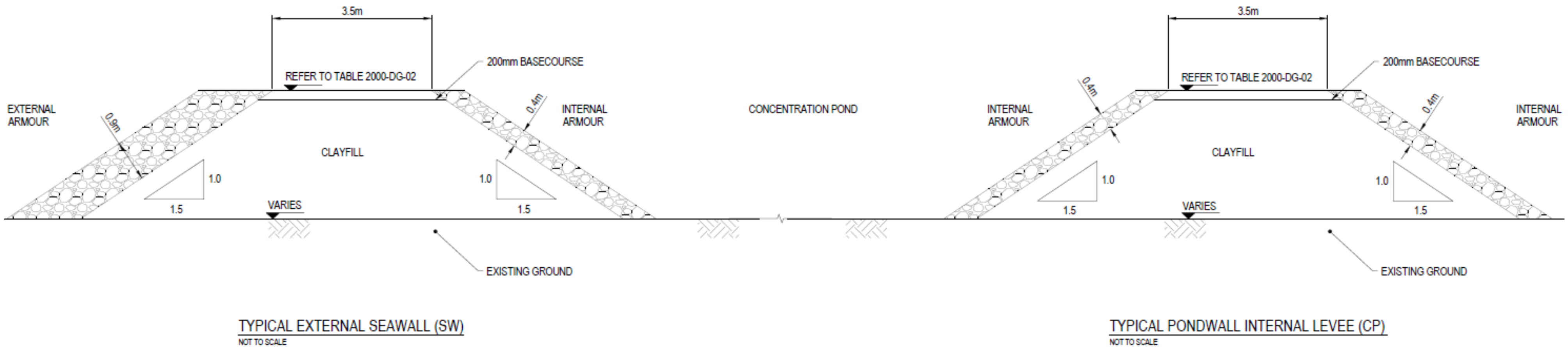


Figure 16: Typical Evaporation Pond Embankment Cross Sections

2.3.4.3 CRYSTALLISER PONDS

Twelve crystalliser ponds are located immediately north of the evaporation ponds. They are laid out in two rows of six ponds (Figure 14). Their purpose is to perform the final crystallisation process, to create the salt product.

Brine transfer into crystalliser ponds

In order to move to concentrated brine from the final evaporation pond (CP8) to the crystalliser ponds, the brine is transferred via the maiden brine transfer pump station into the maiden brine feed channel. The maiden brine channel runs from east to west, along the length of the six southern crystalliser ponds. The channel will be almost flat, adopting a 0.1 m drop end to end. This very slight gradient will facilitate passive brine flow from the eastern end of the channel (where the maiden brine transfer pump station is located), to the western end. As the brine in the channel flows from east to west, it flows past culverts in the southern levee of each pond which feeds each of the six southern crystalliser ponds. Further culverts through the levee between the southern and northern crystalliser ponds in turn feed the northern crystalliser ponds through passive transport.

Crystalliser ponds operation overview

From the maiden brine feed channel, the saturated brine enters the crystalliser ponds, where water is evaporated by solar energy until salt crystals (predominantly sodium chloride) are precipitated. Once the brine reaches an appropriate specific gravity, around 75% of the sodium chloride and most of the remaining calcium will have been precipitated.

For the initial 12 months of operation, the precipitate will be left in situ to accumulate on the pond floors to form a pavement some 300 mm in depth. This will ensure separation between the salt that will be harvested during normal production operations and the underlying mudflats. It will also permit the harvesters and haulage equipment to operate within the ponds to harvest the salt crystals. Under normal operational conditions, it is anticipated that 250-300 mm of harvestable salt will accumulate in the crystalliser ponds over a 12-month period.

Crystalliser pond embankments

Similar to the seawater evaporation ponds, the crystalliser external pond embankment heights have been designed to account for 1 in 50-year storm surge conditions. The maximum wall height will be 2.5 m above ground level for the external embankments, which will be higher than the internal embankments. There will be traversable roads along the internal face of the external embankments and along the central spine of the internal embankments. The crystalliser pond embankments will be constructed of clay fill and have appropriate wall slopes and rock armouring to minimise erosion. Typical cross sections of the crystalliser pond embankments are provided as Figure 17.

Salt harvesting

Salt harvesting will involve the following process, which will be carried out on each crystalliser pond individually when the optimum level of salt has accumulated:

- Draining the crystalliser pond of brine.
- Drying of the crystalliser pond floor via natural evaporation.
- Harvesting the salt within the crystalliser pond using harvesting and loading vehicles (e.g., surface miners, scrapers, loaders or alternative suitable mobile heavy equipment).

A conveyor will be positioned within the crystalliser ponds (e.g., between ponds a and b or another suitable location). Harvested salt will be dumped onto feeder hoppers, an elevating conveyor moves the salt onto the main conveyor.

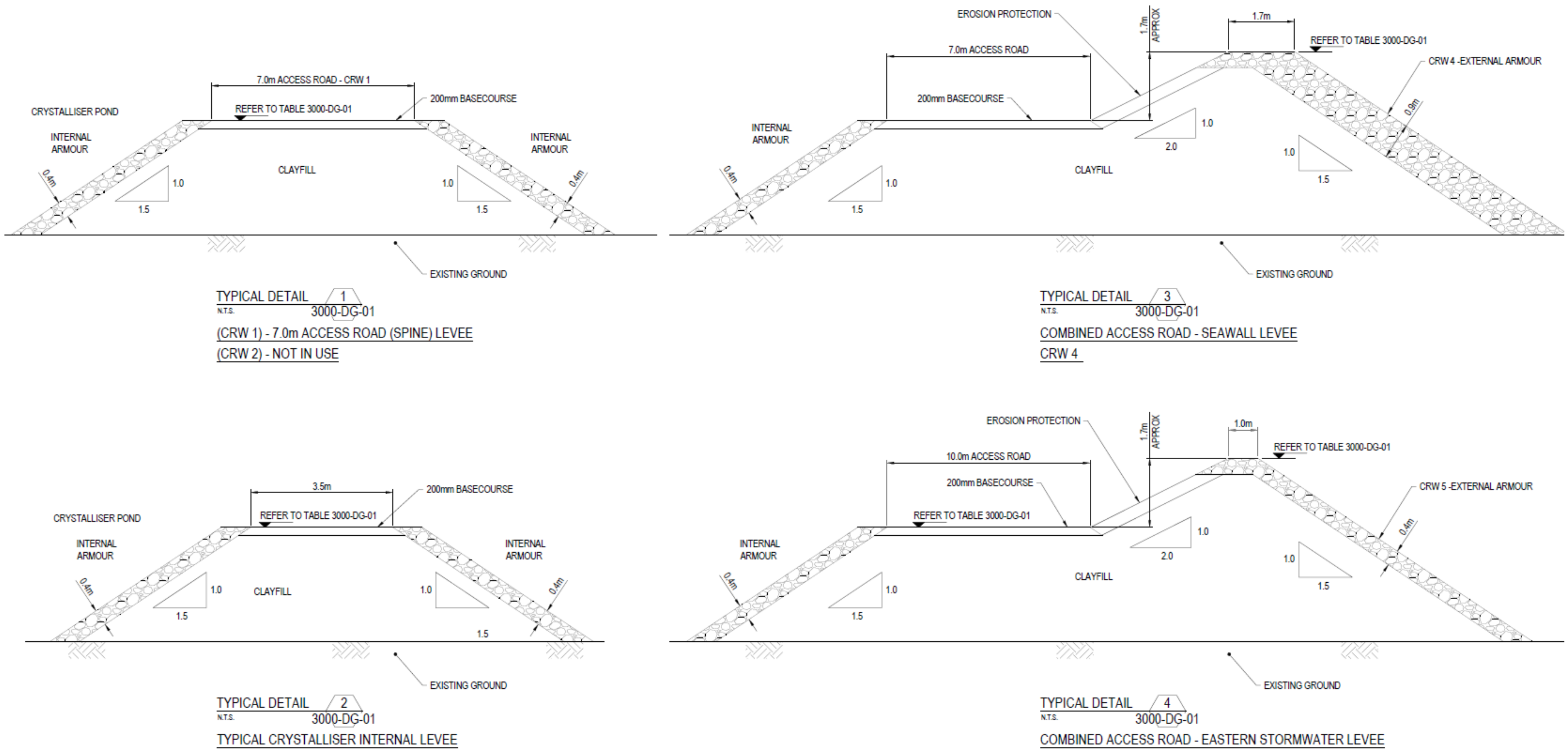


Figure 17: Typical Crystalliser Pond Embankment Cross Sections

2.3.5 WASTEWATER MANAGEMENT

2.3.5.1 OVERVIEW

After the salt has built up to a nominal depth in the crystalliser ponds, the ponds are drained and the salt collected using mechanical harvesters. The leftover wastewater brine (known as bitterns) from the salt farming process contains residual naturally occurring elements from the seawater.

Bitterns solutions generally have a salinity of around 300 Practical Salinity Units (PSU) and a density of 1,250 kg/m^3. They are markedly denser than the local seawater, which in the area has natural range of 35.0 to 53.5 PSU and a corresponding range in density of 1,027 to 1,041 kg/m^3. Being denser than the receiving seawater (negatively buoyant), the bitterns discharge will behave in a similar manner to the wastewater discharge from a desalination plant.

Notwithstanding this, it should be noted that salt production processes which then convert bitterns into potash, result in a much more concentrated bitterns than solar salt farming alone. The final bitterns stream after potash production would consist mainly of magnesium chloride ($MgCl_2$) and be another 5 times more concentrated than the bitterns proposed to be produced by the Proposal.

Discharge of bitterns to the marine environment results in the need for careful consideration of how appropriate dilution and mixing can be achieved on discharge. The approach proposed for the Proposal involves:

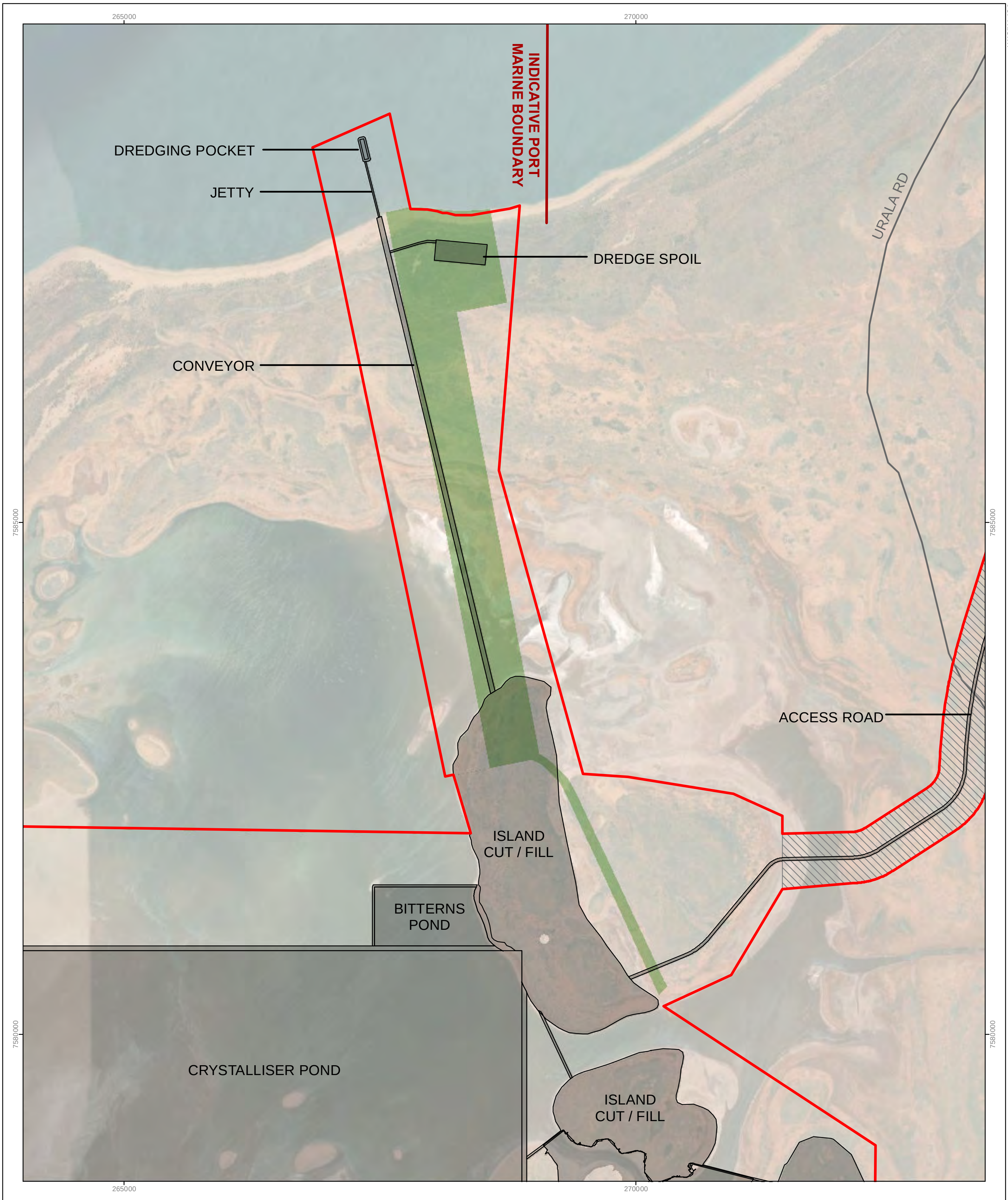
- Pre-dilution with seawater (at a rate of approximately one to one).
- Discharge via a pipeline extending 700 m from the coast.
- Discharge through a specially designed diffuser to optimise mixing with seawater.

2.3.5.2 BITTERNS DILUTION POND

The bitterns will flow from the crystalliser ponds into a bitterns dilution pond. The bitterns dilution pond will be located directly to the north of the northern set of crystalliser ponds (Figure 18). Seawater will be pumped into the bitterns dilution pond to dilute the bitterns to approximately a 1:1 ratio.

2.3.5.3 BITTERNS DISCHARGE PIPELINE

Following mixing in the bitterns dilution pond, the diluted bitterns will be mixed with the washwater and pumped via a pipeline to the jetty for disposal offshore. The pipeline overland route will follow the conveyor route and will extend offshore the along the export jetty (Figure 18 and Figure 19). A bitterns pump station will provide the pumping requirements to transport the bitterns to the coast.



Preston Consulting

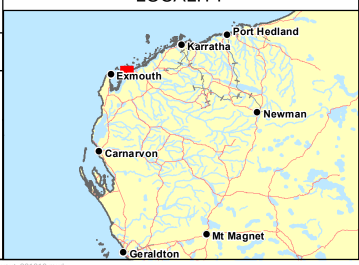
CREATED	JOB	DATE	REVISION
ENVIRONMAPS	PC2900360	19/12/2022	0

Ashburton Salt

0 0.25 0.5 1
km
Scale: 1:50,000 @ A4
N

- NOTE THAT POSITION ERRORS CAN BE >5M IN SOME AREAS

LOCALITY



Legend
- Development Envelope
- Indicative Port Marine Boundary
- Indicative Transhipping Route (no dredging)
- Indicative Transhippment Area
- Disturbance Footprint
- Proposed Road Reserve
- Proposed Landside Port Tenure

ENVIRONMAPS Environmental Mapping Solutions | t: 0406 590 006 www.environmaps.com.au

Figure 18: Northern Infrastructure Layout

ASHBURTON SALT - PORT PLAN

NOT FOR CONSTRUCTION

FOR INFORMATION ONLY

DRAWING NUMBER	REFERENCE DRAWING TITLE	REV	DATE	DESCRIPTION	DRN	ENG	CHK	APP
		D	10.12.21	ISSUED FOR FEASIBILITY STUDY	PLG	SH	TH	SH
		C	13.10.21	ISSUED FOR CLIENT REVIEW	PLG	SH	JKP	SH
		B	13.09.21	ISSUED FOR ESTIMATING	PLG	SH	JKP	SH
RP21032-0000-GE-DG-0002	SITE PLAN	A	03.09.21	ISSUED FOR INTERNAL REVIEW	PLG	SH	JKP	SH

BG&E Resources

DESIGNED	S HOLMES
DRAWN	P GEORGE
CHECKED	T HANKS
BGER APPROVED	S HOLMES
CLIENT APPROVED	
DATUM	

NORTH

ASHBURTON SALT PROJECT
PORT MARINE FACILITY
PORT
PLAN

A1 | SCALE 1:3000 | DRG No RP21032-0000-MA-DG-0006 | REV D

Figure 19: Port Marine Facility

2.3.5.4 BITTERNS DISCHARGE DIFFUSER

A multi-port diffuser will be installed at the end of the bitterns pipeline to ensure mixing of discharged bitterns with seawater is optimised.

K+S has estimated the discharge requirements based on the targeted production rate. Pre-dilution of the bitterns discharge was considered early in the Proposal by K+S. Washwater (ocean water) will be used to wash the harvested salt to get rid of the adherent bitterns and the possible KCl-crystals which could be grown during transport. No additional chemicals or organics are added to the washwater. The bitterns would be diluted 1:1 with an equal amount of seawater before being combined with the washwater and discharged from the diffuser at Locker Point.

The resulting effluent will have an average density of about 1,135 kg/m^3 and a salinity of 174.5 PSU. The discharge rate will range from about 0.14 cubic metres per second (m^3/s) in June to about 0.98 m^3/s in November. The November bitterns flow is critical for the diffuser design given this is the month with peak bitterns production due to highest evaporation rates leading to highest salt and wastewater production.

The bitterns flow is denser than seawater and the bitterns will sink towards the seabed. Several concepts were tested for the diffuser design. The Cormix nearfield model was used to model the various configuration of a 400 m diffuser placed at the end of the jetty. A diffuser located 2.3 m below Low Astronomical Tide (LAT) with the bittern jets oriented towards the sea surface increased the trajectory of the sinking plume towards the seabed. This provided a modelled dilution of approximately 100 times the discharge concentration at the seabed. The diffuser design concept therefore proposed is a 400 m long diffuser with approximately 25 mm diameter ports (nozzle), each discharging bitterns at 6 m/s. Considering redundancies necessary for such a system approximately 350 ports would be required. A diagram of the diffuser concept design is provided below (Figure 20) (Water Technology, 2022b). The final design of the diffuser will be determined prior to construction and documented within the Dredging and Sediment Management Plan (DSMP) as outlined in Appendix BB (K+S, 2021).

The hydrodynamic model was used determine the near field and far field impact of the bittern discharge from such a diffuser. Changing the jetty alignment was also modelled to ascertain the best alignment to optimise the bitterns mixing (by locating the jetty in the deepest water possible). The current alignment presented was optimised after serval iterations to achieve the best bitterns dilution (Water Technology, 2022b).

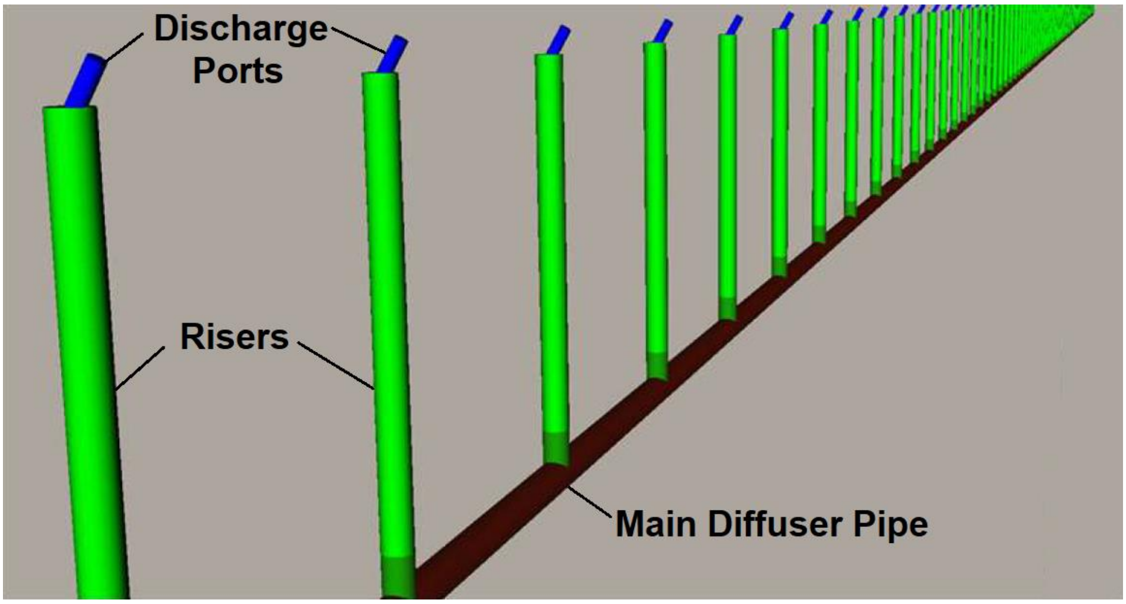


Figure 20: Diffuser Concept

(Water Technology, 2021c)

2.3.6 WASH PLANT

Harvested salt will be transported by conveyor to a wash plant located immediately to the east of the crystalliser ponds (Figure 18). The wash plant will remove impurities via washing of the salt and then dewatering the washed salt to an acceptable level. Impurities will consist mainly of residual organic and inorganic solids. Wastewater from the washing process will be directed to the bitterns dilution pond. The washing process will comprise the following (or similar) steps:

Salt washing, where a saturated brine solution is used to wash the salt to remove insoluble compounds. Washing columns or similar equipment will separate small and liberated insoluble compounds from the coarser salt crystals.

Possibly sizing of the salt rich underflow product using a series of wet vibrating screens, to remove the smaller impurities from the coarse salt product (if necessary to achieve the salt quality required by the market).

Seawater washing, to displace soluble impurities such as magnesium as well as to liberate insoluble, partially occluded impurities such as gypsum, by dissolving the surface layer from the salt crystals.

2.3.6.1 WASH PLANT WATER SUPPLY

A plant feed seawater pump station will provide ocean water for bitterns dilution within the bitterns dilution pond and to supply seawater to the wash plant. Additionally, the pumping station will supply water to the reverse osmosis plant for purifying into fresh water.

2.3.6.2 WASHED SALT STOCKPILING AND RECLAIMING

Washed salt will be stockpiled in a stockyard, located immediately north west of the wash plant (Figure 21). Salt will be stored in this area prior to reclamation onto a conveyor for transport to the jetty.

Salt from the wash plant will be delivered to the stockyard via a conveyor feeding a rail-mounted stacker which will deposit the washed salt into rows of stockpiles, which will be nominally 20 m high (Figure 21).

A separate reclaiming conveyor will be positioned next to the stockpiling conveyor. The two conveyors (one stockpiling and one reclaiming) will run parallel to the stacker rail through the centre of the stockyard.

Reclamation of the salt from the stockpiles to the reclaiming conveyor will be done via suitable equipment. Reclaimed salt will be deposited into hoppers which feed the reclaiming conveyor for transport to the jetty (Figure 18 and Figure 19)

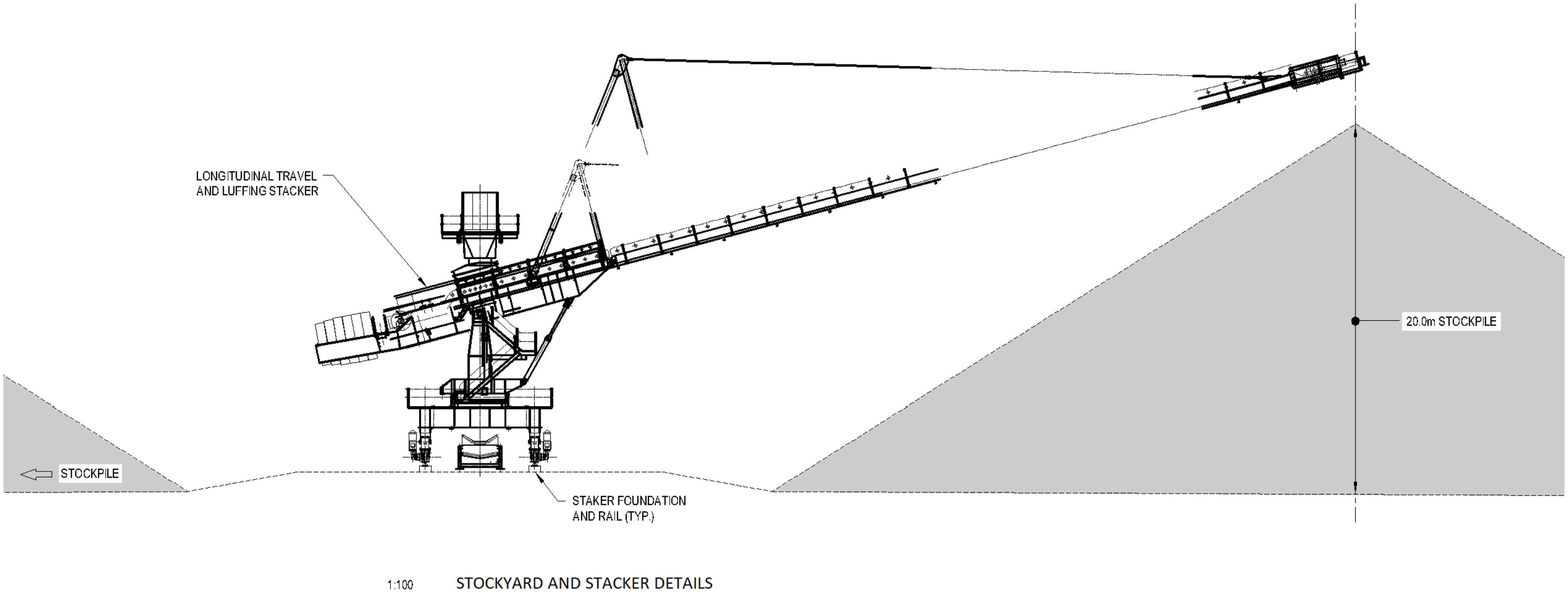


Figure 21: Stockyard and Stacker Details

2.3.7 SALT EXPORT

2.3.7.1 OVERVIEW

Salt carried by the reclaiming conveyor will be delivered to the jetty transfer station, where it will be transferred to the jetty conveyor, for transport along the 660 m long jetty (Figure 18 and Figure 19) for loading onto a purpose-built shallow draft, self-propelled transhipment vessel ('transhipper'), which will carry the salt to a larger ocean-going vessel moored in deeper water offshore. The transhipper will have a maximum draft of 6 m when fully loaded.

An indicative transhipment route and area has been proposed in consultation with Pilbara Ports Authority (PPA) approximately 14 nautical miles (nm) offshore (Figure 23). Ocean-going vessels will anchor in a designated transhipment area, to enable loading from the transhippers at sea. No permanent moorings are proposed within the transhipment area. Allowance has been made for the construction of five (5) flexible dolphins to accommodate berthing and mooring of the self-propelled transhipment vessel (transhipper). Each dolphin comprises of three (3) steel tubular piles (ϕ1050x22) with a steel prefabricated topside jacket to be grouted over the three piles. Each dolphin includes fendering, front fender panels and bollards (75t capacity) with secondary platform steelwork. Suitable anchorages will be designated in sandy areas to ensure sufficient anchor holding capacity. These areas will be identified through a combination of bathymetric and side scan sonar survey. Once target locations have been selected, video footage of the seabed will be taken at each location to confirm the substrate is sand, with sparse to nil benthic habitat present. Final site selection will be done in consultation with PPA. K+S is confident of achieving no loss of Benthic Communities and Habitats (BCH) in the transhipment area.

2.3.7.2 BERTH LOCATION AND JETTY CONFIGURATION

A 660 m long jetty is currently proposed to reach sufficient water depth to allow the transhipper to enter the loading berth (Figure 18 and Figure 19). Wave modelling has shown the prevailing wave direction is from the north-west, thus the jetty and berth pocket will be aligned in the same direction to avoid beam-on waves during transhipper loading. The jetty will accommodate a single conveyor for the out-loading of the salt to the transhipper. Abutment works comprise of earthworks, rock armour protection, steel piling, and reinforced concrete works for the abutment walls and approach slab. The access jetty structure comprises of steel tubular driven piles with steel box headstocks supporting prefabricated 30m long steel truss modules with precast concrete deck slab panels. The deck is approximately 8m wide with a 3.5m wide roadway, Conveyor CV-23 (1200mm wide belt) and services (Figure 24 and Figure 25).

The proposed shore crossing of the infrastructure is presented in Figure 19. The jetty piles will cross the beach face; however, these are not anticipated to impact the coastal processes significantly as sediment will still be free to move between the piles. The proposed jetty abutment is an armoured structure. As per Figure 19, this is proposed to be located well behind the beach face, within the primary dune. Under present day sea level conditions, it is not anticipated that the jetty abutment impact coastal processes as it is beyond the limit of storm activity. Revegetation around the jetty abutment structure will be undertaken in combination with monitoring to avoid any dune blowouts caused by wind action.

The predicted coastal hazard zone was calculated for the 50-year design life (Figure 22) in the vicinity of the abutment, as per the method outlined in Western Australian Planning Commission's (WAPC) State Planning Policy No. 2.6: State Coastal Planning Policy (WAPC, 2013, herein referred to as "SPP2.6"). The coastal hazard zone includes allowances for predicted short-term storm-induced erosion, historical shoreline movement and long-term shoreline retreat as a result of sea level rise. The jetty abutment protrudes approximately 45 m seaward of the predicted 2070 coastal hazard line (refer Figure 22). It is noted this hazard zone is not a prediction of the 2070 shoreline, rather an area of potential erosion hazard by 2070. During the operational phase, if the present design were selected, coastal monitoring will be done to ensure longshore transport processes are not impacted as a result of the abutment. In addition, rock armour of the abutment will be designed to withstand wave impact and run-up, to combat the risk of shoreline retreat and potential exposure to wave action. It is noted the method of SPP2.6 is designed with conservatism in mind.

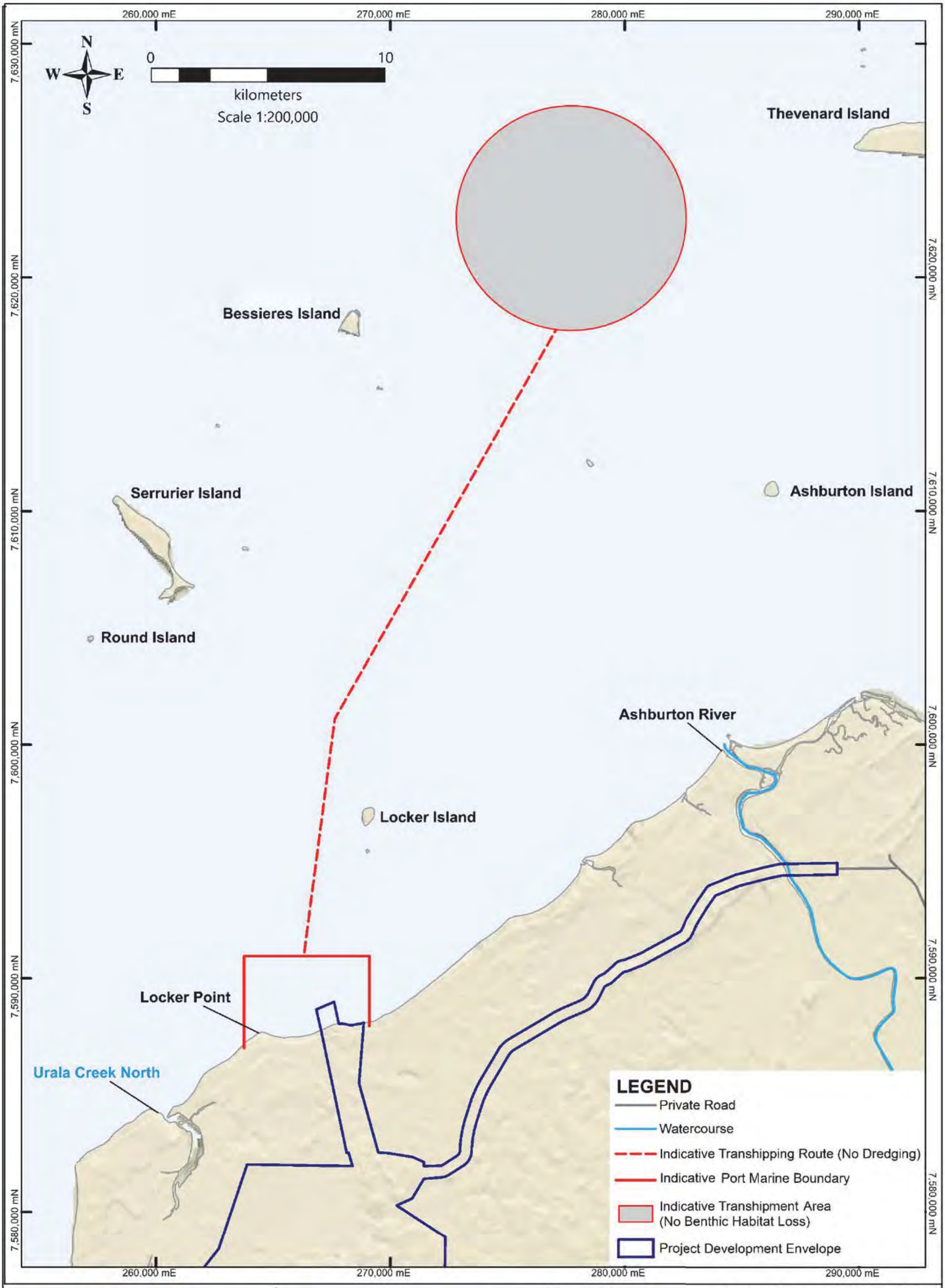
2.3.7.3 VESSEL LOADING AND MOVEMENTS

Following transport along the jetty on the conveyor, the salt will be loaded on to the transhipper via a barge loader. The loader will be positioned on a purpose-built load platform at the end of the jetty. A transfer structure to transfer salt from the jetty conveyor to the barge loader boom will also form part of the overall barge loading structure. The structure comprises of tubular driven piles with site welded pile caps supporting prefabricated steel platform modules with precast concrete deck panels. The deck is approximately 38m long x 20m wide and supports the transhipper machine, Pump Station PS-07 and facilities for operations personnel. Figure 26 provides a preliminary schematic design for the barge loading infrastructure. Either a mechanical or gravity reclaim system within the transhipper will be used to transfer the product, via a conveyor system, into the holds of the export vessel.

A total transhipper cycle time of 13.21 hours has been calculated by the Proposal of which a total of 4.25 hours will be spent travelling to and from the marine jetty to the offshore loading locations. The remainder of the time will be spent loading and unloading. It is estimated that nine cycles (approximately 4.8 days) are required to load the ocean-going vessel. The number of ocean-going vessel and transhipper movements expected will depend on international demand for the salt product, which is difficult to predict with certainty. However, the following estimates are provided to indicate the scale of potential vessel movements:

- Based on a maximum Proposal production level of 4.7 Mtpa, ocean-going vessel capacity of 70,000 tonnes (t) and 8,000 t transhipper parcel loads:
    - 67 ocean-going vessel (OGV) proceeding to anchor points per year.
    - 587 transhipper movements per year.
- Based on a slightly lower Proposal production level of 4.5 Mtpa, ocean-going vessel capacity of 150,000 t and 12,000 t transhipper parcel loads:
    - 30 ocean-going vessels proceeding to anchor points per year.
    - 375 transhipper movements per year.

Figure 22: Coastal erosion hazard zone for 50-year design life, as per SPP2.6 methodology (HSD = Horizontal Shoreline Datum)



K+S

Date: 25/08/2021 Paper: A4 P GDA94, MGA50

Data Source: 4A, 4E, 13D, 17A

File Info: S43a_Transhipment_Port_20210822.WOR

Figure 23: Indicative Transhipment Route and Area

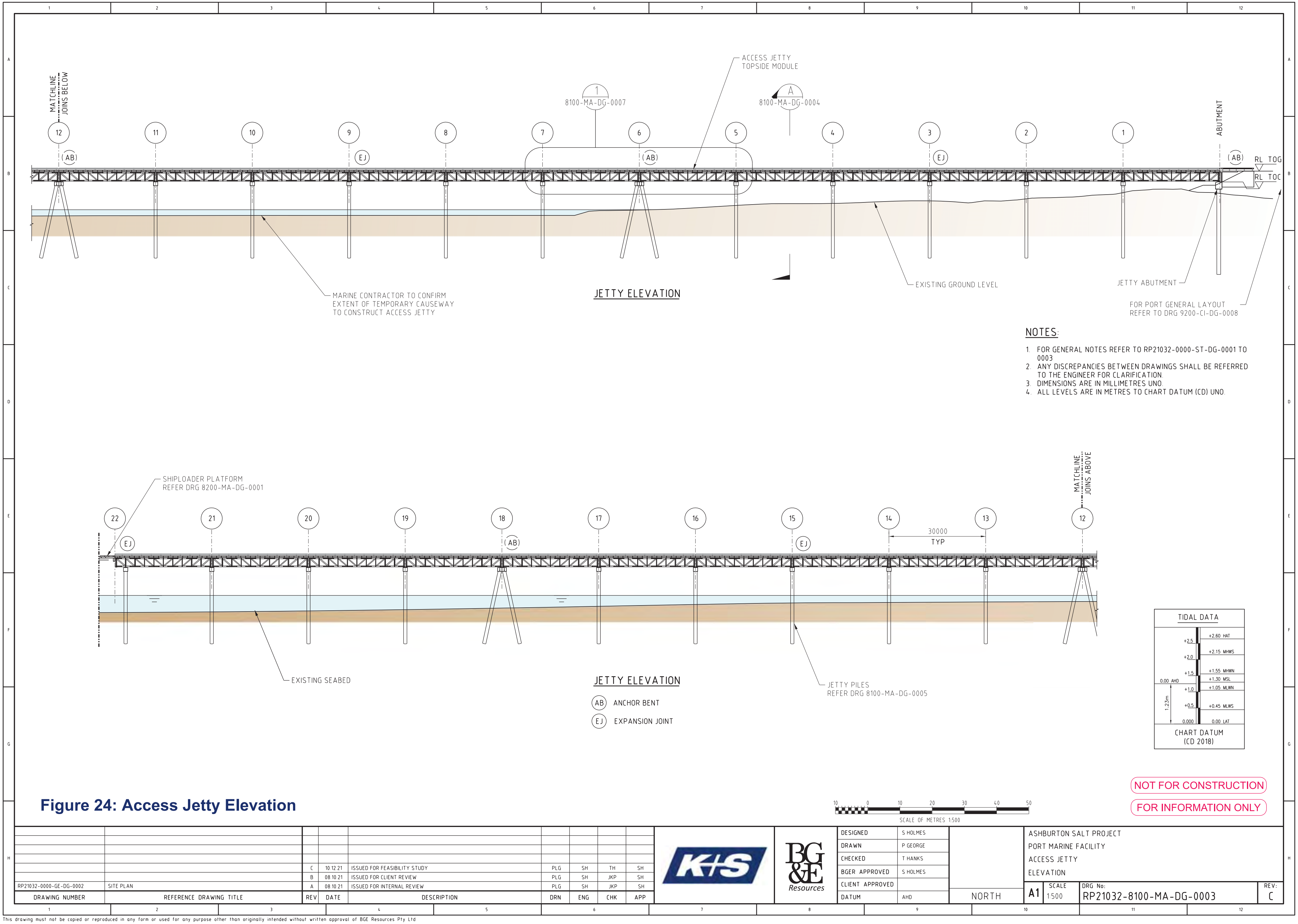
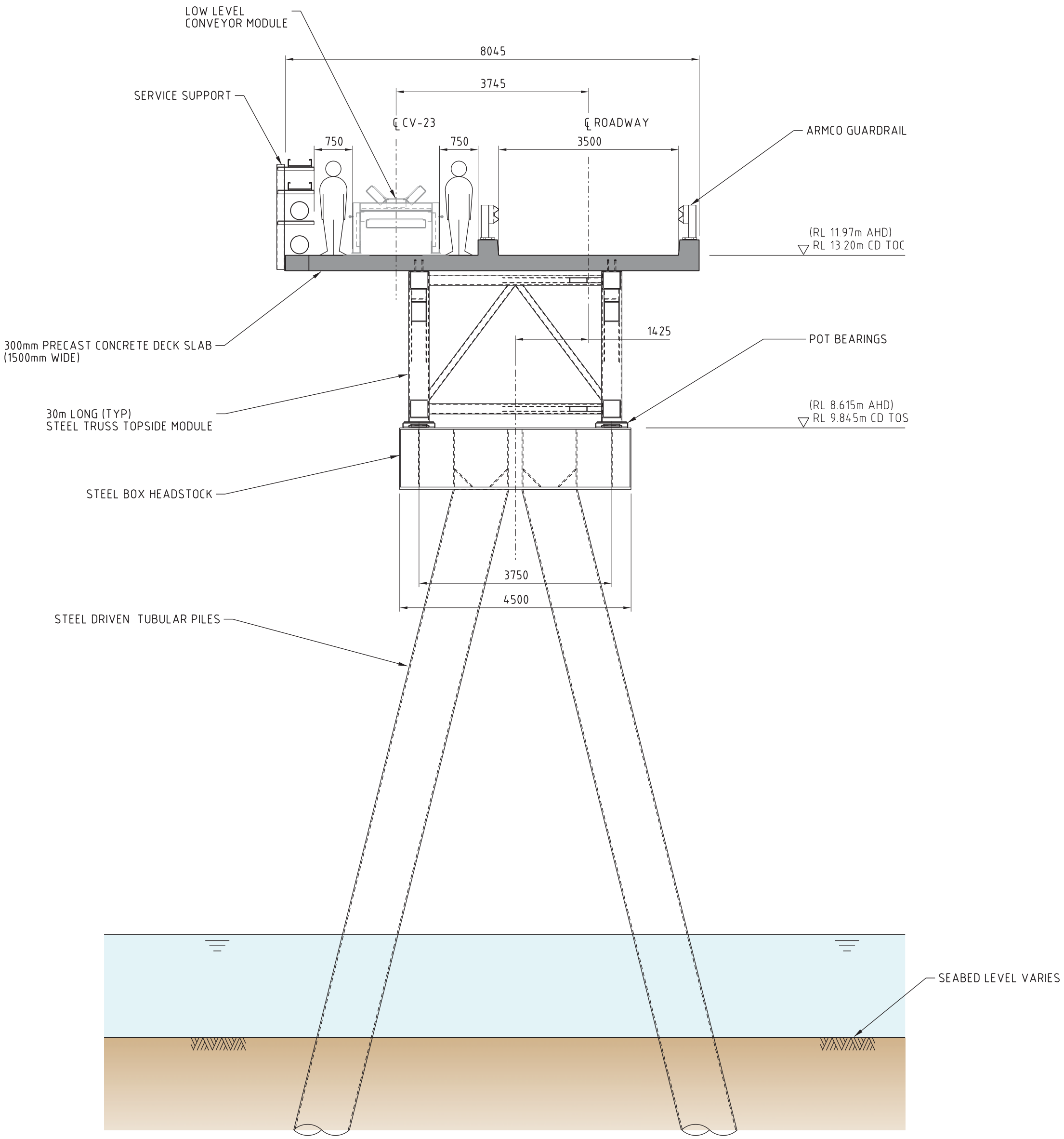


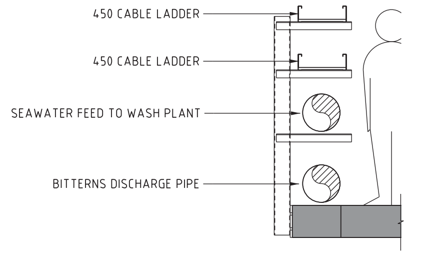
Figure 24: Access Jetty Elevation

NOTES:

1. FOR GENERAL NOTES REFER TO RP21032-0000-ST-DG-0001 TO 0003
2. ANY DISCREPANCIES BETWEEN DRAWINGS SHALL BE REFERRED TO THE ENGINEER FOR CLARIFICATION
3. DIMENSIONS ARE IN MILLIMETRES UNO
4. ALL LEVELS ARE IN METRES TO CHART DATUM (CD) UNO.



TYPICAL JETTY CROSS SECTON



TYPICAL SERVICE SUPPORT

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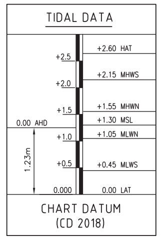

NOT FOR CONSTRUCTION

FOR INFORMATION ONLY

Figure 25: Access Jetty Sections

SCALE OF METRES 1:50

DRAWING NUMBER	REFERENCE DRAWING TITLE	REV	DATE	DESCRIPTION	DRN	ENG	CHK	APP
		D	10.12.21	ISSUED FOR FEASIBILITY STUDY	PLG	SH	TH	SH
		C	13.10.21	ISSUED FOR CLIENT REVIEW	PLG	SH	JKP	SH
		B	13.09.21	ISSUED FOR ESTIMATING	PLG	SH	JKP	SH
RP21032-0000-GE-DG-0002	SITE PLAN	A	06.09.21	ISSUED FOR INTERNAL REVIEW	PLG	SH	JKP	SH

K+S

BG&E Resources

DESIGNED	S HOLMES
DRAWN	P GEORGE
CHECKED	T HANKS
BGER APPROVED	S HOLMES
CLIENT APPROVED	
DATUM	AHD

NORTH

ASHBURTON SALT PROJECT
PORT MARINE FACILITY
ACCESS JETTY
SECTIONS

	SCALE	DRG No:	REV:
A1	1:50	RP21032-8100-MA-DG-0004	D

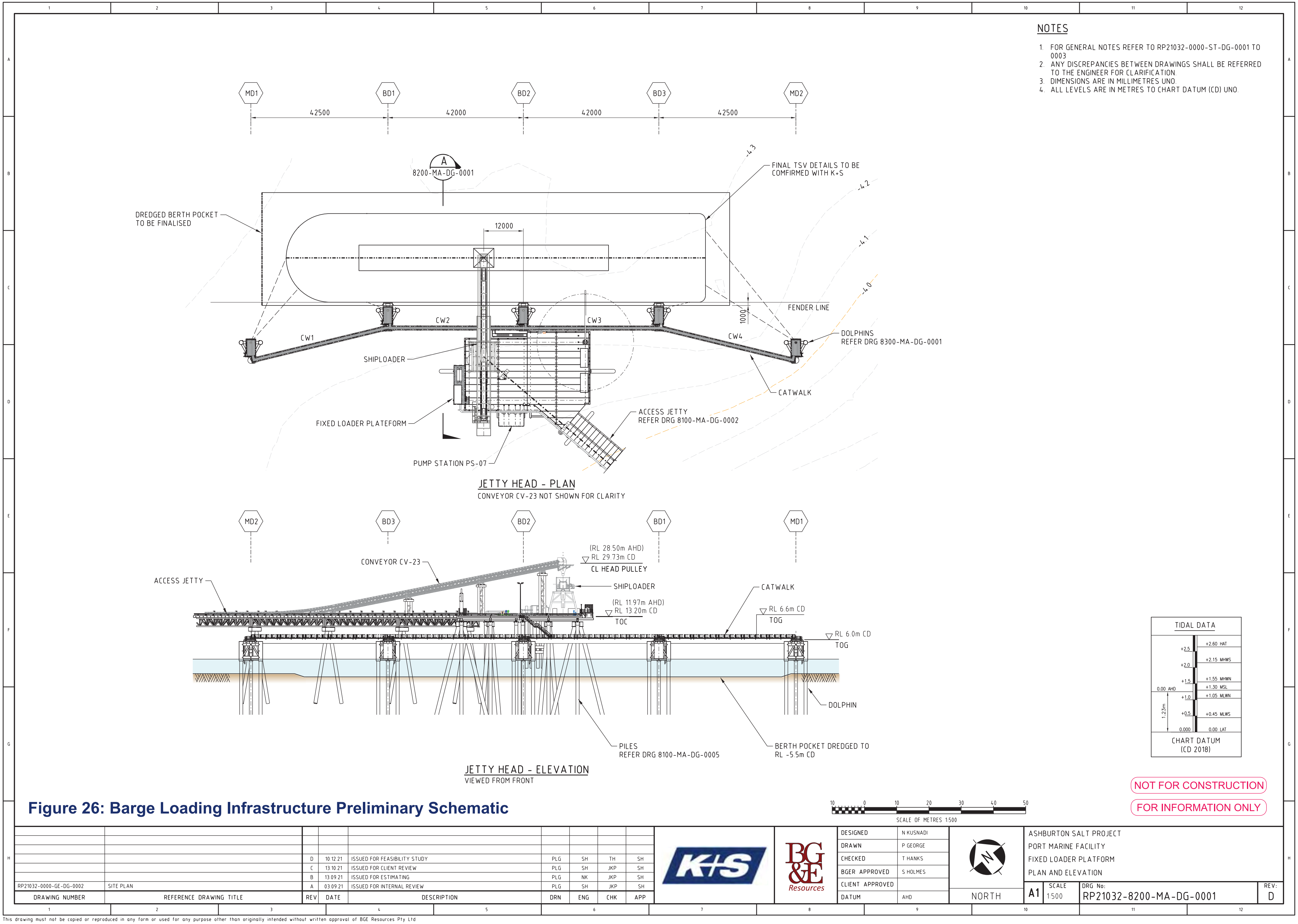

Figure 26: Barge Loading Infrastructure Preliminary Schematic

2.3.8 DREDGED BERTH POCKET

2.3.8.1 OVERVIEW

Dredging of a berth pocket at the end of the jetty is required to allow the transhipper adequate water depth to remain within the berth pocket without tidal restriction. The berth pocket is required to be of sufficient depth, length and width to allow the loaded transhipper adequate under keel clearance to enable unhindered navigation out of the berth pocket. The planned dimensions of the berth pocket are 200 m x 35 m x 6 m of water depth (at low tide) – this requires dredging of approximately 2.5 m of seabed. Total dredge volume is estimated to be 17,000 m^3. The dredging program will take approximately 2 weeks to complete. The location of the dredged berthing pocket is provided in Figure 18 and Figure 19.

2.3.8.2 MAINTENANCE DREDGING

The base of the berthing pocket is expected to consist of stiff sandy clay. This will effectively form a hard base that will resist erosion under the effects of waves, currents and propellor wash from the transhipment barge. By comparison, the natural surface of the surrounding seabed consists of soft clayey silt that can be more readily put into suspension.

A series of water samples were taken from near the location for the end of the jetty at roughly monthly intervals from November 2018 through to February 2020. Samples were taken from the sea surface and near the seabed. These samples had a mean suspended sediment concentration (TSS) of just under 10 milligrams per litre (mg/L). The maximum measured TSS was 32 mg/L, and the 80th percentile was 16 mg/L. These suspended sediments would be expected to consist of fine silt and clay particles consistent with the surrounding seabed. If sediment at these concentrations was allowed to settle continuously in the berthing pocket, it would be expected to result in sediment build-up on the bed of the berthing pocket of just under 1 cm per year. In the absence of other factors, and allowing for the effects of consolidation, this could be expected to result in net sedimentation of only around 0.3 m over the 50 year life of the Proposal.

Further, the transhipment barge is expected to carry out an average of 318 transhipment operations per year. Each barge transhipment cycle is expected to take an average of approximately 21 hours and will involve two manoeuvring operations within the berthing pocket: one for departure when laden, and one for mooring when in ballast. It is expected that propellor wash from these manoeuvring operations would help keep the berthing pocket clear of any unconsolidated fine sediment and empty what may have settled out between each mooring operation.

Based on the above it is unlikely that maintenance dredging will be required over the operational life of the Proposal. If, as a result of tropical cyclones or some other unforeseen circumstance, the rate of sedimentation is higher than expected, then the total volume of material to be removed by maintenance dredging will be significantly less than that for the original capital works dredging, considered above. Similarly, any environmental effects would correspondingly be significantly less. This would result in a shorter dredging timeframe for periodic maintenance of the berthing pocket (approximately 1 week).

2.3.8.3 DREDGE SPOIL DISPOSAL

Dredge spoil disposal (from initial or maintenance dredging) will occur on land near the jetty at the location shown in Figure 18. The spoil will be sent onshore to a bunded area, to allow dewatering and if necessary, treatment of acid sulfate sediment within the spoil. Where possible the dewatered solid material will be used for site construction material. The water produced by dredge spoil dewatering will be clarified, allowing particles to settle on the bottom, before being piped back to the ocean. The onshore disposal area will be located immediately inshore from the jetty location. Neutralising material will be added to the dredged material as necessary to treat any acid sulfate sediment detected. Decant water will be retained for a suitable time to allow appropriate water quality standards to be met (confirmed by monitoring) prior to release to the marine environment. Solids will be tested to ensure appropriate environmental standards are met, then will be reclaimed and used in on-site embankment construction.

2.3.9 NON-PROCESS INFRASTRUCTURE

2.3.9.1 OVERVIEW

A preliminary list of non-process infrastructure (NPI) for the Proposal will include the following (Figure 27):

- Administration building.
- Workshop and store facilities.
- Amenities and crib buildings.
- Laboratory facilities.
- Sewage treatment facilities.
- Refuelling facilities.
- Parking and laydown areas.
- Security and fencing.
- Roadways (site access road and internal roads within the site).

With the exclusion of roadways, all NPI buildings will be located within a portion of high land adjacent to the north-eastern corner of the crystalliser ponds (Figure 18). The wash plant will be located on the same portion of high land.

2.3.9.2 ADMINISTRATION, WORKSHOP, STORE, AMENITIES AND LABORATORY

Administration facilities, workshop and store facilities, amenities and laboratory facilities (Figure 27) will comprise a mixture of temporary modular structures and permanent facilities. All structures will meet cyclone proofing design criteria. The workshop facilities will include a vehicle wash down bay and dirty water collection system which will be treated by an oil water separator.

2.3.9.3 SEWAGE TREATMENT FACILITY

The site will be serviced by a single BioMAX-type sewage treatment plant located to the southern side of the main access road, opposite the amenities building (Figure 27). Below-ground sewerage will connect the main site facilities to the sewage treatment plant. In addition, the plant will receive sewage (transferred via tanker) from self-contained field ablution blocks at the seawater intake, concentration ponds, crystalliser ponds, wash plant, stockyard and jetty. Treated effluent will be used for localised landscape subsurface irrigation within the plant confines.

2.3.9.4 FUEL STORAGE AND REFUELLING FACILITIES

Diesel (for light and heavy vehicles) will be delivered to site via road tankers. Supply will be either from Perth or one of the Pilbara ports, depending on the fuel supply contractor. Typically, delivery will be by triple road train.

The road trains will deliver to a fuel store situated at the western end of the main site access road (Figure 23). The fuel store will consist of up to six 35 kilolitre (kl) tanks within a secure bunded area. The levels within these tanks will be remotely monitored by the fuel provider to allow optimal deliveries. There will be a vehicle refuelling area adjacent to the fuel store.

The transhipper barges will be fuelled by natural gas. A pipeline will be constructed into the Ashburton Salt site to supply the natural gas and applications for environmental approvals will occur separately from the ERD by the gas infrastructure provider.

2.3.9.5 PARKING AND LAYDOWN AREAS

Provision for parking has been included within the design of NPI buildings and offices, for heavy and light vehicles, respectively (Figure 27). Additional room for limited light vehicle parking will be available at remote pump stations and the jetty abutment.

Much of the area where site facilities and NPI buildings are to be developed will be levelled early within the construction works, to provide fill for the pond embankments. Once levelled, this area will be used to establish the main temporary construction facilities and for laydown during construction. A small temporary laydown area will be established near the jetty abutment to facilitate construction of the jetty and conveyor transfer tower.

During the operational phase of the Proposal, the stores yard will provide the main laydown area for the site (Figure 23). If required for major shutdown work, part of the run in/run out area for the truck parking will be cordoned off as a temporary laydown area.

2.3.9.6 SECURITY AND FENCING

A security building will be located on the north-eastern corner of the NPI area, at the western end of the Proposal site access road (Figure 23). The building will be of modular design and will serve as the Proposal gatehouse and emergency response centre. Fencing in the Proposal will be installed around all main high value assets, including all facilities in the NPI envelope as listed below:

- Main plant perimeter.
- Stores compound.
- Fuel farm.
- Potable water compound.
- Jetty abutment.
- Remote pump stations.

2.3.9.7 ROADWAYS

The Proposal site main access road and internal access roads are presented in Figure 28. The main access road will predominantly be an upgrade of existing roads or tracks and has been compared against flood mapping data to avoid low lying areas. Appropriate culverts have been designed to direct surface water flows underneath the road. In addition, initial sections of the road have already been identified for upgrade and development by other proponents in the area including the Shire of East Pilbara and Australian Gas and Infrastructure Group (AGIG). This includes a crossing of the Ashburton River.

The main access road design will be an 8 m wide unsealed road designed to tie into the existing road infrastructure due for construction by neighbouring proponents. Internal site roadways within the Proposal site will be designed to meet the traffic loads and need for traffic.

The internal site roadways for the Proposal will consist of the following:

- 8 m wide two-way unsealed roads, particularly for heavy vehicles access.
- 4 m wide one-way roads.
- Unsealed roadways on top of the various pond embankments 3.5 m in width.

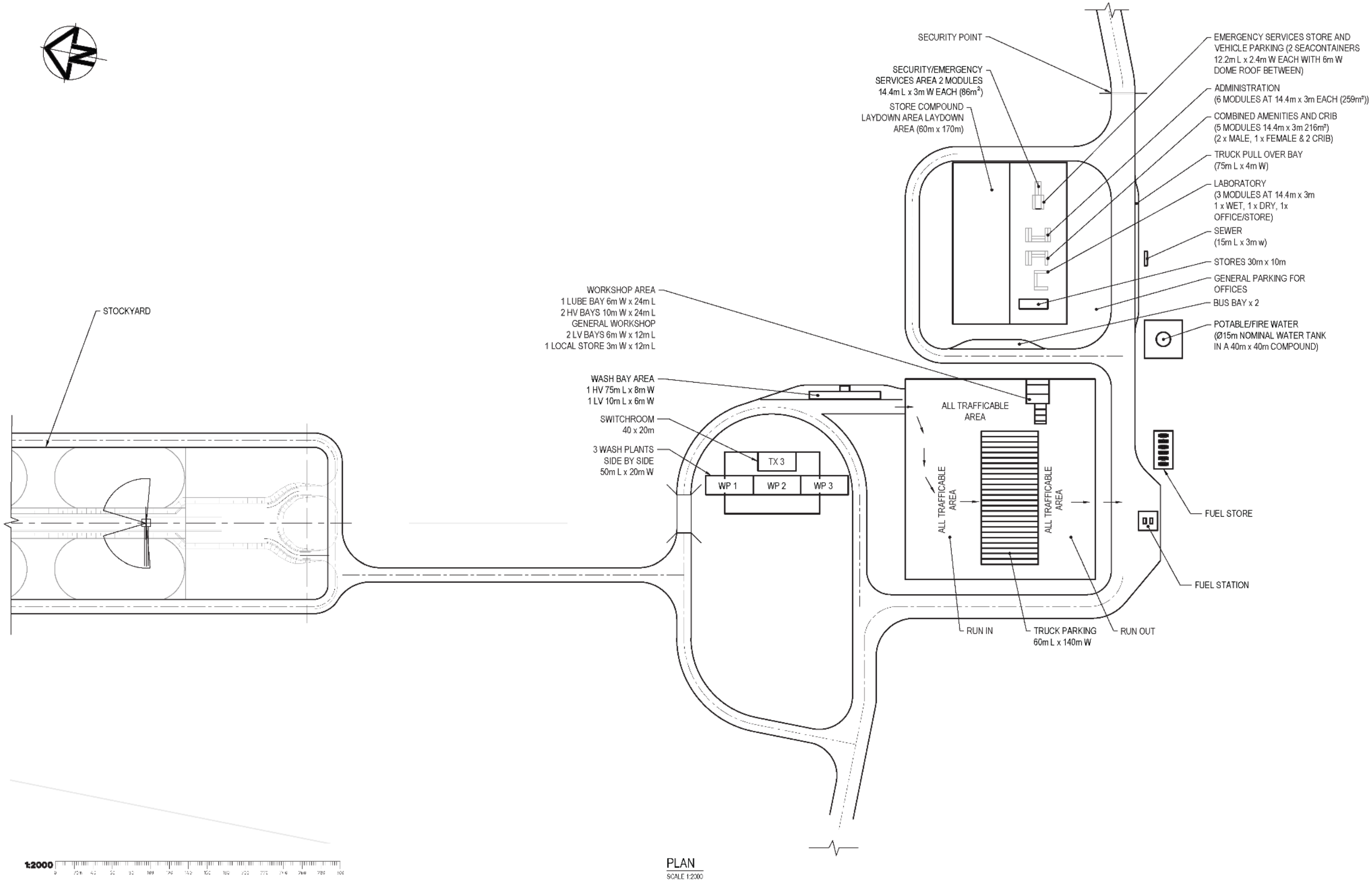

Figure 27: Non-process Infrastructure Schematic

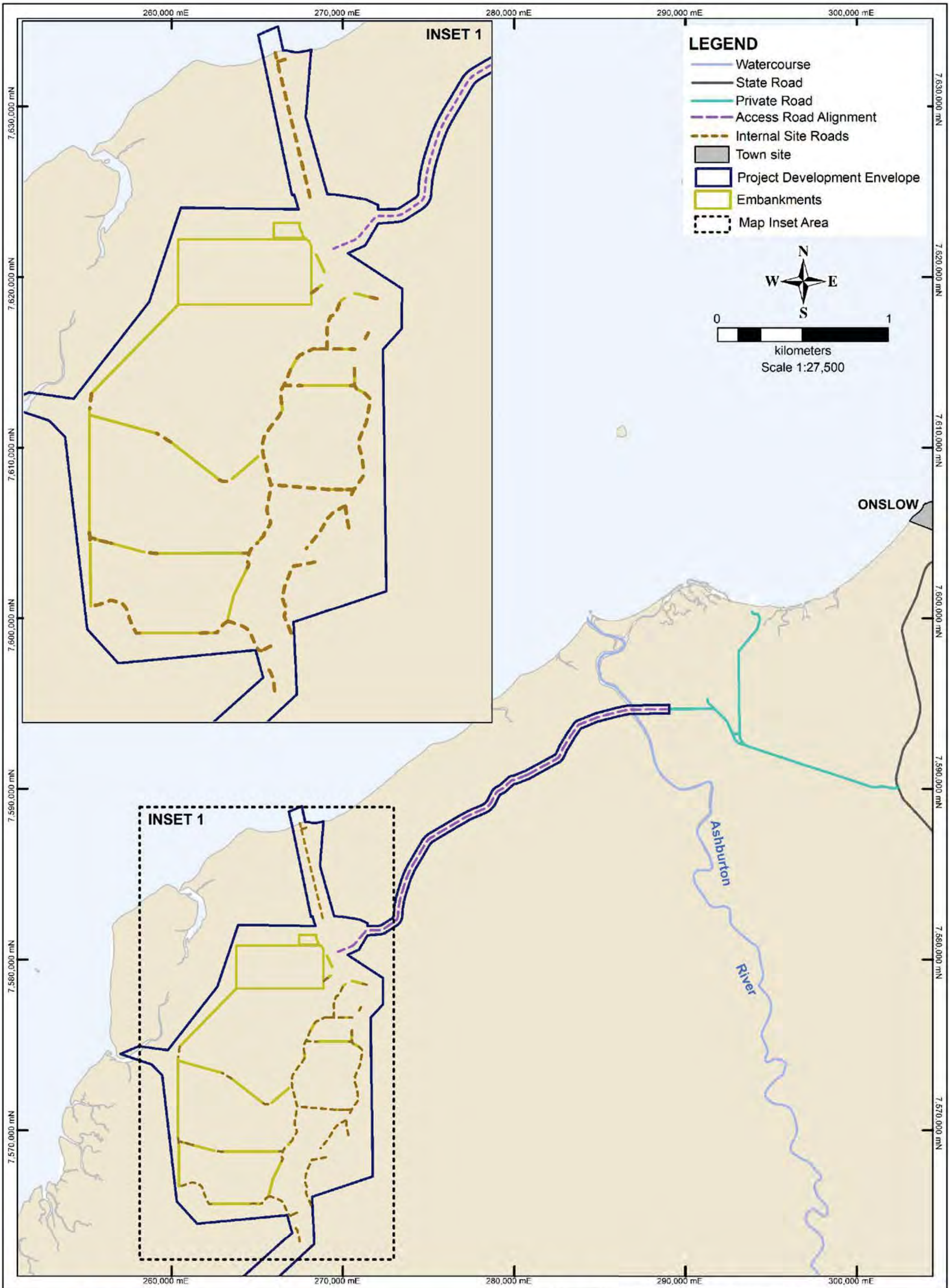

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Figure 28: Access Road Alignments

2.3.10 UTILITIES AND SERVICES

2.3.10.1 POWER GENERATION AND DISTRIBUTION

Electrical power will be provided by an offsite nearby natural gas fired power station. Electrical power lines will be constructed to bring reticulated electricity to the Ashburton Salt site. Environmental approvals for power lines to the site will be undertaken separately to the ERD process.

Only small-scale diesel generators will be provided on site for emergency power.

2.3.10.2 POTABLE WATER, FRESHWATER AND FIREWATER SUPPLY

Reticulated potable water, freshwater and firewater will be generated on site. Seawater supplied by the seawater intake will be treated using a 40 kl/day reverse osmosis system. The treated fresh water will be pumped to the combined potable water/fire water tank in the utilities area to the south of the main plant site. Small-package disinfection facilities will be installed at the main buildings requiring potable water, thereby ensuring compliance with the Australian Drinking Water Guidelines.

The wastewater from the reverse osmosis plant will contain concentrated salts and will be discharged back into a concentration pond to become part of the process stream.

2.3.10.3 SITE COMMUNICATIONS

A communications tower will be installed to provide mobile phone and UHF radio coverage for all plant areas. A microwave or optic fibre connection is envisaged to provide backhaul data from the site to Onslow for integration to Perth.

2.3.10.4 LIGHTING

Light pollution has been shown to have a predicted impact on MNES, in particular, marine fauna and shorebirds. Marine turtle hatchlings have the potential to become disorientated by light pollution, and as such this must be taken into consideration by K+S due to the proximity to potential turtle nesting activity. It is unknown how light may impact on sawfish, as it has not been investigated. However, other elasmobranch species have shown that artificial light during night-time hours has potential to alter their movements and timing of movements, which could be similar for sawfish. Migratory Shorebirds may be drawn to artificial light sources at the Proposal for night-time foraging purposes.

To ensure that the potential risks associated to light pollution are reduced, K+S will enact multiple management actions. Area lighting will typically consist of downward-facing low intensity amber lighting (595 nanometre wavelength) to minimise overspill and to limit light to the region of lowest visual sensitivity for turtles. Where practical, the lighting will be located relatively close to the ground. K+S will implement a Lighting Management Plan (LMP) to ensure that these risks are minimised. K+S will ensure to take guidance from the *Light Pollution Guidelines: National Light Pollution Guidelines for Wildlife Including Marine Turtles, Seabirds and Migratory Shorebirds* (DotEE, 2020).

2.3.11 SOURCES OF CONSTRUCTION MATERIALS

2.3.11.1 GENERAL FILL

Sources of general fill material for construction of levees, embankments and roads include deposits of material which can be found locally within the vicinity of the Proposal area. Such material includes sand and clay.

Levelling earthworks of the sites proposed for the NPI facilities and wash plant, and that of the stockyard will generate a portion of the general fill material volumes needed.

The location and footprint of onsite borrow pits for these general fill construction materials are provided in Figure 29.

2.3.11.2 ROCK

Material for rock armouring, and any rock for additional needs, is expected to be sourced from outside the Proposal area from an external supplier. Rock armour will be provided by an external supplier and transported to site.

2.3.12 STRUCTURES TO CONVEY SURFACE WATER FLOWS

To manage catchment and tidal driven water flows culverts, drainage diversions and levees have been designed via modelling (Water Technology, 2021c).

2.3.12.1 CULVERTS

To ascertain culvert dimensions and numbers along the conveyor and access road, peak discharges were extracted from the hydraulic model. Culverts were then inserted into the model and via an iterative process the size and number of culverts were optimised to ensure conveyance of required flows. Culverts are proposed along the main access to convey the 10% Annual Exceedance Probability (AEP) flood discharge. Table drains to direct flow along the road will have a minimum channel slope of 0.1%. Erosion protection will be provided up and down slope of the road where flow velocities are predicted to be >2 m/s. Culverts will also be installed underneath the conveyor.

The proposed culvert locations along the access road and conveyor embankment are illustrated in Figure 30. annotated as locations A to M. Within each culvert location, multiple culverts are required to mimic natural surface water movement through the site. The modelled culvert arrangement and flow discharge capacity is presented in Table 16. Final culvert designs and modelling of these will be undertaken as part of detailed design.

Table 16: Modelled Culvert Arrangement and Flow Discharge Capacity
(Water Technology, 2021c)

Location	10% AEP Flow (m^3/s)	5% AEP Flow (m^3/s)
A.	7.9	19
B.	185	194
C.	146	259
D.	48	85
E.	3.1	7
F.	35	91
G.	38	59
H.	10	41
I.	232	378
J.	187	251
K.	341	598
L.	75	90
M.	101	143

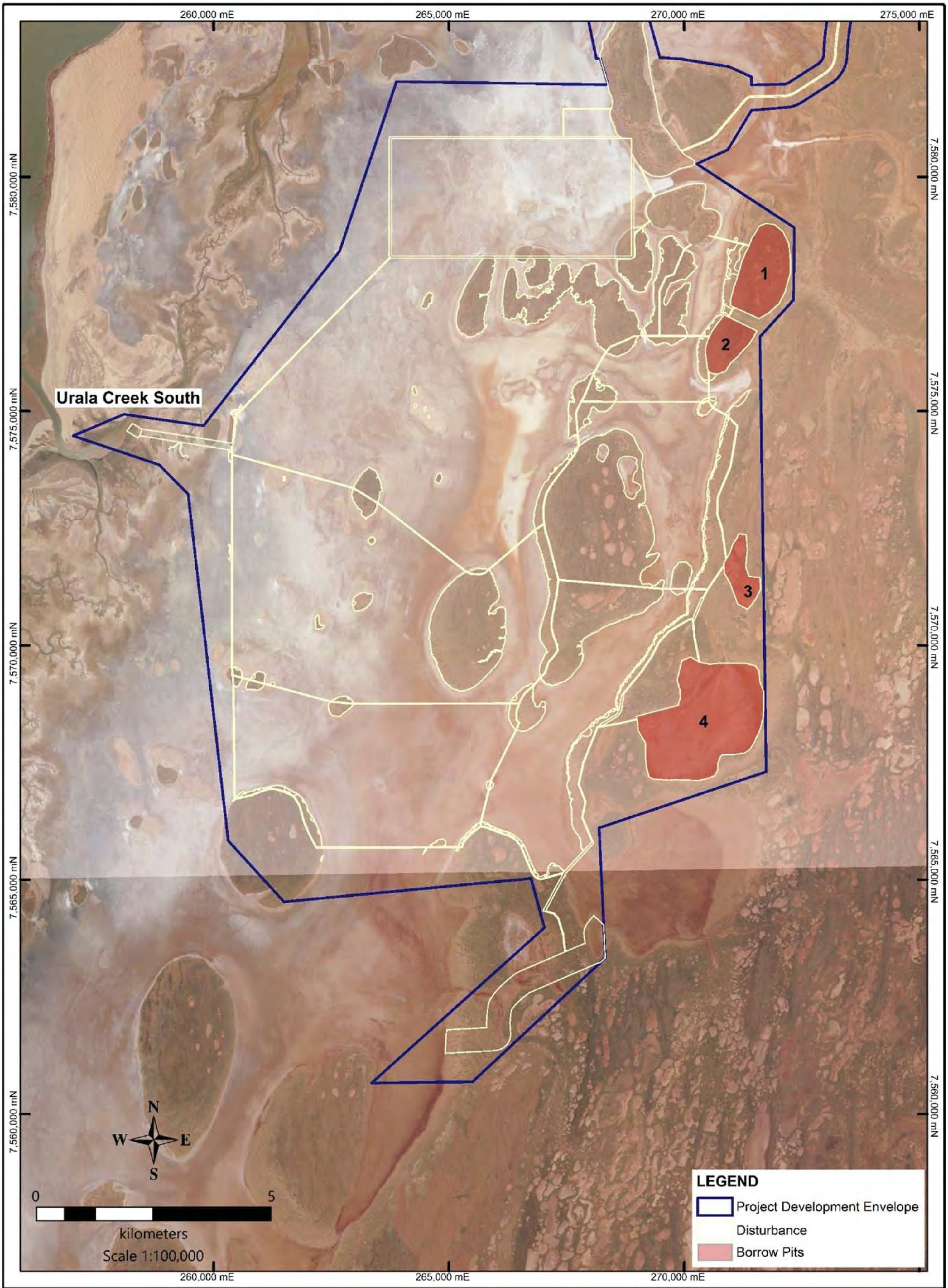

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Figure 29: Borrow Pits

Figure 30: Modelled Culvert Locations
(Water Technology, 2021c)

2.3.12.2 DRAINAGE DIVERSIONS AND LEVEES

Surface water modelling predicted that after rainfall, ponding of water would occur along the eastern margins of the evaporation ponds within "eastern basins" of the salt flats which have been isolated from the main salt flat area (Water Technology, 2021c).

Diversion channels have been proposed and modelled to move water from one basin to the next in a southerly direction via three diversion channels and convey water around the Proposal onto the salt flats. They have been designed to convey flows >2% AEP. The conceptual diversion channel cuts are depicted below in Figure 31. On the site layout plan (Figure 3, Figure 29) they are depicted as a single drainage diversion as disturbance would occur along a continuous strip of land in order to gain access to construct the three cuts.

Nominal locations of levees to protect pond embankments from floodwaters within the eastern basins have also been provided by Water Technology (2021c) (Figure 3, Figure 29).

Final drainage diversion and levee designs and modelling will be conducted as part of detailed design.

2.3.12.3 ASHBURTON RIVER CROSSING

A bridge crossing over the Ashburton River is planned along the main access road to allow access to the site from Onslow (Figure 28). The bridge will convey the 2% AEP. It will be a prefabricated concrete modular design, allowing it to be craned into place, which will minimise onsite disturbance during installation. The bridge system will be designed to the *Australian Standard 5100: Bridge Design* (Standards Australia, 2004) with a pre-engineered, a bolt together configuration comprised of piles, headstocks, planks and end protection beams.

The bridge will be approximately 168 m long (the width of Ashburton River at the crossing location). A preliminary design consists of fourteen 12 m length prefabricated modules each consisting of 9 piles (or 126 piles in total). Cross-sections of 12 m length bridge models are depicted in Figure 32 (Rocla, 2020). The bridge was modelled as ‘Layered Flow Constriction’ to represent the envisaged design. Modelling results suggests water levels, during the 2% AEP, reach a maximum level of 3.45 m AHD and flow velocities are low (<0.5%) both upstream and downstream of the bridge crossing (Water Technology, 2021c). Erosion protection (such as rock riprap) will be installed on the riverbanks to prevent erosion near the bridge abutment.
Piling for the bridge across Ashburton River will occur only when the river bed is dry to prevent potential impacts to sawfish species.

2.3.13 CONSIDERATION OF EXTREME EVENTS AND SEA LEVEL RISE

There is the potential for extreme events such as cyclones or tsunamis. The current engineering design requires that the pond embankment crests are designed to such a level as to accommodate a 1 in 50-year flood event (~ 2% AEP). This includes inclusion of freeboard above the predicted design water level. Stockpiles will also be elevated above this level. The embankments are also designed with rock armouring to limit the potential for breaching due to wind and wave erosion. Exceedance of 1 in 50-year flood levels have a low (~2%) annual probability of occurring (i.e., ~2% AEP). Modelling conducted to inform Proposal design has considered flood levels that would occur in such events (Water Technology, 2022b).

Evaluation of sea level rise (SLR) impacts has been undertaken using the summary of projected SLR developed for coastal planning in WA (DoT, 2010). This recommends a single forecast curve for sea level allowances, based on Intergovernmental Panel on Climate Change (IPCC) model projections, with allowance for 0.4 m of SLR over the next 50 years – the anticipated life of the Proposal (by ~2070) (DoT, 2010). This level of SLR has been considered in modelling conducted to inform Proposal design (Water Technology, 2022b).

Embankments have been designed in consideration of likely inundation (resulting from SLR and extreme episodic weather events). It is considered unlikely that there will be a need for periodic height increases in embankments in response to settling of the embankment over time and SLR, although this can be accommodated by the Proposal in the future, should SLR be much greater than currently predicted by Department of Transport (DoT) (2010).

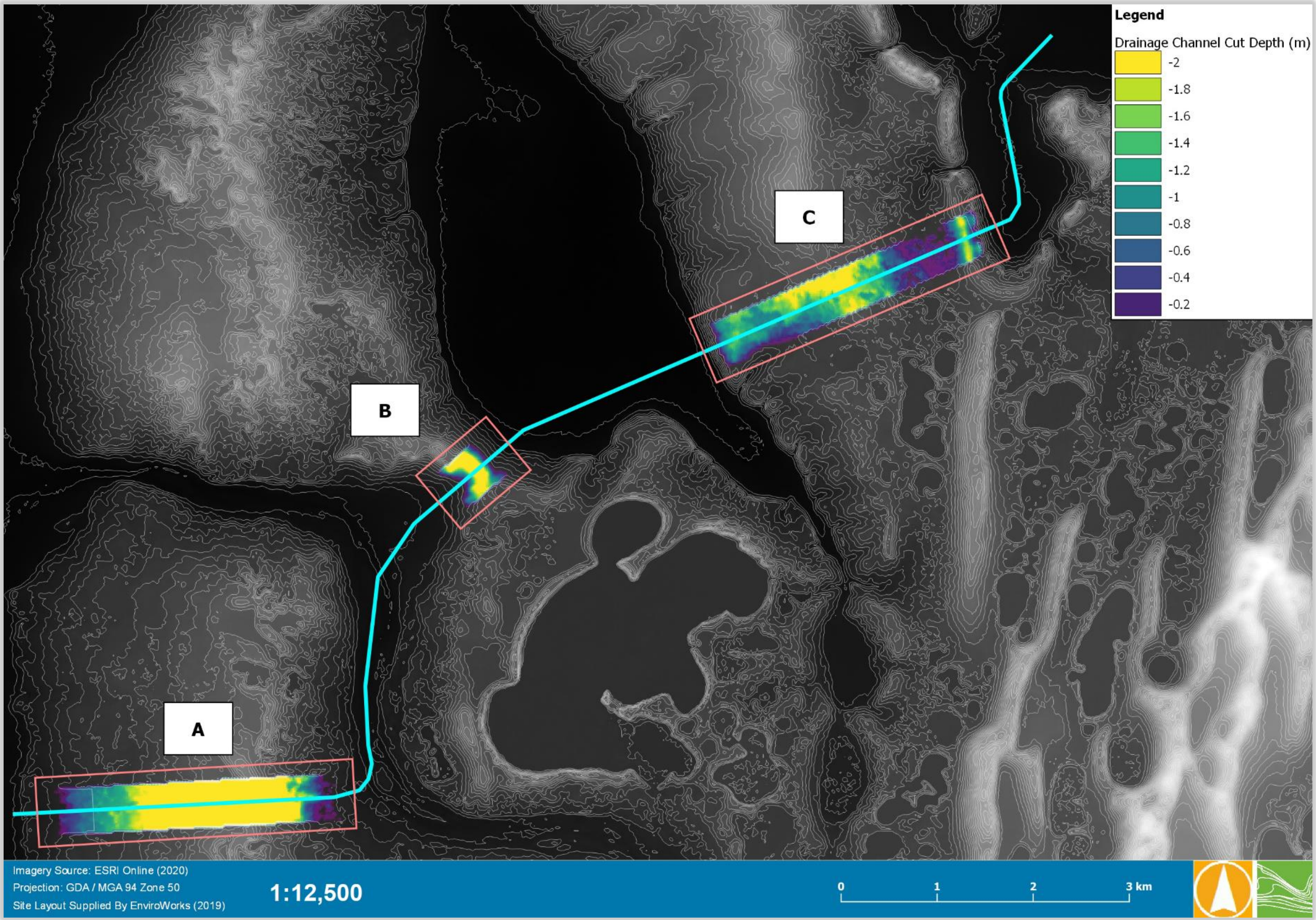

Figure 31: Three-Dimensional Design of Drainage Diversions
(Water Technology, 2021c)

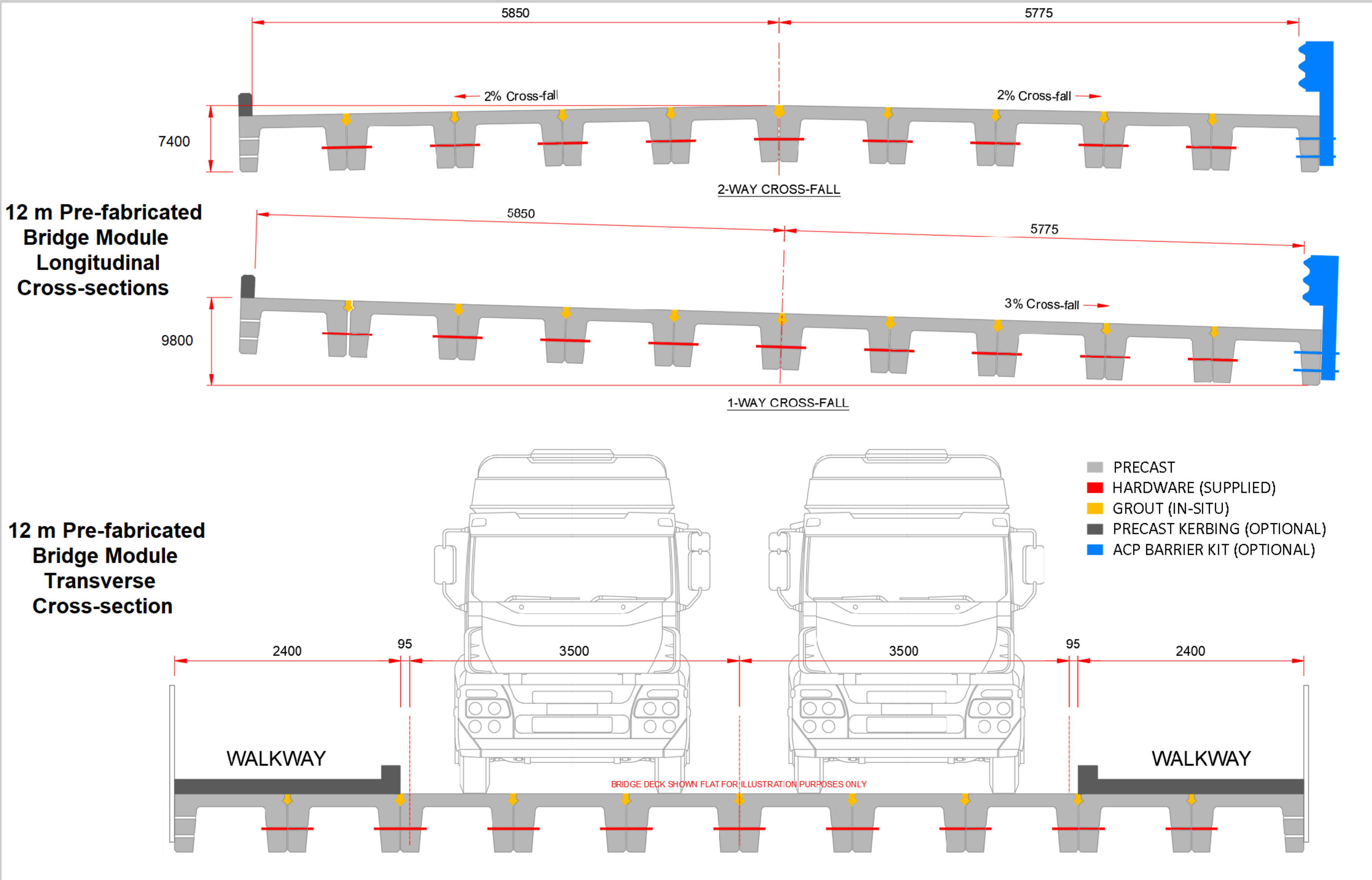

Figure 32: Example of a Prefabricated Bridge 12 m Module Cross-sections
(Rocla, 2020)

2.4 LOCAL AND REGIONAL CONTEXT

2.4.1 LOCAL GOVERNMENT AREA

The Proposal is located within the Shire of Ashburton (Figure 33). The Shire of Ashburton serves communities across a vast region in the Pilbara, WA. The region is known for mining, agriculture and fishing, and for its rugged landscape. At nearly half the size of Victoria (105,647 square kilometres (km^2)), the Shire of Ashburton includes some of the world's largest open cut mines, largest pastoral leases and cattle stations and a strong commercial and recreational fishing industry. The region's 10,000 residents are employed in a variety of industries including oil, gas, mining, cattle, fishing and tourism (Shire of Ashburton, 2020). The boundary of the Shire of Exmouth is located approximately 40 km to the southwest of the Proposal (Figure 33).

2.4.2 PASTORAL LEASES

The Proposal is located on the Urala Pastoral Lease which is held by AGIG (the owner of the Tubridgi Gas Storage operation) – Figure 33. The boundaries of Minderoo Pastoral Lease and Koordarrie Pastoral Lease occur 130 m to the east and 20 m to the south respectively – Figure 33.

2.4.3 TRADITIONAL OWNERS

The traditional owners of the land on which the Proposal is situated are the Thalanyji people. The Thalanyji Native Title Determination covers the Proposal footprint in its entirety (Figure 33). K+S are currently negotiating an Indigenous Land Use Agreement (ILUA) with Buurabalayji Thalanyji Aboriginal Corporation (BTAC). The Gnulli Native Title Claim occurs approximately 700 m to the southwest of the Proposal area (Figure 33).

2.4.4 NEARBY INDUSTRY AND PRAWN FISHERIES

The Proposal is located within an existing industrial hub southwest of the townsite of Onslow WA. The following existing industry are located nearby to the Proposal (Figure 33):

- AGIG Tubridgi Gas Storage operation is located approximately 6 km northeast.
- Chevron Wheatstone operation is located approximately 30 km northeast.
- Onslow Solar Salt operation is located approximately 35 km northeast.
- The WA Government's ANSIA is located approximately 30 km northeast.

Exmouth Gulf Prawn Managed Fishery (EGPMF) and Onslow Prawn Managed Fishery (OPMF) operating prawn fisheries are located adjacent to the Proposal within the marine environment (Figure 33). These fisheries operate by trawling the sea floor with trawling nets.

2.4.5 DIRECTORY OF IMPORTANT WETLANDS IN AUSTRALIA

The Proposal is located within the Exmouth Gulf East wetland (WA007) which is listed in *A Directory of Important Wetlands in Australia* (ANCA, 1993) – Figure 33. The Directory describes the significance of the wetland as "An outstanding example of tidal wetland systems of low coast of northwest Australia, with well-developed tidal creeks, extensive mangrove swamps and broad saline coastal flats." Note that the Directory information has not been updated since 2005 but is retained by the Australian Government for reference purposes.

2.4.6 PROPOSED NATIONAL PARK

In 2019, the State Government announced a plan to create five million hectares of new national and marine parks and conservation reserves across WA. An opportunity to reserve a National Park was identified approximately 8 km southwest of the Proposal along the eastern side of the Exmouth Gulf – called the Proposed Giralia National Park (Figure 33). The State Government is currently consulting with traditional owners regarding Indigenous Land Use Agreements. The completion of final National Park reservations is planned to occur during 2024 (DBCA, 2020).

2.4.7 PROPOSED MARINE PARK

In 2021, the State Government announced a plan to establish a new marine park in the eastern and southern sections of the Exmouth Gulf, with additional Class A reserves being established in local areas of significance, including Qualing Pool, Camerons Cave and the Gulf's islands. These measures have been implemented in response to strategic advice provided under Section (16e) of EP Act by the EPA in partnership with the Western Australian Marine Science Institution (WAMSI; 2021). The request for strategic advice issued in August 2020 by the then W.A. Minister for the Environment originated from several potentially significant development proposals in the Exmouth Gulf region being referred to the EPA under Part IV of the EP Act. Included was the K + S Proposal. The report provided a review on the potential cumulative impacts of these projects on the environmental, social, and cultural values of Exmouth Gulf.

Findings of the report identified Exmouth Gulf to be a multi-use area, with various drivers and pressures across a multitude of sectors. Key values were considered across five themes (sea, land, water, air and people) within the context of the definitions under the EP Act and the EPA's framework of environmental factors and objectives (EPA, 2020b). No key values were identified to be in a state of very poor condition with most categorised in a state of good or very good condition. The EPA did, however, acknowledge that the condition of key values of the gulf are likely to continue to degrade overtime without improved coordination and management. As such, the EPA recommended the establishment of a coordinating body across stakeholders and industry to support the environmental protection, planning and management of the Gulf.

The marine park is intended to be jointly managed with Traditional Owners. Located within the existing Exmouth Gulf Managed Prawn Fishery designated nursery area, the Northern proposed boundary of the park yet to be confirmed is waiting for the K+S Salt proposal assessment and the boundary associated with that (WAMSI, 2021). The boundaries of the marine park will be finalised with planning led by the Department of Biodiversity, Conservation and Attractions (DBCA) with assistance from the Department of Primary Industries and Regional Development (DPIRD). The marine park is set to complement the creation of the Giralia National Park (Section 2.4.6) (DBCA, 2022).

2.4.8 ISLAND NATURE RESERVES AND MARINE MANAGEMENT AREAS

A number of Nature Reserves and Marine Areas managed by DBCA occur on islands adjacent to the Proposal (Table 17) (Figure 33).

Table 17: Nature Reserves and Marine Management Areas

Reserve/Area	Distance from Proposal
Locker Island Nature Reserve	8.7
Rocky Island Nature Reserve	8.2
Gnandaroo Island Nature Reserve	14.8
Victor Island Nature Reserve	23.25
Y Island Nature Reserve	24.5
Tent Island Nature Reserve	14.5
Burnside and Simpson Island Nature Reserve	20.5
Muiron Islands Marine Management Area	30.4

2.4.9 ASHBURTON RIVER

The proposed salt ponds occur approximately 25 km southwest of the mouth of the Ashburton River (Figure 33). The river has a length of approximately 680 kilometres. Its catchment covers an area of 71,000 km^2 and includes the towns of Newman, Paraburdoo and Tom Price (Waters and Rivers Commission, 2005), (Water Technology, 2021c). The Ashburton River is a registered Cultural Heritage Site and is of great significance to the Thalanyji people. The river provided travel routes, food and resources for material culture. Sites along the river would have been repeatedly revisited and utilised, as pools provided permanent water sources and food. Artefact scatters that are repeat visit sites, contain millstones, and a higher number of retouched and utilised artefacts. Evidence of ceremonial activities include stone arrangements and notch scrapers that were used for making dancing sticks (Archae-aus, 2020).

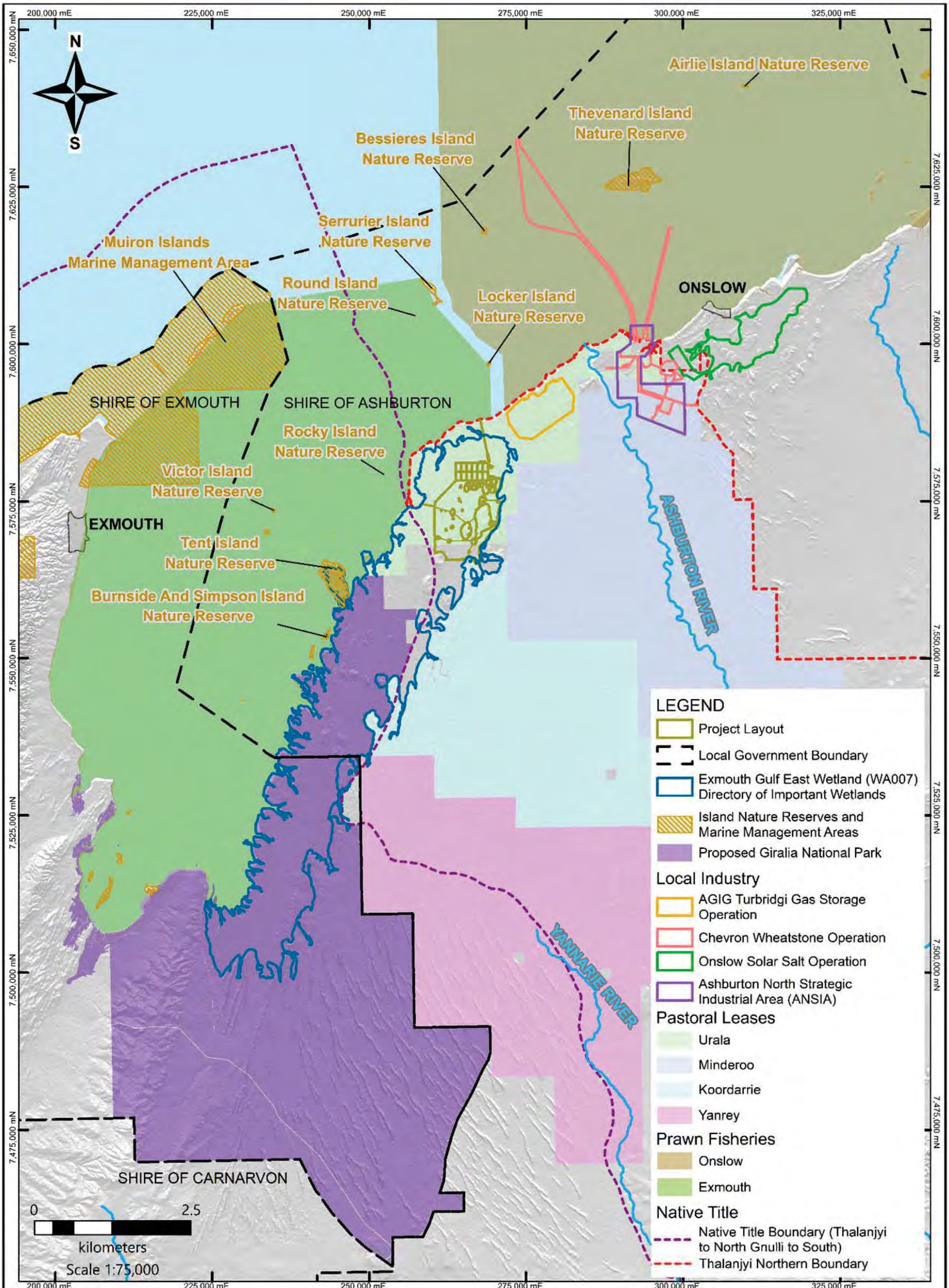

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Figure 33: Local and Regional Context

3 STAKEHOLDER ENGAGEMENT

K+S have undertaken its stakeholder engagement in accordance with Ministerial Council on Mineral and Petroleum Resources (MCMPR) Principles for Engagement with Communities and Stakeholders (2005). These principles are as follows:

- Communication must be open, accessible, clearly defined, two-way and appropriate.
- The process and outcomes of community and stakeholder engagement should, wherever possible, be made open and transparent, agreed upon and documented.
- A cooperative and collaborative approach to seek mutually beneficial outcomes is considered key to effective engagement.
- Inclusiveness involves identifying and involving communities and stakeholders early and throughout the process, in an appropriate manner.
- Community and stakeholder engagement should establish and foster mutual trust and respect.

3.1 KEY STAKEHOLDERS

K+S has consulted with and will continue to consult with all stakeholders who are affected by or are interested in the Proposal. This includes the decision-making authorities, relevant state (and Commonwealth) government agencies, local government authorities, the local community, and environmental non-government organisations.

The foundation of the Stakeholder Engagement Strategy has been a detailed stakeholder identification process to ensure that all relevant stakeholders have been identified and included in consultation activities. The following list of stakeholders have been identified and consulted with:

- Department of Mines, Industry Regulation and Safety (DMIRS)
- EPA
- Department of Jobs, Tourism, Science and Innovation (DJTSI)
- Department of Water and Environment Regulation (DWER)
- DBCA
- DPIRD
- Department of Climate Change, Energy, the Environment and Water (DCCEEW)
- PPA
- Shire of Ashburton
- Shire of Exmouth
- Gascoyne Development Commission
- Pilbara Development Commission
- BTAC
- Cape Conservation Group (CCG)
- Onslow Town Community
- Exmouth Town Community
- Forrest & Forrest – sublessee of Urala Station and owner of the neighbouring Minderoo Station
- AGIG – holder of Urala Pastoral Lease
- Neighbouring Pastoral Stations
- Recreational Fishing Groups
- Exmouth and Onslow Prawn Fisheries.

3.2 STAKEHOLDER ENGAGEMENT PROCESS

The Proposal's stakeholder consultation process is well-established and a detailed understanding of the level of stakeholder interest and key issues, has been developed through consultation undertaken on the Proposal since 2016.

K+S recognise that it is important that all stakeholders have their interests and concerns considered and where appropriate, addressed, and that the key stakeholders have an opportunity to provide feedback on the response or proposed action to address their interests and concerns.

The company maintains regular interactions with the Traditional Owner group BTAC regarding the heritage and environmental values of the Proposal and anticipates this group will have an ongoing interest in the Proposal.

Stakeholder consultation activities have included and continue to include:

- Providing information on the Proposal.
- Providing the results of key environmental studies.
- Seeking feedback from key stakeholder on environmental impacts relevant to them.
- Incorporating stakeholder feedback into the Proposal design and proposed environmental management.

Methods of communication have included and continue to include:

- Media briefings.
- Regulator briefings.
- Meetings.
- Website publications.
- Correspondence (emails, phone calls and letters).
- Newspaper advertising.
- Community information days.

3.3 STAKEHOLDER CONSULTATION

All interactions with stakeholders are recorded in the Proposal's Stakeholder Consultation Register (refer to summary table below).

Table 18: Stakeholder Consultation Summary

Date	Description of Engagement	Stakeholders	Stakeholder comments/ issue	Proponent Response and/or resolution	Stakeholder Response
2016 – ongoing	Meetings; letters	DMIRS	Initial discussions around process and lead agency. Discussions regarding proposed National Park boundaries. Mining Proposal, Mine Closure Plan (MCP) and Post Mining Land-use (fauna habitat) discussed.	Lead agency was transferred to Department of Jobs, Tourism, Science and Industry. Issue was managed by DBCA.	Satisfactory
2016 - ongoing	Meetings; letters	DJTISI	Proposal was given lead agency status. Discussions regarding access, ANSIA and all government regulatory issues.	Continued discussions as Proposal has lead agency status.	Satisfactory

Date	Description of Engagement	Stakeholders	Stakeholder comments/ issue	Proponent Response and/or resolution	Stakeholder Response
2016 – ongoing	Meetings; Environmental briefing session; letters; submission of draft ERD	EPA / EPA Services at DWER	Ongoing discussions with issues raised regarding protection of marine fauna, mangroves and wetlands. Ongoing discussions regarding assessment processes, review of draft ERD	Continued open discussions and addressed any environmental concerns during environmental scoping. Consultation with EPA regarding the three Section 43A applications to change the Proposal during assessment that have been submitted. ERD revised to address comments	ESD approved. Three separate changes to Proposal under section 43A approved. ERD accepted for public release
2016-ongoing	Feedback on Draft ESD	DWER Industry Regulation	Comment on Draft ESD: Potential for prescribed premises 73, 54, 85 and 63 (chemical storage, sewage and landfill). May need to apply for works approval and licence. Need for identification of Acid Sulfate Soils (ASS) and if exist appropriate management. DWER guideline for contaminated sites also should be included.	Works approval and licence will be considered and applied for where relevant at appropriate time. ASS and DWER guideline for contaminated sites included in ESD.	Satisfactory
2016-ongoing	Meetings; letters	DBCA	Local officers of Exmouth DBCA are kept up to date with the Proposal and environmental studies. Discussions with DBCA Perth office on proposed Giralia National Park proposed some distance south of the Proposal. Discussion about offsets and integration with research and management programs planned for proposed marine park	Continue to provide regular updates on the Proposal and environmental studies. Discuss research and management programs and planning progresses.	Satisfactory
2016 - ongoing	Meetings	DPIRD (Fisheries)	Ongoing engagement in development of an agent based model of prawns in Exmouth Gulf in order to predict impact of Proposal on Prawn Fishery	Ongoing engagement as model is developed	Satisfactory
2016 - ongoing	Meetings; submission of S156A application, submission of draft ERD	DAWE - Federal	Engaged during development of EPBC referral. Comments provided on draft ERD	Officially associated with the current EPA assessment as the proposal is being assessed via an accredited assessment process. K+S is keeping DAWE officers up to date where relevant given a final decision re the EPBC assessment will still need to be made by Federal Minister. ERD revised to address comments	S156A application approved ERD accepted for public release
2016-ongoing	Meetings; phone calls; community updates; environmental briefing	PPA	Regular engagement with issued raised around ports, marine safety, environmental studies, shipping providers, anchor points, Native Title and transhipping.	All issues were addressed with follow up meetings with various parties and a site visit was coordinated with PPA. PPA have attended community updates.	Satisfactory

Date	Description of Engagement	Stakeholders	Stakeholder comments/ issue	Proponent Response and/or resolution	Stakeholder Response
2016-ongoing	Meetings; phone calls; community updates; environmental briefing	Shire of Ashburton	Regular engagement with issued raised around river's flood plain, National Park, workforce housing, access road, bridge, turbidity, impact on Onslow Coast and management of infrastructure. Post-mining land use (fauna habitat) discussed.	All issued were addressed and engagement continues with the Shire of Ashburton.	Satisfactory
2016-ongoing	Meetings; phone calls; community updates, letters	Shire of Exmouth	Regular engagement with issued raised around river's flood plain, National Park, workforce housing, access road, bridge, turbidity, impact on Onslow Coast and management of infrastructure.		
2016-ongoing	Community updates; community info sessions; correspondence; community open day	Gascoyne Development Commission (GDC)	Discussions with issues raised around ensuring GDC are kept up to date with the Proposal and local community engagement.	Continue to provide regular updates on the Proposal and local community engagement.	Satisfactory
2016-ongoing	Community updates; meetings	Pilbara Development Commission	Initial meeting to explain the Proposal. Ongoing mailing of Proposal updates.	Continue to provide regular updates on the Proposal and local community engagement	Satisfactory
2016-ongoing	Community updates; meetings; mail outs; phone calls	BTAC	Ongoing discussions with BTAC with issues raised around Native Title and Indigenous Employment. Post mining land use (fauna habitat) discussed.	Continue to be in discussions with BTAC on these issues.	Satisfactory
2016-ongoing	Community updates; meetings; environmental sessions	CCG	Ongoing discussions with issues raised around ensuring CCG are kept up to date with the Proposal, marine life, salt pans and bitterns.	All issues are being considered in PER. CCG is invited to all community update sessions and has been provided updates on environmental studies.	Satisfactory
2016-ongoing	Meetings; community information days; newspaper advertisements; phone calls; mail outs; website and social publications	Onslow Town Community	Regular engagement with issues raised around prawn numbers, fisheries, jetty, dredging, local employment and shipping.	Addressed issues and provide ongoing forums for community feedback.	Satisfactory
2016-ongoing	Meetings; community information days; newspaper advertisements; phone calls; mail outs; website and social publications	Exmouth Town Community	Regular engagement with issues raised around school engagement, jetty, Marine fauna, bitterns, fishing and environmental impacts.	Addressed issues and provide forums for ongoing community feedback.	Satisfactory
2016-ongoing	Meetings; community information days; correspondence; mail outs	AGIG – holder of Urala Pastoral Lease	Discussions with issues raised around road access, bridge, flooding, salt production process, gas storage Proposal and Urala pastoral lease. Post mining land use (fauna habitat) discussed.	All issues are being considered as part of Proposal design. Ongoing communication with AGIG is occurring.	Satisfactory

Date	Description of Engagement	Stakeholders	Stakeholder comments/ issue	Proponent Response and/or resolution	Stakeholder Response
2017-ongoing	Meetings, community information days, correspondence, emails	Forrest & Forrest / Harvest Road – sublessee of Urala Station	Discussions with issues raised around road access, construction traffic, potential impacts to cattle station use, associated infrastructure tenure	Continue to be in correspondence on issues related to pastoral activities	Further consultation required
2016-ongoing	Meetings; emails; phone calls	Neighbouring Pastoral Stations (Koordarrie)	Discussions regarding property access for monitoring and drainage management. Koordarrie has provided access for monitoring and drainage management to be discussed at next Proposal stage.	Continue to be in discussions with Koordarrie on these issues.	Satisfactory
2016-ongoing	Meetings; emails; phone calls	Recreational Fishing Groups	Regular engagement with issues raised around, fisheries, jetty, dredging, local employment and shipping.	Continue to be in discussions on these issues.	Further consultation required
2016-ongoing	Meetings; emails; phone calls	Exmouth and Onslow Prawn Fisheries	Regular engagement with issues raised around prawn fishery and potential impacts	Continue to be in discussions with Prawn Fisheries on these issues.	Further consultation required
2022-ongoing	Meetings, emails, correspondence	Western Australian Fishing Industry Council (WAFIC)	Meeting to explain proposal, updates on project, discussion of potential impacts on fisheries	Continue to be in discussions on these issues.	Further consultation required
2021-oingoing	Correspondence, emails	Protect Ningaloo	Reponse to letter received from Protect Ningaloo, offer to brief Protect Ningaloo	Stakeholder declined offer for briefing, continue to inform via email updates	Further consultation required

4 ENVIRONMENTAL PRINCIPLES

A summary of the EP Act principles considered in relation to the Proposal is provided in Table 19.

Table 19: EP Act Principles

Principle	Consideration
1. The precautionary principle *Where there are threats of serious or irreversible damage, lack of full scientific certainty should not be used as a reason for postponing measures to prevent environmental degradation.* *In application of this precautionary principle, decisions should be guided by:* *a) careful evaluation to avoid, where practicable, serious or irreversible damage to the environment; and* b) *an assessment of the risk-weighted consequences of various options.*	• Environmental Management Plans will be developed which outline a range of mitigation measures to prevent impacts and monitoring to ensure that impacts are monitored with contingencies implemented if triggers or thresholds are reached. • K+S has undertaken several studies to predict the potential environmental impacts and has designed the proposal and developed appropriate mitigation measures to prevent serious or irreversible damage to the environment.
2. The principle of intergenerational equity *The present generation should ensure that the health, diversity and productivity of the environment is maintained and enhanced for the benefit of future generations.*	• The Proposal will ensure environmental values are maintained by minimising and managing potential impact to the environment. • The Proposal will be managed responsibly so that it can be passed on to future generations. • Opportunities for creation of fauna habitat will be fully maximised (for example the ponds are likely to be habitat for migratory birds)
3. The principle of the conservation of biological diversity and ecological integrity *Conservation of biological diversity and ecological integrity should be a fundamental consideration.*	• K+S has undertaken comprehensive baseline studies to understand and assess potential threats to biological diversity and ecological integrity. • Management strategies have been, and will continue to be, developed and implemented to avoid or minimise threats to biological diversity and ecological integrity wherever possible.
4. Principles relating to improved valuation, pricing and incentive mechanisms *(1) Environmental factors should be included in the valuation of assets and services.* *(2) The polluter pays principles – those who generate pollution and waste should bear the cost of containment, avoidance and abatement.* *(3) The users of goods and services should pay prices based on the full life-cycle costs of providing goods and services, including the use of natural resources and assets and the ultimate disposal of any waste.* *Environmental goals, having been established, should be pursued in the most cost-effective way, by establishing incentive structure, including market mechanisms, which enable those best placed to maximise benefits and/or minimise costs to develop their own solution and responses to environmental problems.*	Solar salt farming, by virtue of the natural process used, is inherently sustainable. That is the process utilises a sustainable resource (seawater) and relies on the sun and wind to evaporate water (or produce salt). K+S has, and will continue to, evaluate (and implement wherever possible) opportunities to reduce impact to land, reduce waste and improve efficiencies in water and energy use during the implementation and operation of the pivot irrigation Proposal.
5. The principle of waste minimisation *All reasonable and practicable measures should be taken to minimise the generation of waste and its discharge into the environment.*	All reasonable and practicable measures have been and will continue to be undertaken by K+S to minimise the generation of waste. Very few waste products will be produced by the Proposal and those produced will be managed appropriately.

5 ENVIRONMENTAL FACTORS

5.1 KEY ENVIRONMENTAL FACTORS

The key environmental factors for the environmental review are listed in the diagram below.

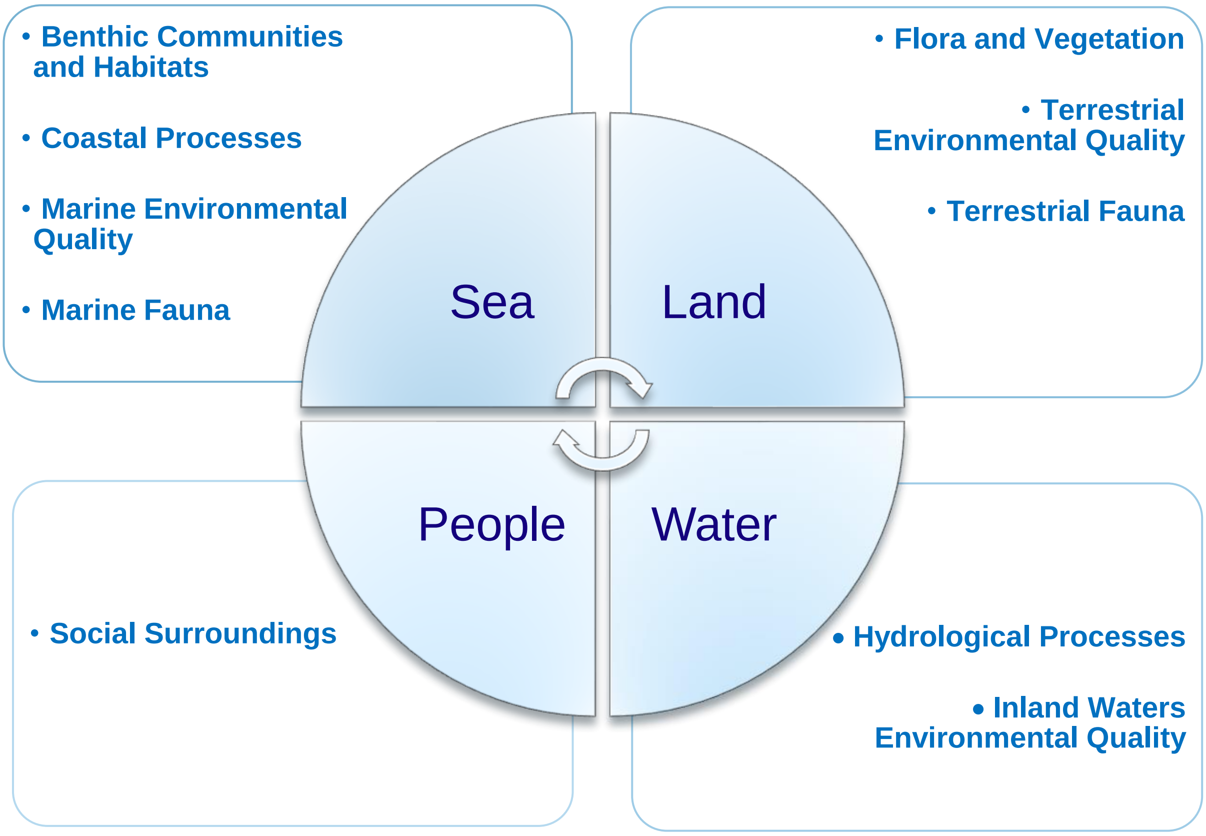


Figure 34: Key Environmental Factors

Each of these factors is discussed in further detail in the sections below.

5.2 ENVIRONMENTAL STUDIES

Table 20 lists the environmental studies that have been completed, as summarised within this ERD.

Table 20: List of Studies Conducted

Report	Reference	Appendix
Marine and Coastal Assessment and Modelling	Water Technology, 2022b	A
Surface Water Assessment and Modelling	Water Technology, 2022a	B
Marine, Coastal and Surface Water Data Collection	Water Technology, 2021a	C
Marine, Coastal and Surface Water Existing Environment	Water Technology, 2021b	D
Surface Water Assessment and Modelling	Water Technology, 2021c	E
Peer Review of Coastal, Surface Water and Nutrient Pathway Modelling	DHI, 2021	F

Report	Reference	Appendix
Ashburton Salt Response to Sea Level Rise	Seashore Engineering, 2021	G
Ashburton Salt Projection of Future Habitat Area	Seashore Engineering, 2022	H
Memorandum Seawater Intake Assessment	Water Technology, 2018	I
Nutrient Pathway Assessment and Modelling	Water Technology, 2021d	J
Acid Sulfate Soil and Sediment Study	GHD, 2021a	K
Technical Memorandum - Phase 2 Ecotoxicology Assessment.	AECOM, 2022c	L
Assessment of Benthic Communities and Habitats	AECOM, 2022a	M
Marine Fauna Impact Assessment	AECOM, 2022b	N
Migratory Shorebird Assessment	Biota, 2022c	O
Prawn Assessments	Water Technology, 2022c	P
Detailed Vegetation and Flora Survey	Biota, 2022a	Q
Targeted Flora Survey 2022	Biota, 2022e	R
Level 2 Seasonal Fauna Survey	Biota, 2022b	S
Claypan Ephemeral Fauna Desktop Review	Biota, 2021	T
Materials Characterisation Study	GHD, 2021d	U
Memorandum Ashburton groundwater modelling- updated results.	GHD, 2022	V
Hydrogeological Investigation	GHD, 2021c	W
Independent Review of Ashburton Salt Project Groundwater Modelling	CyMod Systems, 2022	X
Ashburton Salt Project Groundwater Modelling Independent Review	CyMod Systems, 2021	Y
A Report of the Reconnaissance Assessment of Cultural Heritage Sites within the Ashburton Salt Project Area, Urala Station, Western Australia	Archae-aus, 2020	Z
Meeting Notes: Heritage and Culture Committee - K+S Social Surrounds Discussion	BTAC, 2021b	AA
Environmental Management Plans	K+S, 2021	BB
Interim Offset Strategy	Preston Consulting, 2023	CC
Updated Artificial Light Monitoring and Modelling Report.	Pendoley Environmental (2023)	DD

5.3 CUMULATIVE PRESSURES ON THE DISTINCTIVE VALUES OF EXMOUTH GULF REPORT

In August 2020, the then WA Minister for Environment requested that the EPA provide strategic advice under Section (16e) of EP Act on the potential cumulative impacts on the environmental, social and cultural values of Exmouth Gulf. The request for strategic advice originated from several potentially significant development proposals in the Exmouth Gulf region being referred to the EPA under Part IV of the EP Act. Included was the Shire of Exmouth’s Planning Scheme 4 Amendment 1, Glascoyne Gateway’s Single Jetty Deep Water Port and Renewable Hub, Z1Z Resport’s Ningaloo Lighthouse Resort Project, Main Roads Yardie Creek Road realignment at Vlamingh Head Lighthouse and the Proposal. A cumulative impact study was prepared by the WAMSI in partnership with the EPA to assist in delivering this advice (WAMSI, 2021).

The report provided a review on the potential cumulative impacts of these projects in addition to current activities of commercial and recreational fishing, tourism, quarrying and pastoralism on the environmental, social and cultural values of Exmouth Gulf. Findings of the report identified Exmouth Gulf to be a multi-use area, with various drivers and pressures across a multitude of sectors. Key values were considered across five themes (sea, land, water, air and people) within the context of the definitions under the EP Act and the EPA’s framework of environmental factors and objectives (EPA, 2020b).

A qualitative risk assessment using a consequence versus likelihood approach provided an analysis of the relationship between the Distinctive Values and environmental pressures. No key values were identified to be in a state of very poor condition with most categorised in a state of good or very good condition. The EPA did, however, acknowledge that the condition of key values of the gulf are likely to continue to degrade overtime without improved coordination and management. K+S has considered the EPA's advice regarding cumulative impacts and designed the Proposal to avoid and minimise impacts to key values that were noted to be at threat. The information provided in the Cumulative Pressures on the Distinctive Values of Exmouth Gulf Report (WAMSI, 2021) was used to inform cumulative impacts for the following sections of this ERD.

6 COASTAL PROCESSES

6.1 EPA OBJECTIVE

To maintain the geophysical processes that shape coastal morphology so that the environmental values of the coast are protected.

6.2 POLICY AND GUIDANCE

- *Environmental Factor Guideline: Coastal Process* (EPA, 2016a).
- *Statement of Planning Policy No. 2.6: State Coastal Planning Policy* (WAPC, 2013).
- A Directory of Important Wetlands in Australia (ANCA, 1993).
- WA Environmental Offsets Policy (Government of Western Australia, 2011).
- *WA Environmental Offsets Guidelines* (Government of Western Australia, 2014).

6.3 COASTAL PROCESS STUDIES

Studies to assess coastal processes have been conducted as outlined in Table 21.

Table 21: Coastal Process Studies

Report	Reference	Appendix
Marine and Coastal Assessment and Modelling	Water Technology, 2022b	A
Surface Water Assessment and Modelling	Water Technology, 2022a	B
Marine, Coastal and Surface Water Data Collection	Water Technology, 2021a	C
Marine, Coastal and Surface Water Existing Environment	Water Technology, 2021b	D
Surface Water Assessment and Modelling	Water Technology, 2021c	E
Marine, Surface Water and Nutrient Modelling Peer Review	DHI, 2021	F
Ashburton Salt Response to Sea Level Rise	Seashore Engineering, 2021	G
Ashburton Salt Projection of Future Habitat Areas	Seashore Engineering, 2022	H

6.3.1 MODELLING

Specific hydrodynamic modelling (Water Technology, 2022b) has been conducted to assess the following potential impacts:

- Effect of seawater pumping on the fluvial morphology of Urala Creek South.
- Effect of the jetty on hydrodynamics and coastal morphology.
- Changes in tidal inundation of intertidal areas due to the Proposal.

6.3.2 MODELLING PEER REVIEW

A peer review of the above modelling studies was conducted. The peer review process was undertaken in a comprehensive, rigorous and iterative manner. It is the opinion of the peer reviewer that the models constructed by Water Technology (2022b) can be considered suitable for the purpose of identifying potential environmental impacts for the above processes (DHI, 2021).

6.4 EXISTING ENVIRONMENT

6.4.1 CLIMATE

Coastal processes are predominantly influenced by climatic conditions. The climate at the Proposal site is classified as hot, semi-arid with potentially significant rainfall occurring during late January through March and then May through July. The dry season occurs from late August through to December. There is a tropical cyclone season that runs from the middle of December to April, with a peak occurring in the months of February and March. Climate statistics for the Onslow Airport located approximately 40 km north-east of the Proposal are provided in Table 22 below.

Table 22: Climate Statistics for Onslow Airport

(BOM, 2020a)

Statistics	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual	Years	
Temperature															
Mean maximum temperature (°C)	36.4	36.4	36.2	33.9	29.4	26.0	25.5	27.3	30.1	33.0	34.4	36.0	32.1	54	1940 - 2020
Mean minimum temperature (°C)	24.5	25.0	24.3	21.5	17.4	14.3	13.0	13.6	15.5	18.0	20.1	22.4	19.1	54	1943 - 2020
Rainfall															
Mean rainfall (mm)	37.7	58.9	71.3	11.3	47.7	46.6	19.9	8.3	1.4	0.8	2.7	3.3	308.4	54	1940 - 2020
Decile 5 (median) rainfall (mm)	11.5	12.9	20.7	2.8	22.8	35.0	10.2	1.8	0.2	0.0	0.0	0.0	277.5	51	1940 - 2020
Mean number of days of rain ≥ 1 mm	2.3	2.8	2.2	1.0	2.6	2.4	1.5	0.9	0.3	0.1	0.3	0.4	16.8	50	1940 - 2020
9 am conditions															
Mean 9am temperature (°C)	30.3	30.3	29.4	27.0	22.5	18.9	17.9	19.7	22.9	25.9	28.0	29.7	25.2	47	1940 - 2010
Mean 9am relative humidity (%)	54	59	58	55	58	63	61	54	46	42	44	47	53	47	1940 - 2010
Mean 9am wind speed (km/h)	16.8	16.9	16.9	15.2	15.9	15.5	15.3	17.2	20.4	21.0	19.7	18.0	17.4	46	1940 - 2010
3 pm conditions															
Mean 3pm temperature (°C)	33.8	34.0	34.0	32.0	27.9	24.8	24.2	25.7	28.0	30.2	31.7	33.1	30.0	47	1940 - 2010
Mean 3pm relative humidity (%)	51	53	49	44	45	45	44	39	38	38	43	46	45	46	1940 - 2010
Mean 3pm wind speed (km/h)	27.9	26.5	23.9	19.6	18.1	17.5	17.7	19.6	23.6	26.8	28.8	28.9	23.2	46	1940 - 2010

6.4.1.1 RAINFALL AND EVAPORATION

Areas on the west margin of the eastern side of the Exmouth Gulf are located within the Australian Southern Semi-arid Pasture Region land use with less than 75 mm of rainfall during the dry season. Due to the sparse and highly variable rainfall in this region, surface runoff is usually only generated during extreme weather conditions typically associated with tropical cyclones. During these events, discharge from the catchment causes flooding of the salt flats. This is usually also accompanied by storm tide inundation (Blandford and Associates, 2005). The mean annual rainfall based on data for the last 60 years is 308 mm (Table 22).

The high temperatures in the region lead to high rates of evaporation, which results in high evaporation during summer months and lower rates during winter. Evaporation can impact shallow or still water bodies and cause local increases in salinity within coastal estuaries. Evaporation is measured by the Bureau of Meteorology (BOM) at the Onslow and Learmonth Airports. The Learmonth data is averaged over the period of 1975-2020 and 1966-1975 for Onslow Airport. A summary of the monthly averages can be found in Figure 35 below. As shown, evaporation rates are highest through the summer months (11-12 mm per daily evaporation) and peak in December and are lowest through the winter months with the lowest recorded evaporation occurring in June at 4 mm/day. In this region, the annual average rainfall is significantly exceeded by the mean annual evaporation.

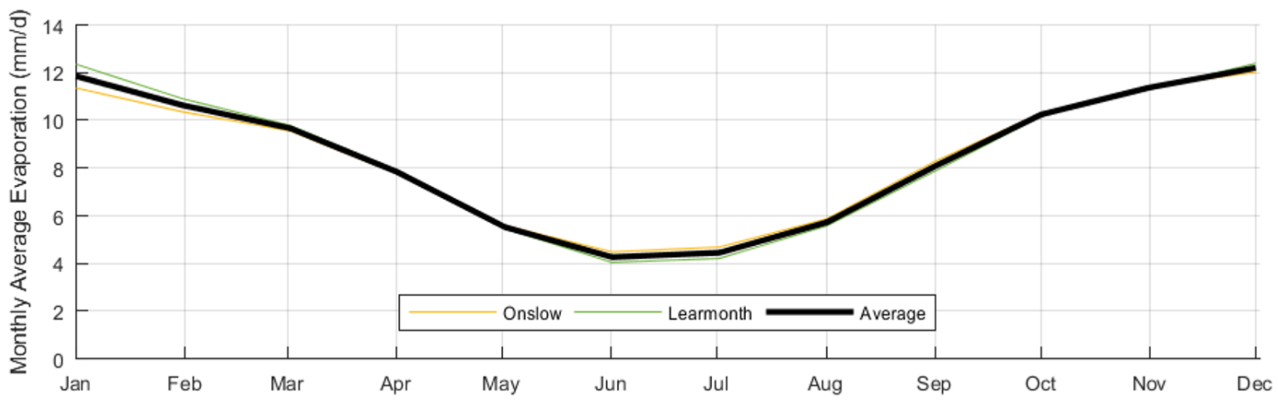


Figure 35: Average Monthly Evaporation for Onslow Airport
(BOM, 2020a)

6.4.1.2 WIND

Dominant weather conditions around Exmouth Gulf are governed by:

- A sub-tropical high-pressure belt to the south; and
- A trough of low pressure that typically extends over the inland Pilbara during the summer months.

These two processes generate a general south or south-westerly wind regime for most of the year, with more south-westerly winds common during the summer months. North-easterly winds are generally common during afternoons in both summer and winter. In the warmer months, sea breezes are predominantly south-westerly or north-easterly.

Wind roses for Onslow Airport, Learmonth Airport and Barrow Island Airport for the duration of hourly data availability are presented in Figure 36 (BOM, 2020a).

Wind roses for the following seasons are also presented for Onslow Airport in Figure 36:

- Winter (May to August)
- Cyclone Season (mid-December to April)
- Dry Season (September to mid-December).

The cyclone season and the dry season demonstrate similar wind patterns with a general south through to north-westerly direction. Most winds during these two seasons are close to 7.5 m/s, with higher wind typically blowing from westerly and north-westerly directions. As illustrated in Figure 36 below, during the winter months relatively lower intensity winds (less than 5 m/s) are generally from the north and south.

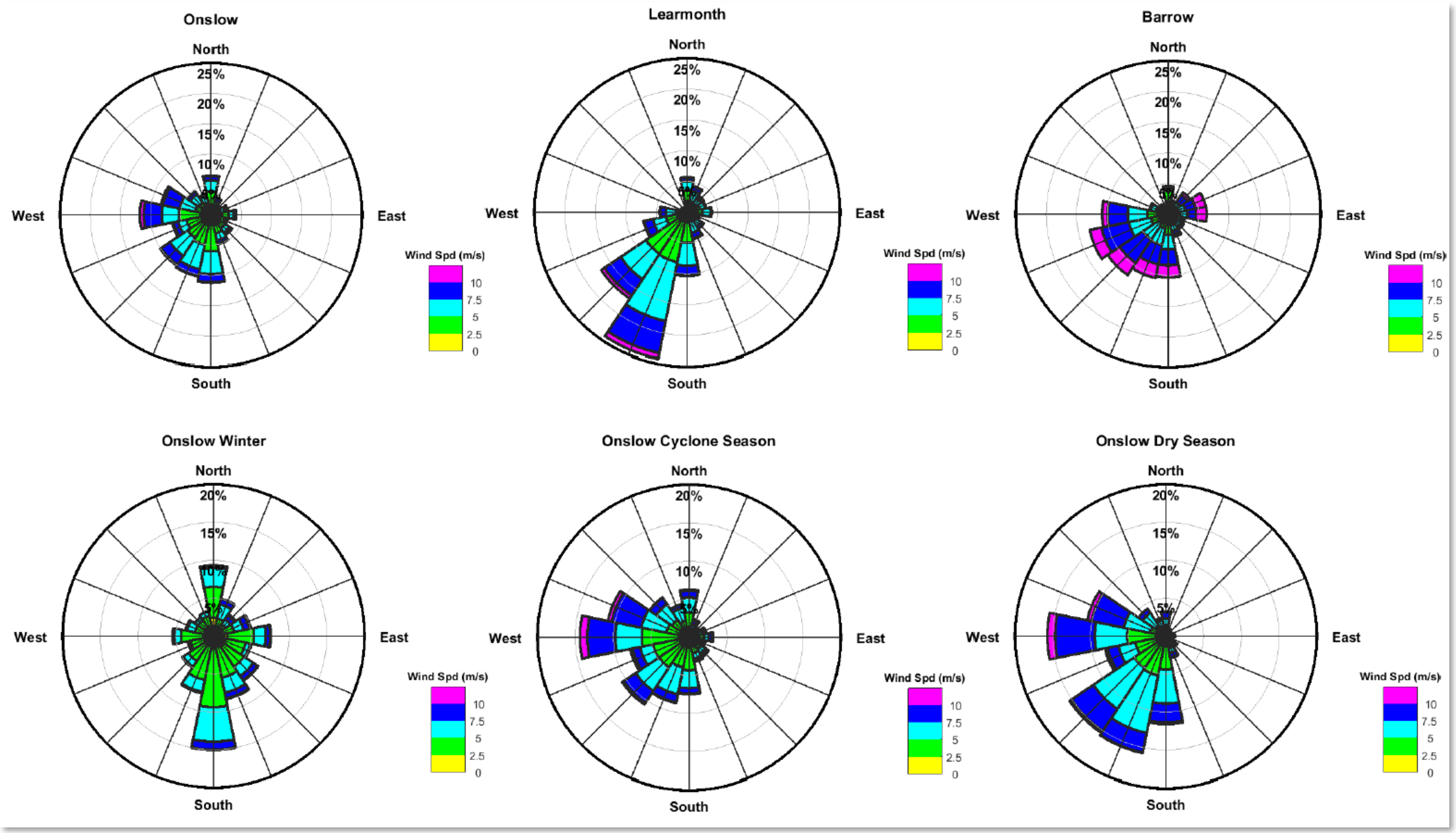


Figure 36: Regional Wind Roses
(BOM, 2020a)

6.4.2 BATHYMETRY AND TOPOGRAPHY

Bathymetry (elevation profile) of the marine and intertidal environment, affects the behaviour of coastal processes.

6.4.2.1 REGIONAL BATHYMETRY

The continental shelf in the Pilbara system is relatively smooth and featureless compared with the Kimberley and Ningaloo systems. The bathymetry of the Pilbara system and the continental shelf are shown in Figure 37 (Water Technology, 2021b). A cross section showing the bathymetry across the shallow shelf to the Muiron Islands is also presented in Figure 37.

The bathymetric profile illustrates the wide shallow waters offshore of the Proposal where the depth remains less than 20 m close to 35 km offshore before gently sloping offshore to a small break in the shelf at 160 m depth which extends roughly 15 km. From this point, the bathymetry slopes downwards to below 1,000 m over approximately 50 km across the Exmouth Plateau.

6.4.2.2 LOCAL BATHYMETRY

A bathymetric survey was undertaken by Fugro along the coastline and within tidal creeks near the Proposal site in 2017. A digital bathymetric terrain model was constructed from the 2017 survey and is presented in Figure 38. Descriptions of bathymetry of the inshore areas and Urala Creek South adjacent to the Proposal are provided below.

As shown in Figure 37 and Figure 38, the inshore marine area adjacent to the Proposal exhibits:

- A shallow bathymetric profile for a relatively long distance offshore.
- Very gradually deepening water depths as follows:
    - 1 – 6 m extending from the beach to approximately 5 km offshore.
    - 10 – 15 m approximately 10 km offshore.
    - 15 – 20 m approximately 20 to 30 km offshore.

The bathymetric terrain model of Urala Creek South is displayed in Figure 39 along with cross sections in various parts of the creek channel. Figure 39 shows that Urala Creek South:

- Channel depth and width decreases upstream with large intertidal areas in the mid estuary.
- At its deepest points the channel depth is approximately 2 m (Water Technology, 2021b).

6.4.2.3 LOCAL TOPOGRAPHY

A Lidar topography survey of the landside Proposal area was undertaken by Fugro in 2017, with the resulting data used by Water Technology (2022b) to generate a Digital Elevation Model (DEM) as shown in Figure 38. The Proposal area exhibits the following landforms with elevation as described below from the DEM:

- Coastal sand dunes exist along Tubridgi Point and extending north to Locker Point ranging 5 – 12 m AHD.
- The coastal fringe occupied by mangroves and algal mats ranges from 0 to 1 m AHD.
- The bare supratidal salt flats range from 0 – 3 m high, interspersed with ancient mainland remnant sand “islands” 3 – 12 m AHD.
- A relict longitudinal dunefield sits inland of the salt flats up to 10 m high interspersed with low lying claypans 0 – 3 m AHD.
- Outwash plains occur at 3 – 5 m height, consisting of alluvial and colluvial sediments, due to floodplain flow from the Ashburton and Yannarie Rivers AHD.

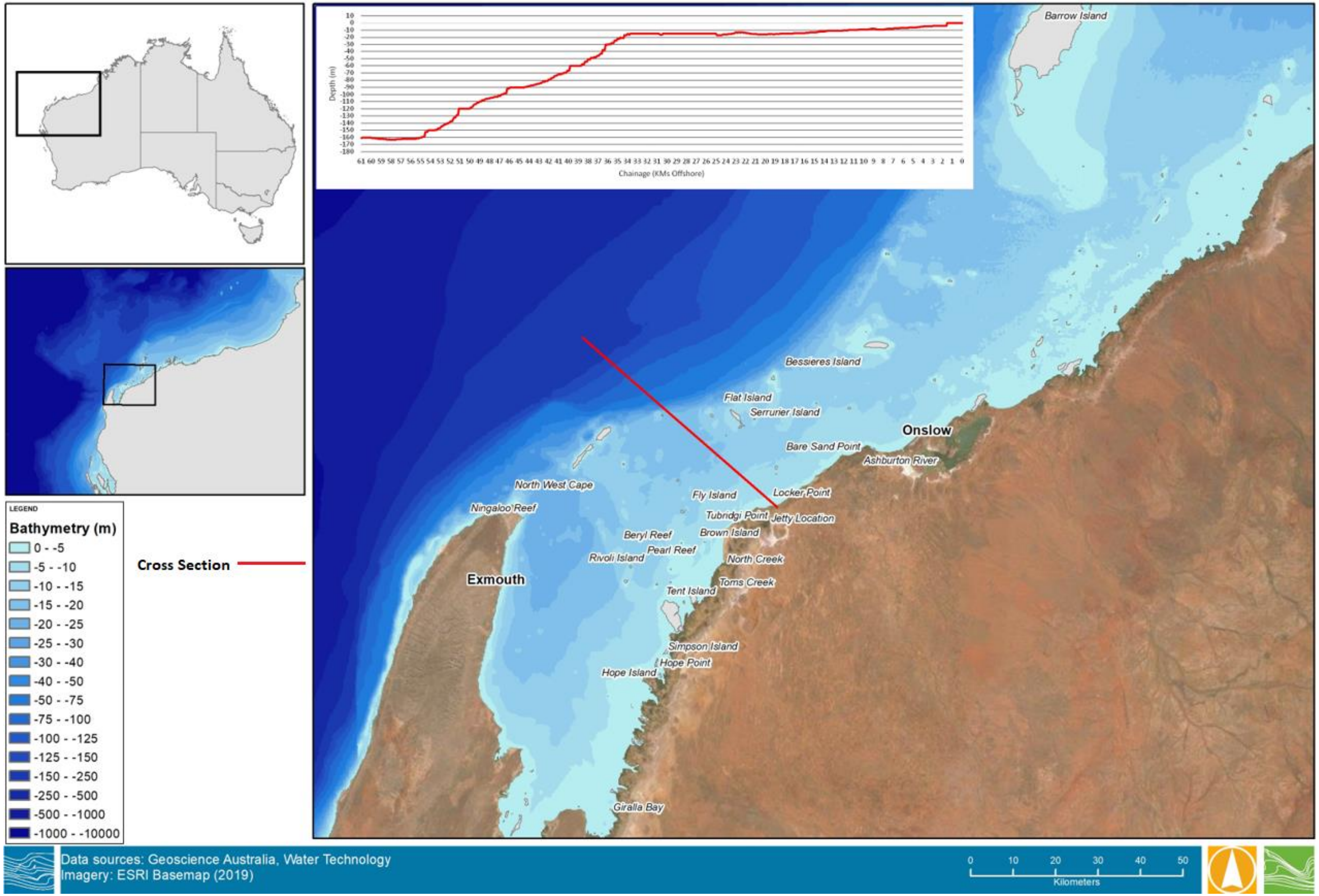


Figure 37: Regional Bathymetry
(Water Technology, 2021b)

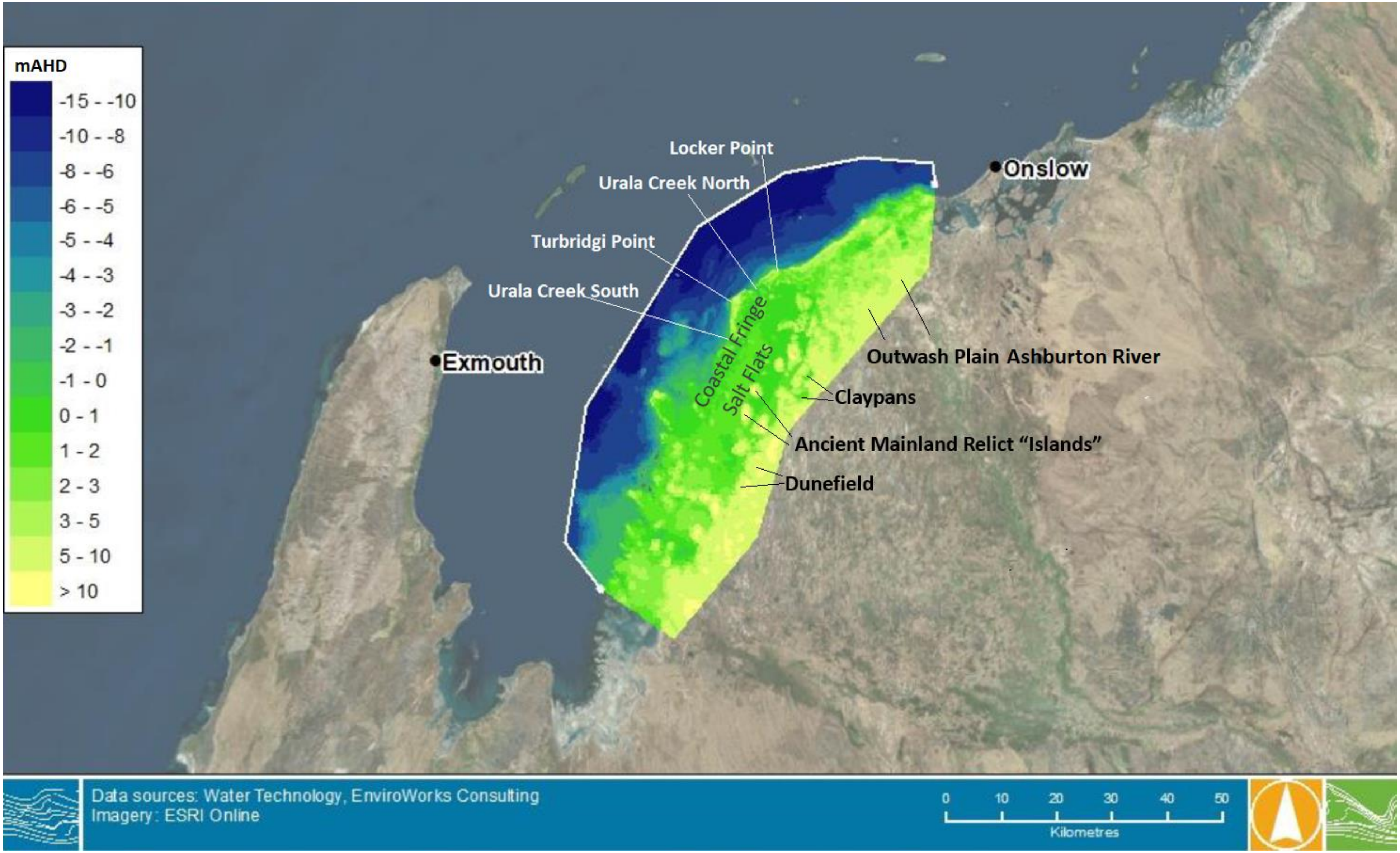


Figure 38: Local Bathymetry and Topography
(Water Technology, 2021b)

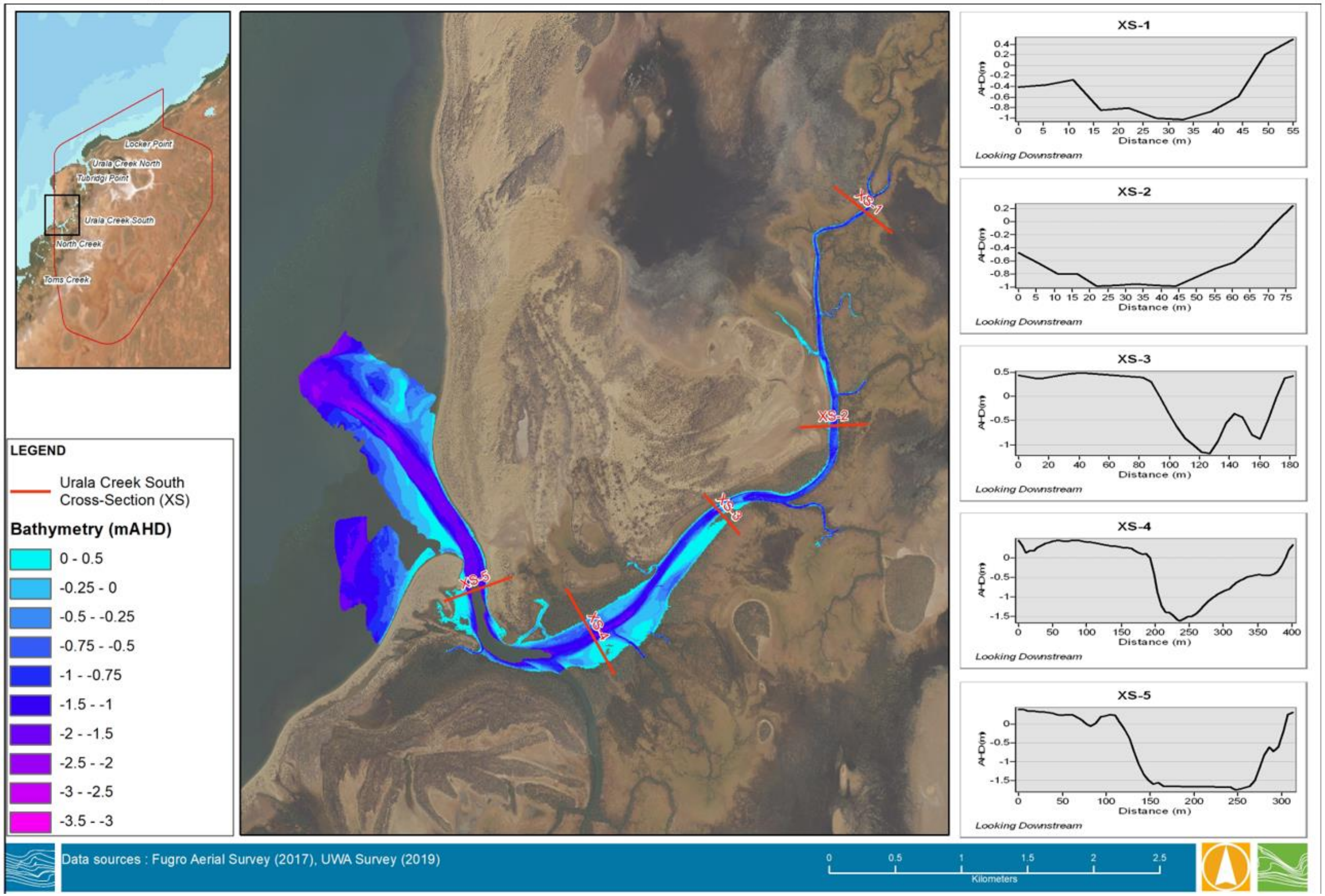


Figure 39: Urala Creek South Bathymetry
(Water Technology, 2021b)

6.4.3 OCEANOGRAPHY

Oceanographic conditions at Ashburton and along the Onslow Coast are described below.

6.4.3.1 SEA LEVELS

Sea levels relative to the coast are developed through a wide array of ocean, atmospheric and earth processes, occurring over different time and space scales, with astronomic tides providing the greatest source of variability. Sea levels affect the coast by modifying the distribution of wave energy across the inner shelf and shore; altering sediment dynamics at marine-land interfaces (e.g., beach-dune, or estuary-floodplain); and being the main driver of physical and water quality change in estuaries and shallow coastal settings (Seashore Engineering, 2021).

Global observations show spatial and temporal variation in trends of relative sea level, including effects of tectonics, vulcanism, subsidence or compression, deformation of the Earth's crust, and inter-annual variability of the ocean surface gradients. The last mechanism can affect sea levels at an ocean basin scale, with substantial responses to climate variability identified in the Pacific Ocean due to the El Niño phenomenon. This mechanism relates to the east-west balance of equatorial ocean heating and consequent prevailing winds.

Similar mechanisms occur for each of the ocean basins, with interaction through connecting zones. A process crucial to Western Australian sea levels occurs at the Pacific-Indian Ocean connection, where the Indonesian Throughflow current provides a source of water forming the Leeuwin Current travelling southward along the continental shelf boundary. This flow causes Ekman setup, with variation in current intensity and position affecting sea levels along the Western Australian coast. Instability of this phenomena has been observed, with the 2012-2013 La Niña phase increasing the volume of tropical water travelling along the coast, causing a marine heatwave and substantially increasing mean sea level (MSL) (Seashore Engineering, 2021)

The significance of climate variability on MSLs has been demonstrated for WA in trends observed from 1990-2014, which capture a transition from El Niño to La Niña dominated conditions, giving a SLR of almost 0.3 m in less than 30 years (White. et. al., 2014). This rate of change has not been subsequently sustained (Seashore Engineering, 2021).

Extreme water levels are primarily driven by storm surges associated with onshore winds and low atmospheric pressure from tropical cyclones. The greatest storm surge levels recorded occurred during Tropical Cyclone (TC) Vance which crossed the coast on the 22nd of March 1999. It led to a 3.6 m storm surge at Exmouth and a 3.3 m storm surge at Onslow according to the tidal gauge records (Water Technology, 2021b).

Observed sea level records from Exmouth and Onslow tide gauges since 1985 are provided in Figure 40, illustrating sea level variations, with extreme storm levels due to TCs labelled.

A summary of the period and magnitude of the major processes that impact sea level variability is provided in Table 23 below (Water Technology, 2021b).

Table 23: Major processes impacting sea level variability
(Water Technology, 2021b)

Sea level driver	Period	Range
Astronomical Tide	0.5 – 1 day	0.5 – 2.0 m
Storm Surge	1 – 10 days	0.2 – 3.6 m
Seasonal/Monsoon	3 – 6 Months	0.1 – 0.2 m
El Nino-Southern Oscillation / Indian Ocean Dipole (IOD)	Inter-annual	0.1 – 0.2 m

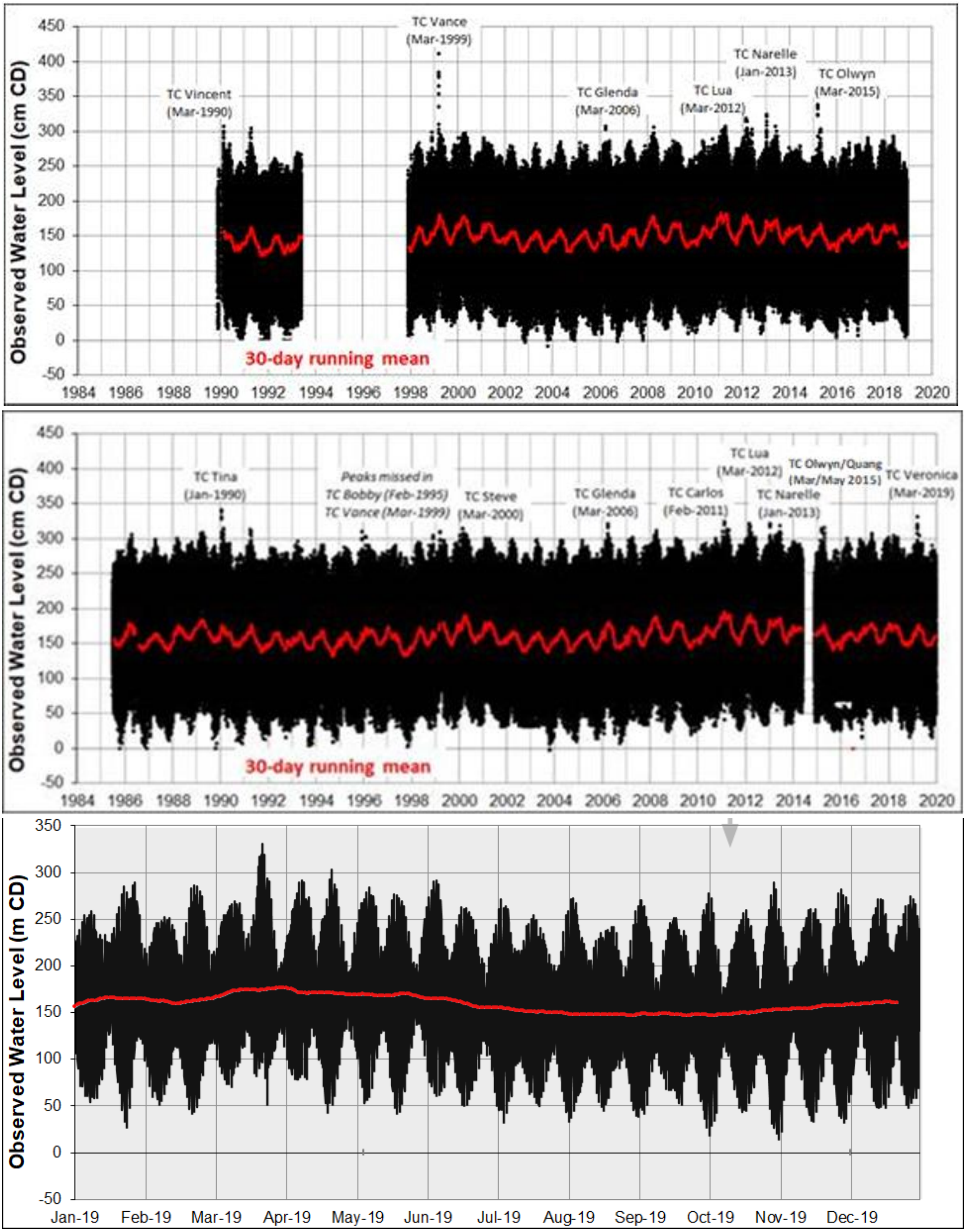


Figure 40: Observed Sea Level Records
Exmouth Tide Gauge Record; (b) Onslow Tide Gauge Record;
(c) Onslow 2019 Water Level Record
(Seashore Engineering, 2021)

6.4.3.2 TIDAL WATER LEVELS

Ocean tidal conditions force water into and out of the Exmouth Gulf on the flood and ebb tides. Tides along the Ashburton coast flow north and south with the forcing of water through the deeper channel to the north of the Northwest Cape (Water Technology, 2021b).

Water levels within Exmouth Gulf are measured at a permanent tide gauge located in Exmouth Boat Harbour, with observations since 1997 allowing definition of tidal planes and examination of MSL variability (DoT, 2004).

An approximation of tidal planes for the Proposal site, has been generated through interpolation of ICSM tidal constituents as outlined in Table 24 below (ICSM, 2019). Worley Parsons also generated tidal planes for Hope Point (approximately 30 km south of the Proposal site, Figure 1) which are included in the Table below (Worely Parsons, 2006). The variation between approximated tidal levels between the Proposal Site and Hope Point is typical for the variety of approaches used for estimating tidal variation and it should be noted that tidal planes can vary over time (Seashore Engineering, 2021).

Table 24: Measured Tidal Planes for Exmouth and Approximation for the Proposal Site and Hope Point
(Seashore Engineering, 2021)

Water Level (all levels mAHD)	Code	Exmouth Measured (DoT, 2004)	Ashburton Salt Site Approximation (ICSM, 2019)	Hope Point Approximation (Worley Parsons, 2006)
Highest Astronomical Tide	HAT	1.47	1.27	1.2
Mean High Water Spring	MHWS	0.95	0.87	0.99
Mean High Water Neap	MHWN	0.36	0.28	0.16
Mean Sea Level	MSL	0.04	0	0.07
Australian Height Datum	AHD	0	0	0
Mean Low Water Neap	MLWN	-0.24	-0.26	-0.05
Mean Low Water Spring	MLWS	-0.85	-0.85	-0.96
Lowest Astronomical Tide	LAT	-1.37	-1.18	-1.18

A comparison of calendar month submergence curves derived from Exmouth tide gauge data is presented in Figure 41. This shows a substantial difference in inundation frequency at the Proposal site, with the Exmouth mean high water springs tidal plane being inundated 10 times more frequently in March than in August. The seasonal variability causes a correspondingly large variation in tidal exchange on and off from the tidal flats over the year with much greater inundation in March and April than in August and September (refer to Figure 41) (Seashore Engineering, 2021).

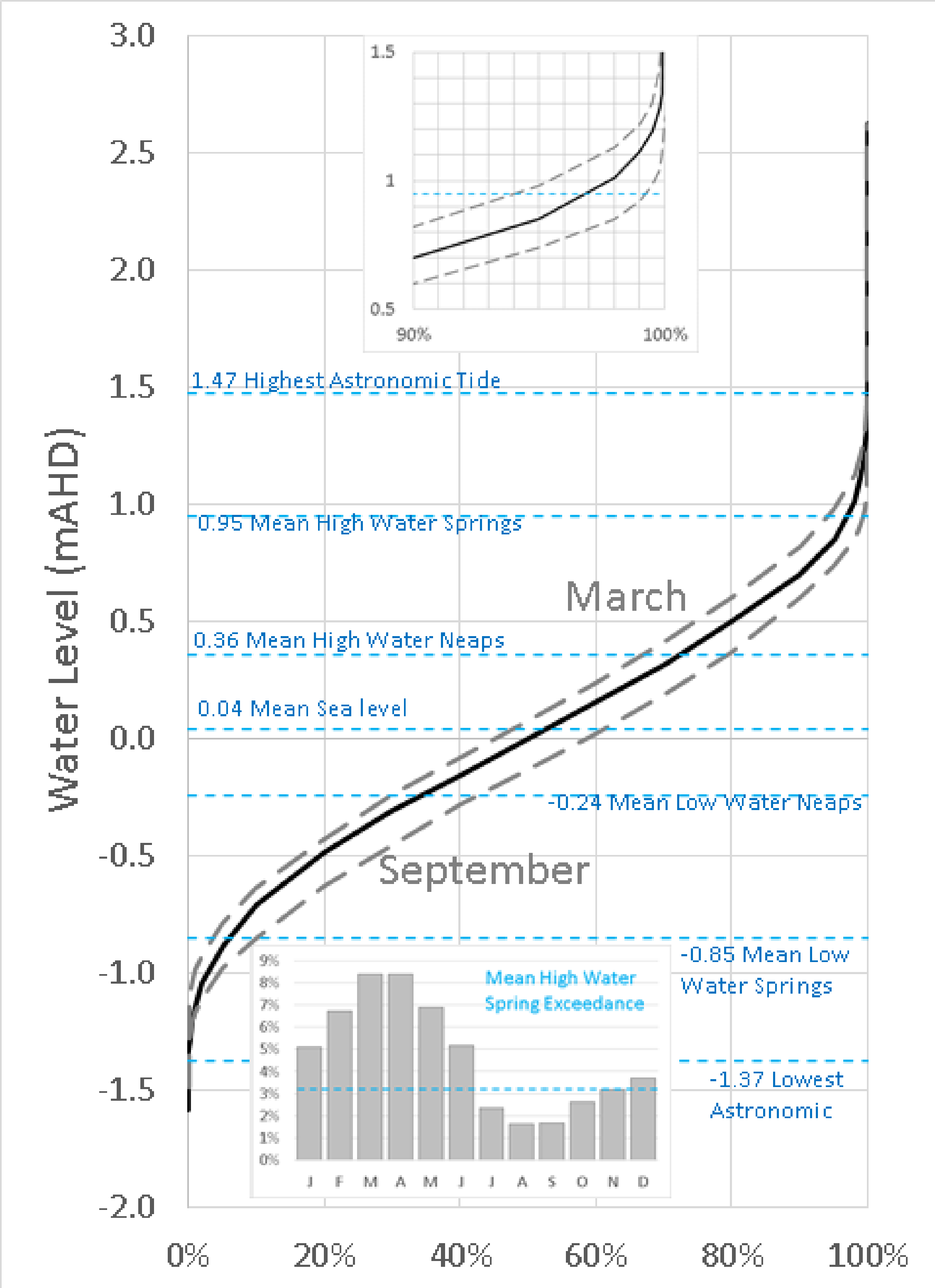


Figure 41: Exmouth Submergence Curve and Seasonal Range
(Seashore Engineering, 2021)

6.4.3.3 WATER TEMPERATURE

The Pilbara coastline, including the nearshore region of Ashburton, is characterised by its shallow and wide continental shelf. The shallow water results in a more direct response to daily air temperature variations than deeper offshore waters. The area has experienced extreme temperature fluctuations including two major marine heat waves in 2011 and 2013 and a more recent event in December 2019. These events have been associated with coral bleaching and significant marine life loss. Risk of extreme temperature could be associated with main La Niña events and elongated summer heating. TCs can cause a rapid drop in surface water temperature within the region as wind driven ocean turbulence causes vertical mixing and transient upwelling. In general, a slower moving cyclone will have a greater impact on water temperature than one which moves rapidly (Water Technology, 2021b).

Monthly average Sea Surface Temperature (SST) data downloaded from Group for High Resolution Sea Surface Temperature (GHRSST; 2020) is presented in Figure 42. The maps indicate a range of close to 10ºC between the summer and winter seasons, with SST around 20ºC in August at the Proposal site and up to 30ºC in March. Waters to the north of the Proposal experience temperatures in excess of 30ºC in the shallower water between Barrow Island and the coast.

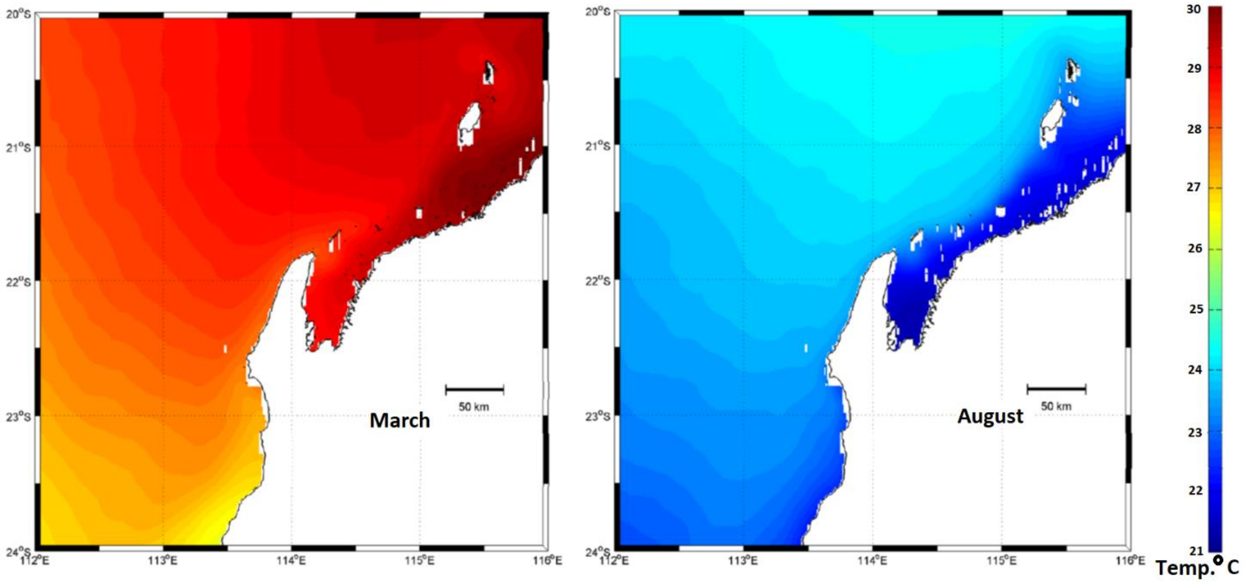


Figure 42: Monthly Sea Surface Temperature
(GHRSST, 2020)

A timeseries of measured water temperature at Urala Creek South and Locker Point during 2019 is displayed below. The clear seasonal variation is shown, with temperature rising from around 20ºC in July to 30ºC and above in late summer (Water Technology, 2021a)

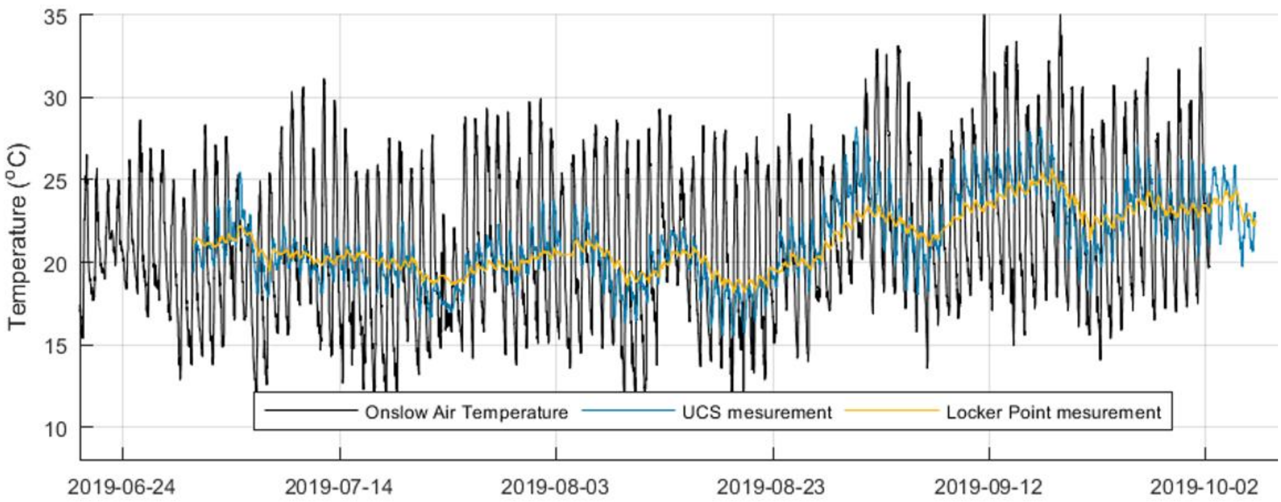


Figure 43: Measured Water Temperature in 2019 Urala Creek South and Locker Point
(Water Technology, 2021b)

6.4.3.4 OCEAN CURRENTS

The Proposal site is located within the Indo-Australian Basin, the region of ocean between the northwest coast of Australia and the Indonesian islands of Java and Sumatra. Dominant currents relevant to the Proposal site include:

- South Equatorial Current;
- Indonesian Through-Flow;
- Eastern Gyral Current;
- Holloway Current; and
- Leeuwin Current (Water Technology, 2021b).

Figure 44 below illustrates the main surface currents of the region (DEWHA, 2007). All these current systems experience strong seasonal to inter-annual variations, which indicate that they are likely to be influenced by climate change over the coming decades (Water Technology, 2021b)

Within Exmouth Gulf, water movement is primarily driven by a combination of tidal and wind forcing, in addition to the large-scale currents mentioned above. The Leeuwin and Holloway currents are warm, southerly flowing currents. The Leeuwin Current is drawn from warm waters north of North West Cape. Salinity measurements on the continental shelf at North West Cape have confirmed the low-salinity Leeuwin Current flows along the outer north-west shelf strongly from February to June (Water Technology, 2021b).

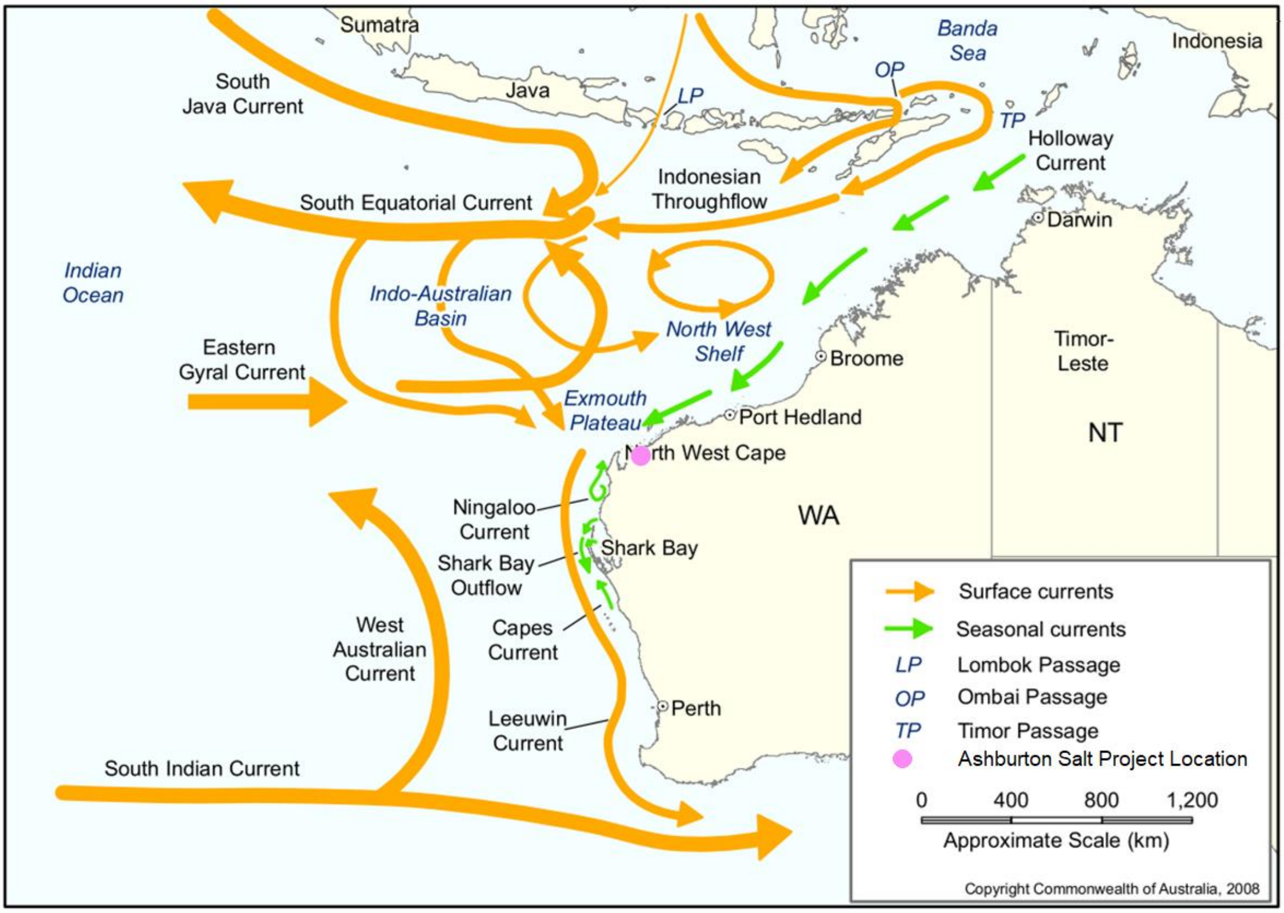


Figure 44: Regional Currents
(DEWHA, 2007)

6.4.3.5 WAVES

Exmouth Gulf is sheltered from the swell wave energy approaching from the south-west by the North West Cape. The fetch at more exposed sites however extends approximately 8,000 km across the Indian Ocean, and therefore large swells (with peak wave periods of up to 20 seconds) could be experienced along the shoreline during both wet and dry seasons.

Swell waves are generated by storms thousands of kilometres away and therefore do not follow local wind patterns. Swells can also be generated during cyclones, and these are more likely to arrive from the north and northwest.

Some attenuation of wave heights from the west through north is provided by the Muiron-Serrurier Island chain. Locally generated wind waves inshore of this are relatively weak due to the weak wind energy environment, particularly from the north through northwest (Water Technology, 2021b).

Wave conditions have been measured by the WA Department of Transport (DoT; 2017) near the Onslow training wall in a water depth of 3.7 m. Wave heights at Onslow were predominantly less than 0.4 m, approaching from the west through north-northeast. The waves had a distinct separation between swell and sea wave component, with 30% of measured waves with a period of between 2 and 6 seconds, largely with a height of 0.2 - 0.6 m; whilst 40% of waves had a peak period between 12 and 18 seconds. These longer period waves were smaller, with the heights less than 0.4 m (DoT, 2017).

It is noted that the location of the DoT data collection site would result in it being sheltered from direct wave action from the south through west-northwest. The data was recorded between 2014 and 2016.

Locker Point would be exposed to locally generated wind-waves and is generally a low wave energy environment, whilst Urala Creek South is a tidal creek and as such is largely sheltered from nearshore waves (Water Technology, 2021b).

However, the open ocean to the south-west, west and north offshore from the Proposal site has sufficient fetch for the growth of cyclone waves. The theoretical unlimited fetch wave height may exceed 15 m offshore, but these waves are significantly attenuated through either refraction or diffusion of wave energy across the Muiron-Serrurier Island chain (Water Technology, 2021b).

6.4.4 CYCLONE EVENTS

Extreme weather can impact coastal processes and morphology. The northwest Australian coastline is the most cyclone-prone region of the entire Australian coastline. Cyclones which may affect the region typically form in the Timor Sea, usually with a south-westerly track. However, the cyclones that affect the Exmouth Gulf take a more southerly or south-easterly track as they move further south (Blandford and Associates, 2005). Cyclones forming in this area typically occur from mid-December to April, peaking in February and March. Table 25 below summarises cyclones since 1985 which have influenced the Onslow/Exmouth region, whilst Figure 45 shows peak water levels experienced and Figure 46 shows each cyclone track (BOM, 2020b).

The most intense tropical cyclone ever recorded to cross the Australian coast, tropical cyclone Vance, passed the Exmouth Gulf in March 1999. Vance was a Category 5 cyclone with the highest wind gust ever recorded on Australian mainland of 267 km/hr at Learmonth Airport on the 22nd of March 1999 (Blandford and Associates, 2005).

Table 25: Cyclones Affecting Exmouth / Onslow Coast Since 1985
(BOM, 2020b)

Name	Year	Description
Tina	1990	A very weak system that did not exhibit a typical tropical cyclone structure. The low passed very close to Exmouth near Learmonth.
Bobby	1995	Bobby crossed the coast as a category three near Onslow on the 25 February causing severe flooding across the north-west.

Name	Year	Description
Vance	1999	Cyclone Vance made landfall over Exmouth as a strong category five, one of the strongest landfalling cyclones recorded in Australia. Exmouth was devastated, with the whole town badly damaged and many houses destroyed.
Steve	2000	Steve made two landfalls in WA, once near Karratha and again near Carnarvon. Damage was severe from flooding in Gascoyne River.
Glenda	2006	Made landfall over Onslow as a category three storm causing moderate damage (severe economic damage however).
Carlos	2011	Carlos brushed the Pilbara coast causing heavy rainfall and high winds from Broome all the way to Exmouth. Building damage was severe in Karratha.
Lua	2012	Cyclone Lua caused severe damage across isolated cattle stations in the Pilbara as a category four.
Olwyn	2015	Olwyn tracked the Western Australian coast from Exmouth, WA to Shark Bay, passing directly over Carnarvon.
Quang	2015	Formed about 1,000km to the northwest of Exmouth, weakened then landed at Exmouth 0n the 1st of May.
Veronica	2019	Veronica made came close to land near Karratha, then weakened below tropical cyclone strength by 26 March. The remaining low tracked over the North West Cape near Exmouth.

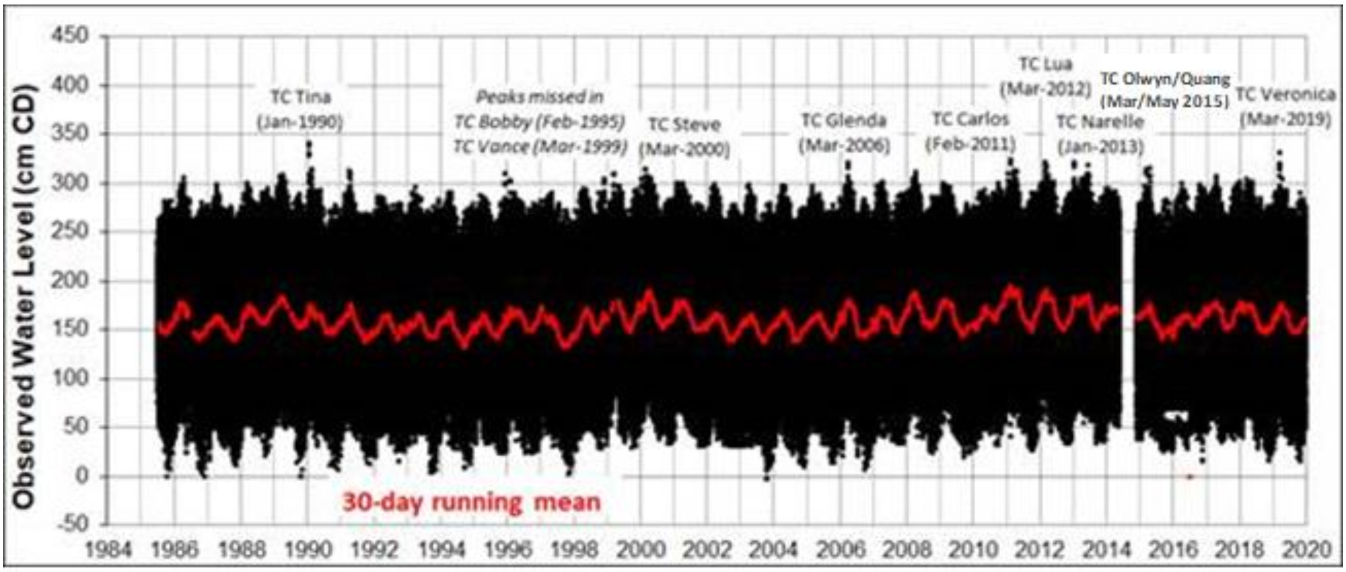


Figure 45: Sea Level Records Onslow Tide Gauge and Tropical Cyclones since 1985
(Seashore Engineering, 2021)

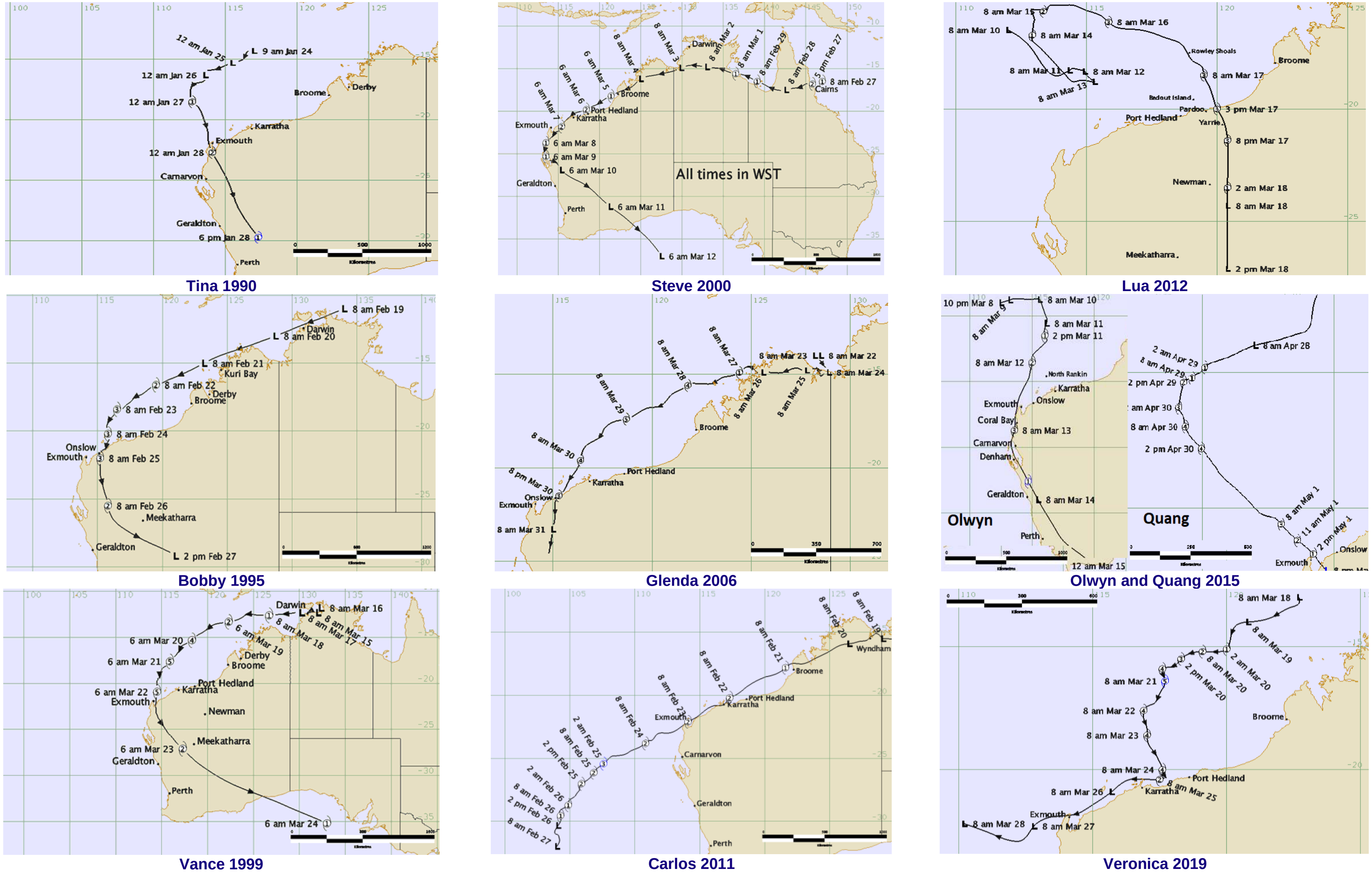


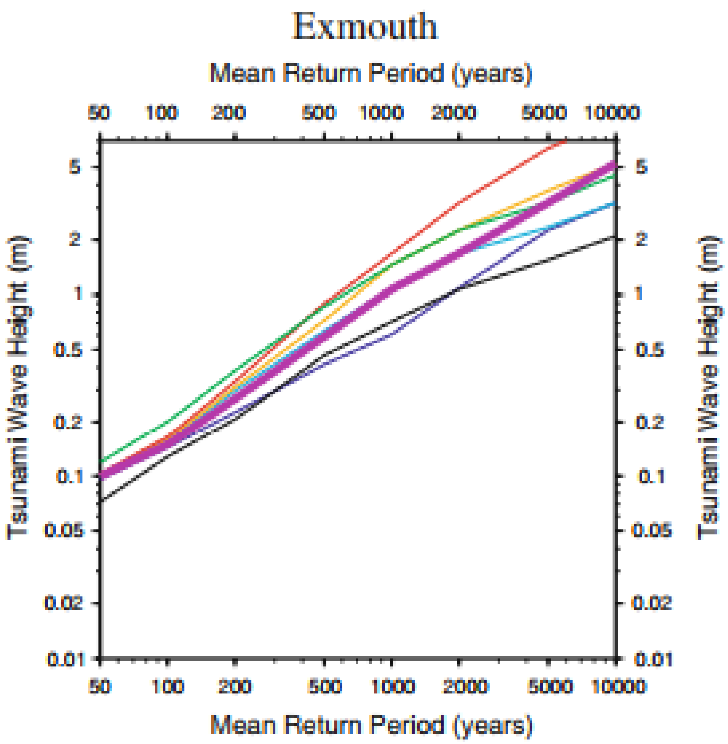
Figure 46: Cyclone Tracks for Tropical Cyclones Affecting Onslow / Exmouth since 1984
(BOM, 2020b)

6.4.5 TSUNAMI

A tsunami is a wave or series of waves, generated in a water body by sudden, largescale displacement of water e.g., earthquake or volcanic eruptions. Due to its orientation and proximity to the Indonesian fault zone known as the Sunda Arc, the north-west of WA is considered as WA's most at risk region from damage due to tsunamis.

Based on available information summarised below, a range of 3-5 m AHD appears to be reasonable estimate of tsunami inundation for the Proposal area, with 5 m AHD a conservative estimate for a 500 year ARI tsunami inundation (Water Technology, 2021b).

Burbidge et al (2008) conducted a detailed tsunami assessment in the region. All tsunamis were assessed as generated from the Sunda Arc Subduction Zone. Whilst the maximum magnitude earthquake possible on the Sunda Arc Subduction Zone is not known, Figure 47 below shows a suite of possible earthquake magnitudes: blue movement magnitude (Mw) 8.5, cyan Mw 9.0, orange Mw 9.3 and red Mw 9.5 and their corresponding return period and wave heights for the 50 m depth contour offshore from Exmouth. The purple line is the preferred model which is a weighted mean of all values. Table 26 presents the wave amplitudes for a range of return periods; the 500-year amplitude is 0.5 m (Burbridge et al., 2008).



Earthquake magnitudes

Blue Mw 8.5
Cyan Mw 9.0
Orange Mw 9.3
Red Mw 9.5
Purple Weighted mean

Figure 47: Exmouth Tsunami Wave Height at 50 m Water Depth
(Burbidge et. al., 2008)

Table 26: Preferred model, tsunami wave height and return period for Exmouth
(Burbidge et al, 2008)

Return Period (Years)	Tsunami Wave Height (m)
50	0.10
100	0.15
200	0.21
500	0.50
1000	1.0

Geoscience Australia (2006) undertook further tsunami modelling to assess the vulnerability of the nearshore Onslow coastline from earthquake generated tsunamis originating from the Sunda Arc Subduction Zone. The assessment was undertaken using a Method Of Splitting Tsunamis (MOST) model to generate and propagate the tsunami from its source to a location slightly offshore from the coastline. The hydrodynamic and inundation modelling tool ANUGA was then used to translate the wave from offshore to onshore.

The maximum magnitude earthquake off the coast of Java was predicted to be between Mw 8.5 and Mw 9. A Mw 9 earthquake was used for the model. This corresponds with the preferred Burbidge et. al. (2008) model. The offshore wave height selected for the study corresponds well with the 500-year ARI values discussed above. The simulation was run for Highest Astronomical Tide (HAT), LAT and MSL. Local bathymetry played a large role in the measured tsunami water level in the nearshore. Figure 48 below presents predicted inundation levels for the HAT scenario at Onslow (Geoscience Australia, 2006).

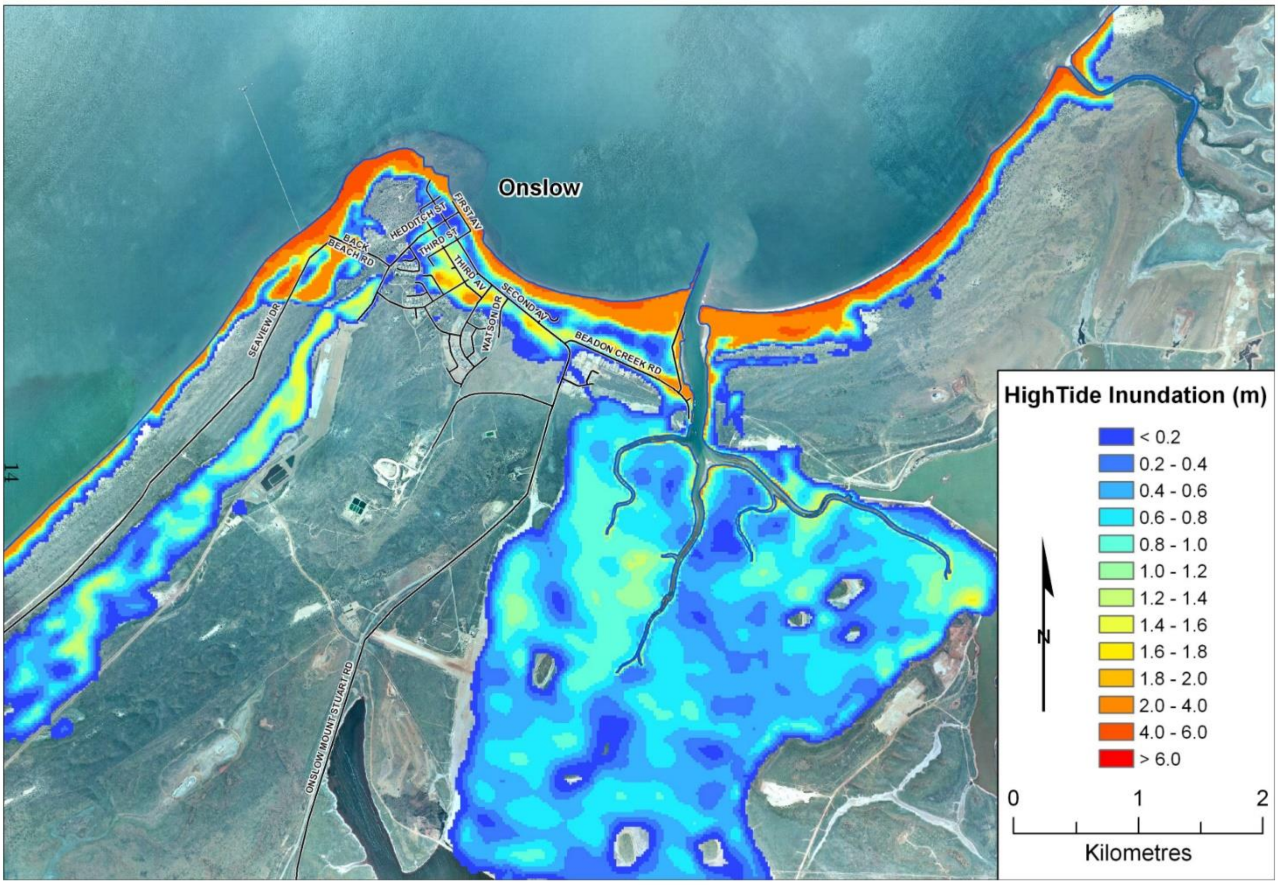


Figure 48: Maximum Tsunami inundation map AT HAT
(Geoscience Australia, 2006)

The maximum observed water level occurred in Beadon Bay East for the HAT scenario where an inundation level of approximately 5 m AHD was modelled (Geoscience Australia, 2006). The inundation varied spatially across the Onslow townsite, as well as with the different water level scenarios. The results are summarised in the Table below (Water Technology, 2021b).

Table 27: Predicted Inundation Levels at Onslow
(adapted from Geoscience Australia, 2006)

Water Level Scenario	Inundation Level (m AHD)
HAT	2.5 – 5
MSL	3 – 4
LAT	0.5 – 1

6.4.6 SEDIMENT CHARACTERISTICS

Sediment composition can affect coastal morphology and dynamics. Sediments within Exmouth Gulf are typically dominated by sand; however, muds and silts are also present, especially in the mangrove and depositional areas near the site. Sediment sampling undertaken within Exmouth Gulf suggests offshore sediments are typically at least 80% sand, in the range of 0.062 – 2 mm (Brunskill et al., 2001).

Blandford and Associates (2005) previously reported on sediment samples within the coastal fringe zone at Hope Island (approximately 30 km south of the Proposal site, Figure 1). The sediment layers of the coastal fringe were found to consist of "an upper 300 mm layer of fine to medium grained sand, overlying 200 mm of marine silt and then 300 mm of sandy silt containing shell fragments", suggesting a muddy sand subject to tidal and current movements. Dunes and beach deposits were found to consist of more coarse-grained sand containing abundant shell fragments.

Sediment samples were taken by Water Technology on 12th and 13th September 2017 from the three locations – Locker Point, Urala Creek North and Urala Creek South. All three samples were classified as fine sand. Table 28 presents the median particle size at each location. Figure 49 shows sampling locations and the sediment composition at Locker Point and the Urala Creek South. Shell fragments dominate the sediment at the beach fronting the ocean, as compared to finer sediment found inside the creek (Water Technology, 2021b).

Table 28: Soil particle size analysis results

Location	Median particle size (mm)	Soil Classification
Locker Point	0.213	Fine sand
Urala Creek South	0.154	Fine sand
Urala Creek North	0.158	Find sand

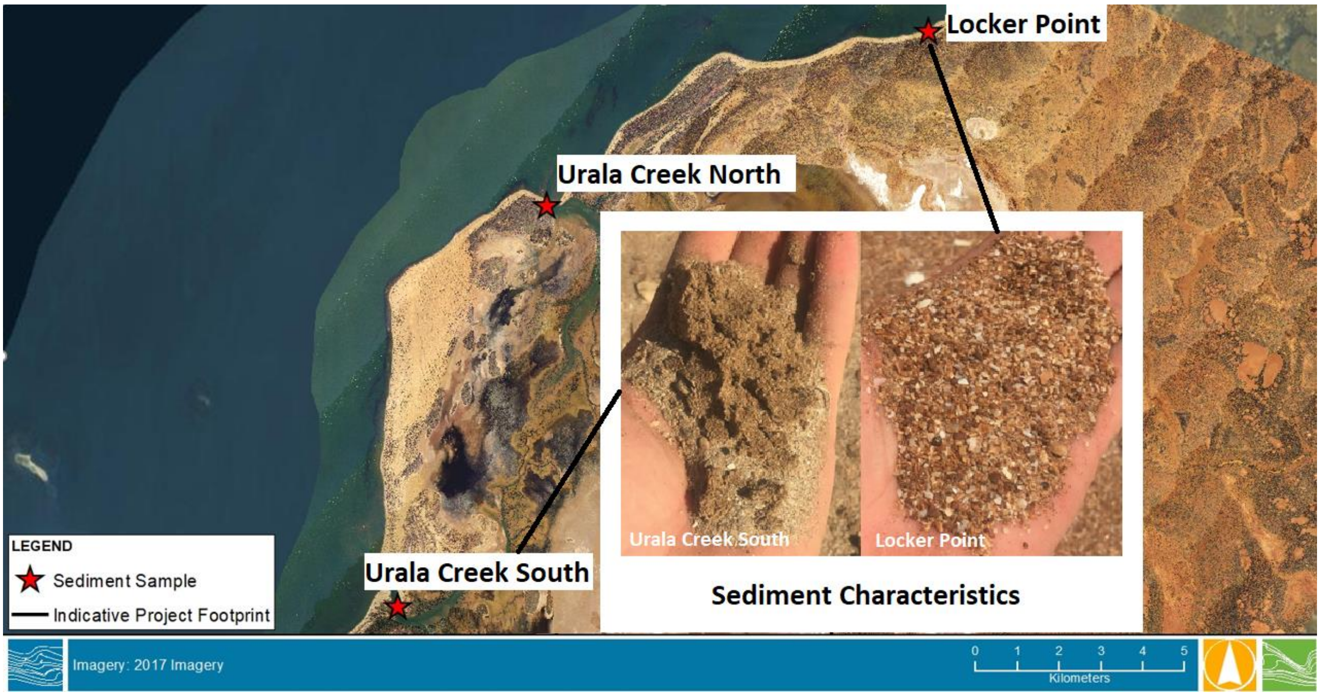


Figure 49: Sediment Characteristics at Locker Point and Urala Creek South
(Water Technology, 2021b)

6.4.7 COASTAL MORPHOLOGY

6.4.7.1 REGIONAL MORPHOLOGY

A schematic of the morphology tidal flat zones of the Exmouth Gulf is provided by Eliot et. al. (2012), presented in Figure 50.

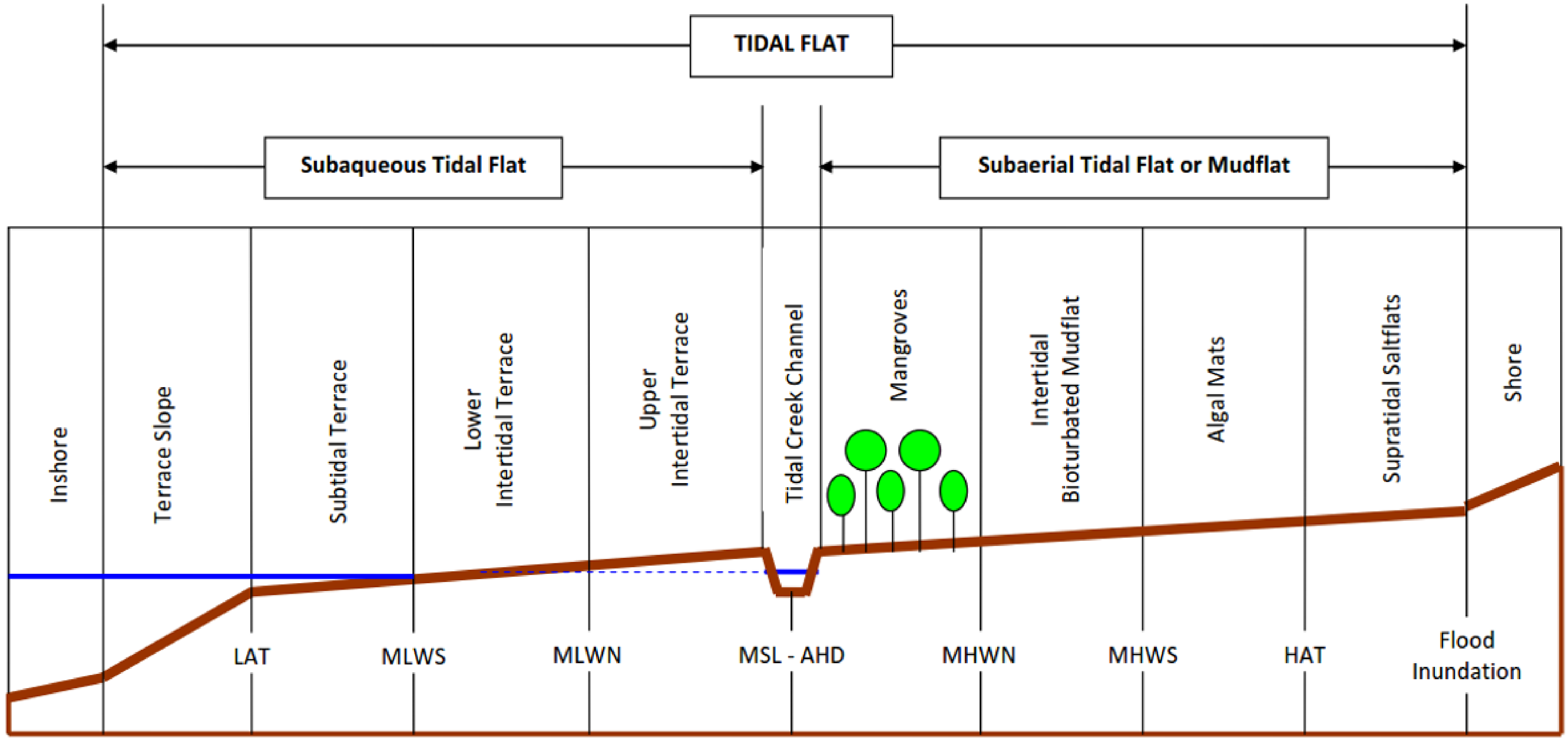
6.4.7.2 LOCAL MORPHOLOGY

The coastal units surrounding the Proposal area can be described as follows:

- Locker Point Barrier Dune.
- Tubridgi Point Perched Barrier.
- Barrier Spit Sequence.
- Mangrove Shore.

The above coastal units are shown in Figure 51, whilst elevation profiles for cross-sections are provided in Figure 52 (Seashore Engineering, 2021):

- Locker Point Barrier Dune (cross section P1; Figure 51 and Figure 52) is exposed to direct ocean wave action, which has enabled it to build a high (~8 m AHD) and wide dune ridge. The dune is underlain by a limestone platform, providing a high degree of coastal stability (Seashore Engineering, 2021).
- Tubridgi Point Perched Barrier (cross section P2; Figure 51 and Figure 52) has high coastal exposure, with strong alongshore wave action due to prevailing southerly wind waves. The underlying limestone platform (~0.5 m AHD) supports a perched beach and dune, with the west-facing alignment conducive to the development of migratory longitudinal dunes. The perched barrier provides a high overall level of landform stability, although the toe of perched dunes may be susceptible to high variability in response to sea level fluctuations – Gallop et. al (2020). Severe dune deflation was identified along the western margin of Tubridgi Point following impact of TC Vance in March 1999 (Blandford and Associates, 2005).
- The sequence of barrier spits south of Tubridgi Point (cross section P3 to P4; Figure 51 and Figure 52) has developed through sequential deposition under different alongshore (and onshore) events, which may be a combination of short-term (e.g. tropical cyclones) and longer-term events (e.g. raised sea level phases). Adjacent to Tubridgi Point, the spit sequence includes high (~9 – 12 m AHD) dunes with multiple ridges to landward. The adjacent shore has 1 in 20 slope, characteristic of a sandy shore. There are small sections of intertidal rock platform apparent along this unit. Southward, the height and number of spits declines, with only a single ridge present for approximately half the length of this coastal sub-unit (Seashore Engineering, 2021). The decline in spit height and width is evident where the spit has been breached by a tidal creek (Figure 51 Point B), although it retains approximately 50m^2 cross-section above the flat. The shore has a 1 in 200 slope, characteristic of a muddy shore at the creek mouth.
- There are morphologic connections between the intertidal rock platform, the coastal barrier and tidal creek systems. This is illustrated by the complex structure shown in Figure 51 and Figure 53, where multiple relict spits (Point A) occur landward of a section of rock platform (cross section P4). These spits are adjacent to a former tidal channel (Point C), which is presently blocked by the coastal barrier, although this feature appears subject to breaching under extreme conditions (Point B) (Seashore Engineering, 2021).
- There is no barrier spit along the mangrove shore (cross section P5; Figure 51 and Figure 52), which has a very gently graded slope (1 in 300) transitioning into an almost horizontal mangrove flat. There is only small variation in level extending across the algal mat area and salt flat, except where incised by tidal channels (Seashore Engineering, 2021).



Approximate tidal limits are indicated with reference to Australian Height Datum (AHD = 0.0m); Highest Astronomical Tide (HAT); Mean High Water Spring Tide (MHWS); Mean High Water Neap Tide (MHWN); Mean Low Water Neap Tide (MLWN); Mean Low Water Spring Tide (MLWS) and Lowest Astronomical Tide (LAT). Actual tidal heights will vary geographically as well as between environments subject to diurnal and semi-diurnal tides.The full sequence of units is not necessarily present at all mudflat locations. The slope of the surface is commonly less than 2°.

Figure 50: Morphology of Tidal Flat Zones

(Eliot et al., 2012)

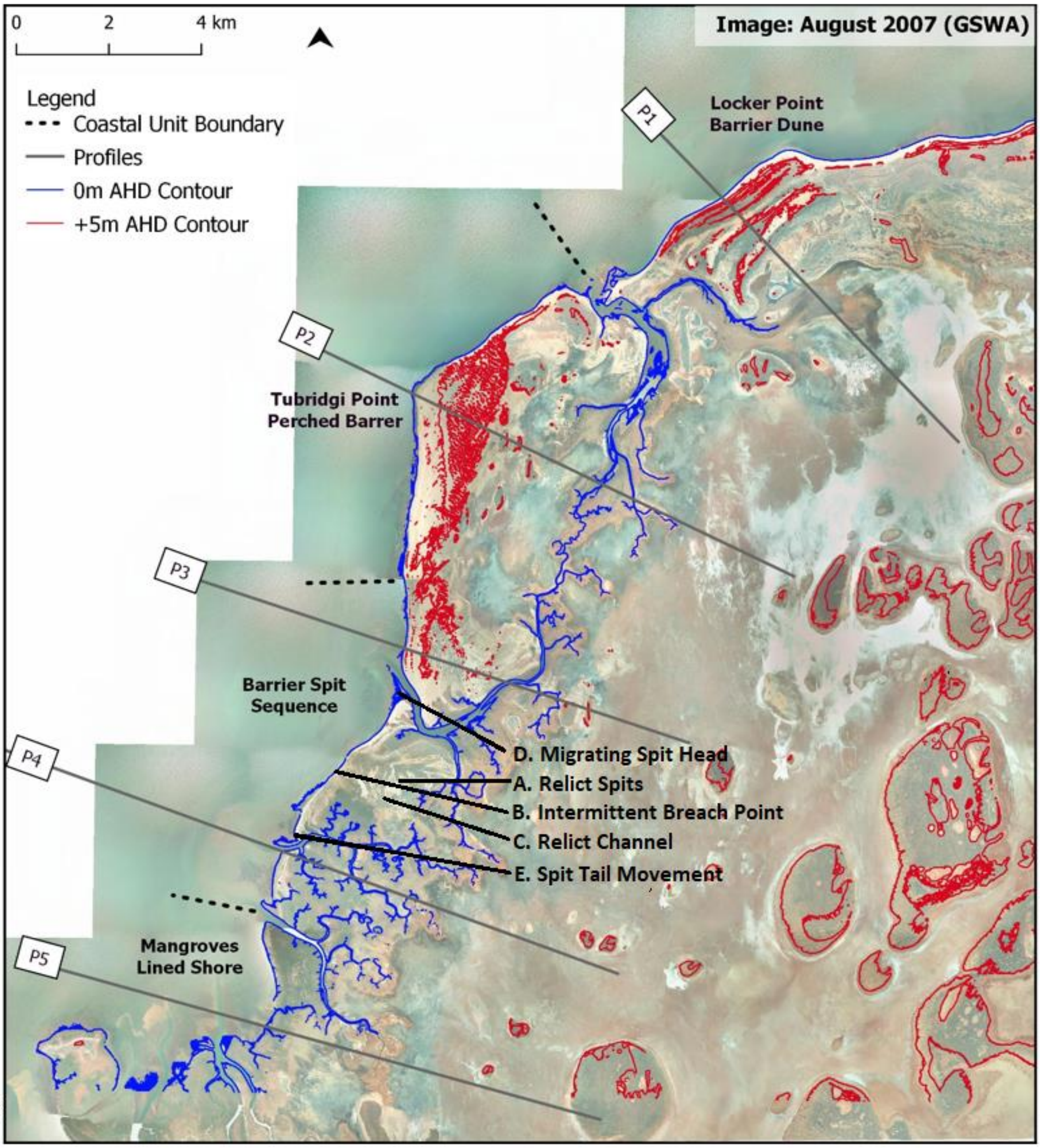


Figure 51: Coastal Units and Cross Sections
(Seashore Engineering, 2021)

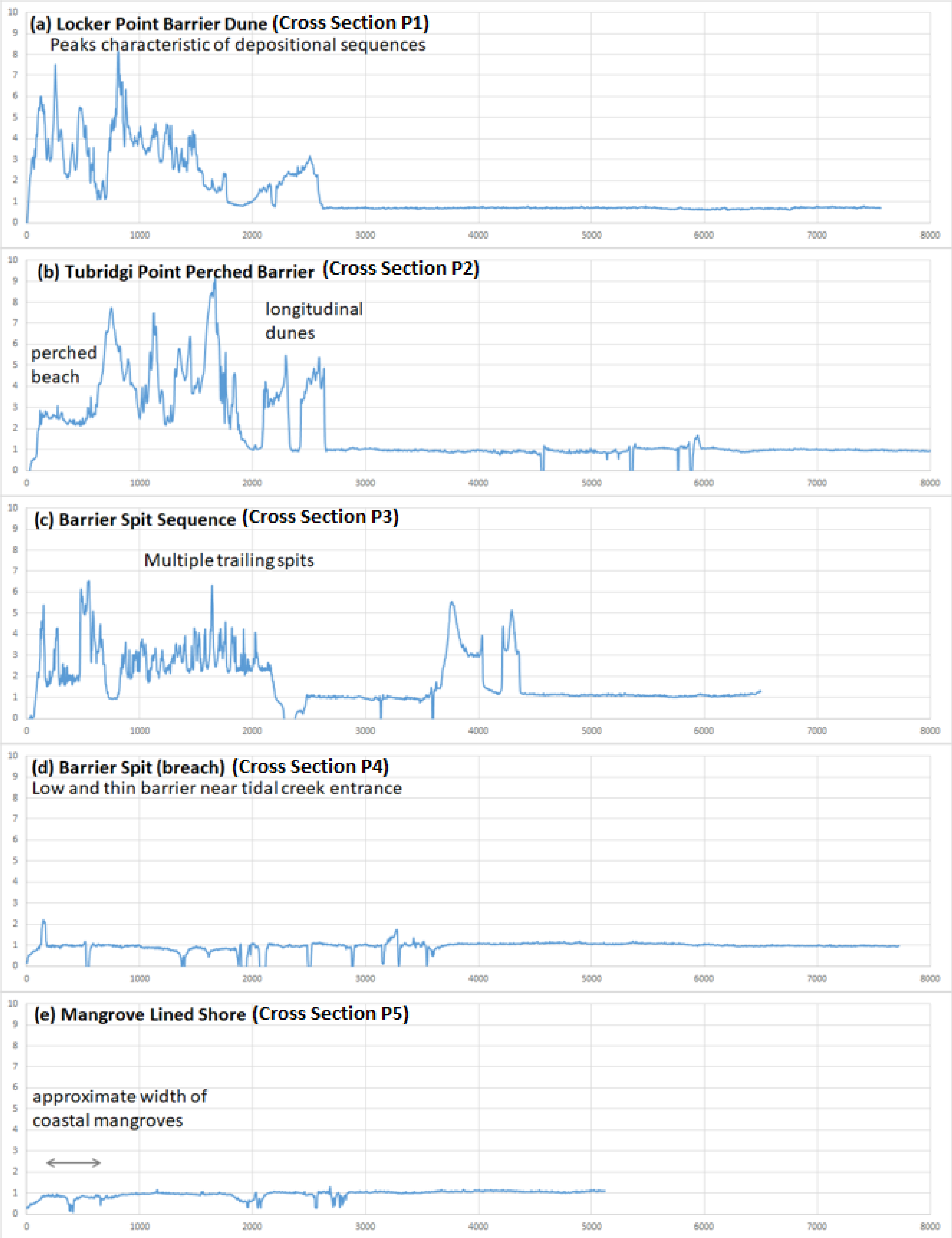


Figure 52: Elevation Profiles of Coastal Unit Cross Sections P1 – P5 on Figure 51
(Seashore Engineering, 2021)

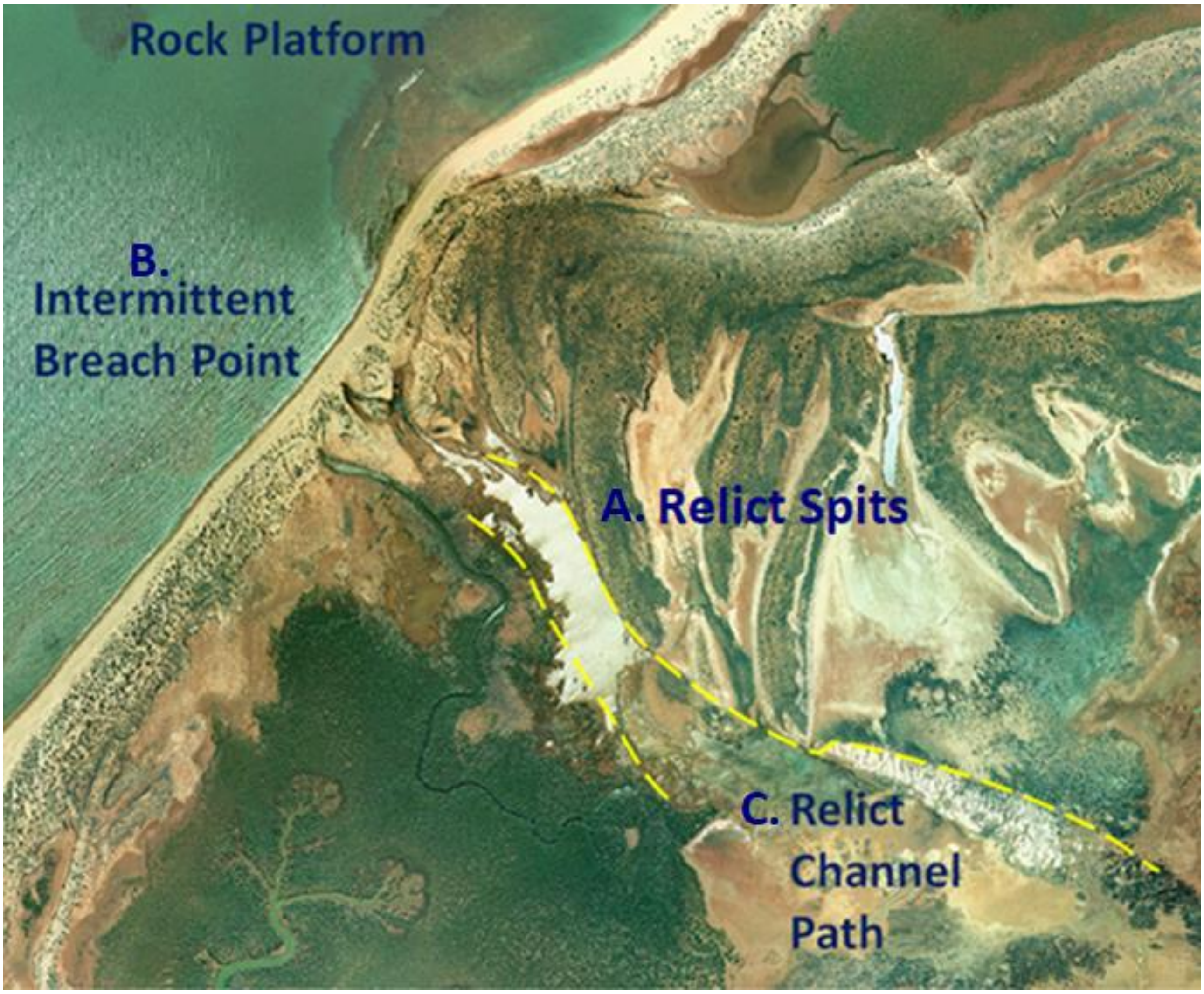


Figure 53: Relict Channel, Spits and Intermittent Breach Point – Points A, B and C on Figure 51
(Seashore Engineering, 2021)

6.4.8 INTERTIDAL MORPHOLOGY

The extremely flat topography of the coast fringing mangroves and salt flats belies the morphologic complexity of the intertidal zone. The main physical driver is tidal exchange through the channel network, which provides a mechanism for redistribution of fine sediments and affects the viability of vegetation through establishment of salinity gradients (as described in Section 8.3). Vegetation, including mangroves, locally modifies sediment mobility through root structures and flow baffling, and may also generate biogenic sediments (Chaudhuri, Chaudhuri and Ghosh, 2019).

Aeolian and hydraulic influences, as well as vegetation structures and heterogeneity of sediments, form depressions and basins over a range of scales (Perillo, 2019). Tidal influx and drainage are approximately proportional to the area of these basins. When basins are connected to a tidal channel network, the size of the channel required to convey the flow tends to be related to the contributing areas, although not always directly (Davies and Woodroffe, 2010), (Perillo, 2019). The range of basin scales can correspondingly provide a 'fractal' dimension to tidal channels, with smaller channels draining downstream into larger channels, with a dendritic structure. Extending from the main tidal channels the progressively smaller scale set of channels form gradually from creeks to gullies, to grooves, down to surface rills, as shown in Figure 54 (Seashore Engineering, 2021).

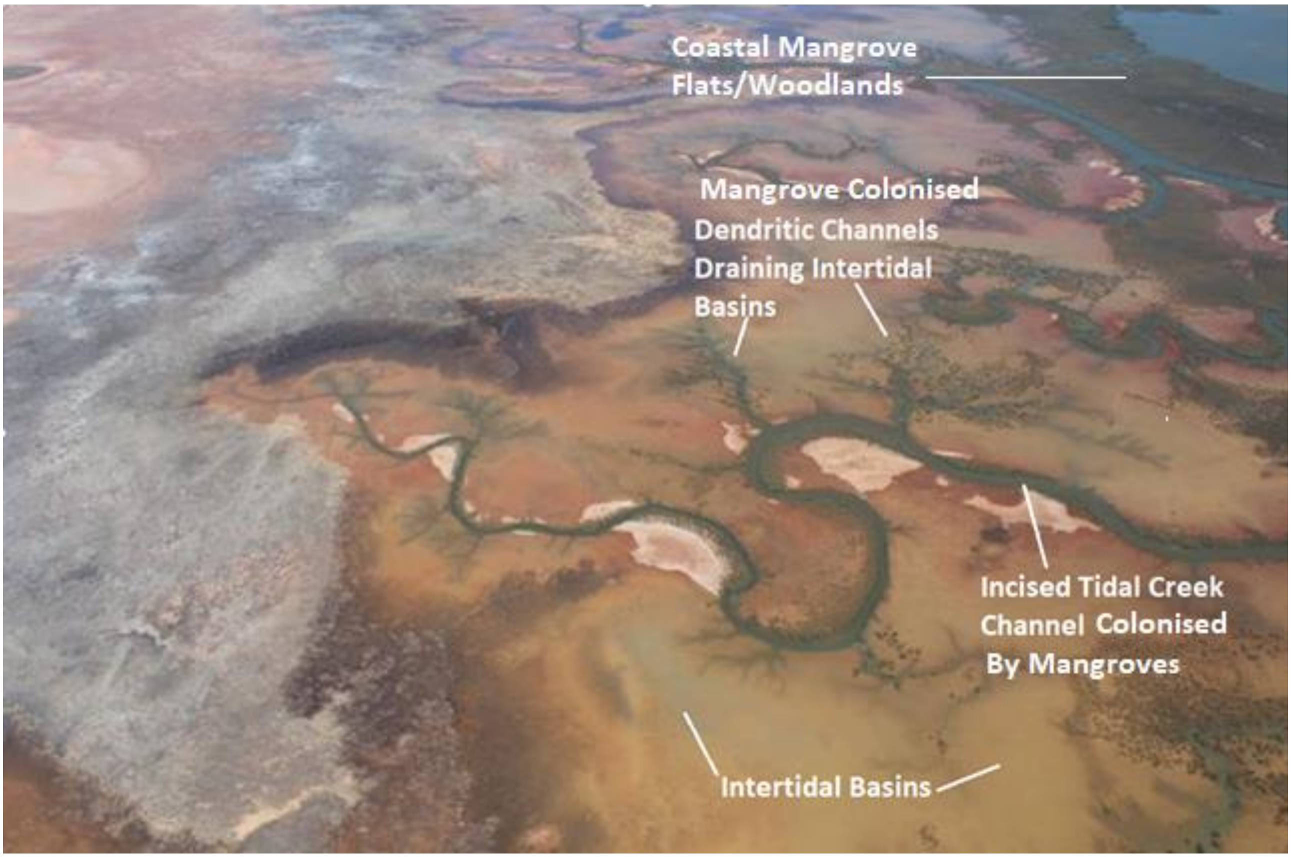


Figure 54: Intertidal Morphological Structure
(Seashore Engineering, 2021)

Tidal movement through the dendritic channel network provides focused flow, which can lead to deeply incised tidal creeks (Figure 55). Incision gives comparative stability under a range of flow conditions, with the shallower and steeper gradient channels of the network, including gullies and tidal grooves, being more susceptible to bed mobilisation or deposition through different tidal phases. Consequently, tidal channel networks are typically most dynamic at their ‘headward’ (or inland) limit, with expansion (channel headcutting) or infilling occurring in response to changes in tide, MSL or channel structure (e.g., restriction due to wave-driven sediment supply at the mouth) (Seashore Engineering, 2021).

Landward expansion of the channel network, also referred to as channel headcutting, can provide a significant precursor to mangrove colonisation. Channel expansion increases flows and drainage, which reduces porewater salinity of the adjacent mudflats, making them better suited to mangrove growth and sustainability (Seashore Engineering, 2021).

Mangroves require nutrients from water exchange and sediment input and are tolerant of a limited salinity range. These conditions result in mangrove colonisation along the fringes of tidal channels, and mangrove flats/woodlands closer to the ocean where there is greater tidal exchange within coastal basins maintaining salinity gradients conducive to mangrove survival (Figure 54), (Seashore Engineering, 2021).

As described in Section 8.5.4.3.2 algal mat distribution is strongly related to hydroperiod, with algal mat colonisation occurring inland of mangrove areas, within intertidal basins which are subject to infrequent (often monthly) inundation (Figure 56). Once developed, the algal mat helps to bind surface sediments and reduces permeability, potentially modifying local drainage and percolation pathways (Seashore Engineering, 2021).

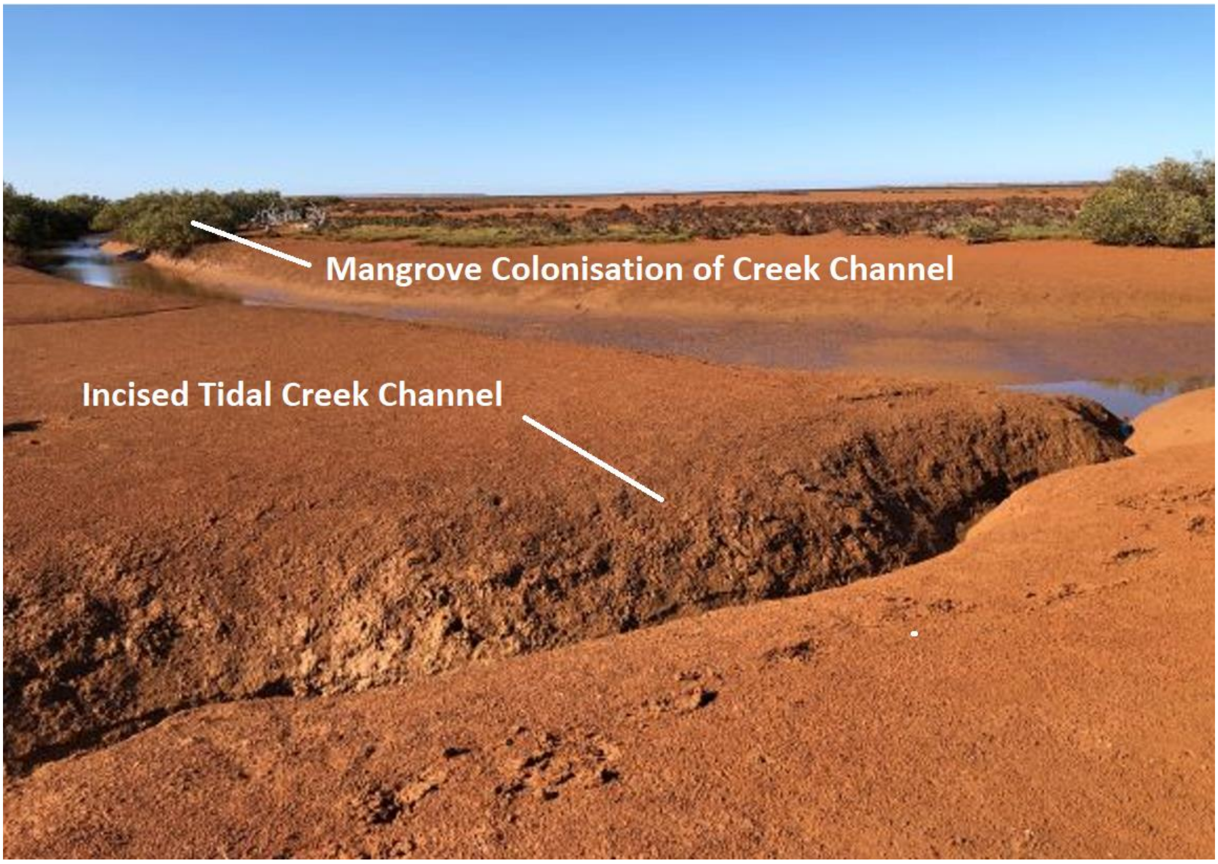


Figure 55: Incised Tidal Creek Channel Colonised by Mangroves
(Seashore Engineering, 2021)

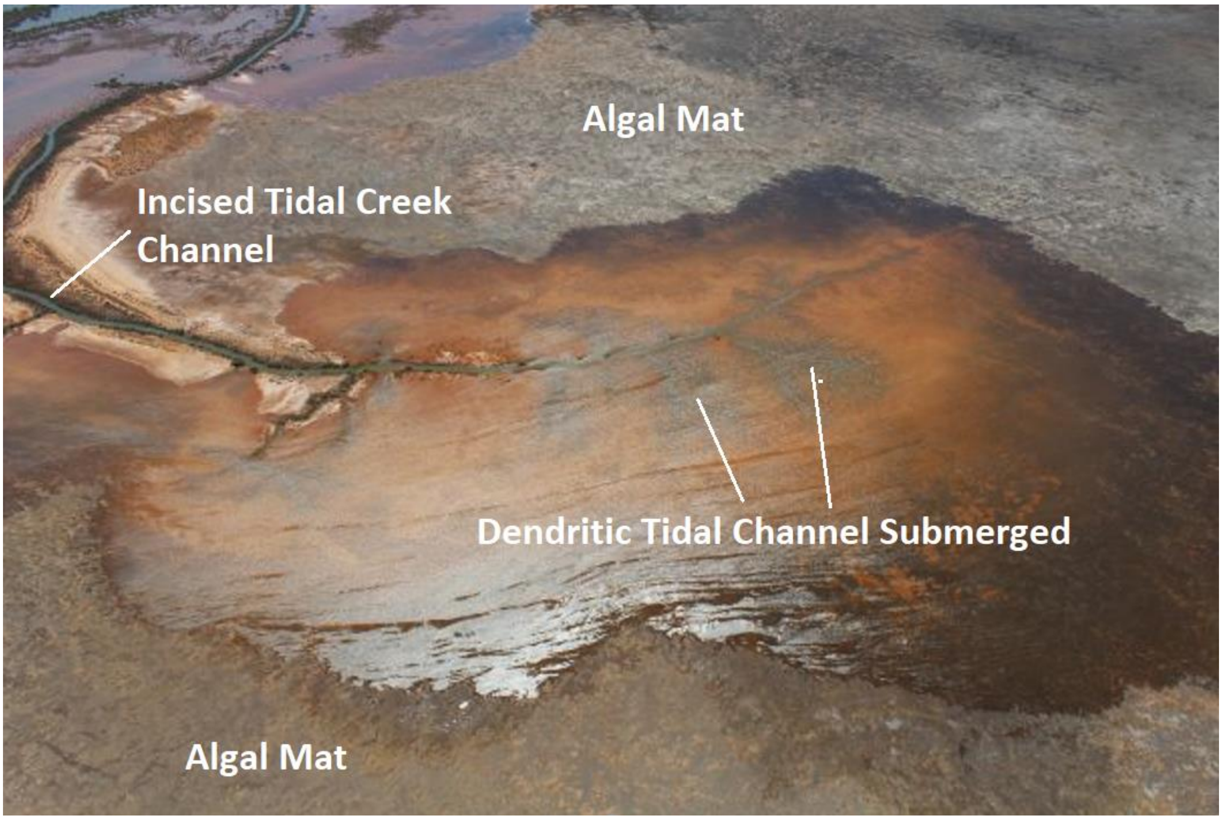


Figure 56: Tidal Inundation of Agal Mat
(Seashore Engineering, 2021)

6.4.9 COASTAL AND INTERTIDAL MORPHOLOGY DYNAMICS

The coastal and intertidal morphology of the Proposal area appears to be overall quite stable. Interpretation of physical changes to the intertidal habitats of the Tubridgi coast has been made through literature review, interpretation of site morphology and comparison of historic aerial imagery from 2004 to 2018 by Seashore Engineering (2021) and from 2001 to 2017 by Water Technology (2021b). Interrogation of the imagery has been used to examine changes in coastal position, mangrove presence and tidal channel structures.

6.4.9.1 HISTORICAL SHORELINE MOVEMENT

Overall, there are no substantial changes in shoreline over 14 to 17 years identified, although seasonal and local-scale dynamics were identified. The most apparent area of (relatively minor) change occurred along the sandy coastal barrier south of Tubridgi Point (Barrier Spit Sequence in Figure 51). In this area Water Technology (2021b) identified a pattern of a slowly accreting shoreline, with the vegetation line moving slightly towards the ocean between 2001 and 2017. The areas of maximum accretion were surrounding the mouths of creeks with up to 45 m (2.8 m/year) of accretion. Observed features include:

- Infilling of a previous breach in the barrier to south of Tubridgi Point and Urala Creek South (Points A, B and C in Figure 51 and Figure 53). This feature was apparently the mouth of a previous tidal channel, which has been closed for a long time (Point C Figure 51 and Figure 53). It is considered likely that the extreme conditions during Tropical Cyclone Vance in 1999 would have caused an inflow of water but was not sufficient to re-establish a tidal network.
- Migration of a new spit head into the Urala Creek South tidal channel mouth occurred over 14 years (Point D, Figure 51). This matches the pattern suggested by the adjacent morphology, with multiple previous recurve spits already present.
- A slight adjustment at the southern end of the barrier spit to the south of the abovementioned barrier breach infilling, with loss of beach sediment causing a slight inwards rotation of the spit head (Point E, Figure 51) (Seashore Engineering, 2021).

6.4.9.2 HISTORICAL INTERTIDAL AREA MOVEMENT

The boundaries of mangrove communities have changed little, but a general increase in canopy coverage is apparent, suggesting greater plant maturity. There are few locations of extensive colonisation, except for individual basins (Seashore Engineering, 2021).

Tidal channels across the area are remarkably stable, particularly as the period of imagery observation (2004 to 2018) included transition from low to high MSL and from few extreme events to a series of severe cyclones. Tropical Cyclone Steve occurred in 2000, after which there were no cyclones until 2006. Then from 2006 to 2015 there were five cyclones – Tropical Cyclone Glenda, Carlos, Luca, Narelle and Olwyn (Table 25, Figure 45) (Seashore Engineering, 2021).

Aerial images are characteristically variable at the upstream end of tidal channels, indicating patterns of channel incision and depositional fan formation. However, the channels themselves remain in the same place, with no clear evidence of channel head-cutting or sustained infilling, that would indicate intertidal floodplain evolution (Seashore Engineering, 2021).

Water Technology (2021b) found there has been very little change in bank alignment of Urala Creek South between 2001 and 2017, other than the migrating spit head mentioned in the previous Section. Water Technology (2021b) concluded that the oscillatory tidal flow appears to have attained a dynamic equilibrium within the body of the creek, showing no clear trend of bed level/shoreline change.

6.4.10 LOCAL ENVIRONMENTAL VALUES

Local environmental values related to coastal morphological processes have been identified as follows:

- Tubridgi Point and Locker Point dune barrier systems which offer the intertidal zone protection from coastal forces such as wind and waves.

- Urala Creek North and South which provide tidal water and sediment exchange.
- Local intertidal mudflat areas which play a role in sediment dynamics, water exchange and intertidal morphology.

These local values have been mapped overlayed by the Proposal in Figure 57 using the following Geographic Information System (GIS) datasets:

- K+S LIDAR DEM (Fugro, 2018a).
- K+S Aerial Imagery (Fugro, 2018b)
- Mangrove, Algal Mat and Intertidal Mudflat Mapping (AECOM, 2022a)
- National Intertidal Digital Elevation Model (NIDEM) (Geoscience Australia, 2019)
- Satellite Imagery (Copernicus Sentinel, 2021).

6.4.11 REGIONAL ENVIRONMENTAL VALUES

Regional environmental values related to coastal morphological processes have been identified within the boundary of the Exmouth Gulf East wetland (WA007) including the following:

- Regional dune barrier systems which offer the intertidal zone protection from coastal forces such as wind and waves (located at Hope Point, Tent Point, Tubridgi Point and Locker Point).
- Regional tidal creeks along the eastern coast of the Exmouth Gulf which provide tidal water and sediment exchange.
- Regional intertidal mudflat areas along the eastern coast of the Exmouth Gulf, which play a role in sediment dynamics, water exchange and intertidal morphology.

These regional values have been mapped overlayed by the Proposal in Figure 58 using the following GIS datasets:

- Exmouth Gulf East Wetland boundary map (ANCA, 1993)
- Mangrove, Algal Mat and Intertidal Mudflat Mapping (AECOM, 2022a), (Biota, 2022c)
- NIDEM (Geoscience Australia, 2019)
- Australian Bathymetry and Topography Grid (Geoscience Australia, 2009)
- Satellite Imagery (Copernicus Sentinel, 2021).

6.5 POTENTIAL IMPACTS

The following potential impacts have been identified for this Proposal:

- Direct disturbance of features important to coastal processes such as tidal creeks, intertidal mudflats and barrier dunes.
- Indirect impacts to the above features through processes such as erosion, sedimentation, morphology change and changes in tidal inundation.
- Altering the coastal response to SLR.
- Cumulative impacts through direct and indirect changes to coastal features and processes.

Each of these impacts has been discussed and quantified in the sub-sections below.

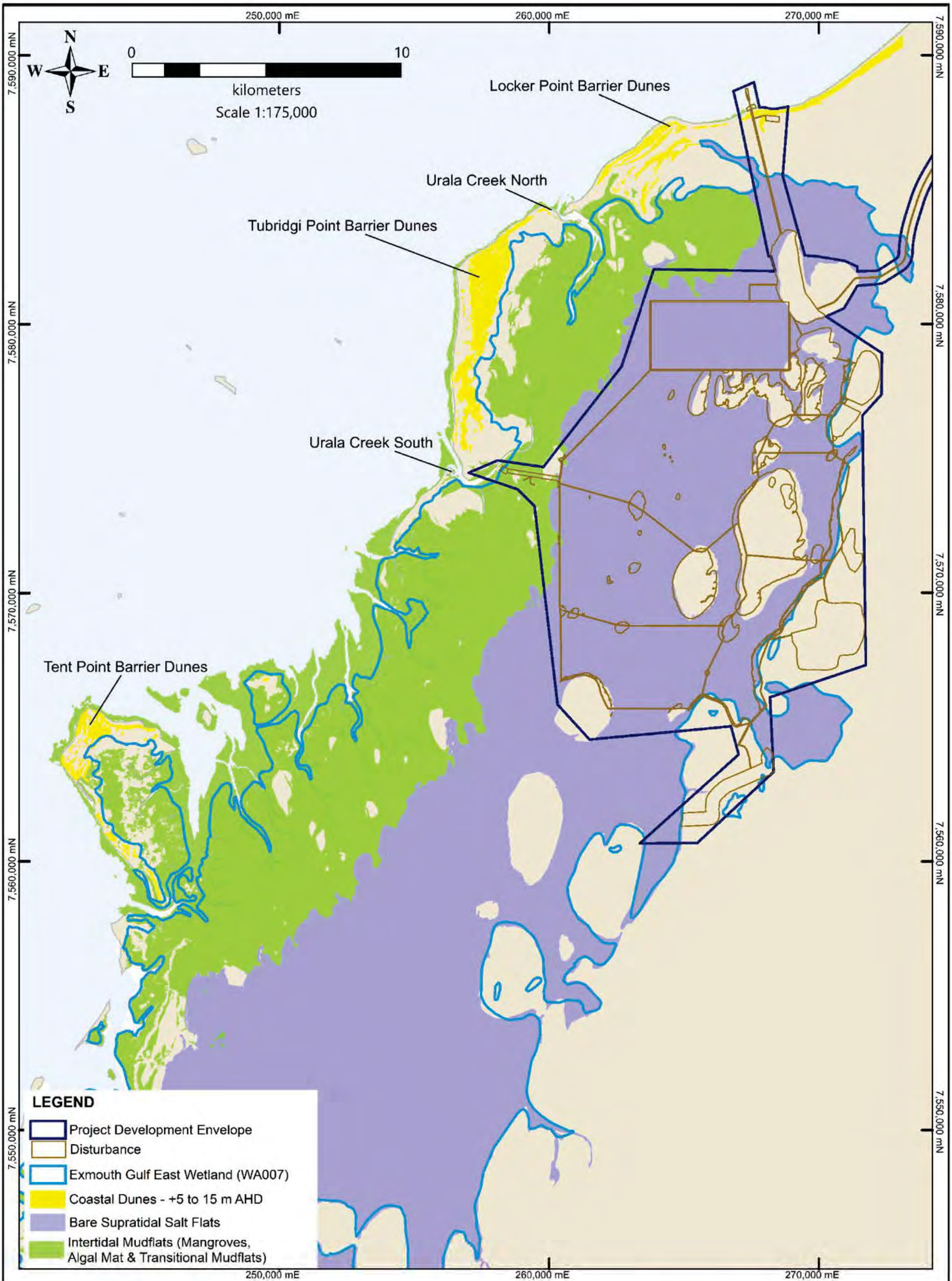


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Figure 57. Local Values Coastal Processes

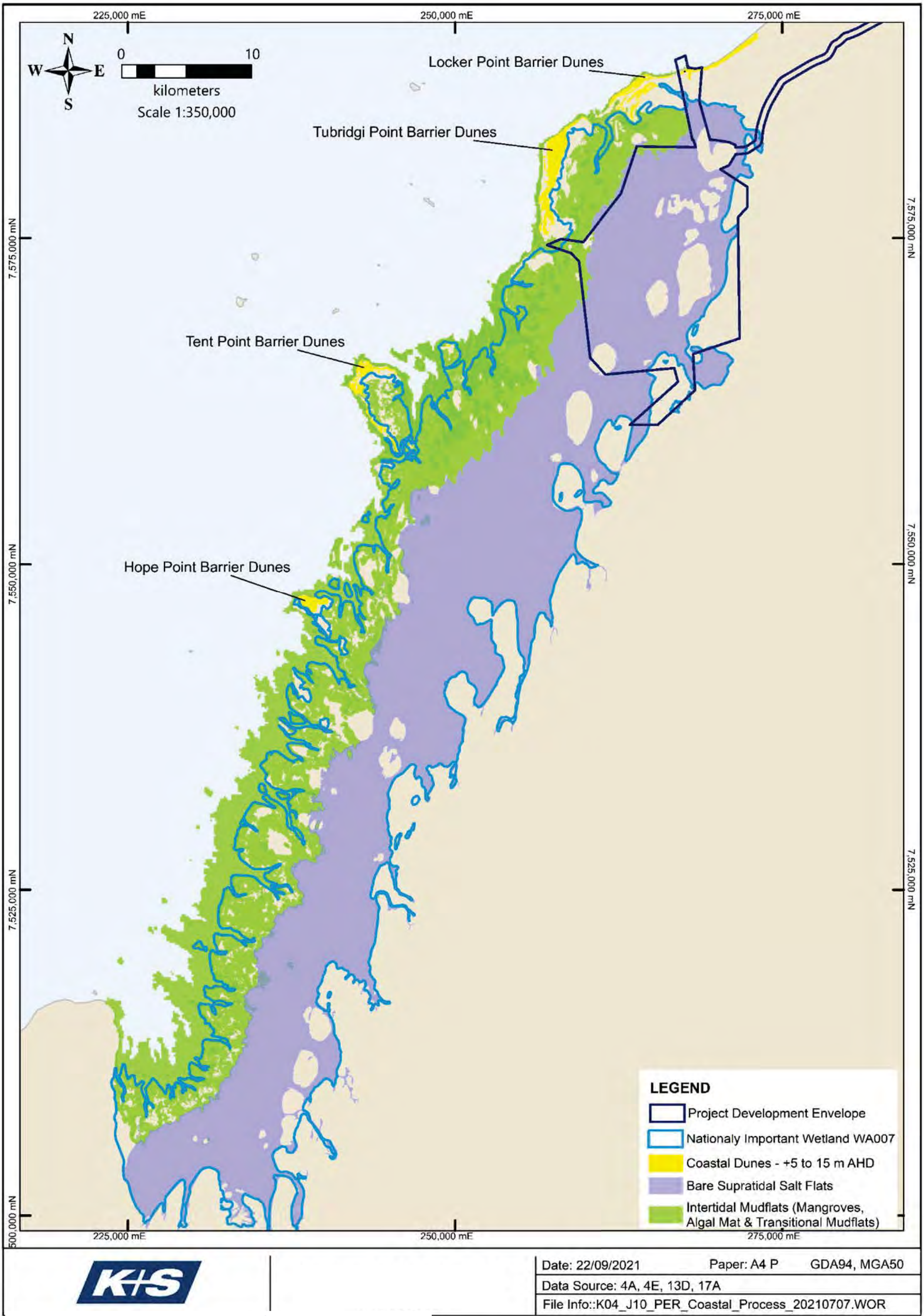


Figure 58. Regional Values Coastal Processes

6.5.1 DIRECT DISTURBANCE

Proposed direct disturbance to features which are important to coastal processes such as intertidal mudflats, tidal creeks and barrier dunes, has been mapped in Figure 57 above. Due to the limited physical footprint of Proposal infrastructure and locating the Proposal predominantly on the supratidal salt flats, direct disturbance of these features is localised and proportionally small on a local and regional basis. Table 29 below indicates that proposed direct disturbance is relatively minor with proportional loss less than 0.3% locally and regionally.

Table 29: Direct Impact to Coastal Features Important to Coastal Processes
(AECOM, 2022a), (Geoscience Australia, 2019), (Fugro, 2018a)

Coastal Features	Direct Impact (ha)	Local Area (All LAUs) (ha)	East Exmouth Gulf Region (ha)	Proportional Loss Locally (%)	Proportional Loss Regionally (%)
Mangroves	3.94	2,185	11,742	0.18%	0.03%
Algal Mats	12.74	5,384	11,617	0.24%	0.11%
Transitional Mudflats	17.81	4,020	20,747	0.44%	0.09%
Intertidal Mudflats (Total of Above Habitats)	34.49	11,589	44,106	0.30%	0.08%
Tidal Creek	0.54	503	2,710	0.11%	0.02%
Barrier Dune	0.17	1,787 (Jetty to tent Point)	2,059	0.01%	<0.01%
TOTAL	35.2	13,879	48,875	0.25%	0.07%

6.5.2 INDIRECT IMPACTS

6.5.2.1 URALA CREEK SOUTH (SEAWATER INTAKE) FLUVIAL MORPHOLOGY

To understand the potential impacts of the proposed seawater intake on the morphology of Urala Creek South, detailed sediment transport modelling of the creek was undertaken using the industry standard modelling package, MIKE by DHI. The model included hydrodynamic (waves and tidal currents) and sediment transport (sand) components to simulate the morphological response of the channel to full 12 months of 'typical' conditions (i.e., the seasonal water level variability was captured). This variability in water level is important to model as the resultant tidally generated currents are the dominant morphological driver for these tidal creeks. Both existing and developed conditions were modelled for the full year period (Water Technology, 2022b).

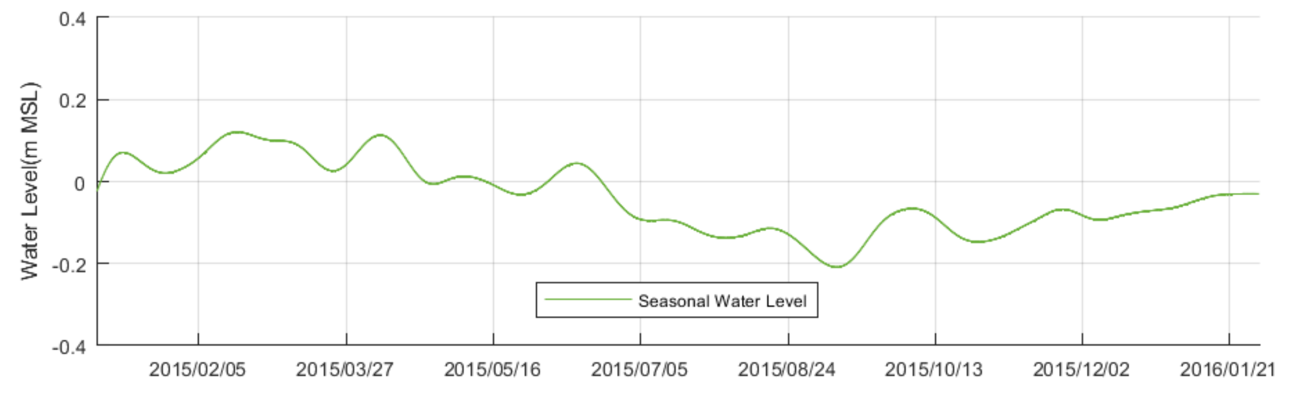


Figure 59: Simulated seasonal water level variability at Locker Point
(Water Technology, 2022b)

The developed conditions modelling conservatively assumed pumping under both high and low tide conditions, whereas the Proposal does not plan to pump seawater at low tide; and that the highest pumping rates would occur concurrently with the highest spring tide scenario whereas these rates would only occur in November/December due to the highest evaporation rates (Water Technology, 2022b).

The aim of the modelling was to understand whether the increase in flood flows and reduced ebb flows due to the intake operation could potentially impact the current morphological conditions in the creek as the tidal channels across the area have been identified to be remarkably stable (Seashore Engineering, 2021), (Water Technology, 2022b).

For the extreme spring tide conditions, applying the maximum pumping rates, peak current speeds during the flood and ebb tides only increased marginally post-development (maximum increase of <5 cm/s). The resultant predicted change in morphology of the creek is a minor increase in bed levels in the main channel and some minor increase in bed level variability near the entrance. Over the 12-month simulation, the morphology changes were minor, in the order of 10 cm, limited in extent and localised (Figure 60).

The contribution of Urala Creek North and South to coastal processes, is to provide tidal water and sediment exchange which contributes to local sediment dynamics and coastal morphology. The minor localised changes predicted by conservative modelling (Water Technology, 2022b), are unlikely to impact coastal processes.

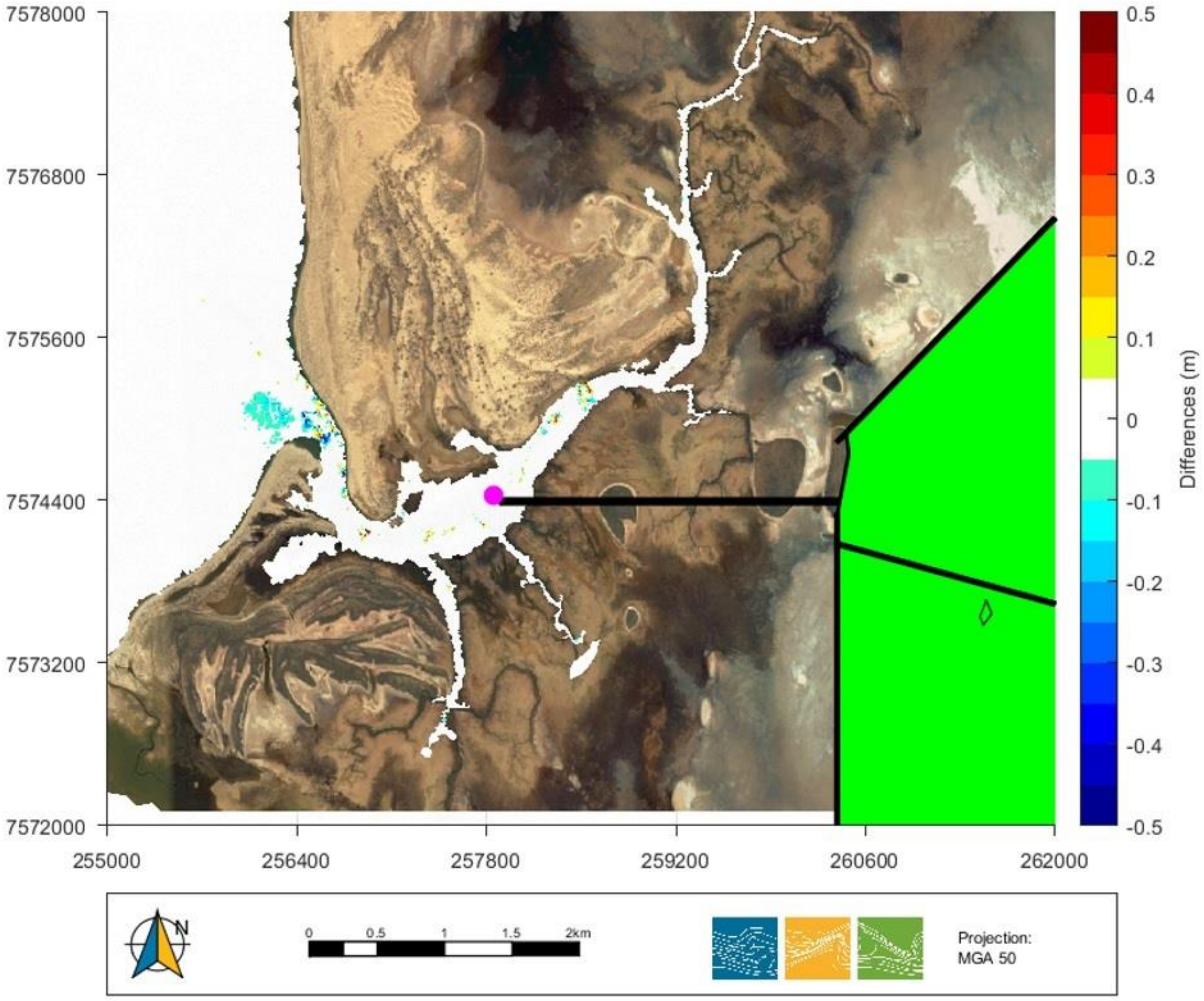


Figure 60: Sand Transport Model Difference Pre- and Post-Development for 1 Year
(Water Technology, 2022b)

6.5.2.2 JETTY SITE HYDRODYNAMICS AND COASTAL MORPHOLOGY

The jetty site near Locker Point is in a weak energy environment with low tidal currents and low wave heights under most conditions. This is reflected in the limited historical shoreline variability in this area (Water Technology, 2021b).

To understand the potential impacts of the proposed jetty structure on the shoreline, detailed hydrodynamic modelling was undertaken using the industry standard modelling package, MIKE by DHI. The model scheme allowed the wave and current conditions to be resolved on a very fine 5 m grid in the nearshore region (Water Technology, 2022b).

A series of representative scenarios were modelled for both existing and proposed development conditions:

- Spring tide: seasonal high spring tide conditions.
- Spring tide plus SLR: ambient spring tide plus 0.4 m SLR.
- 2-year ARI: Storm event with a 2-year return interval.
- 20-year ARI: Storm event with a 20-year return interval.
- 500-year ARI Cyclone: Synthetic cyclone with a 500-year return interval to comply with State Planning Policy No. 2.6 – State Coastal Planning Policy SPP2.6 WAPC (2013). The model was a 'coupled' model, with both waves and hydrodynamics included.

The modelled results showed that the proposed development layout including construction of a pile-supported jetty, minor dredging at the berthing pocket, installation of discharge diffuser and bitterns discharge (<1 m^3/s) has negligible influence on the hydrodynamic regime of the site since:

- The pile-supported jetty is a transmissive structure and therefore is predicted to provide no direct interruption to hydrodynamics, or longshore sediment transport/littoral drift process.
- It is predicted there will only be marginal impacts to wave propagation across the berthing pocket due to its limited footprint of dredging offshore (Water Technology, 2022b).

Sedimentation may occur during tropical storms when the bottom shear stress will be enhanced by storm waves. This will likely drive resuspension/transportation/deposition of seabed materials and periodic morphology variations. The shoreline morphological impacts from the proposed jetty and berth facilities are expected to be minimal because the jetty is open to incoming waves and the piles do not obstruct the wave propagation towards the shore.

The area surrounding the proposed jetty predicted to be indirectly impacted by minor changes to waves and currents is negligible. For example, the difference between existing and post development conditions for the extreme 500-year ARI cyclone event is shown on Figure 61. No discernible difference is observed (Water Technology, 2022b).

On the basis of the modelling described above, the jetty structure is predicted to have no impacts on coastal processes.

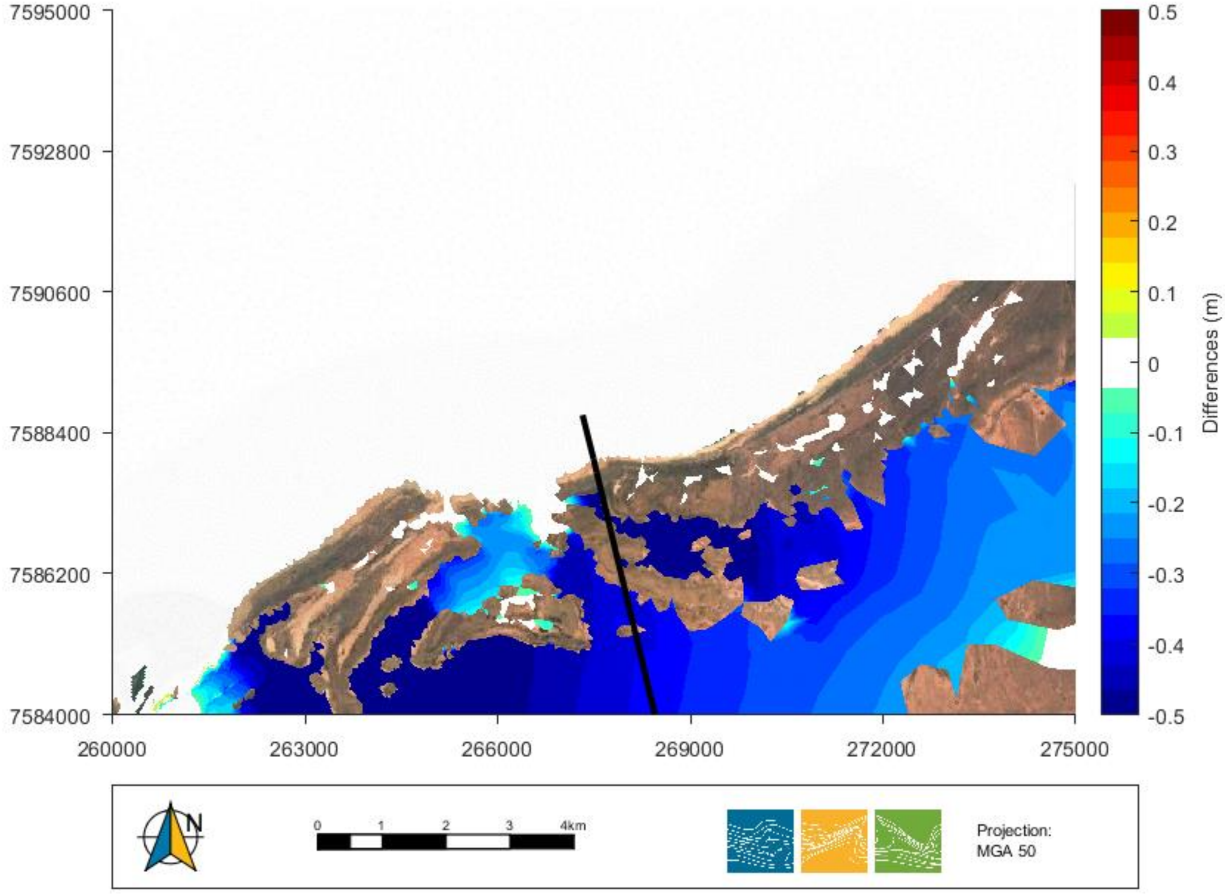


Figure 61: Model Water Level Difference Pre- and Post-Development (500-yr storm tide)
(Water Technology, 2022b)

6.5.2.3 CHANGES IN INTERTIDAL MUDFLAT INUNDATION

To understand the potential impacts on tidal inundation of the proposed development, detailed hydrodynamic modelling was undertaken using the industry standard modelling package, MIKE by DHI. This involved the development of a detailed topographic and bathymetric map of the intertidal areas, combining a range of datasets (Water Technology, 2022b). The model used a fine resolution in Urala Creek South to better resolve flow pathways along narrow creek branches and intertidal areas, as shown in Figure 62.

A series of seven representative scenarios were modelled for both existing and proposed development conditions:

- A one-year simulation of tidal conditions.
- Spring tide: seasonal high spring tide conditions.
- Spring tide plus SLR: ambient spring tide plus 0.4 m SLR.
- 2-year ARI: Storm event with a 2-year return interval.
- 20-year ARI: Storm event with a 20-year return interval.
- 500-year ARI Cyclone: Synthetic cyclone with a 500-year return interval to comply with State Planning Policy No. 2.6 – State Coastal Planning Policy SPP2.6 WAPC (2013).

The one-year simulation of tidal conditions was used to assess the water movements across intertidal areas. The two spring tide scenarios were simulated to evaluate potential impacts to tidal inundation for both present-day conditions and for a SLR scenario of 0.4 m, which is representative of the 50-year design period. It also aligns with the 2070 planning period in SPP 2.6 (WAPC, 2013). While the three representative storm events (i.e., 2-year, 20-year and 500-year ARI), were simulated to evaluate the potential post-development changes to inundation of mangrove habitats and salt flats from storm events.

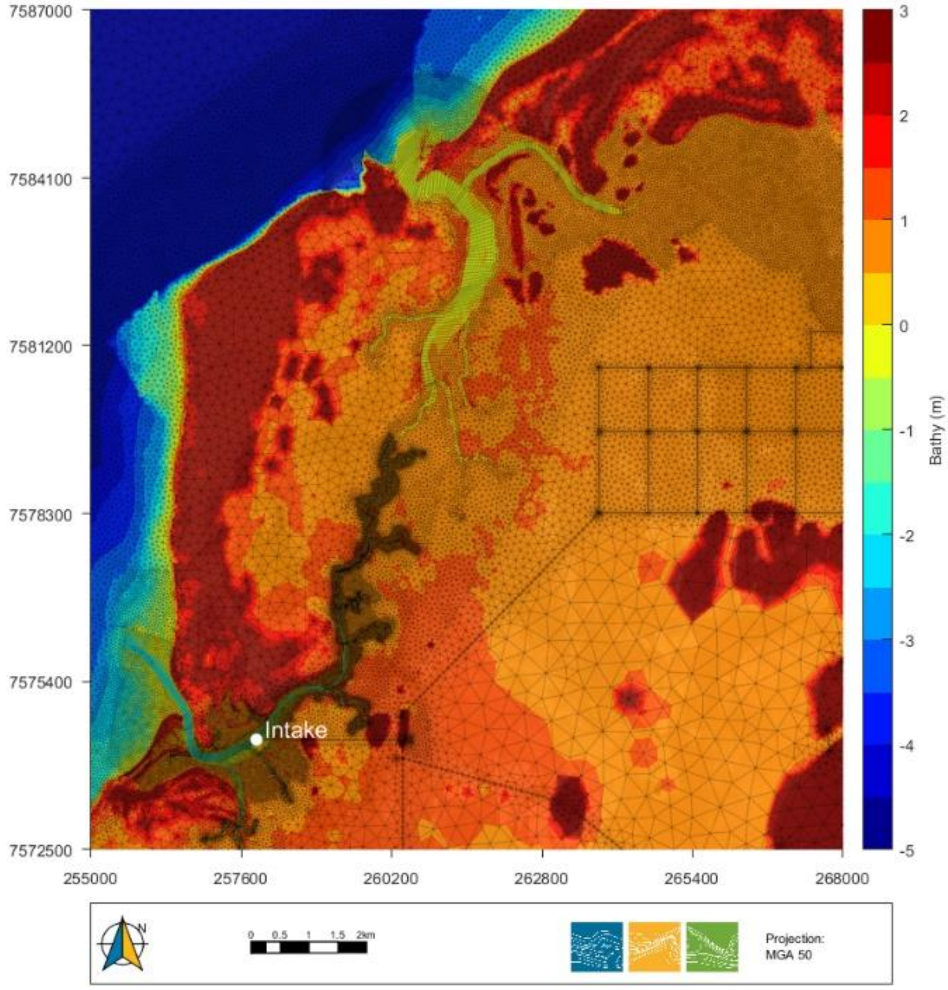


Figure 62: Model Mesh
(Water Technology, 2022b)

Submergence curves at Urala Creek South, which show the relationship between the percentage of time the water level is above or below a given elevation were developed from the model results for existing and post-development conditions and are shown in Figure 63 (Water Technology, 2022b).

The submergence curve comparison above highlights the following due to the pumping from the seawater intake at Urala Creek South (Water Technology, 2022b):

- There is negligible impact to the percentage time submerged at high tide i.e., at Mean High Water Neap (MHWN), Mean High Water Spring (MHWS) or Highest Astronomical Tide (HAT).
- There is a very small impact (a few centimetres difference in submergence pre- and post-development) when the water level is at MSL or lower.
- There is a moderate impact to submergence at low tide. The modelled impact increases gradually from ~5 cm difference in submergence pre- and post-development at Mean Low Water Neap (MLWN) to over 20 cm difference in submergence at LAT with the submergence curves moving gradually apart. This reduction in level would only affect the main creek channel as the mangroves are naturally exposed (not submerged) at this part of the tidal cycle. Furthermore, this predicted impact would only occur if pumping occurred during low tide as has been modelled, however the Proposal plans to cease pumping at low tide and therefore this modelled impact is unlikely to occur.

The effect of the overall Proposal on tidal inundation was also modelled over an entire year (Figure 64). Due to its position largely on the supratidal salt flats, the proposed development showed very minimal impacts to duration of tidal inundation as most of the development is situated beyond the reach of most tides. A marginal increase of inundation time (about 5%) was observed against the seaside pond embankment walls and over the tidal flat connecting to Urala Creek North. A very localised increase in duration of inundation was predicted over a small area adjacent to the southern embankment of the seawater intake channel where inundation time is predicted to increase by about 30% due to blockage of a minor drainage path (Water Technology, 2022b).

The predicted increases in inundation time are unlikely to impact coastal processes such as tidal exchange or sediment deposition given these increases are relatively minor and localised. The potential impacts of tidal inundation time changes on BCH are assessed separately in Section 8.

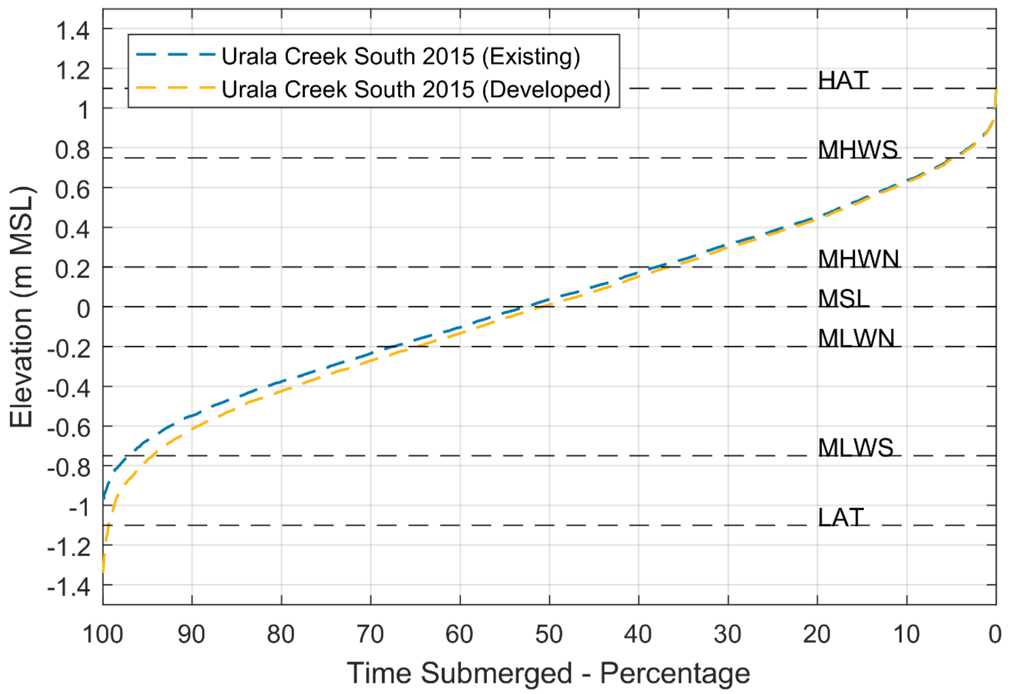


Figure 63: Submergence Curves Urala Creek South Pre- and Post-Development Conditions
(Water Technology, 2022b)

6.5.2.4 COASTAL PROCESS RESPONSE TO SEA LEVEL RISE

Sea level rise (SLR) itself was found to have a far greater impact to the existing coastal environment (40 cm water level increase over the entire region by 2070) compared to the proposed development (mostly less than 10 cm localised water level increase near the embankment walls) (Water Technology, 2022b).

Predicted post-development changes to tidal inundation depth or duration are considered unlikely to have any costal processes impact, given the areas are already subject to tidal inundation and only marginal increases in tidal inundation depth or duration are predicted. These minor and localised changes in tidal inundation depth or duration are unlikely to significantly impact the coastal process values of the intertidal area including sediment dynamics, water exchange and intertidal morphology, particularly when compared to the large scale changes predicted in the area due to SLR.

Coastal response to SLR will result from the interactive response of the different landform units and associated habitats that comprise the Tubridgi coast (Seashore Engineering, 2021). The following coastal process responses are predicted with and without the Proposal in place (Table 30).

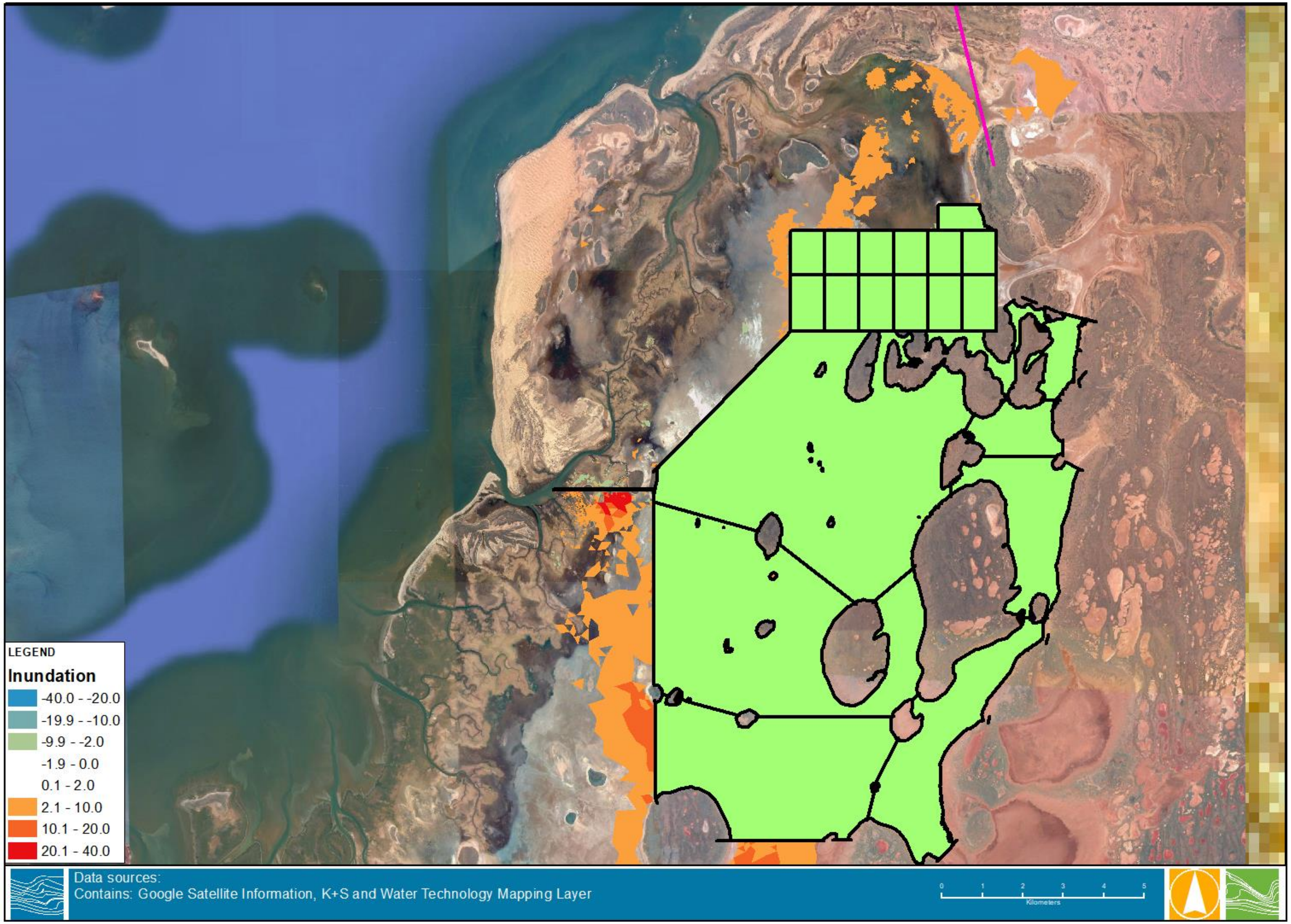


Figure 64: Modelled Percent Difference in Tidal Inundation Time Pre- and Post-development for 1 Year
(Water Technology, 2022b)

Table 30: Predicted Coastal Process Responses to Sea Level Rise With and Without Proposal
(Seashore Engineering, 2021)

Coastal Feature / Process	Without Proposal	With Proposal
Sediment transfer	The sedimentary shore includes the sandy beach in front of the coastal barrier as well as mudflats seaward of the mangrove shore to the south. These landforms are actively subject to tides and waves, so they are expected to respond directly to SLR, primarily through an upward and landward migration.	Sediment transfer along the coast due to SLR is expected to remain largely unaltered due to the Proposal, given this process will be occurring along the coastline some distance from the Proposal. Intertidal sediment transfer may result in localised sediment deposition increasing the elevation of mudflats adjacent to the Proposal.
Coastal barrier dunes	The existing coastal barrier dunes, which protect the intertidal area from wave action, is almost entirely above 3.0 m AHD and the barrier is likely to remain substantially intact for SLR less than 0.75 m (until approximately 2095). With continued SLR, the barrier is likely to become increasingly breached and collapse progressively.	Increased breaching risk of the coastal barrier due to SLR is expected to remain largely unaltered due to the Proposal. This process will be occurring along the coastline some distance from the Proposal site.
Tidal exchange	Tidal exchange will increase with SLR, which is expected to cause tidal creek extension and expansion, at around 300-400 m per 0.1 m SLR.	The proposed facilities will reduce how much tidal exchange increases with SLR. The Proposal is expected to offset the tidal exchange increases due to SLR for the life of the Proposal. Given there will be no significant change in tidal exchange, the tidal creek network adjacent to the Proposal is predicted to remain largely steady.
Salt flats	The supratidal nature of the eastern basin area of the salt flats, is likely to reduce with SLR potentially resulting in eventual direct connection of the salt flats to the ocean (conversion from a supratidal to an intertidal environment). This is unlikely to occur until SLR is above 0.5 m (by 2075).	The proposed development will enhance the existing hydraulic isolation of the eastern basin area of the salt flats. The areas on which the ponds will be built will not reconnect with the ocean under SLR, unless the embankments are deliberately breached to re-establish tidal connection (which will be considered as part of closure of the site).

In summary, the impacts of the Proposal on coastal process response to SLR are as follows:

- The Proposal is not expected to significantly effect sediment transfer processes that would otherwise occur without the Proposal in place. A localised increase sediment deposition may occur adjacent to pond embankments.
- The Proposal is not expected to alter response of the coastal barrier dunes to SLR. The coastal barrier dunes are expected to eventually breach under SLR, with or without the Proposal in place.
- The Proposal is predicted to offset the local increase in tidal exchange that would otherwise occur under sea level rise without the Proposal in place. This will prevent the eventual conversion of the salt flats beneath the ponds from a supratidal to intertidal environment under sea level rise. However tidal reconnection of the salt ponds is being considered as part of the closure objective for the site.

The Proposal will not impact the seashore or coastal dune barrier response to SLR due to distance from the Proposal. The key impact of the Proposal is preventing expansion of intertidal environment. This environmental impact is considered to be related to intertidal BCH response, rather than to the coastal processes themselves. Intertidal BCH response to SLR has been assessed separately in Section 8.

6.5.3 CUMULATIVE IMPACTS

As outlined in Section 6.5.2, the Proposal is not predicted to cause any significant indirect impacts to coastal processes, with all indirect impacts minor and localised, or assessed separately under Section 8 (BCH).

Table 31 provides the cumulative direct and indirect impacts to coastal features important to Coastal Processes. Table 31 includes indirect impacts to intertidal BCH which has been assessed separately under Section 8 (BCH).

Table 31: Cumulative Impact to Coastal Features Important to Coastal Processes
(AECOM, 2022a), (Geoscience Australia, 2019), (Fugro, 2018a)

Coastal Feature	Direct Impact (ha)	Indirect Impact (ha)	Cumulative Impact (ha)	Local Area (All LAUs) (ha)	Eastern Exmouth Gulf Region (ha)	Proportional Loss Locally (%)	Proportional Loss Regionally (%)
Mangroves	3.94	0.34	4.28	2,185	11,742	0.2%	0.04%
Algal Mats	12.74	3.94	16.68	5,384	11,617	0.31%	0.14%
Transitional Mudflats	17.81	-	17.81	4,020	20,747	0.44%	0.09%
Intertidal Mudflats - Total of Above Habitats	34.49	4.55	38.77	11,589	44,106	0.33%	0.09%
Tidal Creek	0.54	-	0.54	503	2,710	0.11%	0.02%
Barrier Dune	0.17	-	0.17	1,787 (Jetty to tent Point)	2,059	0.01%	0.008%
TOTAL	35.2	4.55	39.48	13,879	48,875	0.28%	0.08%

Therefore, cumulative impacts of the Proposal are estimated as follows:

- 0.33% locally and 0.09% regionally of intertidal mudflats.
- 0.11% locally and 0.02% regionally of tidal creeks.
- 0.01% locally and 0.008% regionally of coastal barrier dunes.

6.6 ASSESSMENT OF IMPACTS

Detailed investigations have been completed to develop a comprehensive understanding of the existing coastal environment at a local and regional scale and how it may be impacted by the Proposal. The focus of these assessments has been to inform the Proposal such that processes that shape the coastal morphology are maintained and therefore ensure that the environmental values of the coast are protected (Water Technology, 2021b), (Water Technology, 2022b), (Seashore Engineering, 2021).

Direct impacts include disturbance of important coastal features such as tidal creeks, intertidal mudflats and barrier dunes. Due to the limited physical footprint of the Proposal infrastructure and locating the Proposal predominantly on the supratidal salt flats, direct disturbance to these coastal features is proportionally small on a local and regional basis (less than 0.3%), as summarised in Table 31.

Potential indirect impacts to coastal processes are associated with the seawater intake in Urala Creek South, the jetty near Locker Point and the salt ponds located on the supratidal tidal flats. Indirect impacts are predicted to be minor and unlikely to significantly impact coastal processes as summarised below:

- The presence of the pile-supported jetty is predicted to have negligible influence on the hydrodynamic regime or coastal morphology of the area due to the transmissive nature of the structure design.
- In Urala Creek South:
  - Only minor and localised changes to fluvial morphology are predicted due to the seawater intake. It is unlikely these changes will alter coastal processes.
  - Seawater intake pumping is predicted to have a negligible impact on tidal submergence time at high tide, with a very small impact when the water level is at low tide (although this modelled impact is unlikely to occur in reality given pumping will cease at low tide).
- Due to its position largely on the supratidal salt flats, the overall development is predicted to have minimal impact on tidal inundation given it is beyond the reach of most tides. A marginal increase in inundation time (~5%) was predicted against the seaside embankment walls and over the tidal flat connecting to Urala Creek North. A very localised increase in inundation time (~30%) was predicted

over a small area adjacent to the seawater intake channel embankment. These predicted increases in inundation time are unlikely to impact coastal processes including overall tidal exchange or sediment deposition given they are relatively minor and localised.

- The Proposal will not impact the seashore or coastal barrier dune response to SLR due to distance from the Proposal. The Proposal will prevent local expansion of the intertidal environment in response to SLR, however the environmental impact of this is related to intertidal BCH response, rather than to the coastal processes themselves.
- Indirect impacts on BCH are assessed separately in Section 8 and where relevant have been included above in Table 31.

6.7 MITIGATION

6.7.1 AVOID

The infrastructure necessary for the Proposal includes a seawater intake, solar evaporation ponds, crystalliser ponds and a salt export jetty. To avoid impacts on coastal processes and morphology this infrastructure has been located largely outside the intertidal areas and with a minimal footprint to avoid direct disturbance of the tidal creeks and only minimal disturbance to a barrier dune for the conveyor.

The jetty is designed as a pile support transmissive structure, which means that it does not impede water flows and therefore has minimal effects on local currents. The footprint of the piles is also too small to generate any material impact on the nearshore hydrodynamic or longshore sediment transport conditions in such a low energy environment.

6.7.2 MINIMISE

The seawater intake has been positioned on the banks of Urala Creek South which has a deeper channel than Urala Creek North, thereby minimising erosion and fluvial morphology impacts due to seawater pumping.

The inlet well of the seawater intake on the banks of Urala Creek South will be positioned in the optimal location to minimise environmental impacts such as erosion and scour. Design considerations include locating the inlet well on the creek bank rather than within the creek channel to minimise hydrodynamic impacts. The proponent does not plan to pump water at low tide and the highest pumping rates will only occur in November/December which does not coincide with the extreme spring tide range. Likely impacts will be significantly below the modelled unrealistic worst-case scenario of pumping November/December intake rates during an extreme low tide (which only occur in March/April).

Other mitigation measures include:

- Ensure the jetty abutment does not extend onto the sandy beach to prevent impacts to sediment movement;
- Monitor erosion and implement additional erosion prevention measures as required to prevent further erosion. In the event of significant changes in sediment supply to intertidal areas as a result of the Proposal, a Coastal Processes Monitoring and Management Plan will be prepared and implemented; and
- Implement the DSMP (Appendix BB).

6.7.3 REHABILITATE

At the completion of the Proposal the site will be rehabilitated to reinstate the existing environment. A MCP will be required under the *Mining Act 1978* for the majority of the Proposal and an interim MCP is provided in Appendix BB. Temporary disturbance of areas due to construction are limited, however construction of the conveyor embankment connecting to the jetty could expose areas of the coastal dune barrier to wind erosion.

Appropriate protection measures including dune revegetation will be used to rehabilitate and protect these areas from wind erosion.

At the completion of operations, all buildings and structures will be removed from the site and the pond areas may be selectively reconnected to the existing tidal flat system. K+S preferred post end land use is to leave the evaporation ponds in situ so that they become fauna habitat for shore birds (including migratory birds which require “wetland areas” for migratory stop over rest and feeding).

The MCP will be to breach selected embankments that will enable inwards tidal movement bringing sediments and allowing tidal channels to expand naturally. Natural tidal flows will allow movement of mangrove plant and seed material which will passively revegetate the reconnected tidal areas. This will enhance the habitat values of the ponds post closure.

There is evidence to suggest that impacts from solar salt activities may be reversible and that it will be possible to reinstate “natural” ecosystems to be as similar as possible to the existing environment. Other salt operations worldwide have similar MCPs in recognition of the important intertidal, benthic and fauna habitat that salt ponds create. One example is the Dry Creek Salt field which is in closure stage after operating in Adelaide since the late 1930s. The Dry Creek Salt field has recently demonstrated a successful tidal reconnection trial for one of its salt evaporation ponds - Mosley et. al (2019).

The total area of salt evaporation ponds proposed by the Proposal is almost 9,000 ha. There is the potential that large areas of the evaporation ponds could, with appropriate post closure works, become functioning intertidal habitat hosting both mangroves and algal mats, possibly with greater resilience to SLR than the existing intertidal habitats. Within the concentration ponds at the Port Hedland salt field, deltas have formed from the accumulation of fine sediments transported into the ponds by the pumping of tidal waters. The deltas support high densities of infauna and thereby attract a large number and diversity of migratory shorebirds as well providing as habitat for mangrove recolonisation. In the long term, man-made salt pond habitats have the potential to replace and preserve natural intertidal wetland and mangrove habitats which will be otherwise lost due to SLR (AECOM, 2022a). The effect of SLR will be considered during the closure planning process, and it may be possible to create a “niche” environment for mangroves and/or algal mats which may enable them to continue to exist.

An Interim MCP (Appendix BB) for the Proposal has been developed and will continue to evolve during the life of the Proposal. If the Proposal receives Ministerial Approval under Part IV of the EP Act as well as under the EPBC Act, the Interim MCP will be developed in more detail and submitted to DMIRS for approval as required by the *Statutory Guidelines for MCPs under the Mining Act 1978* - DMIRS (2020b).

6.8 PREDICTED OUTCOME

The EPA objective in relation to coastal processes is *to maintain the geophysical processes that shape coastal morphology so that the environmental values of the coast are protected*. This objective is met by the proposed development due to the limited footprint of proposed infrastructure which can directly or indirectly influence coastal processes. Detailed technical assessments were undertaken to gain a comprehensive understanding of coastal processes and the potential impacts associated with the Proposal. Potential impacts were found to be localised, minor and/or negligible on coastal landforms and processes. These impacts are also proportionally small on both a local and regional basis.

As discussed in Section 8, substantial changes are predicted to occur to intertidal habitats due to sea level rise both in the study area and broader Exmouth Gulf East area (i.e., with or without the Proposal). For Exmouth Gulf East these changes related to sea level rise represent large areas (several thousand hectares) of mangrove and algal mat habitat.

Seashore Engineering (2022) has identified that some areas of new habitat associated with SLR may potentially be constrained from developing due to Proposal infrastructure by either modification to SLR related increases in tidal exchange (in the case of mangroves) or from the presence of the salt ponds being in areas that algal mats would have expanded into. There are large changes to habitat distribution that are predicted to occur from SLR regardless of the presence of the Proposal. In comparison there are relatively small proportions of habitat that maybe potentially constrained by the Proposal at either the scale of the study area or Exmouth Gulf East.

K+S will consider the creation of ongoing habitat for algal mat and mangroves as a part of closure planning for the Proposal. K+S's preferred post closure land use is to leave the evaporation ponds in situ so that they become a 'wetland' habitat and likely create habitat opportunities for the survival of mangroves and/or algal mats. At the completion of operations, all building and structures will be removed from the site and the pond areas may be selectively reconnected to the existing tidal flat system. If ponds are to be reconnected, the closure plan will establish which bunds to breach that will enable inwards tidal movement bringing sediments and allowing tidal channels to expand naturally. Natural tidal flows will allow movement of mangrove plant and seed material which will passively revegetate the reconnected tidal areas. This will enhance the habitat values of the ponds to BCH and fauna post closure.

There is the potential that large areas of the evaporation ponds (which total approximately 9,000 ha) could, with appropriate post-closure works, become functioning intertidal habitat hosting both mangroves and algal mats, possibly with greater resilience to SLR than the existing intertidal habitats predicted to be progressively lost due to the rate of SLR with or without the Proposal in place.

It is therefore considered that with appropriate closure planning, the Proposal will not significantly impact the long term response of key intertidal habitats to SLR.

Based on the information provided above, the Proposal is considered unlikely to result in any significant residual impacts for this factor.

7 MARINE ENVIRONMENTAL QUALITY

7.1 EPA OBJECTIVE

To maintain the quality of water, sediment and biota so that environmental values are protected.

7.2 POLICY AND GUIDANCE

- *Environmental Factor Guideline: Marine Environmental Quality* (EPA, 2016b).
- *Technical Guidance - Protection of Benthic Communities and Habitats* (EPA, 2016c).
- *Technical Guidance - Environmental Impact Assessment of Marine Dredging Proposals* (EPA, 2016d).
- *Technical Guidance - Protecting the Quality of Western Australia's Marine Environment* (EPA, 2016e).
- *Identification and investigation of acid sulfate soils and acidic landscapes* (DER, 2015a).
- *Treatment and management of soil and water in acid sulfate soil landscapes* (DER, 2015b).
- *Pilbara Coastal Water Quality Consultation Outcomes — Environmental Values and Environmental Quality Objectives, Department of Environment, Government of Western Australia, Marine Series Report No. 1* (DoE, 2006).
- *Australian and New Zealand Guidelines for Fresh and Marine Water Quality* (ANZG, 2018)
- *National Assessment Guidelines for Dredging* (Commonwealth of Australia, 2009)
- *A Directory of Important Wetlands in Australia* (ANCA, 1993).
- *WA Environmental Offsets Policy* (Government of Western Australia, 2011).
- *WA Environmental Offsets Guidelines* (Government of Western Australia, 2014).
- "Appendix B: Potentially contaminating industries, activities and land uses" in *Assessment and management of contaminated sites: Contaminated sites guidelines* (DER, 2014).

7.2.1 LEVELS OF ECOLOGICAL PROTECTION

The environmental quality of the coastal waters of WA are managed through the EPA framework that involves setting different Levels of Ecological Protection (LEP) over particular areas of the marine environment on the basis of the existing water quality and uses. Each LEP (defined as Maximum, High, Moderate or Low) is characterised by a different set of Environmental Quality Criteria (EQC) stating the expectation for maintenance of water quality and the abundance, biomass and diversity of the biota. These details are summarised in *Technical Guidance - Protecting the Quality of Western Australia's Marine Environment* (EPA, 2016e).

LEP's for the coastal water surrounding the Proposal have been recommended within Pilbara Coastal Water Quality Consultation Outcomes — Environmental Values and Environmental Quality Objectives, Department of Environment, Government of WA, Marine Series Report No. 1 (DoE, 2006). The waters of Urala Creeks North and South, and the coastal waters southward have been recommended for Maximum Protection, whilst the waters including the proposed jetty, dredged berthing pocket and bitterns discharge site have been recommended for High Protection (DoE, 2006) (refer to Figure 79).

7.3 MARINE ENVIRONMENTAL QUALITY STUDIES

Studies to assess marine environmental quality have been conducted as outlined in Table 32.

Table 32: Marine Environmental Quality Studies

Report	Reference	Appendix
Marine and Coastal Assessment and Modelling	Water Technology, 2022b	A
Surface Water Assessment and Modelling	Water Technology, 2022a	B

Report	Reference	Appendix
Marine, Coastal and Surface Water Data Collection	Water Technology, 2021a	C
Marine, Coastal & Surface Water Existing Environment	Water Technology, 2021b	D
Nutrient Pathways Assessment and Modelling	Water Technology, 2021d	J
Marine, Surface Water and Nutrient Modelling Peer Review	DHI, 2021	F
Acid Sulfate Soils Study	GHD, 2021a	K
ASSSMP	GHD, 2021b	BB
Technical Memorandum – Phase 2 Ecotoxicology Assessment	AECOM, 2022	L

7.3.1 MODELLING

Specific hydrodynamic modelling studies (Water Technology, 2021d) (Water Technology, 2022b), have been conducted to assess the following potential impacts:

- Effect of bitterns discharge on marine environmental quality.
- Effect of dredging on marine environmental quality.
- Effect of the Proposal on nutrient pathways.

7.3.2 MODELLING PEER REVIEW

A peer review of the above modelling studies was conducted, and can be found in Appendix F. The peer review process was undertaken in a comprehensive, rigorous and iterative manner. It is the opinion of the peer reviewer that the models constructed by Water Technology (2021d and 2022b) can be considered suitable for the purpose of identifying potential environmental impacts for the above processes (DHI, 2021).

7.4 EXISTING ENVIRONMENT

7.4.1 BASELINE DATA COLLECTED

A wide range of marine water quality monitoring has been undertaken for this Proposal from 2017 to 2021. This monitoring is summarised in Table 33

Table 33: Marine Water Quality Monitoring 2017 to 2021
(Water Technology, 2021a)

Timeframe	By Whom	Description
Sept - Nov 2017	Water Technology	Water level logger deployment, water quality profiling, conductivity/temperature logger deployment, sediment sampling, wave logger deployment and Acoustic Doppler Current Profiler (ADCP) transects.
April 2018	Water Technology	Logger deployment for temperature, salinity and water level.
Nov 2018 – Nov 2020	University of WA and Terrafirma Offshore	Water quality (pH, salinity, turbidity, nutrients, metals, hydrocarbons) Deployment of loggers for water level. ADCP transects.
April 2019	Biota	Water sampling of salt flats, claypans and creek lines after a rainfall event (water quality and nutrients)

Timeframe	By Whom	Description
Feb, May, Aug, Oct 2019	AECOM	Creek water level, creek water sampling (nutrients), sub-creek water sampling (nutrients), algal mat and salt flat sampling (moisture and photosynthetic activity)
Oct 2019 - Mar 2020	GHD	Sediment Sampling for Potentially Acid Forming (PAF) properties, physical properties, metals, organic and naturally occurring radioactive materials (NORMs).
December 2020 – April 2021	Terrafirma Offshore	Water quality sampling Locker Point (copper at low levels).
March 2021	Terrafirma Offshore	Water quality sampling of salt flats after a rainfall event (water quality and nutrients).

7.4.2 BASELINE DATA ANALYSIS RATIONALE

Baseline marine water quality analysis has focused on the key locations where the Proposal will have interface with the marine environment as outlined in Table 34.

Table 34: Rational for Baseline Data Analysis

Location	Rational for Location	Monitoring Parameters	Relevance of Parameter
Locker Point (monitoring location to northeast of Locker Point in vicinity of Jetty)	The proposed location of the jetty, dredged berthing pocket and bitterns discharge	• Salinity • Metals • Turbidity • Sediment – as per table above	• Bitterns Discharge • Bitterns Discharge • Dredging • Dredging and Jetty Construction
Urala Creek South	The proposed location of the seawater intake	Turbidity	Seawater Intake Construction and Operation
Selected Sub-Creeks	Characterising the nutrient flows from tidal sub-creeks into the marine environment	Nutrients	Assessment of Nutrient Flows Post-development

7.4.3 SALINITY

Modern oceanography uses the Practical Salinity Scale defined by the PSU to derive salinity from seawater's electrical conductivity, temperature, and pressure (related to depth). In practical terms salinity in PSU is roughly equivalent to salinity in parts per thousand (ppt) (NASA, 2020).

7.4.3.1 OVERVIEW

Ashburton has a dry coast with sporadic ephemeral freshwater inputs. The lack of freshwater inputs, high air temperatures and evaporation rates contribute to the generation of high salinity nearshore waters. Strong evaporative processes at the coast can lead to underflows of hot saline water (Water Technology, 2021b).

Surveys of marine water quality have been completed on the eastern side of Exmouth Gulf by Oceanica (2006). Salinity was measured between September 2004 and December 2005 at sites along creeks south of Hope Point and in nearshore waters outside of the creeks. The median and 80th percentile salinity measurements at all sites were relatively high compared to further offshore in Exmouth Gulf (McKinnon and Ayukai, 1996) and generally increased with distance up the creeks (Table 35). The observed salinity gradient was attributed to the high evaporation rates and low input of water from rainfall leading to a build-up in salinity over time in the intertidal sediment and water. Oceanica (2006) noted that it would be likely that pulses of the higher salinity water build up in the creeks, then exits the creeks and disperses into the near coastal waters due to tidal exchange.

Measured salinity in the nearshore waters ranged from 38 to 41 PSU. Salinity midway along the creek ranged up to 45 PSU and an extreme of 65 PSU was measured at the back of one of the creeks. Salt ions were elevated in concentration at rates that were correlated with the increased salinity, indicating that the natural ionic balance is maintained in waters within the nearshore and creeks (Oceanica, 2006).

Table 35: Summary of Salinity Measurements from the East Coast of Exmouth Gulf
(Oceanica, 2006)

Location	Median salinity (PSU)	80th percentile salinity (PSU)	Number of sample points (times/places)
Upper parts of creeks	43.7	53.5	19
Mid parts of creeks	44.4	45.7	5
Mouths of creeks	41.5	43.5	14
Nearshore	37.9	40.9	9

7.4.3.2 LOCKER POINT BASELINE SALINITY

Salinity was monitored at Locker Point (near the proposed jetty) from December 2018 until October 2020 with both in-situ probe readings and samples for National Association of Testing Authorities (NATA) accredited laboratory analysis. The resulting data is presented in Table 36 and Figure 65 below. These data show that at Locker Point during the monitoring period:

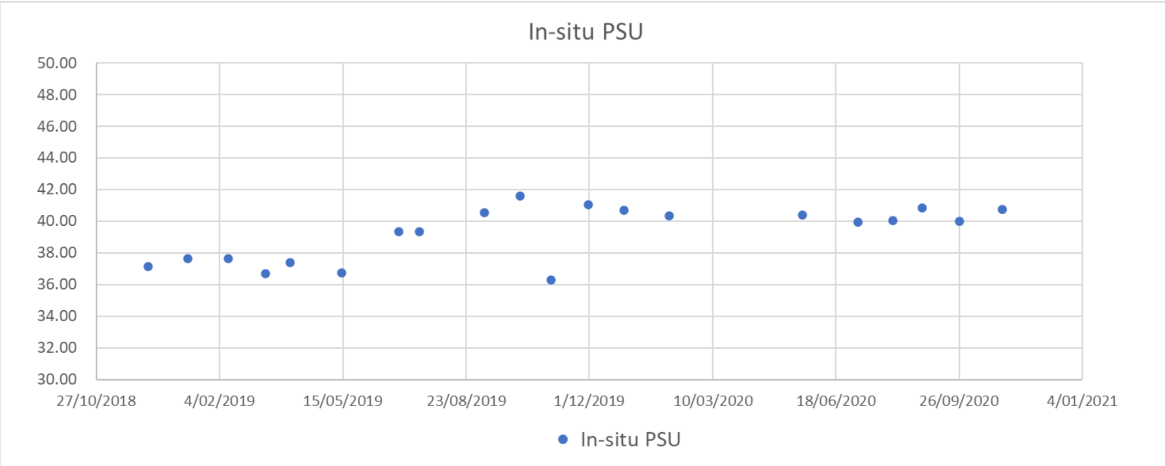
- In-situ salinity ranged from 36.3 PSU to 41.6 PSU, with a median salinity of 40 PSU and an 80th percentile salinity of 40.7 PSU.
- In-situ Total Dissolved Solids (TDS) ranged from 35,621 to 40,155 mg/L, with a median TDS of 38,755 mg/L and an 80th percentile TDS of 39,456 mg/L.
- Laboratory TDS ranged from 36,000 to 41,000 mg/L, with a median TDS of 39,000 mg/L and an 80th percentile TDS of 41,000 mg/L (Water Technology, 2021b).

As shown in Figure 65 and Table 36, there was reasonably good agreement between the laboratory and in-situ TDS results. Laboratory TDS was measured by a NATA accredited laboratory with appropriate quality controls using the gravimetric method whereby water samples are evaporated, and the remaining residue is weighed. This gravimetric analysis method is considered unlikely to be prone to significant error. On the basis that the laboratory TDS measurements based on gravimetric analysis are considered likely to be reasonably reliable, and do not vary considerably from the in-situ monitoring results for TDS, it can be concluded that the in-situ salinity measurements in PSU form a reasonable baseline dataset at Locker Point for the monitoring period (Water Technology, 2021b).

Table 36: In-situ and Laboratory Baseline Salinity at Locker Point
(Water Technology, 2021b)

Month #	Year	Month	Sample Date	In-situ Salinity (PSU)	In-situ TDS (mg/L)	Laboratory TDS (mg/L)
1	2018	Dec	8/12/2018	37.12	36,336	36,000
2	2019	Jan	9/01/2019	37.65	36,905	41,000
3	2019	Feb	11/02/2019	37.64	36,899	38,000
4	2019	Mar	13/03/2019	36.70	36,122	41,000
5	2019	Apr	2/04/2019	37.41	36,726	39,000
6	2019	May	14/05/2019	36.74	35,976	37,000
7	2019	Jun	29/06/2019	39.33	38,194	40,000
8	2019	Jul	16/07/2019	39.33	38,192	37,000
9	2019	Aug	3/08/2020	40.03	38,795	39,000
11	2019	Sep	7/09/2019	40.57	39,264	38,000
12	2019	Oct	6/10/2019	41.60	40,155	41,000
13	2019	Oct	31/10/2019	36.30	35,621	41,000
14	2019	Nov	30/11/2019	41.03	39,757	40,000

Month #	Year	Month	Sample Date	In-situ Salinity (PSU)	In-situ TDS (mg/L)	Laboratory TDS (mg/L)
15	2019	Dec	29/12/2019	40.69	39,573	38,000
16	2020	Feb	4/02/2020	40.35	39,184	39,000
17	2020	May	22/05/2020	40.41	39,137	41,000
18	2020	Jul	6/07/2020	39.95	38,740	41,000
19	2020	Aug	27/08/2020	40.83	39,478	39,000
20	2020	Sep	26/09/2020	39.98	38,770	39,000
21	2020	Oct	31/10/2020	40.73	39,451	41,000
Range				36.3 to 41.6	35,621 to 40,155	36,000 to 41,000
Median				40	38,755	39,000
80th Percentile				40.7	39,456	41,000



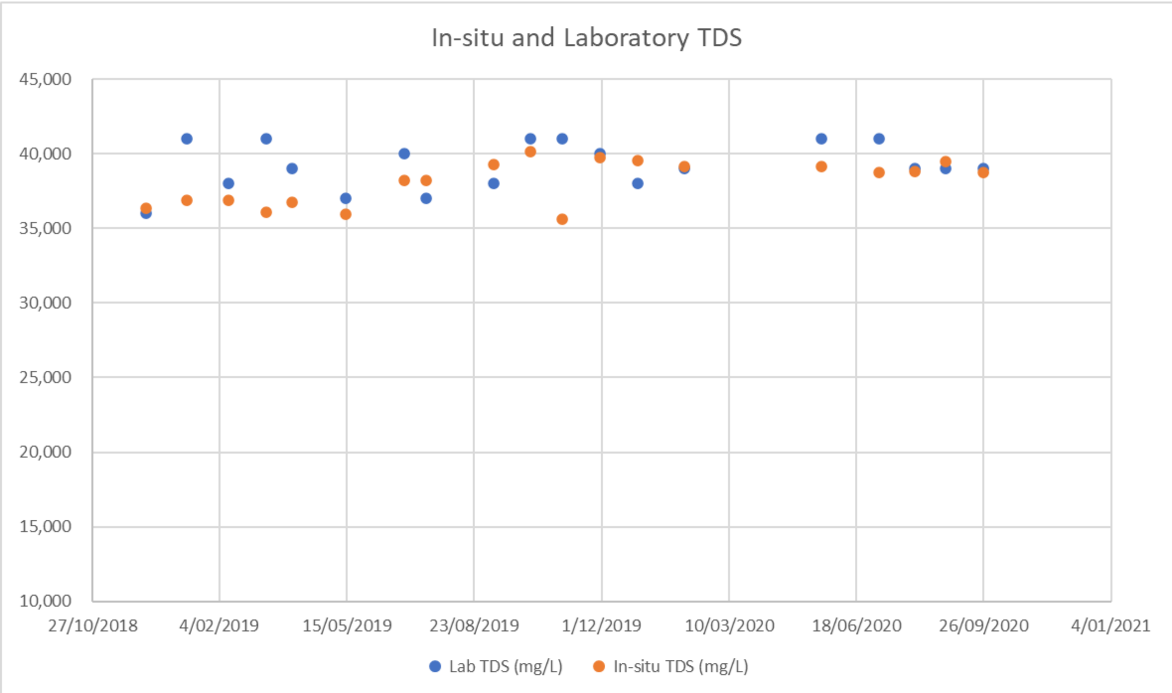


Figure 65: In-Situ and Laboratory Baseline Salinity Locker Point (PSU and TDS)
(Water Technology, 2021b)

7.4.4 METALS

7.4.4.1 OVERVIEW

Metals occur naturally in seawater at very low concentrations. Locality specific concentrations can be influenced by surrounding geology and anthropogenic sources. Elevated concentrations are generally caused by wastewater discharges and if levels are sufficiently high, they can be toxic, or bioaccumulate through the food chain (EPA, 2012).

Metal concentrations in seawater can be made up of both dissolved and particulate fractions, with the dissolved fraction considered to be better correlated to bioavailability of the metal. The particulate or mineralised fractions are generally considered to include metals that are unavailable for biological uptake and are therefore unlikely to affect the health of marine organisms (EPA, 2012).

MScience undertook monitoring of dissolved metals content, north of the Proposal within the nearby Wheatstone Project area. Most of the metals analysed were below the recommended EQC specified for the protection of North West Shelf ecosystems (Wenziker et al., 2006), (EPA, 2016e), (ANZG, 2018). The exceptions were zinc and aluminium (MScience, 2009).

7.4.4.2 LOCKER POINT BASELINE METALS

Dissolved metals in water were monitored at Locker Point (near the proposed jetty) from December 2018 until February 2020 with samples taken for NATA accredited laboratory analysis. The resulting data is presented in Table 38.

These data in Table 38 show that at the Locker Point monitoring location during the monitoring period:

- Most of the metals analysed were below the recommended EQC specified for the protection of North West Shelf ecosystems (99% species protection levels for all metals, except cobalt which is set at 95% species protection) (Wenziker et al., 2006), (EPA, 2016e), (ANZG, 2018).
- Aluminium exceeded the ANZG (2018) low reliability screening level of 0.0005 mg/L on two occasions. However, it should be noted that the Laboratory Practical Quantitation Level (PQL) was set above this screening level of 0.0005 mg/L, with a PQL of 0.01 mg/L. This is the lowest PQL that can be achieved by the laboratories engaged, without additional onerous laboratory validation work which is considered not be necessary given the proposed bitterns discharge characteristics. A recent study of aluminium combining chronic biological effects data generated over several years with toxicity data from the open literature to construct species sensitivity distributions (SSDs) has enabled the computation of water quality guidelines for aluminium. An EQC concentration of 0.002 mg/L was derived for a 99% species protection level in tropical waters (van Dam et al., 2018). Aluminium monitoring for this Proposal exceeded this EQC of 0.002 mg/L on two occasions. However, it should be noted that the Laboratory PQL was set above this this EQC level of 0.002 mg/L, with a PQL of 0.01 mg/L as described above.
- Zinc exceeded the ANZG (2018) EQC (99% species protection level) of 0.007 mg/L on two occasions.
- Copper exceeded the ANZG (2018) EQC (99% species protection level) of 0.0003 mg/L on two occasions. However, it should be noted that the Laboratory PQL was set above this EQC level of 0.003 mg/L, with a PQL of 0.001 mg/L. A PQL of 0.0003 mg/L can be achieved by the laboratories engaged and further monitoring using this lower PQL was conducted for an additional five months (Table 37). This additional monitoring indicates that the ANZG (2018) EQC (99% species protection level) of 0.0003 mg/L is regularly exceeded as outlined in Table 37 below. Duplicate samples were taken for each sampling event and tested by NATA accredited laboratory Analytical Reference Laboratory (ARL).

Table 37: Low Concentration Copper Results at Locker Point
(Water Technology, 2021a)

Sample Date	Copper Result (mg/L)
3/12/20	<0.0003
3/12/20	<0.0003
4/1/21	<0.0003
4/1/21	0.0003
7/2/21	0.0006
7/2/21	0.0009
6/3/21	0.0006
6/3/21	0.0007
5/4/21	0.0007
5/4/21	0.0008

Table 38: Locker Point Baseline Metals Water Quality Results (mg/L)

Metal		Aluminium	Manganese	Vanadium	Zinc	Arsenic	Chromium	Cobalt	Copper	Lead	Nickel	Cadmium	Mercury	Selenium
PQL	*(mg/L)*	*0.01#*	*0.01*	*0.01*	*0.005*	*0.001*	*0.001*	*0.001#*	*0.001*	*0.001*	*0.001*	*0.0001*	*0.0001*	*0.001*
Stratum	Date													
Bottom	8/12/2018	<0.01	<0.01	<0.01	0.01	0.002	<0.001	<0.001	<0.001	<0.001	<0.001	<0.0001	<0.0001	<0.001
Top	8/12/2018	<0.01	<0.01	<0.01	<0.005	0.002	<0.001	<0.001	<0.001	<0.001	<0.001	<0.0001	<0.0001	<0.001
Bottom	9/01/2019	<0.01	<0.01	<0.01	<0.005	0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.0001	<0.0001	<0.001
Bottom	9/01/2019	<0.01	<0.01	<0.01	<0.005	0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.0001	<0.0001	<0.001
Top	9/01/2019	<0.01	<0.01	<0.01	<0.005	0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.0001	<0.0001	<0.001
Top	9/01/2019	<0.01	<0.01	<0.01	<0.005	0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.0001	<0.0001	<0.001
Bottom	15/03/2019	<0.01	<0.01	<0.01	<0.005	0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.0001	<0.0001	<0.001
Top	15/03/2019	<0.01	<0.01	<0.01	<0.005	0.001	<0.001	<0.001	0.001	<0.001	<0.001	<0.0001	<0.0001	<0.001
Bottom	2/04/2019	<0.01	<0.01	<0.01	<0.005	0.002	<0.001	<0.001	<0.001	<0.001	<0.001	<0.0001	<0.0001	<0.001
Top	2/04/2019	<0.01	<0.01	<0.01	<0.005	0.002	<0.001	<0.001	0.001	<0.001	<0.001	<0.0001	<0.0001	<0.001
Bottom	14/05/2019	<0.01	<0.01	<0.01	<0.005	0.002	<0.001	<0.001	<0.001	<0.001	<0.001	<0.0001	<0.0001	<0.001
Top	14/05/2019	0.05	<0.01	<0.01	0.016	0.002	<0.001	<0.001	<0.001	<0.001	<0.001	<0.0001	<0.0001	<0.001
Bottom	29/06/2019	0.01	<0.01	<0.01	<0.005	0.002	<0.001	<0.001	<0.001	<0.001	<0.001	<0.0001	<0.0001	<0.001
Top	29/06/2019	<0.01	<0.01	<0.01	<0.005	0.002	<0.001	<0.001	<0.001	<0.001	<0.001	<0.0001	<0.0001	0.001
Bottom	16/07/2019	<0.01	<0.01	<0.01	0.006	0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.0001	<0.0001	<0.001
Bottom	16/07/2019	<0.01	<0.01	<0.01	<0.005	0.002	<0.001	<0.001	<0.001	<0.001	<0.001	<0.0001	<0.0001	<0.001
Top	16/07/2019	<0.01	<0.01	<0.01	0.006	0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.0001	<0.0001	<0.001
Top	16/07/2019	<0.01	<0.01	<0.01	<0.005	0.002	<0.001	<0.001	<0.001	<0.001	<0.001	<0.0001	<0.0001	<0.001
Bottom	7/09/2019	<0.01	<0.01	<0.01	<0.005	0.002	<0.001	<0.001	<0.001	<0.001	<0.001	<0.0001	<0.0001	<0.001
Bottom	7/09/2019	<0.01	<0.01	<0.01	0.006	0.002	<0.001	<0.001	<0.001	<0.001	<0.001	<0.0001	<0.0001	<0.001
Top	7/09/2019	<0.01	<0.01	<0.01	<0.005	0.002	<0.001	<0.001	<0.001	<0.001	<0.001	<0.0001	<0.0001	<0.001
Top	7/09/2019	<0.01	<0.01	<0.01	0.005	0.002	<0.001	<0.001	<0.001	<0.001	<0.001	<0.0001	<0.0001	<0.001
Bottom	6/10/2019	<0.01	<0.01	<0.01	<0.005	0.002	<0.001	<0.001	<0.001	<0.001	<0.001	<0.0001	<0.0001	<0.001
Top	6/10/2019	<0.01	<0.01	<0.01	<0.005	0.002	<0.001	<0.001	<0.001	<0.001	<0.001	<0.0001	<0.0001	<0.001
Bottom	30/11/2019	<0.01	<0.01	<0.01	<0.005	0.002	<0.001	<0.001	<0.001	<0.001	<0.001	<0.0001	<0.0001	<0.001
Top	30/11/2019	<0.01	<0.01	<0.01	<0.005	0.002	<0.001	<0.001	<0.001	<0.001	<0.001	<0.0001	<0.0001	<0.001
Bottom	29/12/2019	<0.01	<0.01	<0.01	<0.005	0.002	<0.001	<0.001	<0.001	<0.001	<0.001	<0.0001	<0.0001	<0.001
Top	29/12/2019	<0.01	<0.01	<0.01	<0.005	0.002	<0.001	<0.001	<0.001	<0.001	<0.001	<0.0001	<0.0001	<0.001
Bottom	4/02/2020	<0.01	<0.01	<0.01	<0.005	0.002	<0.001	<0.001	<0.001	<0.001	<0.001	<0.0001	<0.0001	<0.001
Top	4/02/2020	<0.01	<0.01	<0.01	<0.005	0.002	<0.001	<0.001	<0.001	<0.001	<0.001	<0.0001	<0.0001	<0.001
ANZG (2018) EQC		0.0005*	0.08	0.05	0.007	0.0023	0.0001	0.001	0.0003	0.0022	0.007	0.0007	0.0001	0.003
Van Dam et. al. (2018) EQC		0.002**												

Table Notes:

- EQC = Environmental Quality Criteria
- PQL = Practical Quantitation Limit, # = PQL set above EQC
- ANZG (2018) EQGs are set at 99% species protection level, except cobalt which is set at 95% species protection level in accordance with EPA, 2016.
- *ANZG (2018) does not provide a 99% species protection level for Aluminium (0.0005 mg/L is provided as a low reliability screening level by ANZG, 2018).
- **van Dam et. al. (2018) has proposed a 99% species protection level for Aluminium of 0.002 mg/L

7.4.5 TURBIDITY

7.4.5.1 OVERVIEW

MScience undertook monitoring of background water turbidity north of the Proposal within the nearby Wheatstone Project area (MScience, 2009). It used a combined approach of field measurements and remote sensing using four years of MODIS optical satellite images. The conclusions of the study were that the area routinely experiences relatively low turbidity, with median turbidity at both nearshore and offshore survey locations ranging from 1- 3 Nephelometric Turbidity Units (NTU) and Total Suspended Solids (TSS) ranging from 2- 5 mg/L (MScience, 2009).

However, the area experiences occasional cyclones and heavy rainfall events during the summer period, which results in elevated turbidity for a number of weeks. Based on turbidity measurements collected by a turbidity sensor deployed in the area during Cyclone Dominic in late January 2009, the median turbidity during the 24-hour period when the cyclone passed over was 77 NTU, with the 80th percentile exceeding 143 NTU. Turbidity in the Wheatstone Project area remained in excess of 20 NTU for more than ten days after the passage of the cyclone due to strong discharges from the nearby Ashburton River.

Even discounting the periodic effects of cyclones, the median turbidity in the nearshore area (within the 5 m isobath) was generally elevated and more variable during both summer and winter periods, averaging 7- 8 NTU, due to strong winds and wave action causing re-suspension of sediment particles in these shallow nearshore areas (MScience, 2009).

7.4.5.2 LOCKER POINT BASELINE TURBIDITY

Turbidity was monitored at Locker Point (near the proposed jetty) from December 2018 until February 2020 with both in-situ readings and samples for NATA accredited laboratory analysis. The resulting data is presented in Table 39 and Figure 66 below.

The data in Table 39 and Figure 66 show that at the Locker Point monitoring location during the monitoring period:

- Laboratory TSS ranged from 5 to 32 mg/L, with a median and 80th percentile of 8.5 and 16.4 mg/L respectively.
- Laboratory turbidity ranged from 0.6 to 8.3 NTU, with a median and 80th percentile of 1.55 and 2.98 NTU respectively.
- In-situ turbidity varied throughout the monitoring period and within the depth profile of the water column (Figure 66). Some of the in-situ data at depth was removed from the dataset, because very high turbidity was recorded (around 1000 NTU) at the seabed in some of the in-situ profiles, which was considered erroneous data due to the instrument interacting with the seabed.
- The minimum in-situ turbidity was 0.29 NTU, whilst the maximum in-situ turbidity was 13.4 NTU. The median in-situ turbidity was 3.5 NTU and the 80th percentile was 5.9 NTU.
- In-situ monitoring reverse turbidity profiles (higher turbidity near the surface and lower turbidity near the seabed) were observed on some occasions (Figure 66).

Table 39: Laboratory Baseline Turbidity Results Locker Point

Stratum	Sample Date	Total Suspended Solids (mg/L)	Turbidity (NTU)
	PQL	*5*	*0.1*
Bottom	18/11/2018	<5	1.2
Top	18/11/2018	<5	1.2
Bottom	8/12/2018	<5	1.6
Top	8/12/2018	<5	0.9
Bottom	9/01/2019	8	0.9
Bottom	9/01/2019	7	1.7
Top	9/01/2019	15	1.8
Top	9/01/2019	<5	1.5
Bottom	15/03/2019	<5	2.9

Stratum	Sample Date	Total Suspended Solids (mg/L)	Turbidity (NTU)
Top	15/03/2019	<5	0.8
Bottom	2/04/2019	18	1.3
Top	2/04/2019	16	1.3
Bottom	14/05/2019	32	2
Top	14/05/2019	24	0.9
Bottom	29/06/2019	7	7
Top	29/06/2019	<5	5.3
Bottom	16/07/2019	9	8.3
Bottom	16/07/2019	6	1
Top	16/07/2019	7	5.1
Top	16/07/2019	5	1.4
Bottom	7/09/2019	5	0.7
Bottom	7/09/2019	20	3
Top	7/09/2019	<5	1.3
Top	7/09/2019	12	3.1
Bottom	6/10/2019	6	1
Top	6/10/2019	8	1.4
Bottom	30/11/2019	<5	2.5
Top	30/11/2019	6	3.9
Bottom	29/12/2019	10	1.6
Top	29/12/2019	9	0.6
Bottom	4/02/2020	<5	1.7
Top	4/02/2020	<5	1.7
Statistics	Max	32	8.3
	Min	5	0.6
	Median	8.5	1.55
	80th percentile	16.4	2.98

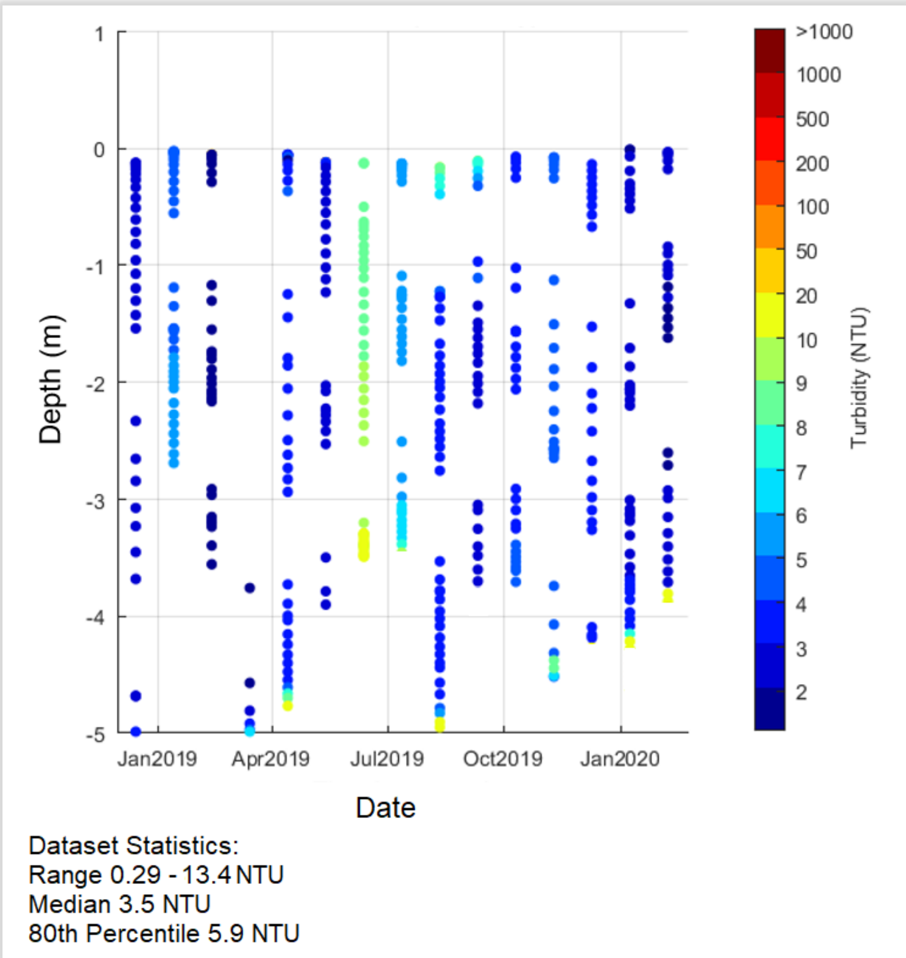


Figure 66: In-situ Baseline Turbidity Results Locker Point

7.4.5.3 URALA CREEK SOUTH BASELINE TURBIDITY

Turbidity was monitored at Urala Creek South (near the proposed seawater intake) from December 2018 until February 2020 with both in-situ readings and samples for NATA accredited laboratory analysis. The resulting data is presented in Table 40 and Figure 67 below.

These data show that at Urala Creek South during the monitoring period:

- Laboratory TSS ranged from 6 to 16 mg/L, with a median and 80th percentile of 9.5 and 13.4 mg/L respectively (Table 40).
- Laboratory turbidity ranged from 0.7 to 6.7 NTU, with a median and 80th percentile of 2.1 and 3.56 NTU respectively (Table 40).
- In-situ turbidity varied throughout the monitoring period and within the depth profile of the water column (Figure 67). Some of the in-situ data at depth was removed from the dataset, because very high turbidity was recorded (around 1000 NTU) at the seabed in some of the in-situ profiles, which was considered erroneous data due to the instrument interacting with the seabed.
- The minimum in-situ turbidity was 0.12 NTU, whilst the maximum in-situ turbidity was 14.3 NTU. The median in-situ turbidity was 3.7 NTU and the 80th percentile was 8.4 NTU.
- In-situ monitoring reverse turbidity profiles (higher turbidity near the surface and lower turbidity near the seabed) were observed on some occasions (Figure 67).

Table 40: Laboratory Baseline Turbidity Results Urala Creek South

Stratum	Date	Total Suspended Solids (mg/L)	Turbidity (NTU)
	PQL	*5*	*0.1*
Bottom	9/01/2019	11	0.7
Bottom	9/01/2019	6	3.4
Top	9/01/2019	<5	0.9
Top	9/01/2019	8	3.4
Top	15/03/2019	<5	2.5
Bottom	3/04/2019	16	2.1
Top	3/04/2019	15	2.1
Top	14/05/2019	11	2
Top	30/06/2019	6	2
Top	16/07/2019	10	6.7
Top	16/07/2019	8	3.8
Top	8/09/2019	<5	1.1
Top	8/09/2019	14	3.1
Top	6/10/2019	<5	0.9
Top	30/11/2019	<5	3.9
Top	29/12/2019	9	1
Top	4/02/2020	6	3.6
Statistics	Min	6	0.7
	Max	16	6.7
	Median	9.5	2.1
	80th percentile	13.4	3.56

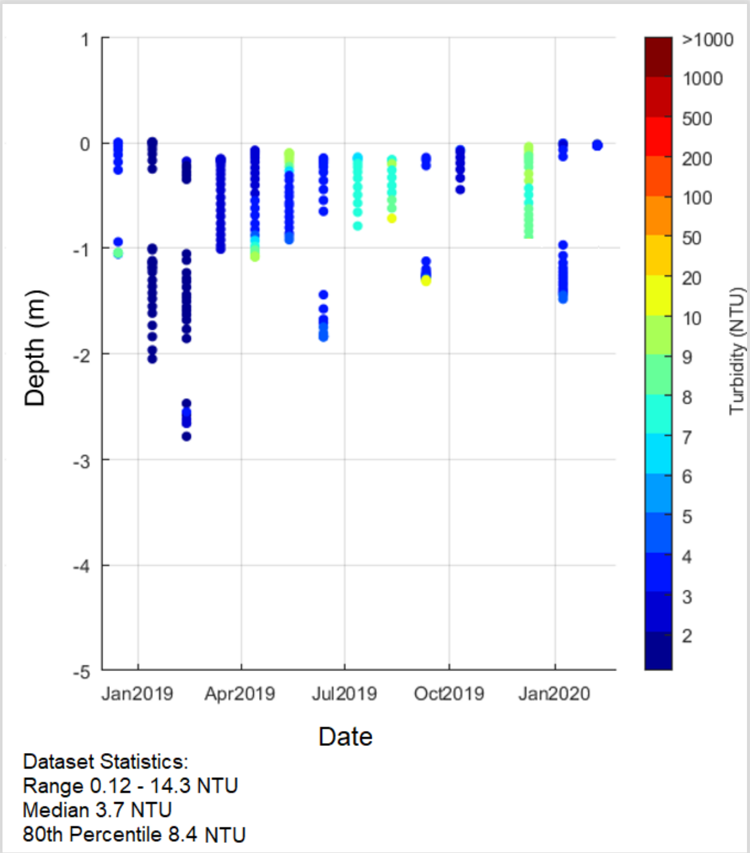


Figure 67: In-situ Baseline Turbidity Results Urala Creek South

7.4.6 NUTRIENTS

7.4.6.1 OVERVIEW

Nitrogen (N_2) is the most abundant gas in the atmosphere, and it dissolves into the surface layers of the ocean. To be utilised as a nutrient source by marine organisms, nitrogen must first be converted into other nitrogenous products by marine bacteria. Some bacteria (cyanobacteria) take the dissolved N_2 and convert it into ammonium (NH_4^+) through nitrogen fixation. Some of this ammonium can be used directly by phytoplankton, but the majority of it is converted by bacteria into nitrite (NO_2^{2-}) or nitrate (NO_3^-) through the process of nitrification (Webb, 2020).

Nitrate is the main nitrogenous compound utilised by primary producers in the ocean; it is a major nutrient required for photosynthesis. The nitrogen taken in by phytoplankton gets passed on to consumer organisms, and then is returned to the ocean through decomposition of wastes and organic matter as these organisms die and sink into deeper water. Finally, the ammonium, nitrate and nitrite can undergo denitrification another group of bacteria and get converted back into N_2, which can re-enter the cycle or be exchanged with the atmosphere (Webb, 2020). Figure 68 provides a simplified illustration of the ocean nitrogen cycle.

Two key processes deliver nutrients into Exmouth Gulf from offshore waters:

- Ocean upwelling is the process by which deep, cold, nutrient rich water rises toward the surface. Winds blowing across the ocean surface along the coast push water away. Water then rises up from beneath the surface to replace the water that was pushed away. This process is known as “upwelling”. It is caused by a phenomenon known as “Ekman transport” whereby sustained winds in a consistent direction move the top layer (about 30 metres depth) of seawater. As the top layer of water is moved by the wind, it needs to be replaced, drawing deeper water to the surface. Conditions are optimal for upwelling along the coast when winds blow along the shore. Figure 69 illustrates the process of ocean upwelling (National Ocean Service, 2020), (BOM, 2017).

- Tidal exchange is the regular (daily) ebb and flood of tides providing water from offshore sources and removing water from nearshore sources, which has a "mixing effect" combining nutrients from offshore sources into nearshore water.
- The two offshore nutrient sources work in tandem with small daily loads delivered from offshore waters due to tidal exchange, in addition to large scale intermittent nutrient pulses related to upwelling (Water Technology, 2021d).

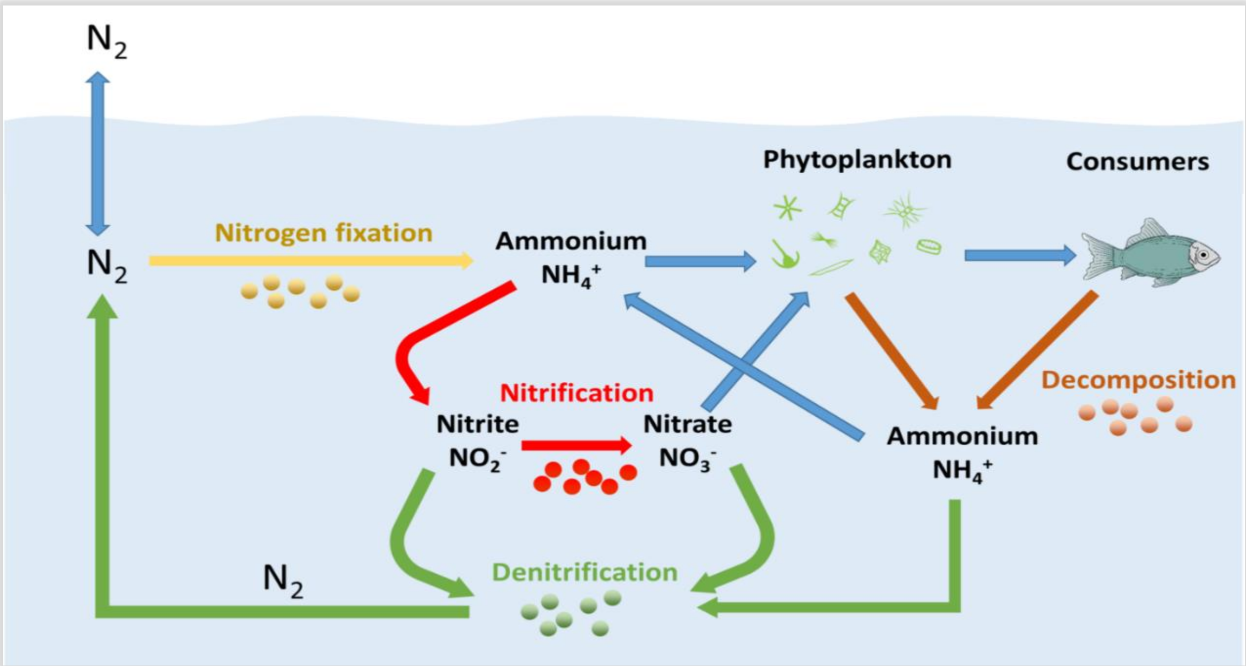


Figure 68: Ocean Nitrogen Cycle (Webb, 2020)

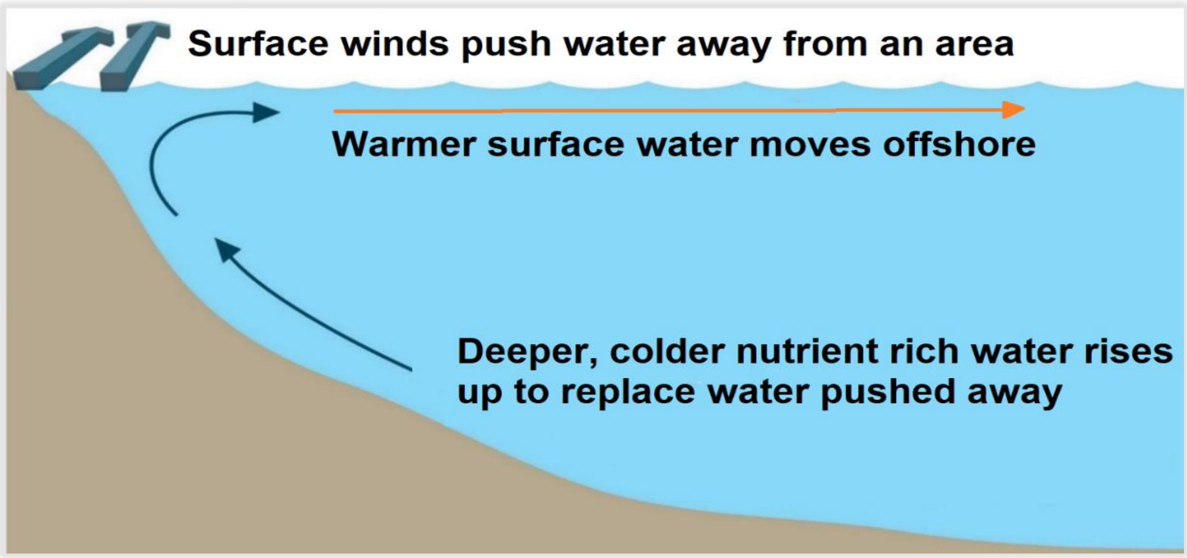


Figure 69: Process of Ocean Upwelling (National Ocean Service, 2020)

Upwelling and tidal influx of nutrients is well-established phenomenon at Exmouth Gulf and can be caused by seasonal winds, counter currents, or internal waves. Holloway et al. (1985) concluded that tides and persistent upwellings contributed substantially to the flux of nutrients in Exmouth Gulf, as tidal forcing advects the nutrient rich surface waters into nearshore waters. The Ningaloo Current has been studied extensively, with Hanson et al. (2005) finding that the oligotrophic (low nutrient) Leeuwin Current can be offset by equatorial counter currents which create upwelling events and deliver nutrients which increase primary productivity. Meekan et al. (2006) concluded that flood tide intrusions of upwelled nutrient rich waters are mixed throughout the Exmouth Gulf and play a major role in supporting primary productivity in Exmouth Gulf. According to Xu et al. (2016) there is also the potential for offshore nutrient delivery to nearshore waters related to the formation of offshore eddies. The general scientific consensus is that Exmouth Gulf is reliant on these transient coastal upwelling events and eddies as they provide substantial fluxes of deep-water nutrients which support primary productivity (Meekan et al. 2006, Xu. Et al 2016, Hanson et al. 2005).

The area surrounding the Proposal, is comprised of tidal creeks dominated by mangrove habitats in the intertidal zone with algal mats and salt flats beyond the tidal limit of the mangrove zone. These habitats provide a nutrient source for creek and nearshore waters during regular tidal inundation. The Proposal terrestrial rainfall catchment area also provides a source of nutrients to nearshore waters related to overland flows and rainfall run-off, particularly after extreme rainfall events (Water Technology, 2021d).

7.4.6.2 MONTHLY BASELINE MONITORING OF NUTRIENTS

Nitrogen, phosphorus, dissolved organic carbon and chlorophyll in water were monitored at a range of locations near the Proposal area from December 2018 until February 2020 with samples sent for NATA accredited laboratory analysis. The resulting data Figure 70 and Figure 71 shows that:

- Total Nitrogen (TN) concentrations ranged between 0.2 mg/L (the laboratory PQL) and 1.1 mg/L.
- The form of nitrogen present is primarily Total Kjeldahl Nitrogen, which is comprised of organic nitrogen and ammonia.
- There were two significant pulses in nitrogen observed (January 2019 and August 2019), however these do not correspond to rainfall events and therefore are likely related to ocean upwelling and/or offshore eddies (Section 7.4.6.6).
- Phosphorus, carbon and chlorophyll-a remained consistently low and frequently below the laboratory PQL.
- In general, offshore sites surrounding the islands had slightly lower nitrogen concentrations, with the exception of Locker Point and Locker Island which recorded higher levels
- The monitoring indicates that the marine waters are nitrogen limited, as TN: Total Phosphorous (TP) ratios ranged from 18-50:1 (Water Technology, 2021a).

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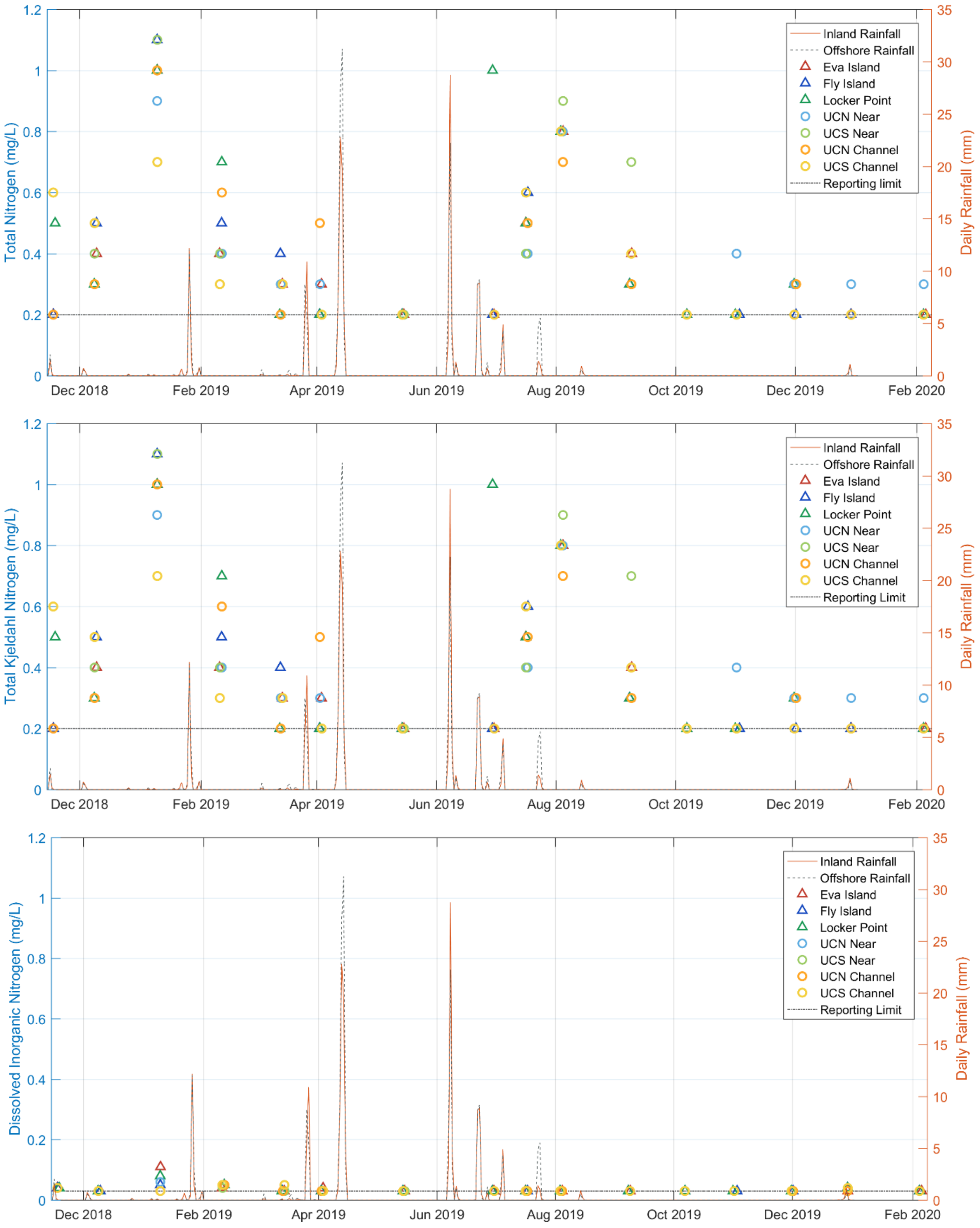


Figure 70: Laboratory Total Nitrogen, Total Kjeldahl Nitrogen, Dissolved Inorganic Nitrogen
(Water Technology, 2021a)

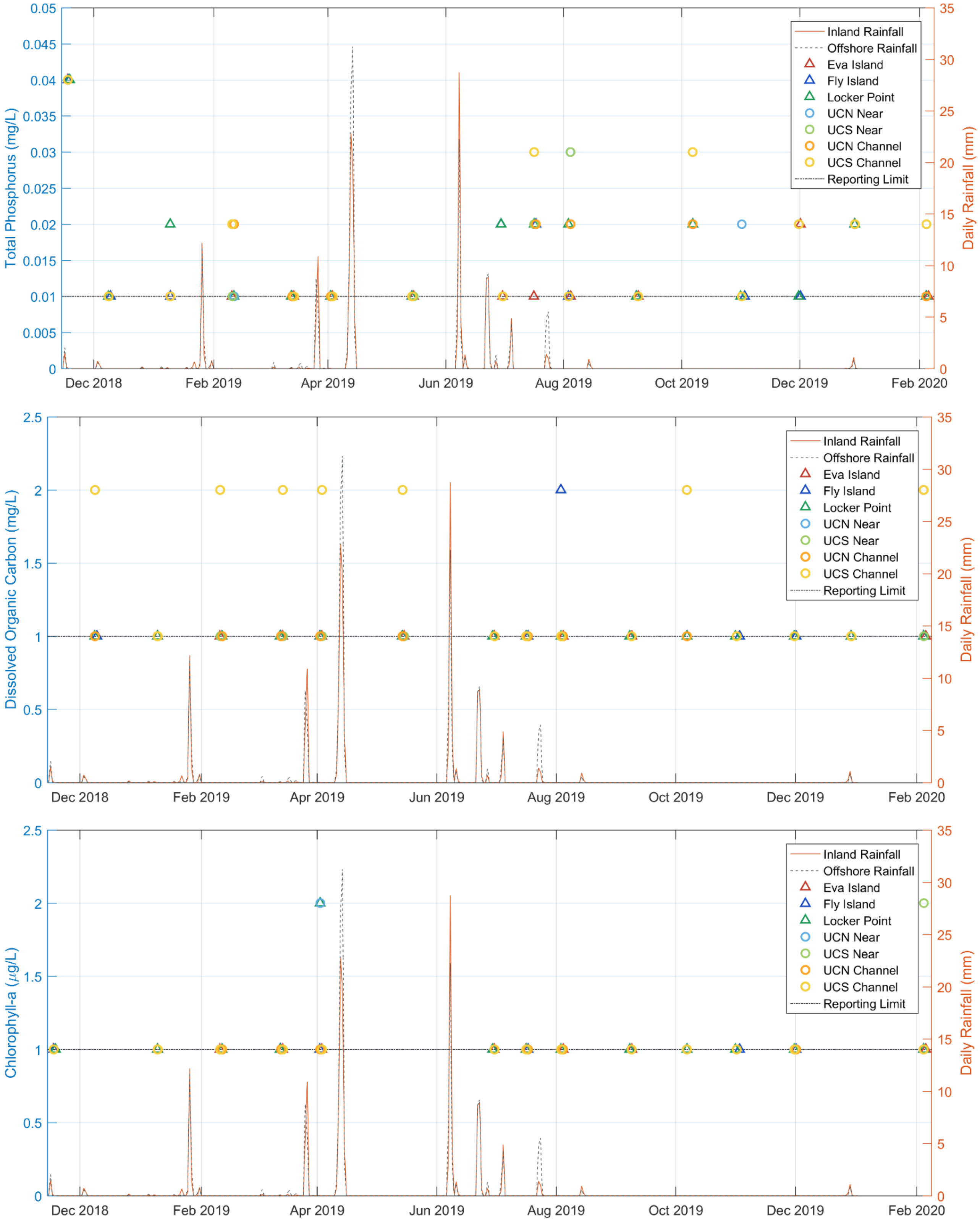


Figure 71: Laboratory Total Phosphorus, Dissolved Organic Carbon and Chlorophyll
(Water Technology, 2021a)

7.4.6.3 TARGETED BASELINE MONITORING OF NUTRIENTS IN URALA CREEK NORTH AND SOUTH

AECOM undertook targeted sampling events in Urala Creek North and South in February and October 2019 with samples sent for NATA accredited laboratory analysis. As sampling was conducted at a range of tidal stages, in order to establish the nitrogen gradient in Urala Creek North and South boxplots were generated with data from both surveys (Figure 72 and Figure 73). The monitoring of Urala Creek North and South shows:

- The majority of nitrogen detected was dissolved organic nitrogen. Particulate nitrogen and dissolved inorganic nitrogen made up only a small portion of total nitrogen.
- Total nitrogen concentrations ranged from 140 µg/L at Urala Creek North Middle to 640 ug/L at Urala Creek South Upper.
- Total nitrogen concentrations were higher during the neap tide in October, this could be due to less dilution due to decreased tidal flows.
- The average Total Nitrogen to Total Phosphorous (TN:TP) ratio was 14:1, which indicates the creeks are nitrogen limited.
- The boxplot for Urala Creek South shows there is an observable gradient whereby nitrogen concentrations are greatest upstream, however this trend is not observed in Urala Creek North.
- Median nitrogen concentrations were more consistent between upstream and downstream sites in Urala Creek North, indicating little to no gradient. Concentrations were slightly higher in the mid-estuary at Urala Creek North Mid which is closest to the tributary that leads to algal mats, which receive more frequent inundation.
- Particulate samples collected at each site were predominantly comprised of the zooplankton size class (50 – 1,000 µm) (Water Technology, 2021a).

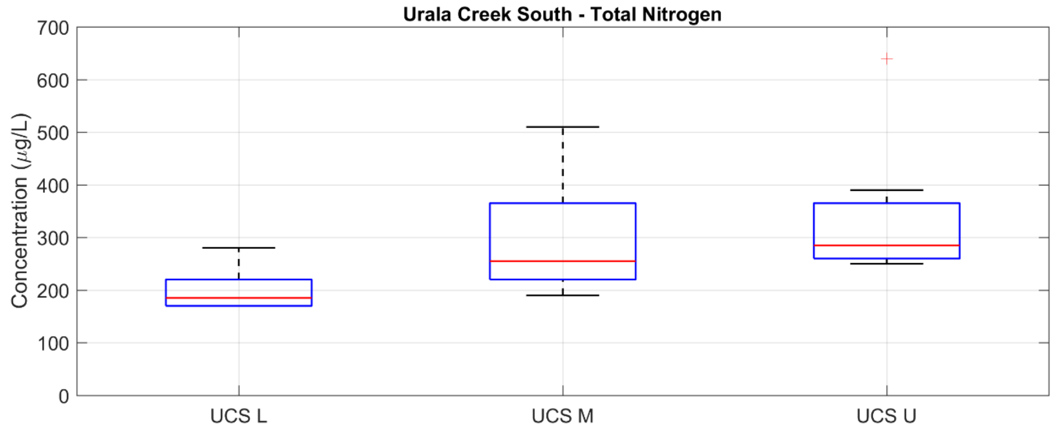


Figure 72: Nutrient Survey Total Nitrogen Boxplot – Urala Creek South
(Water Technology, 2021a)

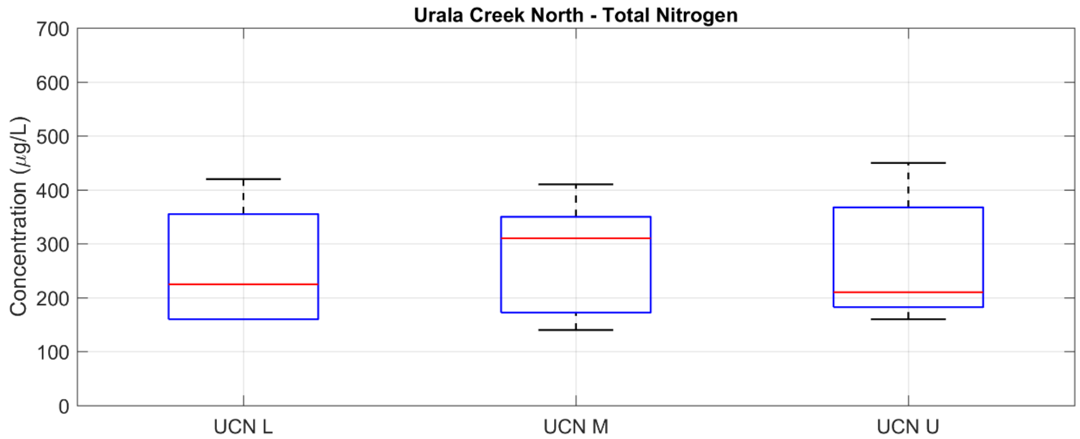


Figure 73: Nutrient Survey Total Nitrogen Boxplot – Urala Creek North
(Water Technology, 2021a)

7.4.6.4 TARGETED BASELINE MONITORING OF NUTRIENTS IN SUB-CREEKS

AECOM undertook targeted sampling events two sub-creeks in August/September 2019 with samples for NATA accredited laboratory analysis. The purpose was to provide an additional understanding of the contribution of algal mats to nutrient levels in adjacent waterways. The nitrogen results for the sub-creek survey are shown in Figure 74 along with water levels measured at Urala Creek South. Sub-creek monitoring results show that:

- Nitrogen concentrations are lowest at highwater, which could be related to the dilution of nitrogen rich water in the sub-creeks by less nutrient rich oceanic water brought in with incoming tide.
- Concentrations of nitrogen then increase after highwater on the ebb tide. Adame et al. (2012) observed similar trends in creeks adjacent to algal mats within Exmouth Gulf and concluded that these tidal related increases in nitrogen were due to nutrient influx from flooded algal mats. In the AECOM survey, the trend was most noticeable for nitrogen and indicates the sub-creeks act as a nitrogen source for the nearshore waters – Adame et al. (2012).
- With regard to speciation, nitrogen concentrations are largely comprised of dissolved organic nitrogen. Although the plots only show organic nitrogen, it can be inferred that this is predominately dissolved due to the low levels of particulate nitrogen. Dissolved organic nitrogen is generated by microorganisms related to mangroves and algal mats.
- Similar tidal trends were also shown for phosphorus and carbon indicating tidal influx of these nutrients from algal mat areas into tidal sub-creeks (Water Technology, 2021a).

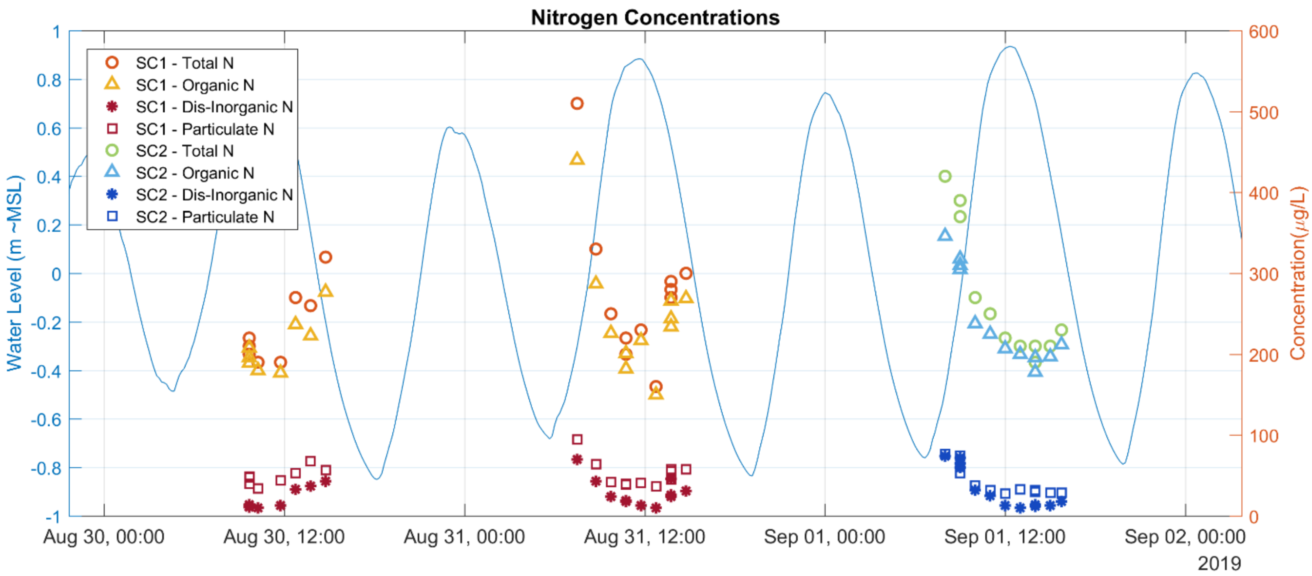


Figure 74: Sub-creek Survey Nitrogen Results
(Water Technology, 2021a)

7.4.6.5 NUTRIENT PATHWAYS

Water Technology (2021d) has conceptualised nutrient pathways of the Exmouth Gulf region and Proposal area based on:

- A comprehensive review and analysis of available literature and data.
- The understanding of the coastal processes detailed in Section 0.
- The nutrient data described in the preceding sections.

Historically, marine and terrestrial systems have primarily been considered as nitrogen limited, whereas lakes are often phosphorus limited. Comparing nitrogen to phosphorus ratios is a common way to assess nutrient limitation on planktonic production in waterbodies (Ptacnik et al., 2010).

An analysis of the water quality data collected as part of this study found creeks and offshore waters to be nitrogen limited (Water Technology, 2021a). Consequently, the Nutrient Pathways Assessment has focussed on quantification of nitrogen, as this is considered the key nutrient for the functioning of marine ecosystems within the Exmouth Gulf and will provide a reasonable indication of the likely nutrient impact of the Proposal, with respect to other nutrient types (Water Technology, 2021d).

The following sections provide an overview of the various nutrient pathways identified by Water Technology (2021d) for the Proposal area and Exmouth Gulf.

7.4.6.6 OFFSHORE NUTRIENT SOURCES

Water Technology (2021d) identified two key offshore (ocean) pathways/sources which work in tandem to deliver nutrients to the Proposal area and Exmouth Gulf:

- Upwelling and eddies which deliver large intermittent pulses of nutrients.
- Tidal exchange which delivers small daily loads of nutrients.

These offshore nutrient pathways/sources are discussed in greater detail below.

Upwelling and Eddies

The monthly baseline water quality monitoring (Section 7.4.6.2) recorded two significant pulses in nitrogen in January 2019 and August 2019, however these events did not correspond to rainfall events. An analysis of metocean conditions during these events found that:

- The January 2019 event occurred during persistent south-westerly winds that would have strengthened the Ningaloo Counter Current and induced Ekman transport resulting in the upwelling of nutrient rich waters. During this time cold surface waters were also observed travelling into Exmouth Gulf, indicative of an upwelling event
- The August 2019 event was not accompanied by conditions conducive to upwelling from the Ningaloo Current, as winds were from the northeast however it could be due to the interaction of the southward flowing Leeuwin Current and transient local effects of offshore eddy advection, combined with a spring tide (Water Technology, 2021d).

In order to quantify the nitrogen contributions from the above two events on a volumetric basis:

- The average nitrogen concentration recorded from four key sampling sites (Figure 75) during the two events was determined at three tidal stages (high, low and mid tide) to represent upper, middle and lower nitrogen concentrations.
- These nitrogen concentrations were then applied to the volume of water in the local area and the entire Exmouth Gulf (Figure 75).

The resulting timeseries show the calculated mass of nitrogen in the local area and Exmouth Gulf is shown in Figure 76. By subtracting the mass of nitrogen in the pulse month from the mass in the preceding month it is estimated:

- For the local area, the January 2019 event contributed 1,500 to 2,200 t and the August 2019 event contributed 1,100 to 1,800 t of nitrogen (a combined total of 2,600 to 4,000 t).
- At any one time there is more than 1,000 t of nitrogen available in waters within the local area.
- For the Exmouth Gulf, the January 2019 event contributed 9,100 t to 11,800 t and the August 2019 event contributed 6,800 t to 8,900 t of nitrogen (a combined total of 15,900 to 20,700).

These estimates are consistent with the scientific literature consensus that Exmouth Gulf is reliant on nutrients from upwelling and eddies (Meekan et al. 2006, Xu. Et al 2016, Hanson et al. 2005).

Tidal Exchange

A previous estimate by Oceanica (2006) quantified nitrogen contribution from offshore sources by analysing the twice daily tidal exchange in Exmouth Gulf and estimated that the annual exchange of water in the shallows is ~7.71×10^{11} m^3. This annual volume of tidal exchange was then combined with a nearshore measurement of dissolved inorganic nitrogen (DIN) (~9.4 µg/L) to derive an annual load of 7,400 tpa of nitrogen from offshore waters. This estimate focuses on the daily tidal exchange nitrogen contribution from offshore waters as opposed to the event-based estimation of intermittent upwelling and eddies performed above.

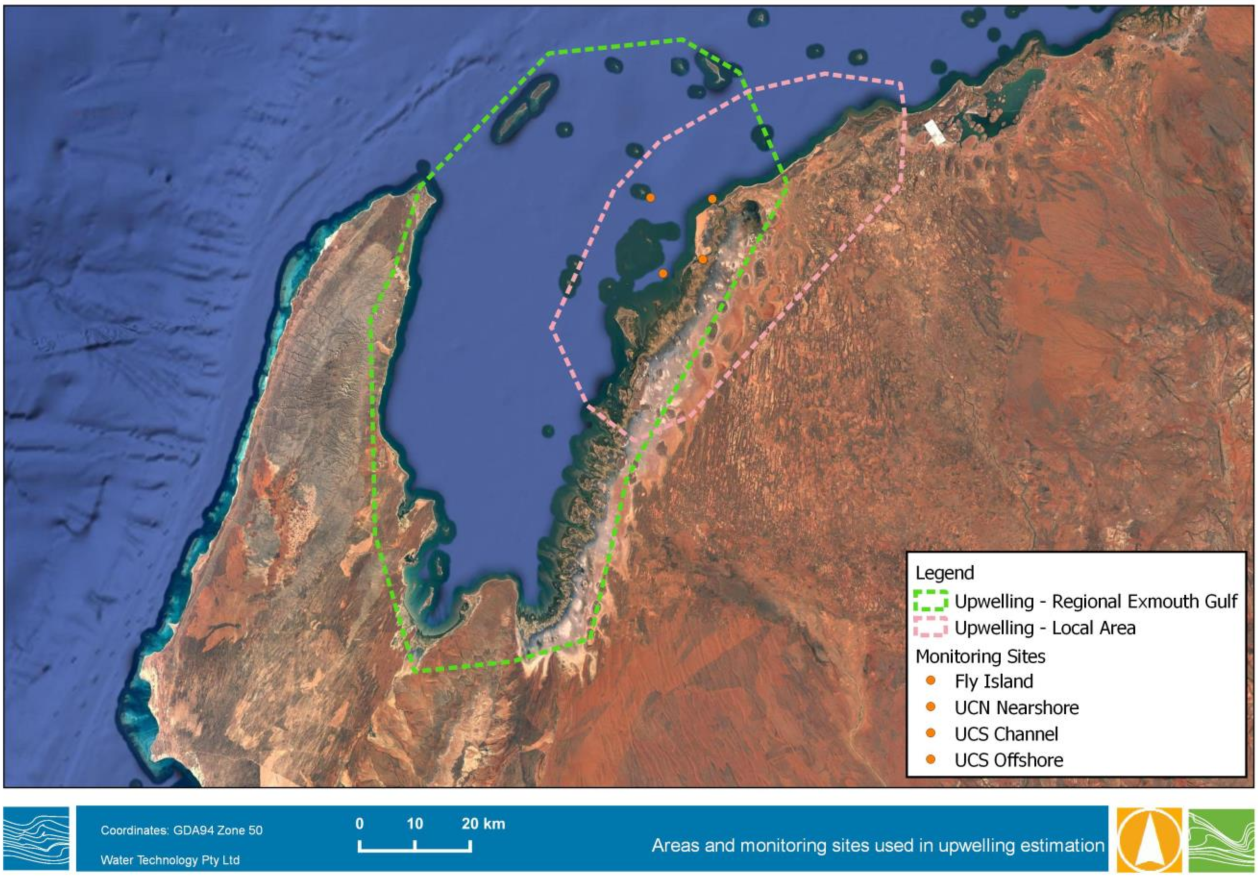


Figure 75: Monitoring Locations and Areas Used of Offshore Nitrogen Estimation
(Water Technology, 2021d)

Conservative Offshore Nitrogen Estimate

Upwelling, eddies and tidal exchange deliver offshore nutrients in tandem, with small daily loads due to tidal exchange and large scale intermittent nutrient pulses related to upwelling and eddies. To ensure conservatism in the Nutrient Pathway Assessment conducted for the Proposal:

- Estimates for the Exmouth Gulf were conservatively reduced by 50% and the lower value adopted (7,950 tpa of nitrogen).
- The lower value was adopted for the Proposal area (2,600 tpa of nitrogen).
- Any additional load due to tidal exchange was ignored (Water Technology, 2021d).

7.4.6.7 INTERTIDAL AND TERRESTRIAL NUTRIENT SOURCES

Water Technology (2021d) found there are several intertidal and terrestrial (land) nutrient pathways/sources relevant to the Proposal area and Exmouth Gulf including:

- Tidal Creeks
- Mangroves
- Algal Mats
- Bare Intertidal Mudflats (or transitional mudflats)
- Overland Flows
- Supratidal Salt Flats.

Each of these nutrient pathways/sources is described in greater detail below.

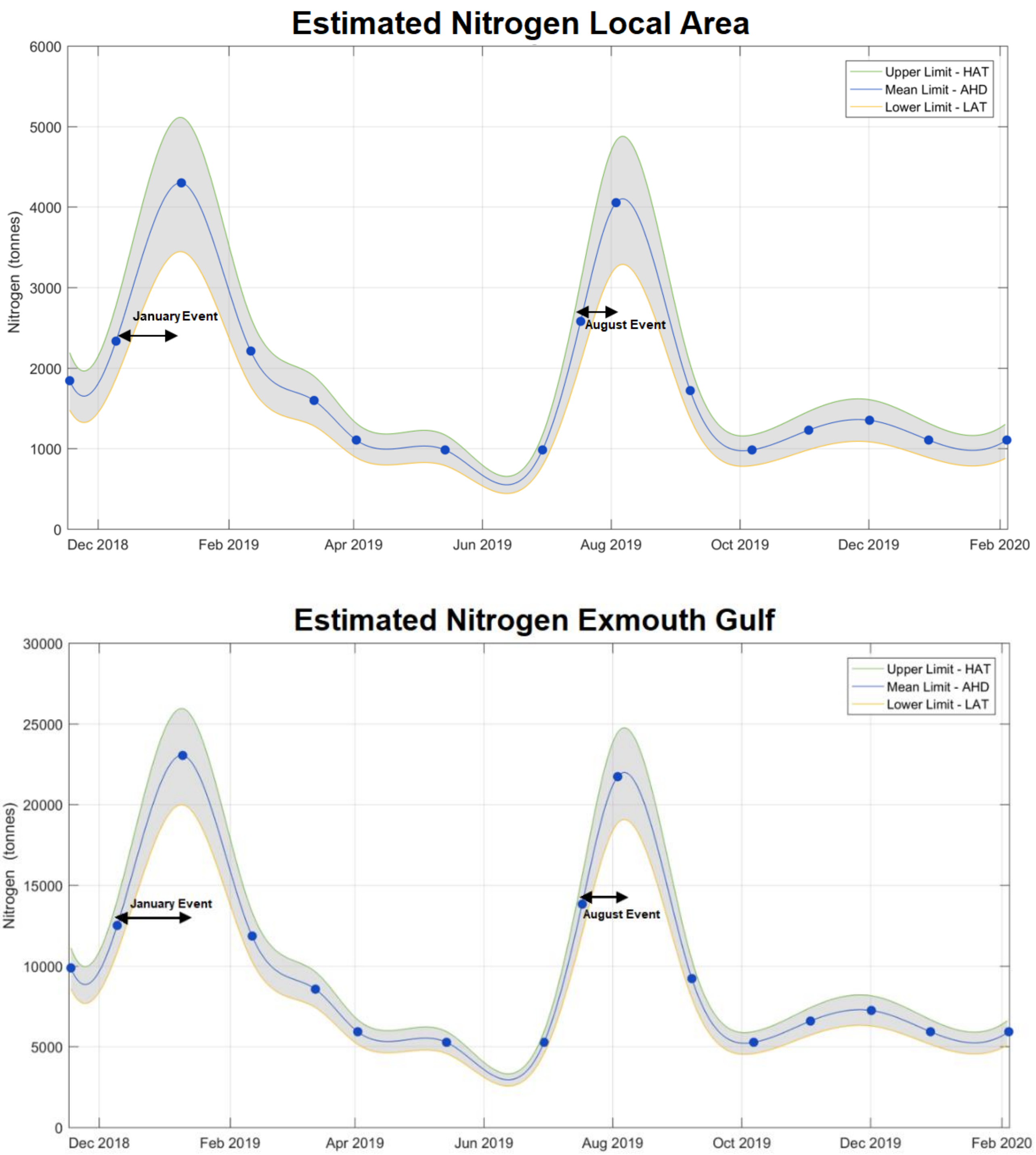


Figure 76: Estimated Offshore Nitrogen Local Area and Exmouth Gulf
(Water Technology, 2021d)

7.4.6.7.1 TIDAL CREEKS

Brewer et al. (2007) found that tidal flows and inundation through creek systems are the main factors that maintain mangroves and algal mats. Tidal creeks act as conduits of tidal flows and nutrients. The upstream-downstream nutrient cycling process within tidal creeks produces a distinct longitudinal pattern, which indicates that nutrients in tidal creeks can remain trapped upstream due to limited tidal flushing, and when the system is flushed the nutrient rich water is likely to remain nearshore due to coastal trapping. In other words, nutrients are largely recycled within the tidal creeks and associated mangrove systems, with limited exports to the wider Exmouth Gulf.

7.4.6.7.2 MANGROVES

Boto and Wellington (1988) found that mangrove systems are generally in a finely balanced state with respect to primary macronutrients, which are efficiently recycled within the system. Limited tidal export of nitrogen is evident from local mangroves with Adame and Lovelock (2011) finding there is overall net import of nitrogen into local mangrove systems. It is hypothesised, based on water levels, water quality monitoring and literature that nutrients in mangroves are largely recycled in the Proposal area and act as minor sink of nitrogen (Water Technology, 2021d).

7.4.6.7.3 ALGAL MATS

Cyanobacterial (or algal) mats fix nitrogen from the atmosphere and are an important component of the coastal nitrogen cycle. Nitrogen is exported from cyanobacterial mats primarily as organic nitrogen during tidal inundation (Paling and McComb 1994). As stated above, nutrients from algal mat areas are likely to be largely recycled in tidal creeks and mangrove systems or remain nearshore due to coastal trapping with limited exports to the wider Exmouth Gulf (Water Technology, 2021d).

7.4.6.7.4 BARE INTERTIDAL MUDFLATS

Bare intertidal mudflats are likely to contribute minimally to the nutrient budget for the Proposal area, Brunskill et al. (2001) and Adame et al. (2012).

7.4.6.7.5 OVERLAND FLOWS

Overland flow paths connect to extensive salt flats and in large storm events produce overland flows from the terrestrial catchment into tidal creeks and the coastal marine environment, providing an intermittent surge of nutrients that results in increased productivity. In general, it is agreed that catchment derived sources of nitrogen are less important in tidal creeks as input only occurs during extreme events (versus daily tidal inundation), however in low nutrient environments they have greater value (Harris, 2001). During smaller rainfall events with an ARI of 5 years or less, these overland flows are unlikely to reach tidal creeks, however under large events such as cyclones they will be delivered to creeks, with some coastal trapping followed by transportation further into Exmouth Gulf (Water Technology, 2021d).

7.4.6.7.6 SUPRATIDAL SALT FLATS

Supratidal salt flats occur fringing the hinterland and experience infrequent inundation due to seasonal spring tides, storm surge or rainfall. The salt flats have a salt crust which causes the water when flooded to be hypersaline. They do not directly produce significant nutrients (as evidenced by very low levels of chlorophyll-a and pheophytin and absence of cyanobacteria/algae) (AECOM, 2022a). They may receive, store and convey nutrients from water and entrained sediments during infrequent inundation events (Water Technology, 2021d).

7.4.6.8 OVERALL NUTRIENT CONCEPTUAL MODEL AND BUDGET

Based on a comprehensive review and analysis of available literature, as well as extensive monitoring data collected for this Proposal, Water Technology (2021d) have developed for the Proposal area and Exmouth Gulf (areas depicted in Figure 75):

- A conceptual nutrient model (diagram) summarising nutrient pathways, sources and sinks (Figure 77).
- A serious of quantitative assumptions which allow estimation of amounts of nitrogen contributed by various sources (Table 41).
- A quantitative nutrient budget (Table 42) which based on the above assumptions estimates amounts of nitrogen contributed by various sources.

The nitrogen budget has focussed on nitrogen, as analysis of the water quality data collected found in creeks and offshore waters to be nitrogen limited (Water Technology, 2021a), and therefore nitrogen is considered a key nutrient for the functioning of intertidal and marine ecosystems locally, and provides a reasonable estimate with respect to other nutrients (Water Technology, 2021d).

The nutrient budget is considered conservative, as it does not include oceanic nitrogen sources from tidal exchange and only those from observed upwelling which has the effect of reducing the offshore contribution to the budget. Other assumptions applied to the model are also inherently conservative as summarised in Water Technology (2021d).

Table 41: Nutrient Budget Assumptions
(Water Technology, 2021d)

Pathway	Source / Sink	Nutrient Budget Assumptions
Tidal Creeks and Flats	Mangroves	Boto and Wellington (1988) found that there was net import (sink) of nitrogen into mangroves of 0.16 mg N m^{-2} h^{-1}. A conservative import rate less than this of 0.1 mg N m^2 h^{-1} has been adopted in the nutrient budget to under-estimate the amount of nitrogen taken up by mangroves and therefore over-estimate the amount of nitrogen flowing from mangroves into the coastal system.
	Algal mats	Paling and McComb (1994) estimated an annual nitrogen leaching rate for algal mats of 3 - 7 mg N m^2 h^{-1}. A conservative leaching rate has been applied in the nutrient budget at the upper end of this range of 6.5 mg N m^2 h^{-1} to estimate upper amounts of nitrogen flowing from the algal mats into the coastal system.
	Bare intertidal mudflats	Brunskill et al. (2001) estimated that bare intertidal sediment leaching rates can approximate 0.0017 mg N m^2 h^{-1} on an annual basis, whilst Adame et al. (2012) postulated that wet bare intertidal sediments can uptake nitrogen at a rate of -0.24 mg N m^2 h^{-1}. A conservative leaching rate of 0.1 mg N m^2 h^{-1} has been applied in the nutrient budget, 100 times larger than the estimated annual rate of 0.001 mg N m2 h-1 to over-estimate the amount of nitrogen flowing from the bare sediment into the coastal system.
Overland Flows	Supratidal salt flats	Nitrogen fixing cyanobacteria are not present in the salt flats. Analysis of salt flat samples found the average chlorophyll-a concentration was 29 mg/m^2 (10.5% of the algal mat level), likely attributable to small amounts of microalgae present (AECOM 2021). The Redfield ratio is a stoichiometric ratio used to describe the composition of phytoplankton biomass and nutrient concentrations in marine waters (Ptacknik et al. 2010). On average, each atom of phosphorus in phytoplankton biomass is attended by 16 atoms of nitrogen and 106 atoms of carbon, which equates to a C:N:P ratio of 106:16:1, whereby a reduction in nitrogen results in a proportional reduction in carbon and phosphorus and therefore plankton biomass. Chlorophyll-a is an indicator of plankton biomass and using the Redfield ratio, a reduction in chlorophyll-a (plankton biomass) within the salt flats, would correspond to a complimentary reduction in nitrogen. Thus, it could be assumed that the nitrogen leaching rate of the salt flats would be 10.5% of the algal mat rate. This would result in a nitrogen leaching rate of 0.6 mg N m^{-2} h^{-1} for salt flats (compared to 6.5 N m^{-2} h^{-1} adopted for algal mats). A conservative nitrogen leaching rate of 2 mg N m^{-2} h^{-1} (more than 3 times the above estimate) has been adopted for the salt flats to avoid under-estimating its potential nutrient leaching rate.
	Hinterland	The nitrogen contribution from the hinterland areas beyond the intertidal zone and salt flats was based on 0.8 mmol/m^2/year as estimated by (Brunskill et al., 2001) converted to 0.12 kg/ha/year.
Offshore Sources	Nearshore waters	Monitoring data has been used to develop a conservative estimate of contribution of offshore sources of nitrogen (Water Technology, 2021d) consistent with the scientific consensus within available literature (Meekan et al. 2006, Xu. et al 2016, Hanson et al. 2005). This is summarised in Section 7.4.6.6.

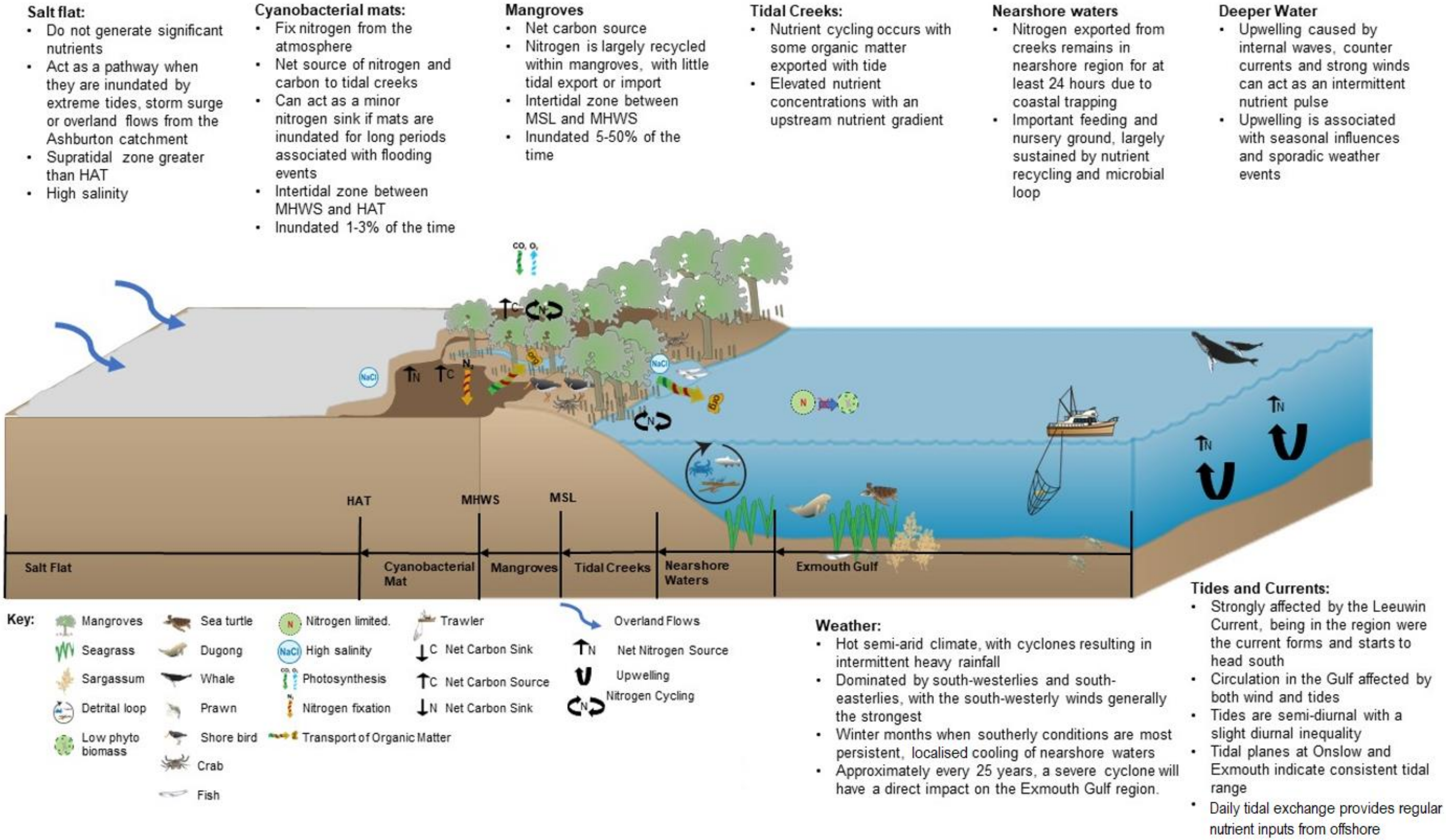


Figure 77: Conceptual Nutrient Pathway Model

(Water Technology, 2021d)

Table 42: Regional Land and Ocean Nitrogen Contributions to Exmouth Gulf Waters
(Water Technology, 2021d)

Habitat	N Source or Sink	Primary Nutrient Pathway	Area (ha)	Exchange rate (kg/ha/y)	Net TN (tpa)	% of Total to Exmouth Gulf	Information Source
Mangroves	Sink	Tidal creeks/inundation	11,780	-3	-34.7	N/A – no net N export to Exmouth Gulf	Boto and Wellington (1988)
Algal Mats	Source and sink	Tidal creeks/ inundation/	8,080	68	541	6.3	Paling and McComb (1994)
Salts Flats	Source	Overland flows	50,500	0.9	44.7	0.5	Paling and McComb (1994), Project data collection
Hinterland	Source	Overland flows	560,000	0.12	55.1	0.6	Brunskill et al. (2001)
Offshore	Source	Upwelling/Eddies	-	-	7,950	92.5	Meekan et al. (2006), Xu. et al (2016), Hanson et al. (2005), Project data collection
Intertidal and terrestrial total					**641**	**7.5**	
Total					**8,591**	-	

Table 43: Local Land and Ocean Nitrogen Contributions to Proposal Area Nearshore Waters
(Water Technology, 2021d)

Habitat	N Source or Sink	Primary Nutrient Pathway	Area (ha)	Exchange rate (kg/ha/y)	Net TN (tpa)	% of Total to Exmouth Gulf Nearshore	Information Source
Mangroves	Sink	Tidal creeks/inundation	650	-3	-1.9	N/A – no net N export to Exmouth Gulf	Boto and Wellington (1988)
Algal Mats	Source and sink	Tidal creeks/ inundation/	3,600	68	241	8.4	Paling and McComb (1994)
Salts Flats	Source	Overland flows	14,000	0.9	12.4	0.4	Paling and McComb (1994), Project data collection
Hinterland	Source	Overland flows	197,000	0.12	19.4	0.7	Brunskill et al. (2001)
Offshore	Source	Upwelling/Eddies	-	-	2,600	90.5	Meekan et al. (2006), Xu. et al (2016), Hanson et al. (2005), Project data collection
Intertidal and terrestrial total					**273**	**9.5**	
Total					**2,872**	**-**	

7.4.7 DREDGING AREA ACID SULFATE SEDIMENT

7.4.7.1 OVERVIEW

The Proposal site is located within an area of naturally occurring saline soils considered to be a consequence of primary salinity sources and potentially an Acid Sulfate Soils and Sediment (ASSS) environment with the occurrence of sulfide minerals from the shallow soil surface and at depth. In this landscape generally, if the acid generating potential (oxidation of sulfides) exceeds the buffering capacity of the local landscape (alkalinity sources such as calcium carbonate), then acidification occurs. Additionally, disturbance (excavation, dredging and dewatering) of sulfidic materials may result in the leaching of sulfuric acids and further acidification of sulfides as well as potential liberation of other naturally occurring substances such as heavy metals (GHD, 2021a).

A review of the Acid Sulfate Soils (ASS) risk map of the Pilbara Coastline (DER-011) accessed from the National Map website (Australian Government, 2020) was undertaken for the site. The ASS risk map does not extend into the domain of the proposed berthing pocket to be dredged (dredge pocket). However, the section of coastline immediately adjacent to the dredge pocket is classified as 'Moderate to low risk of ASS occurring within 3 m of natural soil surface but high to moderate risk of ASS beyond 3 m of natural soil surface'. In addition, there is a narrow offshore area of 'High to moderate ASS risk' extending approximately 4 km north-east along the coastline, from the Urala Creek northern inlet, towards the proposed jetty location, within 1 km of the coastal boundary. The ASS map indicates that the 'High to moderate risk' area ceases approximately 3 km west of the proposed jetty location (Figure 78).

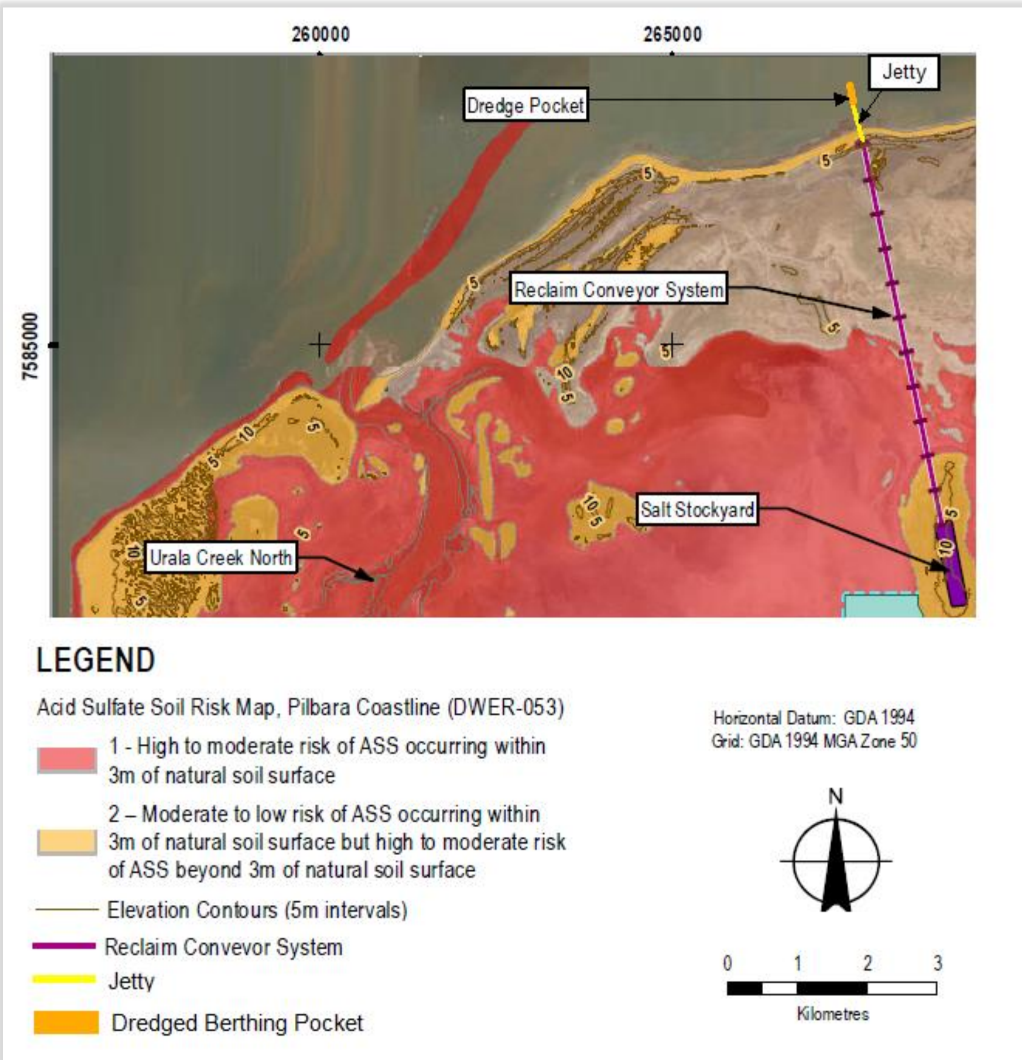


Figure 78: ASS Risk Map Pilbara Coastline - Jetty and Dredged Berthing Pocket

7.4.7.2 SITE SPECIFIC DATA

GHD (2021a) collected sediment samples to assess the proposed dredge pocket for ASS and other properties via NATA accredited laboratory testing. The sampling program and methodology was undertaken in accordance with National Assessment Guidelines for Dredging (NAGD) (Commonwealth of Australia, 2009). Due to the remote location and capital dredging proposal, typically only the upper 1 m of the sediment would be required to be sampled (for chemical analysis). However, due to the location of the proposed works and mobilisation challenges, sampling was also completed on available samples greater than 1 m.

Thirteen locations (includes one additional location due to refusal) were sampled to a maximum depth of 2.2 m based on the assumed dredge volume (17,000 m^3) to assess sediment chemical composition prior to disturbance. The site investigation locations were selected randomly prior to attending site and based on the square grid analysis approach detailed in NAGD (Commonwealth of Australia, 2009).

Site investigation locations were undertaken using a 450 vibracore, which retrieves an un-disturbed core (as far as practically possible) within a de-contaminated polycarbonate liner with a nominal diameter of 50 mm. Sub-samples were obtained from the core at discrete intervals based on the sediment conditions encountered. Composite samples were also obtained in order to preserve sufficient volumes of sample for analysis. In total 25 samples were tested. The results are summarised below.

Acid Sulfate Properties

- pH_{LAB} values presented limited variability between the samples submitted for analysis, with a population variance of 2.90 pH units. Of the samples submitted for pH screening the following were reported: maximum pH_{LAB} of 9.2, minimum of 4.6 and average concentration of 8.0.
- pH_{FOX} values presented limited variability between the samples submitted for analysis, with a population variance of 0.33 pH units. Of the samples submitted for pH screening the following were reported: maximum pH_{FOX} of 9.2, minimum of 7.7 and average concentration of 8.5.
- The acid based accounting for the sediments indicated that net acidity (utilising chromium reducible sulfur (CRS) method) ranged between 220 mol H+ /t and less than the laboratory limit of reporting.
- Material analysed was dominated by potential acidity due to the sub-oxic and potentially anoxic conditions.
- Suspension Peroxide Oxidation Combined Acidity ad Sulphur (SPOCAS) suite indicated slightly increased net acidity values likely due to the presence of organic sulfur forms within the sediment profile.
- Acid Neutralising Capacity (ANC) ranged between 140 and 3400 mol H+ /t (utilising SPOCAS method) indicating a significant potential for neutralisation within sediments less than 2 mm (GHD, 2021a).

Physical Properties

- The initial surface samples (maximum 0.7 m depth) analysed were typically less than 0.63 mm in size.
- Logs indicate that finer sediments such as silts and clays may be present at greater depths and refusal during coring was experienced between 0.7 and 2.7 m at all vibracore locations (GHD, 2021a).

Metals and Metalloid Compounds

- All samples analysed were below the Interim Sediment Quality Guidelines (ISQG) low value for metals and metalloids with the exception of Arsenic, which presented one sample slightly in excess of the guideline value at 23 mg/kg (GHD, 2021a).

Organic Compounds

- All samples analysed were below the laboratory limit of reporting for organic compounds including Polycyclic aromatic hydrocarbons, BTEX, Total Recoverable Hydrocarbons, Polychlorinated biphenyls and organochlorine pesticides (GHD, 2021a).

Naturally Occurring Radioactive Materials

- All samples analysed for radionuclides (alpha and beta screen), indicated NORM was present.
- Gross alpha values ranged between 204 and 258 Bq. Kg^{-1} and gross beta values ranged between 514 and 680 Bq. Kg^{-1}. The maximum sum of gross alpha and beta values was 938 Bq. Kg^{-1} and below the ISQG low value for radionuclides (GHD, 2021a).

7.4.8 LOCAL ENVIRONMENTAL VALUES

Local environmental values related to marine environmental quality have been identified as follows (DoE, 2006):

- Maximum Level of Environmental Protection (MLEP) for the waters of Urala Creeks North and South.
- High Level of Environmental Protection (HLEP) for the waters including the proposed jetty, dredged berthing pocket and bitterns discharge site (north of Locker Point).

Maximum Level of Environmental Quality Values extend down the entire coastline south-west of Locker Point (Figure 79).

These local values have been mapped overlayed by the Proposal in Figure 79 using GIS data from (DoE, 2006).

7.4.9 REGIONAL ENVIRONMENTAL VALUES

Regional environmental values related to marine environmental quality have been identified as follows (DoE, 2006):

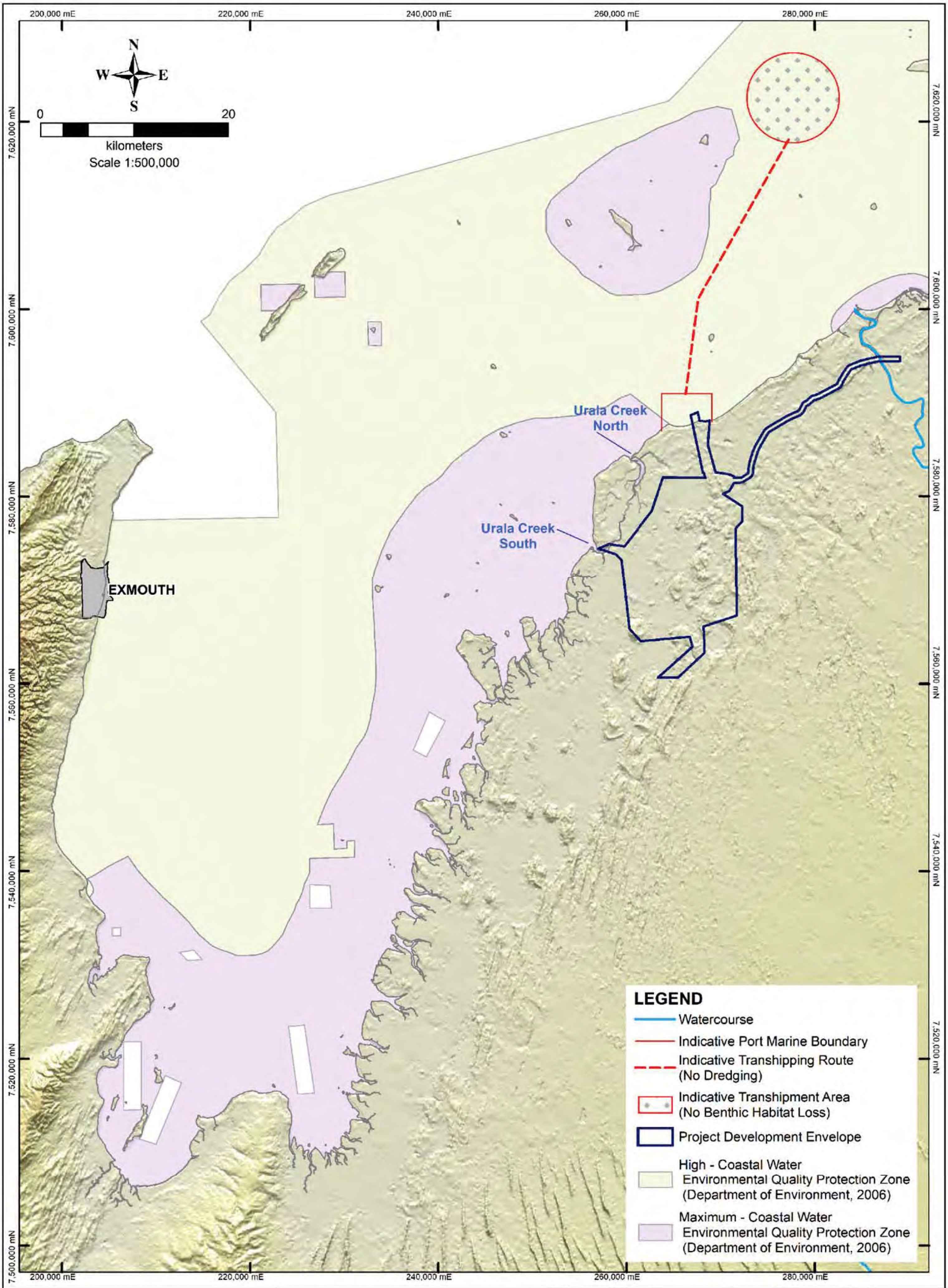
- MLEP for the waters of Eastern Exmouth Gulf
- HLEP for the north of Locker Point.

These regional values have been mapped overlayed by the Proposal in Figure 79 using GIS data from (DoE, 2006).

7.5 POTENTIAL IMPACTS

The following potential impacts have been identified for this Proposal and each of these impacts has been discussed in the sub-sections below:

- Direct impacts:
  - Elevation in naturally occurring salts or metals above background levels due to bitterns discharge.
  - Elevation in water turbidity due to dredging activities.
  - Water pollution due to product spillages during barge loading or transfer, hydrocarbon spills or ballast water.
  - Release of toxicants (metals) in bitterns or dredging activities causing ecotoxicology impacts such as bioaccumulation and mortality
- Indirect impacts:
  - Altered nutrient availability and cycling (pathways).
  - Disturbance of acid sulfate soils or sediment, potentially increasing water acidity and introducing contaminants such as metals.



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Data Source: 4A, 4E, 5A, 17A	
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Figure 79: Regional Values Marine Environmental Quality

7.5.1 WATER QUALITY IMPACT OF BITTERNS DISCHARGE

7.5.1.1 OVERVIEW

The Proposal will produce a hypersaline wastewater stream (bitterns), which is essentially the left-over components of natural seawater after removal of water and sodium chloride.

The bitterns will flow from the crystalliser ponds into a dilution pond. Washwater (ocean water) will be used to wash the harvested salt to get rid of the adherent bitterns and the possible potassium chloride (KCl) crystals which could be grown during transport. No additional chemicals or organics are added to the washwater. The bitterns would be diluted 1:1 with an equal amount of seawater before being combined with the washwater. The diluted bitterns will be pumped via a pipeline along the conveyor route, to the jetty for disposal offshore. A multi-port diffuser will be installed at the end of the 700 m jetty to ensure mixing of discharged bitterns with seawater is optimised. Conceptually the diffuser will be 400 m long and contain 350 discharge ports each 25 mm diameter (Section 1.1.1.1) (Water Technology, 2022b). The final design of the diffuser will be determined prior to construction and documented within the MEQMMP as outlined in Appendix BB .(O2 Marine, 2022b).

7.5.1.2 REGULATORY FRAMEWORK

The regulatory framework for the proposed discharge of bitterns is contained within:

- *Australian and New Zealand Guidelines for Fresh and Marine Water Quality* (ANZG, 2018).
- *Technical Guidance – Protecting the Quality of Western Australia's Marine Environment* (EPA, 2016e).

According to EPA (2016e) the predicted concentration of constituents at the point of a wastewater discharge must be compared to Environmental Quality Criteria (EQC) which are scientifically based limits of acceptable change to an environmental quality indicator. EPA (2016e) defines an Environmental Quality Plan (EQP) as a plan that identifies the environmental values that apply to an area and spatially maps the zones where Levels of Ecological Protection (LEP) should be achieved. The EPA has already established an EQP for Pilbara coastal waters which assigns a High LEP to the proposed bitterns discharge area northeast of Locker Point (DoE, 2006) (Figure 79). The regulatory framework provides the following guidance for developing EQC:

- *Physical Chemical (PC) Stressors:* ANZG (2018) and EPA (2016a) recommend the use of reference data to develop EQC for PC stressors. The recommended approach is to calculate an appropriate percentile of measured site baseline data to determine an allowable level above background (AECOM, 2022c).
- *Toxicants:* ANZG (2018) provides Default Guideline Values (DGVs) for assessing a range of toxicants in marine waters. The use of the ANZG DGVs for toxicants is recommended by the WA EPA (2016a) which recommends that 99% species protection levels are adopted for a high Level of Ecological Protection (LEP) with the exception of cobalt where 95% species protection levels are recommended (EPA, 2016a) (AECOM, 2022c).

7.5.1.3 BITTERNS CHARACTERISTICS

Bitterns solutions generally have a salinity of around 300 PSU and a density of 1,250 kg/m^3. They are markedly denser than the local seawater, which in the area has natural range of 35.0 to 53.5 PSU and a corresponding range in density of 1,027 to 1,041 kg/m^3. Being denser than the receiving seawater (negatively buoyant), the bitterns discharge will typically sink to the bottom if not mixed in the water column by a diffuser. Monthly variations in the proposed bitterns discharge were determined based on the targeted seasonal production rates. The highest bitterns discharge will be in November, which is the month with the highest production rate (Water Technology, 2022b).

The key impact that bitterns can have on biota within the receiving environment is osmotic stress due to high salinity. The salinity component of bitterns is classified as a Physical Chemical (PC) stressor and is not a "toxicant". Given no additives are introduced during the solar salt production process, the only toxicants that exist in the bitterns are naturally occurring elements of seawater (specifically metals) which are concentrated by the solar evaporation process. This process does not lead to chemical reactions that produce substances within bitterns that do not commonly occur in seawater because it is essentially an evaporation/crystallisation process for removal of sodium chloride. This process leaves behind only naturally occurring seawater elements within the bitterns (predominantly magnesium sulfate). The specific metal concentrations within bitterns can vary according to the geographic location of the bitterns source seawater, given seawater constituents vary geographically (AECOM, 2022c). Therefore, to determine the level of metals within the bitterns to be generated from the Proposal, the following approach was adopted (AECOM, 2022c):

- A 30 L sample of local seawater (from the location of the proposed seawater intake in Urala Creek South) was collected by AECOM.
- This sample was provided to NATA-accredited ARL to concentrate the sample using evaporation, to mimic the bitterns creation process.
- Sodium chloride was precipitated (crystallised) and removed, and the evaporation process was continued until the solution remaining reached a density typical of bitterns (1.248 g/cm^3).
- The bitterns sample was then tested for levels of expected macro level chemical composition to confirm it was representative of bitterns constituents at expected levels (based on known main constituent levels of bitterns analysed for other salt projects such as salinity and density).
- Laboratory testing was then undertaken by ARL on the laboratory generated bitterns sample for a comprehensive analytical suite to identify and assess toxicants within the Proposal bitterns discharge.

The results were used to inform the modelling assessment of the bitterns discharge described further below.

7.5.1.4 SALINITY ENVIRONMENTAL QUALITY CRITERIA

The salinity of receiving environment at the proposed bitterns discharge location (northeast of Locker Point) changes throughout the year, with monitoring data showing salinities ranging from around 36 to 42 PSU. Vertical salinity profiles showed minimal variation, indicating well-mixed conditions (Section 7.4.3.2) (Water Technology, 2021a).

The WA EPA recommends that PC stressors such as salinity should remain within the 80th and 95th percentile of natural background for a High and Moderate LEP respectively, and no EQC should apply for a Low LEP (EPA, 2016e). The rolling 12-month average of the 80th and 95th percentile minus the median has been calculated for the in-situ baseline salinity dataset at the bitterns discharge reference site (Locker Point). On this basis:

- The High LEP salinity EQC was calculated as 1.6 PSU above background (being the 12-month rolling average of the difference between the rolling 80th percentile and rolling median of the dataset).
- The Moderate LEP salinity EQC was calculated as 2.2 PSU above background (being the 12-month rolling average of the difference between the rolling 95th percentile and rolling median of the dataset) (Water Technology, 2022b).

7.5.1.5 METALS ENVIRONMENTAL QUALITY CRITERIA

Metals EQC for a High LEP have been formulated by AECOM (2022c) following the recommendations of ANZG (2018) and EPA (2016a). Laboratory analysis of the bitterns sample prepared from local seawater showed that:

- Concentration of several metals within the bitterns sample was already lower than the ANZG (2018) 99% species protection DGVs (specifically manganese, vanadium, cobalt, lead, nickel, cadmium, mercury and selenium). Therefore, these metals will meet a High LEP at the discharge point.
- Concentration of several metals within the bitterns sample exceeded ANZG (2018) 99% species protection DGVs (specifically aluminium, zinc, arsenic, chromium and copper). Therefore, EQC have been formulated based on DGVs for these metals as follows:
    - For zinc, arsenic and chromium, it is proposed that the ANZG (2018) 99% species protection DGVs are met by the bitterns discharge within the High LEP Zone (at the boundary of a Moderate LEP zone).
    - For aluminium, no DGV is specified in ANZG (2018). However, van Dam et al (2018) conducted a study combining several years of chronic biological effects data with toxicity data from the open literature and proposed an aluminium DGV of 0.002 mg/L for 99% species

protection level in tropical waters. Therefore, it is proposed that the DGV of 0.002 mg/L is met by the bitterns discharge within the High LEP Zone (at the boundary of a Moderate LEP zone).

- For copper, background water quality data collected has shown that the ANZG (2018) 99% species protection DGV of 0.0003 mg/L is regularly exceeded naturally in seawater at Locker Point (Water Technology, 2021a). Therefore, it is proposed that the ANZG (2018) 95% species protection level of 0.0013 mg/L is met by the bitterns discharge within the High LEP Zone (at the boundary of a Moderate LEP zone) (AECOM, 2022c).

AECOM (2022c) also noted that ANZG (2018) toxicant DGVs are based on laboratory effects data from single-toxicant and single-species ecotoxicity laboratory tests. SSDs of chronic laboratory ecotoxicity data for a number of species and life stages have been used by ANZG (2018) to derive DGVs that will protect 80, 90, 95 or 99% of species. Therefore, it is reasonable to consider that these DGV's have relevance to local indicator species including benthic and pelagic species, prawn larvae and juveniles, and the most vulnerable pearl oyster life stages. The proposed metals EQCs are outlined in Table 44 along with the estimated dilution of the bitterns plume required to achieve them.

Table 44: Proposed Metals EQC's and Dilutions Required
(AECOM, 2022c)

Metal	Proposed EQC (mg/L)	% Species Protection Level	Dilution Required in Plume	Notes
Manganese	0.08	99	0	Bitterns concentration less than ANZG (2018) DGV, therefore no dilution is required to meet the DGV.
Vanadium	0.05	99	0	
Lead	0.0022	99	0	
Nickel	0.007	99	0	
Cadmium	0.0007	99	0	
Mercury	0.0001	99	0	
Selenium	0.003	99	0	
Cobalt	0.001	95	0	
Arsenic	0.0023	99	6.7	Lower ANZG (2018) DGV for As III applied
Chromium	0.0001	99	38	Lower ANZG (2018) DGV for Cr VI applied
Zinc	0.007	99	2.3	ANZG (2018) DGV applied
Aluminium	0.002	99	17.7	No ANZG (2018) DGV available. Proposed DGV based on van Dam et. al. (2018)
Copper	0.0013	95	19.7	Background water exceeds ANZG (2018) 99% DGV

7.5.1.6 WHOLE OF EFFLUENT TESTING

In the absence of a project-specific K+S bittern sample, the Onslow bitterns sample is considered to be a suitable surrogate, sufficiently representative of K+S operations (AECOM, 2022c; Appendix L).

The Mardie Project took an approach that involved the use of a prototype bitterns effluent from a different operation [the Onslow facility (O2 Marine, 2019)], which was determined by the EPA (2021, Section 2.5.2 in that report) as "adequate to inform the EPA's assessment of the proposal".

Mardie Whole Effluent Toxicity (WET) analysis was undertaken on six marine organism groups (microalgae, echinoderm, crustacean, cnidarian, mollusc and fish) to represent local marine indicator species.

The WET testing undertaken using the prototype sample indicated that salinity, which is expected to reach 325 ppt, was the primary causative agent for the toxic effects observed (O2 Marine, 2019).

AECOM (2022c; Appendix L) conducted a review of the WET procedure, local marine water quality and background data collected by K+S for the Proposal. This review suggested that the species protection levels derived by the Mardie WET ecotoxicology assessment are suitable for application to this Proposal also.

7.5.1.7 DIFFUSER DESIGN INVESTIGATIONS

Numerous options were investigated through a combination of near-field and far-field modelling to ensure the bitterns discharge impacts were minimised. These investigations are detailed in Section 4 of Water Technology (2022b; Appendix A) and a summary of the parameters assessed during the investigations included:

- Pre-dilution with seawater.
- Diffuser alignment with respect to prevailing ocean currents.
- Bathymetry.
- Diffuser depth, port size, direction, spacing, length and discharge velocity.

A total of 30 different modelling scenarios were run to determine the best diffuser location, alignment and design, with the final option used to determine Ecological Protection Areas (discussed below).

7.5.1.8 DEFINING ECOLOGIAL PROTECTION AREAS

The above EQC have been used to define a proposed Low Ecological Protection Area (LEPA) and Moderate Ecological Protection Area (MEPA), as illustrated diagrammatically in Figure 80. The boundaries of these areas is defined by the number of dilutions required to meet the required species protection levels (90% for LEPA/MEPA boundary and 99% for MEPA/HEPA boundary). A minimum 263 and 417 dilutions are required to achieve 90% and 99% species protection levels respectively.

7.5.1.9 PREDICTED SALINITY ECOLOGICAL PROTECTION AREAS

To design an appropriate diffuser and understand the potential impacts of the bitterns discharge on marine water quality, detailed near and far field modelling of salinity was undertaken using industry standard modelling packages. Mixing zone contours were generated to determine the predicted size of the LEPA and MEPA zones for the yearly average, best case (June) and worst case (November) bitterns discharges.

The bitterns dilution modelling undertaken by Water Technology (2021a) was applied to the species protection levels derived from WET assessment to determine the number of dilutions required to meet Moderate and High LEP (i.e., the boundaries of the LEPA and MEPA). It was predicted that for the annually averaged bitterns discharge the modelled width (distance from the diffuser) would be:

- LEPA - approximately 2,400 m in an along shore direction and 1,200 m in an offshore direction.
- MEPA - approximately 2,900 m in an alongshore direction and 1,700 m in an offshore direction.

For the worst-case scenario (Figure 81), the predicted size of the LEPA zone was 3,000 m in width, extending approximately 1,500 m from the end of the jetty (219.4 ha). This covers an area of 217 ha of soft sediment habitat (with the potential to support seagrass), 0.18 ha of macroalgae and 2.2 ha of macroalgae and sparse coral habitat within the worst-case LEPA zone. The MEPA was predicted to be approximately 4,300 m in width to approximately 2,000 m from the end of the jetty.

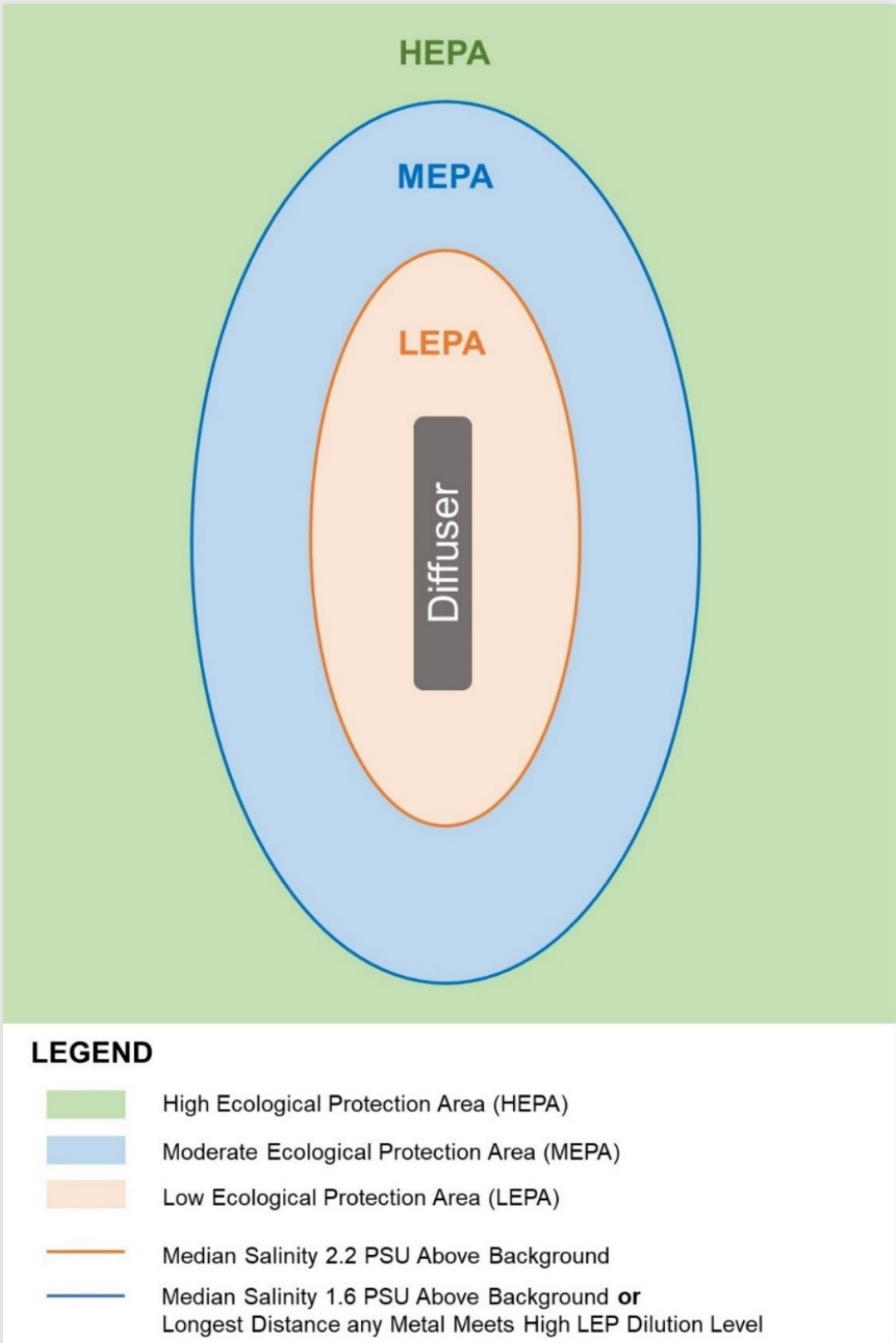

Figure 80: Diagrammatic Representation of Bitterns LEPA and MEPA Zones

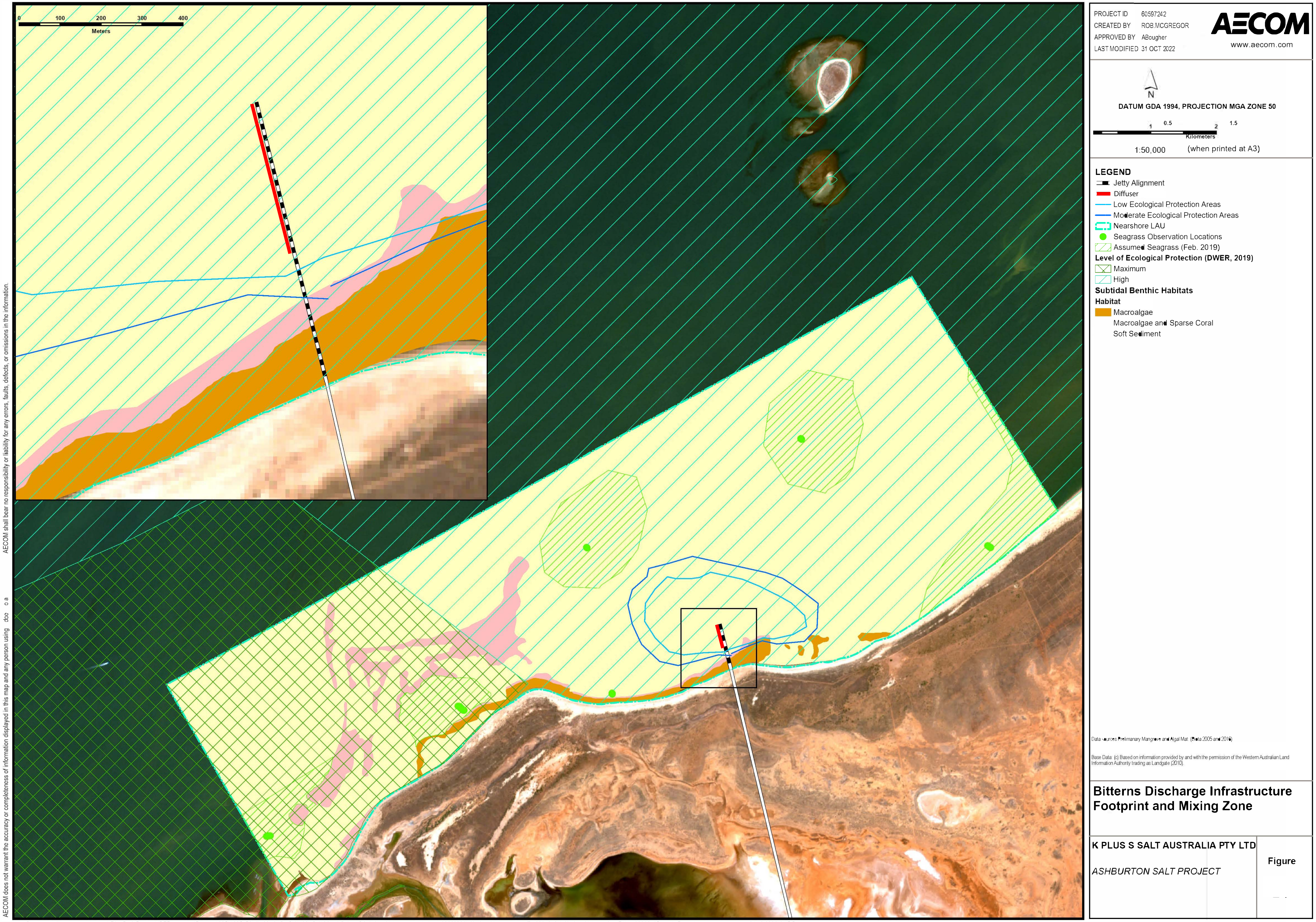

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Figure 81: Predicted LEPA and MEPA Zones (AECOM, 2022b)

7.5.2 WATER QUALITY IMPACT OF DREDGING

7.5.2.1 OVERVIEW

The jetty has been designed to load salt product onto a transhipment barge for transport to an offshore OGV. Dredging of a berthing pocket is required so transhipment vessels can remain docked at the jetty during low tide and tranship offshore at higher tide. The planned dimensions of the berth pocket are 200 m x 35 m x 6 m of water depth (at low tide) – this requires dredging of approximately 2.5 m of seabed. Total dredge volume is estimated to be 17,000 m^3. The dredging program will take approximately 2 weeks to complete. The location of the proposed berthing pocket is shown in Figure 82. The final proposed dredging methodology (cutter suction), final proposed method of transport onshore and modelling to demonstrate EPA requirements will be met will be included in the DSMP as outlined in Appendix BB (K+S, 2021).

The dredged slurry will be transported onshore to a bunded Dredge Spoil Disposal Area (Figure 18). The bunded area will have a sufficient volume such that the material can be retained for a long enough period to achieve necessary water quality standards. In accordance with the ASSSMP (GHD, 2021b) nneutralising material will be added to the dredged material as necessary to treat any acid sulfate sediment detected. Decant water will be retained for a suitable time to allow appropriate water quality standards to be met (confirmed by monitoring) prior to release to the marine environment. Solids will be tested to ensure appropriate environmental standards are met, then will be reclaimed and used in on-site embankment construction.

The seawater intake inlet well on the banks of Urala Creek South will not be dredged, but instead excavated and spoil contained within the embankments of intake channel. The spoil will be treated and managed in accordance with the ASSSMP (GHD, 2021b), and any water within the spoil will be retained on land and evaporated, with no discharges to waterways.

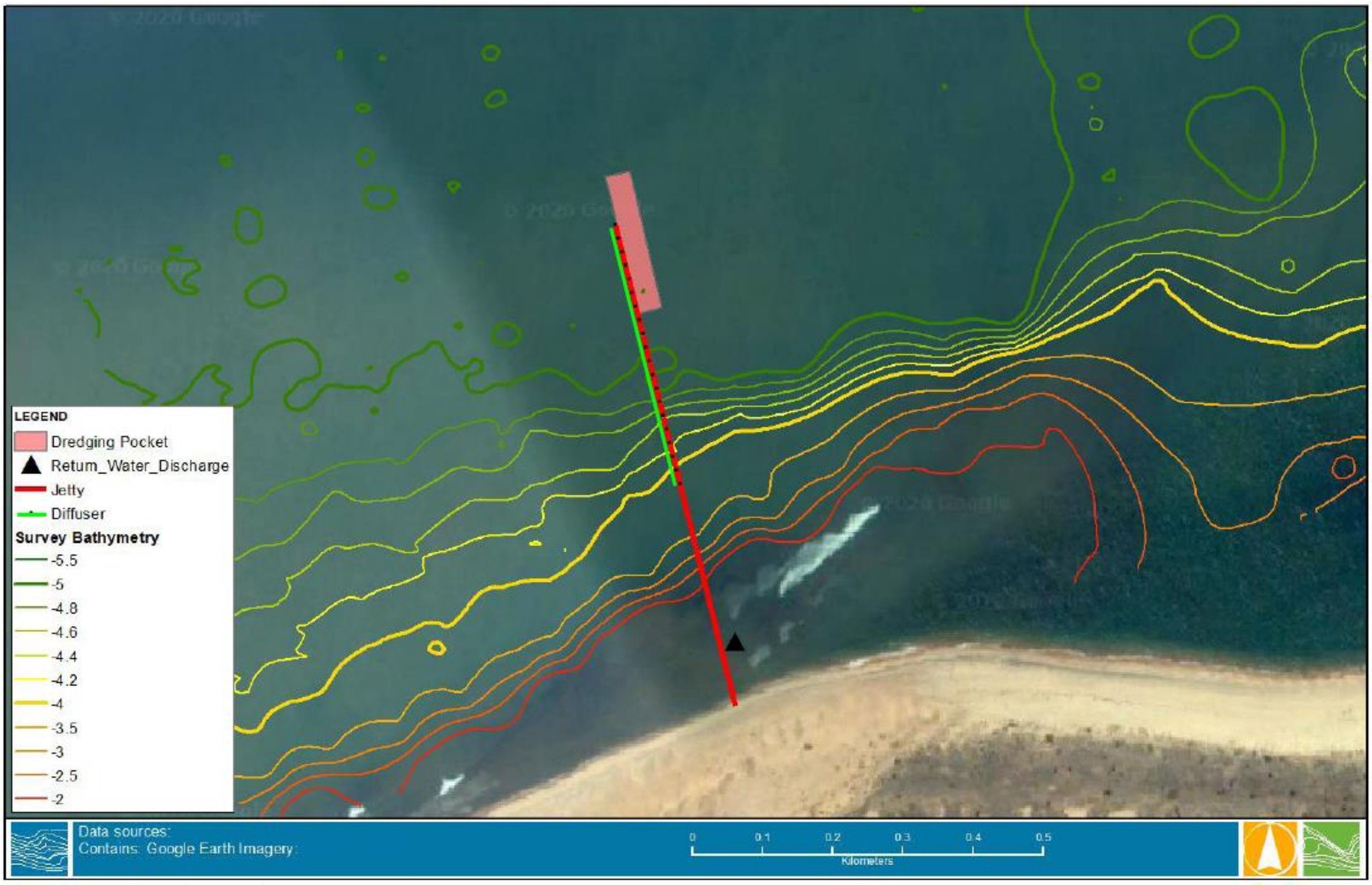

Figure 82: Proposed Dredged Berthing Pocket (bathymetry contours are in metres)

7.5.2.2 REGULATORY FRAMEWORK

The regulatory framework for dredging activities and resulting sediment discharge is contained within:

- *Australian and New Zealand Guidelines for Fresh and Marine Water Quality* (ANZG, 2018).
- *Technical Guidance – Environmental Impact Assessment of Marine Dredging Proposals* (EPA, 2016d)
- *National Assessment Guidelines for Dredging (NAGD*) (Commonwealth of Australia, 2009)

With regards to assessing the potential toxicity of dredged material, the NAGD endorse the use of "Screening Levels" for potential toxicants within the material to be dredged. The toxicant Screening Levels are based on the interim sediment quality guideline values presented in the ANZECC/ARMCANZ (2000) *Guidelines for Fresh and Marine Water Quality*, which are superseded by DGV's presented in ANZG (2018). If these Screening Levels are exceeded and ocean disposal of dredged material is proposed, then further testing of bioavailability, bioaccumulation and ecotoxicity is recommended (Commonwealth of Australia, 2009).

The EPA (2016d) has developed a spatially based zonation scheme for proponents to use as a common basis to describe the predicted extent, severity and duration of impacts associated with dredging proposals. The scheme consists of three zones to represent different levels of impacts:

- *Zone of High Impact (ZoHI)* is the area where impacts on benthic communities or habitats are predicted to be irreversible. The term irreversible means 'lacking a capacity to return or recover to a state resembling that prior to being impacted within a timeframe of five years or less'. Areas within and immediately adjacent to proposed dredge and disposal sites are typically within zones of high impact.
- *Zone of Moderate Impact (ZoMI)* is the area within which predicted impacts on benthic organisms are recoverable within a period of five years following completion of the dredging activities. This zone abuts, and lies immediately outside of, the zone of high impact. The outer boundary of this zone is coincident with the inner boundary of the next zone, the Zone of Influence.
- *Zone of Influence (ZoI)* is the area within which changes in environmental quality associated with dredge plumes are predicted and anticipated during the dredging operations, but where these changes would not result in a detectible impact on benthic biota. These areas can be large, but at any point in time the dredge plumes are likely to be restricted to a relatively small portion of the ZoI.

7.5.2.3 SEDIMENT CHARACTERISTICS

GHD (2021a) undertook sampling of sediment representative of proposed dredged material, via mobilisation of a vibracore system mounted on a marine vessel to collect sediment samples at 13 locations. The sampling program and methodology were undertaken in accordance with NAGD (Commonwealth of Australia, 2009). Samples were then sent for analysis at a NATA accredited laboratory and the toxicant concentrations were compared to the sediment DGVs in ANZG (2018).

Sediment sampling indicates the dredge material is likely to consist of medium to fine sands with a significant proportion of clay. GHD (2021a) did not detect any toxicants for which the 95% Upper Confidence Limit (UCL) concentrations exceeded the ANZG (2018) sediment DGVs NAGD Screening Levels (Commonwealth of Australia, 2009). Therefore, there is no indication that any further assessments of ecotoxicology or bioaccumulation are warranted for dredged material (AECOM, 2022c).

It was identified by GHD (2021a) that the dredged material is likely to be acid generating. In accordance with the Proposal ASSSMP (GHD, 2021b), the dredge spoil will be transported onshore to a bunded Dredge Spoil Disposal Area where it can be treated with neutralising material and decant water will be monitored prior to release to the ocean.

7.5.2.4 DEFINING DREDGING ZONES OF INFLUENCE AND IMPACT

In dredging plume assessments, cumulative probability and running mean methods are often used to identify the zones of influence / impact. Calculation of each zone is based on analysis of either cumulative probability (% days) or running mean TSS (equivalent to Suspended Solid Concentration against possible coral mortality thresholds (Table 45) developed by WAMSI (Fisher et al (2019)). The use of hard coral thresholds was deemed appropriate for this assessment due to these communities, as mixed coral and macroalgae communities, being the closest BCH sensitive to reduced light conditions to the Proposal disturbance footprint. While soft sediments across the Proposal area have been assumed as potential seagrass habitat, no seagrass was observed within 1.8 km of the proposed jetty nearshore adjacent to the intertidal rock platform and not within approximately 2.3 km from the end of the jetty in an offshore direction during surveys (Geo Oceans 2019). Should seagrass be detected in closer proximity to the jetty and berth pocket during pre-construction baseline surveys, appropriate measures will be included into environmental management plans (e.g., DSMP) to assess the potential impacts of these seagrass beds and implement appropriate monitoring based on thresholds for seagrasses. It should be noted that natural background turbidity levels at Locker Point regularly exceed some of these thresholds. Each zone was defined as follows (Water Technology, 2022b):

- ZoHI is determined by thresholds corresponding to a high probability of observing non-zero coral mortality (TSS >6.9 mg/L for 20% cumulative probability/80th percentile, TSS >13.2 mg/L for 28 days running average).
- ZoMI is determined as the area that encompasses the region immediately outside the ZoHI up to distances where thresholds are indicative of only possible coral mortality (TSS >5 mg/L for 20% cumulative probability/80th percentile, TSS>9.3 mg/L for 28 days running average).
- ZoI is where changes to water quality may occur, but not to an extent that constitutes a hazard to any underlying coral communities. It is determined up to distances where modelled exceedance of TSS is above 2 mg/L. Note 2 mg/L represents a typical lower range (5th percentile) of TSS measured at Locker Point.

Table 45: Derived Coral Mortality Thresholds Developed by WAMSI

Fisher et al. (2019)

Thresholds type		Possible effects (*strict*)			Probable effects (*permissive*)		
		>NTU	>SSC	<DLI	>NTU	>SSC	<DLI
Cumulative probability (% days)	**90%**	0.7	1.3	7.4	0.7	1.3	6.6
	80%	1.0	1.9	6.3	1.2	2.1	5.4
	70%	1.3	2.3	5.5	1.6	2.8	4.6
	60%	1.5	2.8	4.9	1.9	3.4	4.0
	50%	1.8	3.2	4.4	2.3	4.1	3.4
	40%	2.0	3.7	3.8	2.6	4.8	2.8
	30%	2.3	4.2	3.2	3.1	5.6	2.3
	20%	2.8	5.0	2.6	3.8	6.9	1.7
	10%	3.5	6.3	1.7	5.1	9.1	1.0
Running mean (days)	**1 d**	15.5	27.9	0.4	32.4	58.3	0.1
	3 d	**10.8**	**19.4**	**1.1**	**19.9**	**35.7**	**0.3**
	7 d	**8.2**	**14.7**	**1.8**	**13.6**	**24.5**	**0.6**
	10 d	7.3	13.1	2.2	11.6	20.9	0.9
	14 d	**6.5**	**11.7**	**2.5**	**10.0**	**18.0**	**1.1**
	17 d	6.1	11.0	2.7	9.2	16.5	1.3
	21 d	5.7	10.2	2.9	8.3	15.0	1.5
	28 d	**5.2**	**9.3**	**3.1**	**7.3**	**13.2**	**1.8**
	30 d	5.1	9.1	3.1	7.1	12.8	1.9

7.5.2.5 PREDICTED DREDGING ZONES OF INFLUENCE AND IMPACT

To understand the potential impacts of the dredging on the water quality in and around the jetty location and the broader coastal environment, detailed hydrodynamic and sediment transport modelling was undertaken using industry standard software. Two model periods were selected to represent the typical seasonal climate of the site (Water Technology, 2022b):

- A summer season during January and February 2015 representing a high wind (non-cyclonic) energy season with prevailing winds from the southwest.
- A winter season during June and July 2015 representing a low wind (non-cyclonic) energy season with winds from various directions.

The predicted zones of influence/impact are described in Table 46 and illustrated in Figure 83. These impacts will be temporary as the proposed dredging plan is around 2 weeks. Modelling predicts that plumes of elevated turbidity will not persist for more than a week following cessation of the dredging activity. The results are also conservative as they as based on a 30-day assumed dredging period simulation (Water Technology, 2022b).

Potential impacts of dredging on BCH have been assessed separately in Section 8.

Table 46: Predicted Dredging Zones of Influence and Impact
(Water Technology, 2022b), (AECOM, 2022a)

Season	Impact Zone Description
Summer	• The ZoHI is predicted to be limited in extent to an area of 'soft sediment' habitat around the dredging footprint, which could provide future habitat for seagrass. • The ZoMI is predicted to extend some 1.5 km eastwards from the dredging footprint, whilst remaining offshore over 'soft sediment' habitat and not encroaching upon the nearshore macroalgae and coral habitats. • The ZoI is predicted to extend some 4 km eastwards from the dredging footprint, also not encroaching upon the nearshore macroalgae and sparse coral habitats. • Within the resolution of the model, there was no influence predicted to occur from the tailwater discharge; i.e., elevations in TSS were predicted to be limited to the immediate vicinity of the discharge location and were not predicted to enter the model domain at sufficient frequency or intensity to exceed the thresholds defined by Water Technology (2022b).
Winter	• The ZoHI is predicted to be larger than in summer, but still limited in extent to a 6.2 ha area of 'soft sediment' habitat in the general vicinity of the dredging footprint, which could provide future habitat for seagrass. There is evidence of a predicted ZoHI in the immediate vicinity of the tailwater discharge, extending over the macroalgae habitat at that location. • The ZoMI is predicted to extend no further than approximately 0.5 km from the dredging footprint, well offshore from the nearshore macroalgae and sparse coral habitats. The ZoMI associated with the tailwater discharge is predicted to extend only marginally further from shore than the ZoHI, with minimal encroachment upon mixed macroalgae and sparse coral habitat. • The ZoI is predicted to extend some 3 km westwards from the dredging footprint, though not encroaching upon the macroalgae and coral habitats offshore from Locker Point. In combination with the ZoI associated with the tailwater discharge, though, the ZoI is predicted to extend across macroalgae and coral habitats up to approximately 0.5 km either side of the base of the jetty.

7.5.2.6 MAINTENANCE DREDGING

Only minor maintenance dredging would be needed over the life of the Proposal, with much less removal of sediment required than the construction dredging program (at least 50% less or no more than 8,500 m^3 of sediment removal), resulting in a shorter dredging timeframe for maintenance of the berthing pocket. Therefore, no additional impacts are considered likely to occur from maintenance dredging.

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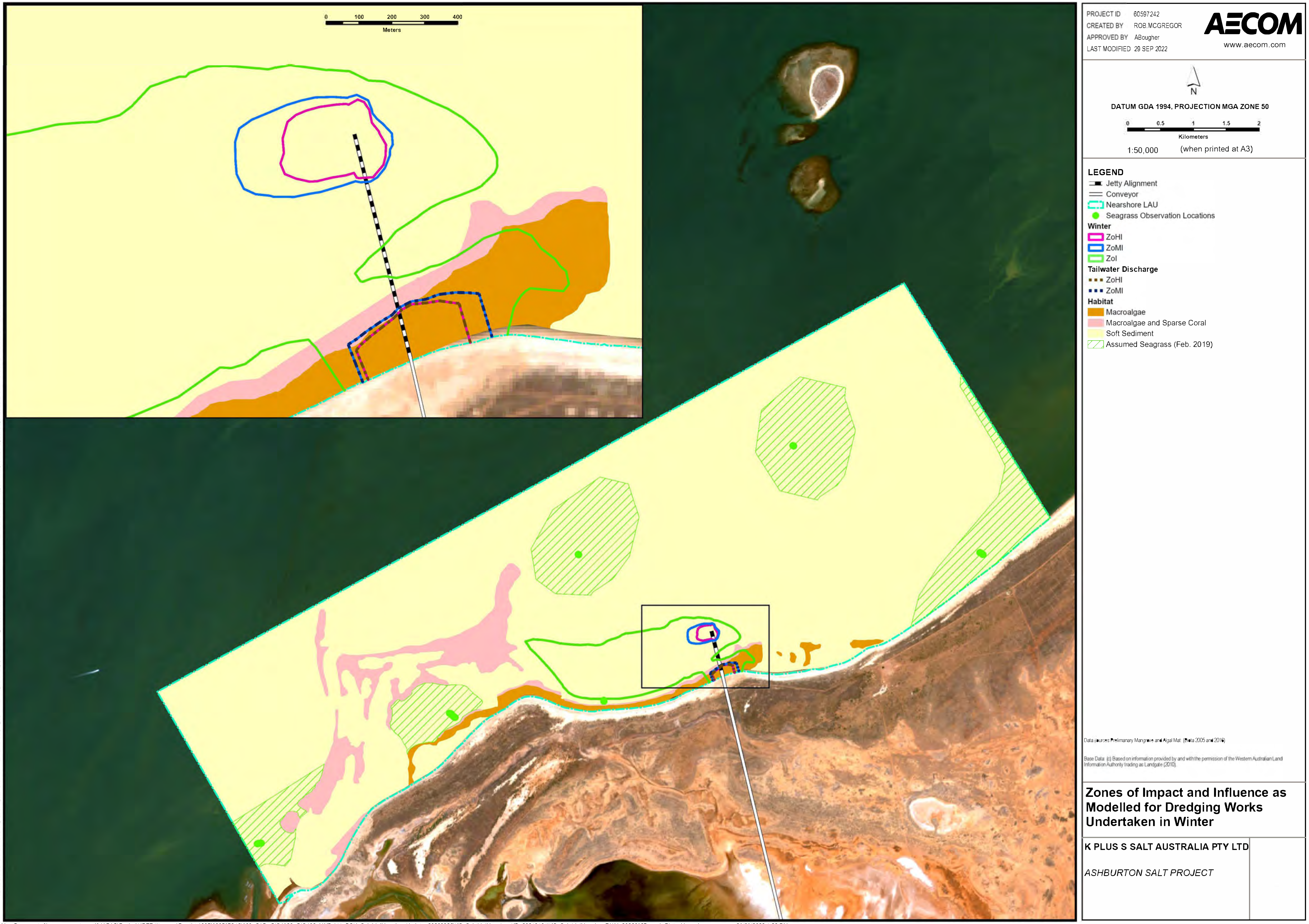
Figure 83: Modelled Dredging Zones of Influence and Impact - Summer (Water Technology, 2022b)



Map Document: (\\na.aecomnet.com\lfs\APAC\Perth-AUPER1\Legacy\Projects\605X\60597242\900_CAD_GIS \920_GIS \02_MXDs\11_BCH_SubtidalMapping_Update_20200622\KS_SubtidalMapping_KD_20210401\KS_SubtidalMapping_RNM_20220927.aprx) Plotted by: rob.mcgregor on 29/09/2022 1:32 PM

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Figure 84: Modelled Dredging Zones of Influence and Impact - Winter (Water Technology, 2022b)

7.5.3 POTENTIAL INDIRECT IMPACTS

7.5.3.1 ALTERED NUTRIENT PATHWAYS

Altering nutrient pathways, sources and sinks in intertidal and subtidal areas, has the potential to affect primary and secondary productivity. Local ecosystems are nitrogen limited. Therefore, ensuring nitrogen flows into and out of key habitat types is not significantly affected by the Proposal, is important to the ongoing health of these intertidal and subtidal ecosystems (AECOM, 2022b).

Water Technology (2021d) undertook a detailed Nutrient Pathways Assessment and Modelling study to:

- Develop a conceptual nutrient pathway model and nutrient budget.
- Develop a numerical model simulating nutrient pathways related to tidal inundation and overland flows.
- Undertake project related impact assessment regarding nutrient pathways including:
  - Modelling impacts to tidal inundation and overland flow nutrient pathways.
  - Calculating nutrient loss, due to habitat loss.

The assessment focussed on nitrogen as previous studies and monitoring conducted for the Proposal indicated it is the key limiting nutrient for local and regional marine and intertidal ecosystems. The assessment was very conservative because:

- Conservative nitrogen imports and leaching rates were applied.
- Months which have limited inundation due to seasonally lower water levels were not considered, therefore increasing the potential nitrogen exports from algal mats.
- The annual estimate for nitrogen contribution from offshore waters was conservative, ignoring tidal exchange and using lower observed levels of ocean upwelling.
- The modelling results represent changes to nitrogen exports from the mouths of Urala Creek North and Urala Creek South only and did not account for altered overland flow paths which may result in some nutrients being exported via different land/water interfaces.
- The design rainfall events used were considered extremely conservative as they applied a spatially constant rainfall rate over the entire model domain, which in reality would be very unlikely to occur due to the vast extent of the catchment.
- Estimated habitat modification areas were conservative with larger disturbance areas than expected being included in the salt flats and hinterland.
- Nitrogen losses associated with modelled overland flows and habitat modification overlap in the salt flats, and therefore were accounted for twice (Water Technology, 2021d).

The full findings of the study are presented the report by Water Technology (2021d). The study predicted small impacts to nutrient pathways in proportion to the total estimated nutrient flows into the Proposal catchment and Exmouth Gulf. Water Technology (2021b) estimated:

- A regional post-development proportional reduction in nitrogen flows into the Exmouth Gulf of 0.24% of land and ocean sources.
- A local post-development proportional reduction in nitrogen flows into the Proposal catchment of 0.8% of land and ocean sources.

Based on this highly conservative assessment, it can be concluded that the proposed development will not significantly alter nutrient exports or pathways due to the small scale of the predicted reductions and their infrequent nature, particularly when compared to the overall nitrogen budget of the Exmouth Gulf.

7.5.3.2 ACID SULFATE SEDIMENT

Marine sediment sampling indicates that there is likely to be acid generating sediment in the proposed dredge pocket and seawater intake. However, in accordance with the ASSSMP (GHD, 2021b) the dredged slurry from the berthing pocket will be transported to a bunded area onshore (Figure 18). Potential ASS material from the seawater intake will be placed in the intake channel and treated, which will not be connected to the marine environment. Any acid generating material will be neutralised, to avoid acid generation and potential leaching of metals. Decant water will be retained for a suitable time to allow appropriate water quality standards to be met (confirmed by monitoring) prior to release to the marine environment. Solids will be tested to ensure appropriate environmental standards are met, then will be reclaimed and used in on-site embankment construction.

7.5.3.3 MARINE WATER POLLUTION

Indirect impacts may be associated with pollution of marine waters through salt product spillages during barge loading or transfer, bitterns spills, hydrocarbon spills and ballast water. Such impacts could adversely affect marine environmental quality. The management approach is to avoid such spills as far as practicable and if an accidental spill occurs, ensure it is contained and remediated through appropriate management measures.

Management plans will be in place as outlined in Section 7.7.2.

7.5.3.4 ECOTOXICOLOGY

Release of toxicants (metals) in bitterns discharge or dredging, has the potential to cause ecotoxicology impacts such as bioaccumulation and biota mortality. AECOM (AECOM, 2022c) conducted an ecotoxicology assessment of dredged material and bitterns.

The ecotoxicity of dredged material was determined by comparison of representative sediment sample test results against NAGD (Commonwealth of Australia, 2009) and ANZG (2018) screening criteria. Given none of the screening criteria were exceeded and land disposal of dredged material is proposed, no further assessment was warranted. The dredged material is likely to present a very low risk of ecotoxicity or bioaccumulation in the marine environment (AECOM, 2022c).

The ecotoxicity of bitterns was determined by analysis of metals concentrations within a bitterns sample created from local seawater, to determine the dilution required to meet appropriate ANZG (2018) DGVs. Once the metals within the bitterns plume are diluted such that they meet the nominated 99% or 95% species protection level at the boundary of the modelled MEPA, they present very low risk of ecotoxicity or bioaccumulation in the marine environment (AECOM, 2022c).

7.5.3.5 OTHER SPILL AND CONTAMINATION RISKS

During construction and operations there is the potential for accidental spills or inappropriate waste disposal to occur that may cause contamination of marine waters. Potential contaminants could include salt product, bitterns, hydrocarbons, dredge spoil/tailwater and general site wastes. With appropriate mitigation these impacts should not occur, therefore they are considered low risk. Spills and contamination will be prevented and mitigated through appropriate planning and management measures.

Other potential sources of marine/intertidal sediment plumes (e.g., construction activity in the intertidal zone, excavation activities in the path of surface runoff) are not considered to be significant. Potential sources of Project-related marine/intertidal waters sediment deposition are likely to be very localised and limited to (AECOM, 2022a):

- A temporary and localised increase in the turbidity of tidal waters of Urala Creek South during construction of the seawater intake inlet well. Background turbidity concentrations along the Onslow coastline are high under existing conditions and intertidal environments in the area already cope with periods of very high turbidity during flood events. In this context, it is unlikely that any temporary increases to turbidity from the seawater intake construction works would result in additional sedimentation at a scale that could threaten the tidal creek habitat or mangrove communities. Spoil from the excavation of the inlet well will be contained within the seawater intake channel embankments and managed in accordance with the ASSSMP (GHD, 2021b). Any water within the spoil will be retained on land, treated, and evaporated, and sediment used in construction works (i.e., there will be no tailwater discharge into the creek). Sedimentation reduction measures will be included in a Construction Environmental Management Plan (CEMP) such as silt curtains.

- Construction of the outer or western levees for the pond system and intake channel. Prior to the containment of the levee fill materials by the placement of rock armour on sides of levees, there is the potential for some fill material to be washed into intertidal areas. Localised sediment run-off during construction works within sensitive areas can be managed by employing appropriate sediment run-off measures and erosion control measures. These include the following:
  - Incorporate a buffer area between the outer disturbance boundary and the outer construction boundary (e.g., toe of the perimeter bund).
  - Containment of sediment within perimeter levee walls in sensitive areas by use of geofabric and rock armour.
- Sediment loss during cyclone or heavy rainfall events. In these events sediment from construction areas may be carried downslope. This is likely to be rare however, and once the downslope walls are in place the sediment will be contained within each pond. As with most coastal areas of the Pilbara, elevated sediment loads in stormwater run off occurs during most flow events, and additional sediment from the Proposal is unlikely to significantly increase the turbidity of coastal waters.

7.5.4 SPATIAL EXTENT OF INDIRECT IMPACTS

The spatial extent of indirect impacts is considered to be negligible given these impacts are very minor proportionally (such as altered nutrients) or will be prevented through management measures (such as acid generation, marine water pollution and ecotoxicology/bioaccumulation).

7.5.5 CUMULATIVE IMPACTS

Given the spatial extent of indirect impacts is considered to be negligible, the spatial extent of cumulative impacts equates to that of impacts as summarised in Sections 7.5.1 and 7.5.2.

7.6 ASSESSMENT OF IMPACTS

Detailed investigations (Water Technology, 2021a), (Water Technology, 2021b), (Water Technology, 2021d), (Water Technology, 2022b), (GHD, 2021a) and (GHD, 2021b) have been completed to develop a comprehensive understanding of existing marine environmental quality at a local and regional scale and how it may be impacted by the Proposal. The focus of these assessments has been to inform the Proposal design and management, such that the quality of water, sediment and biota is maintained, and environmental values are protected.

Water quality impacts could include increases to salinity and metals levels associated with the bitterns discharge, and turbidity increases associated with dredging of the small berthing pocket adjacent to the jetty. With regards to these impacts:

- Predilution of bitterns and the design of the bitterns diffuser has:
  - Optimised the predicted dilution and mixing of bitterns with seawater on discharge.
  - Resulted in average, best case and worst case predicted LEPA and MEPA sizes which exceed the EPA (2016a) guideline sizes of 70 and 250 m respectively, however are predicted to be as small as reasonably can be achieved.
- The small scale two-week dredging program to remove 17,000 m^3 of sediment adjacent to the jetty has:
  - Been planned with onshore disposal of dredge spoil, including appropriate treatment and monitoring of decant water prior to return to the ocean.
  - Resulted in a predicted:
    - ZoHI localised immediately around the small dredging and tailwater discharge area.
    - ZoMi up to 1.5 km eastwards of the dredging area.
    - ZoI up to 4 km eastwards of the dredging area and 0.5 km either side of the tailwater discharge.
  - Been predicted to only cause elevated turbidity impacts for one week after the cessation of dredging.

Potential indirect impacts to the marine environmental quality are associated with potentially altered nutrient pathways, acid sulfate sediment disturbance and marine water pollution through normal activities during construction and operations. With regards to these indirect impacts:

- The Proposal will not significantly alter nutrient pathways due to the small and infrequent nature of the predicted terrestrial reductions and no impact to marine nitrogen sources on which the Exmouth Gulf is reliant. Conservative modelling predicted the Proposal will reduce nitrogen sources transported into the Exmouth Gulf by only 0.24% (Water Technology, 2021d).
- All potentially acid-generating sediment removed through dredging will be treated on land with appropriate monitoring of decant water prior to marine disposal, in accordance with the ASSSMP (GHD, 2021b).
- AECOM (2022c) conducted an ecotoxicology assessment of dredged material and bitterns, concluding that:
    - The dredged material is likely to present a very low risk of ecotoxicity or bioaccumulation in the marine environment, given none of the NAGD (Commonwealth of Australia, 2009) and ANZG (2018) screening criteria were exceeded in sample tests and land disposal of dredged material is proposed.
    - Once the metals within the bitterns plume are diluted such that they meet the nominated 99% or 95% species protection level at the boundary of the modelled MEPA (as predicted by Water Technology, 2022b), they present very low risk of ecotoxicity or bioaccumulation in the marine environment.
- Appropriate management is proposed to prevent and manage accidental spills of pollutants during construction and operations as outlined in Section 7.7.2.

Overall, the proposed development shows localised impacts on marine environmental quality. These impacts are also proportionally small on both a local and regional basis as outlined in Section 7.5.3.

7.7 MITIGATION

7.7.1 AVOID

The marine infrastructure necessary for the Proposal includes a salt export jetty, an outfall for the discharge of bitterns, a dredged berthing pocket alongside the jetty and a seawater intake. To avoid impacts on marine environmental quality this infrastructure has been designed as follows:

- A transhipping approach has been adopted for export of the salt product which avoids the need to dredge a shipping channel to the berth at the jetty.
- The bitterns are being discharged to the ocean to avoid long-term large-scale storage on site which would create a risk of spillage.
- The alignment of the jetty has been moved to deeper water (compared to the original proposed alignment) to minimise dredging and improve the mixing and dilution of the bitterns.
- Pre-dilution of the bitterns will be undertaken prior to discharge through the specifically designed diffuser at the jetty.
- All dredge spoil will be disposed of on land and tailwater will be monitored to meet required water quality criteria as listed in the ASSSMP prior to discharge to the marine environment.
- Excavation spoil from the seawater intake will be contained in the seawater intake channel embankments and managed in accordance with the ASSSMP (GHD, 2021b), and water within the excavated material will be treated and evaporated rather than disposed of back to the waterways, minimising tidal creek water quality impact.

7.7.2 MINIMISE

The following engineering and project design has occurred to minimise impacts of bitterns discharge:

- The diffuser design was developed iteratively to minimise impacts on the marine environment (Water Technology, 2022b).

- Pre-dilution of the bitterns using seawater before being discharged to reduce the average density of the bitterns and maximise the efficiency of initial dilution at the diffuser.
- The diffuser design includes an upward discharge from part-way up the water column to further maximise initial dilution and ensure mixing occurs throughout the full water depth.
- The diffuser design uses a relatively high discharge velocity and many small port diameters at the diffuser to achieve the desired level of mixing.

The following management plans will be implemented to further minimise potential impacts on marine environmental quality (Appendix BB):

- Marine Environmental Quality Monitoring and Management Plan (MEQMMP).
- DSMP.
- Waste Management Plan (WMP).
- ASSSMP.

The MEQMMP will be revised prior to operations to include the results of updated WET testing using Proposal-specific bitterns and local indicator species (or agreed surrogates).

7.7.3 REHABILITATE

At the completion of the Proposal the site will be rehabilitated to reinstate the marine environmental quality. A MCP will be required under the *Mining Act 1978* for most of the Proposal. An Interim MCP (Appendix BB) for the Proposal has been developed and will continue to evolve during the life of the Proposal. If the Proposal receives Ministerial Approval under Part IV of the EP Act as well as under the EPBC Act, the Interim MCP will be developed in more detail and submitted to DMIRS for approval as required by the *Statutory Guidelines for MCPs under the Mining Act 1978* – DMIRS (2020b).

The bitterns discharge infrastructure will be removed from site; however, the jetty may be transferred to the ownership of another user. Alternatively, it could be decommissioned and removed. All closure options for the jetty will be discussed with relevant stakeholders as part of ongoing development of the MCP.

7.8 PREDICTED OUTCOME

The EPA objective in relation to marine environmental quality is *to maintain the quality of water, sediment and biota so that environmental values are protected*.

This objective is met by the Proposal due to:

- The high level of dilution in a localised area achieved through the optimised design of the bitterns discharge diffuser.
- The limited footprint of proposed dredging for the pocket berth and land disposal/treatment of the spoil.

In addition, the Proposal is located predominantly within areas which are not major nutrient sources for local or regional ecosystems, therefore resulting in minimal impacts to nutrient pathways. The detailed technical assessments developed a comprehensive understanding of local marine environmental quality and the potential impacts associated with the Proposal were found to be localised. These impacts are also proportionally small on both a local and regional basis.

Based on the above the Proposal is unlikely to result in significant residual impacts to this factor, however the predicted water quality impacts occur within marine areas that are Biologically Important Areas (BIAs) and/or critical habitat for some marine fauna species. As a result, even localised water quality impacts may contribute to significant residual impacts to BCH and marine fauna. These impacts are assessed in Section 8 and 9 respectively.

8 BENTHIC COMMUNITIES AND HABITATS

8.1 EPA OBJECTIVE

To protect BCH so that biological diversity and ecological integrity are maintained.

8.2 POLICY AND GUIDANCE

- *Environmental Factor Guideline: Benthic Communities and Habitats* (EPA, 2016f).
- *Technical Guidance - Protection of Benthic Communities and Habitats* (EPA, 2016c).
- *Technical Guidance - Environmental Impact Assessment of Marine Dredging Proposals* (EPA, 2016d).
- *Technical Guidance - Protecting the Quality of Western Australia's Marine Environment* (EPA, 2016e).
- *Guidance Statement 1 – Protection of Tropical Arid Zone Mangroves along the Pilbara Coastline* (EPA, 2001).
- *Pilbara Coastal Water Quality Consultation Outcomes — Environmental Values and Environmental Quality Objectives,* Department of Environment, Government of Western Australia, Marine Series Report No. 1 (DoE, 2006).
- *Australian and New Zealand Guidelines for Fresh and Marine Water Quality* (ANZG, 2018)
- National Assessment Guidelines for Dredging (Commonwealth of Australia, 2009)
- *A Directory of Important Wetlands in Australia* (ANCA, 1993).
- *WA Environmental Offsets Policy* (Government of Western Australia, 2011).
- *WA Environmental Offsets Guidelines* (Government of Western Australia, 2014).“Appendix B: Potentially contaminating industries, activities and land uses” in *Assessment and management of contaminated sites: Contaminated sites guidelines* (DER, 2014).
- Barging and transhipment operations will be carried out under a Works Approval and Environmental Licence issued under Part 5 of the Part IV of EP Act.

8.3 BENTHIC COMMUNITIES AND HABITAT ASSESSMENT

Environmental Factor Guideline: Benthic Communities and Habitats (EPA, 2016f) sets out the EPA's contemporary approach for considering activities which may directly or indirectly cause impact to or irreversible loss of BCH. It includes a framework for considering cumulative loss of BCH and the potential consequences for marine ecological integrity, biological diversity and considerations for impact mitigation.

The geographic scope of EPA (2016f) guidance includes all Coastal Waters of WA to the high water mark of the intertidal zone. Therefore, the BCH assessment in Section 8 has included BCH located within the following habitats (Figure 85):

- Subtidal zone defined as the zone of ocean close to shore, but constantly submerged by seawater.
- Intertidal zone defined as the area of land where the ocean meets the land between mean high and mean low spring tides. It is submerged by seawater at high tide and exposed to air at low tide.

The supratidal zone is defined as the portion of land which lies above the level of mean high water for spring tides. It is inundated only occasionally by exceptional tides or by tides augmented by a storm surge. The supratidal zone is a transition zone between the intertidal and terrestrial environment. Whilst supratidal habitats have been discussed under Section 8 to provide context, they are not considered specific to the geographic scope of EPA (2016f) which includes BCH up to the high water mark of the intertidal zone.

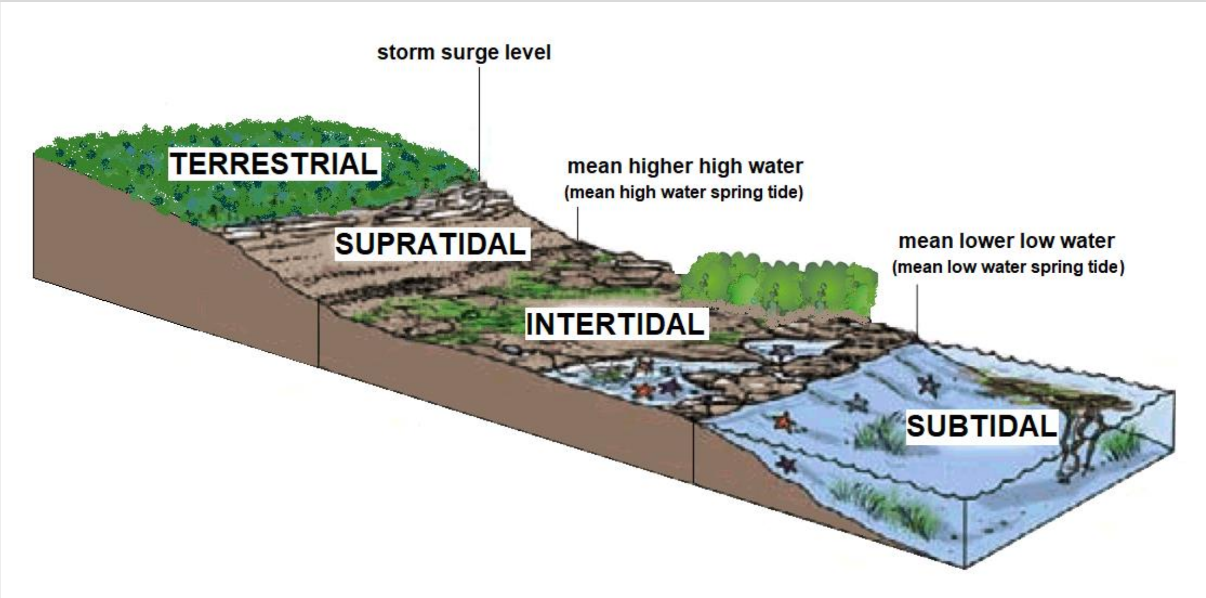


Figure 85: Subtidal to Terrestrial Zonation

8.4 BENTHIC COMMUNITIES AND HABITAT STUDIES

A range of studies to assess impacts to BCH have been conducted (Table 47).

Table 47: Intertidal Benthic Community and Habitat Studies

Study	Reference	Appendix
Marine and Coastal Assessment and Modelling	Water Technology, 2022b	A
Surface Water Assessment and Modelling	Water Technology, 2022a	B
Marine, Coastal and Surface Water Data Collection	Water Technology, 2021a	C
Marine, Coastal and Surface Water Existing Environment	Water Technology, 2021b	D
Surface Water Assessment and Modelling	Water Technology, 2021c	E
Nutrient Pathways Assessment and Modelling	Water Technology, 2021d	J
Marine, Surface Water and Nutrient Modelling Peer Review	DHI, 2021	F
Ashburton Salt Response to Sea Level Rise	Seashore Engineering, 2021	G
Ashburton Salt Projection of Future Habitat Areas	Seashore Engineering, 2022	H
Technical Memorandum – Phase 2 Ecotoxicology Assessment	AECOM, 2022	L
Assessment of Benthic Communities and Habitats	AECOM, 2022	M
Detailed Vegetation and Flora Survey	Biota, 2022a	Q
Acid Sulfate Soils Study	GHD, 2021a	K
ASSSMP	GHD, 2021b	BB
Materials Characterisation Study	GHD, 2021d	U
Memorandum Ashburton groundwater modelling- updated results	GHD, 2022	V
Hydrogeological Investigation	GHD, 2021c	W
Hydrogeology Modelling Peer Review	Cymod, Systems, 2022	X
Hydrogeology Modelling Peer Review	Cymod, Systems, 2021	Y

8.4.1 MODELLING

Specific hydrodynamic modelling studies (Water Technology, 2021c) (Water Technology, 2021d) (Water Technology, 2022b) and a hydrogeology modelling study (GHD, 2021c) have been conducted to assess potential impacts of the Proposal regarding:

- Surface water flows.
- Nutrient pathways.

- Groundwater seepage and associated salt crusting.
- Bitterns discharge and marine environmental quality.
- Dredging and marine environmental quality.

8.4.2 MODELLING PEER REVIEWS

Peer reviews of the above modelling studies have been conducted. The peer review process was undertaken in a comprehensive, rigorous and iterative manner.

- It is the opinion of the surface water, nutrient and marine peer reviewer that the models constructed by Water Technology (2021c, d and e) can be considered suitable for the purpose of identifying potential environmental impacts for the above processes (DHI, 2021).
- It is the opinion of the groundwater model peer reviewer that the groundwater model (GHD, 2021c) is fit for the purpose of assessing groundwater related environmental impacts of the Proposal (CyMod Systems, 2022).

8.5 EXISTING ENVIRONMENT

8.5.1 BENTHIC HABITAT TYPES

Table 48 below summarises the BCH types which have been identified across the development envelope with further details in subsequent Sections and mapping of all BCH presented in Figure 97.

Table 48: Benthic Habitat Types Across the Proposal Area

Environment	Habitat Types	Reference
Supratidal	Salt flat and samphire	Appendix Q (Biota, 2022a)
Intertidal	Mangroves, transitional mudflats, algal mats, sandy beaches and tidal creeks	Appendix M (AECOM, 2022a)
Subtidal	Soft sediment (potential seagrass), macroalgae dominated reef and macroalgae and sparse coral reef	

8.5.2 MANAGEMENT FRAMEWORK

8.5.2.1 TIDAL WETLAND OF NATIONAL IMPORTANCE

The proposed development is located within the Exmouth Gulf East wetland (WA007) which is listed in A Directory of Important Wetlands in Australia (ANCA, 1993) (Figure 86).

The Directory describes the significance of the wetland as “An outstanding example of tidal wetland systems of low coast of northwest Australia, with well-developed tidal creeks, extensive mangrove swamps and broad saline coastal flats”. The criteria for listing the wetland are:

- It is a good example of a wetland type occurring within a biogeographic region in Australia.
- It is a wetland which plays an important ecological or hydrological role in the natural functioning of a major wetland system/complex. Specifically, the mangroves buffer the coast from erosion, especially during cyclones, which occur in this area in most years.
- It is a wetland which is important as the habitat for animal taxa at a vulnerable stage in their life cycles. Specifically, the site is one of the major population centres for dugongs in WA and its seagrass beds and extensive mangroves provide nursery and feeding areas for marine fishes and crustaceans in the Exmouth Gulf (ANCA, 1993).

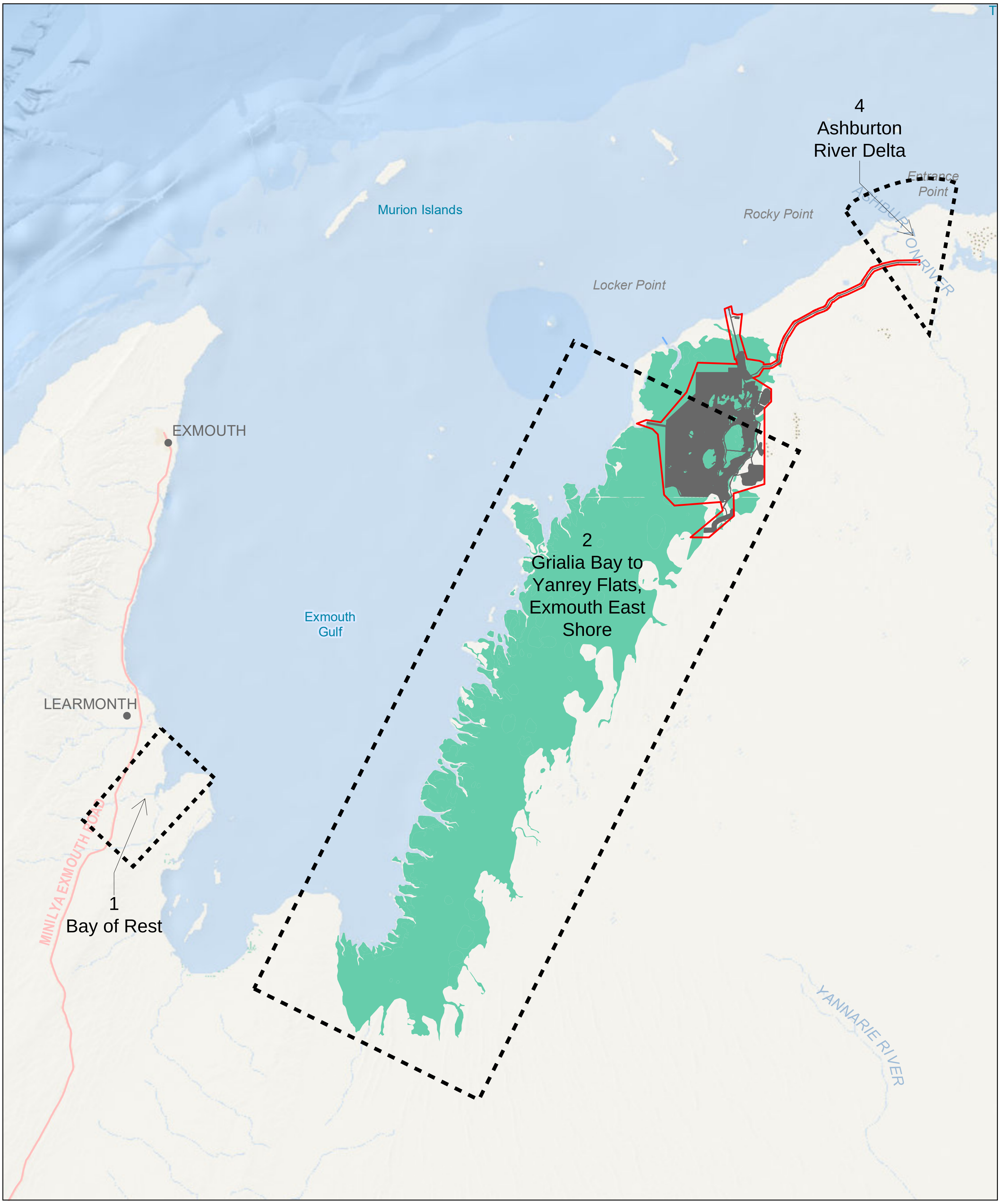
8.5.2.2 MANGROVE MANAGEMENT AREA

The EPA Guidance Statement (GS No. 1) for protection of tropical mangroves along the Pilbara coastline (EPA, 2001) identifies Mangrove Management Areas (MMAs) that support arid zone mangroves that have conservation significance. It also sets out the EPA's expectations for the protection of mangroves, while recognising current and potential future development areas. The proposed Proposal coincides with an area designated as having high conservation value within the GS No. 1 as 'Area 2 - Exmouth East Shore' (Figure 86).

The EPA's operational objective for GS No. 1 management areas is that no development should take place that would adversely affect the mangrove habitat, the ecological function of these areas and the maintenance of ecological processes which sustain the mangrove habitats (EPA, 2001).

8.5.2.3 PROPOSED NATIONAL PARK

In 2019, the State Government announced a plan to create five million hectares of new national and marine parks and conservation reserves across WA. An opportunity to reserve a National Park was identified approximately 8 km southwest of the Proposal along the eastern side of the Exmouth Gulf – called the Proposed Giralia National Park (Figure 33). The State Government is currently consulting with traditional owners regarding Indigenous Land Use Agreements. The completion of final National Park reservations is planned to occur during 2024 (DBCA, 2020).



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km
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- NOTE THAT POSITION ERRORS CAN BE >5M IN SOME AREAS

LOCALITY

Legend
- Development Envelope
- Disturbance Footprint
- Nationally Important Wetland (Exmouth Gulf East Wetland)

Preston Consulting

CREATED	JOB	DATE	REVISION
ENVIRONMAPS	PC2900360	9/05/2023	0

Ashburton Salt

ENVIRONMAPS | t: 0406 590 006 www.environmaps.com.au
Environmental Mapping Solutions

C:\GIS\Jobs\Preston Consulting\PC2900360 - s156a, K+S Salt\Figures\PC2900360_Nationally Important Wetland (Exmouth Gulf East Wetland)_230509.mxd

Figure 86: Exmouth Gulf East Wetland (WA007) and GS1 Mangrove Management Area

8.5.3 SUPRATIDAL HABITATS

8.5.3.1 SURVEY AND MAPPING METHODS

Detailed vegetation mapping conducted by Biota (2022a) has identified supratidal habitats in the study area in accordance with *Technical Guidance – Flora and Vegetation Surveys for Environmental Impact Assessment* (EPA, 2016i).

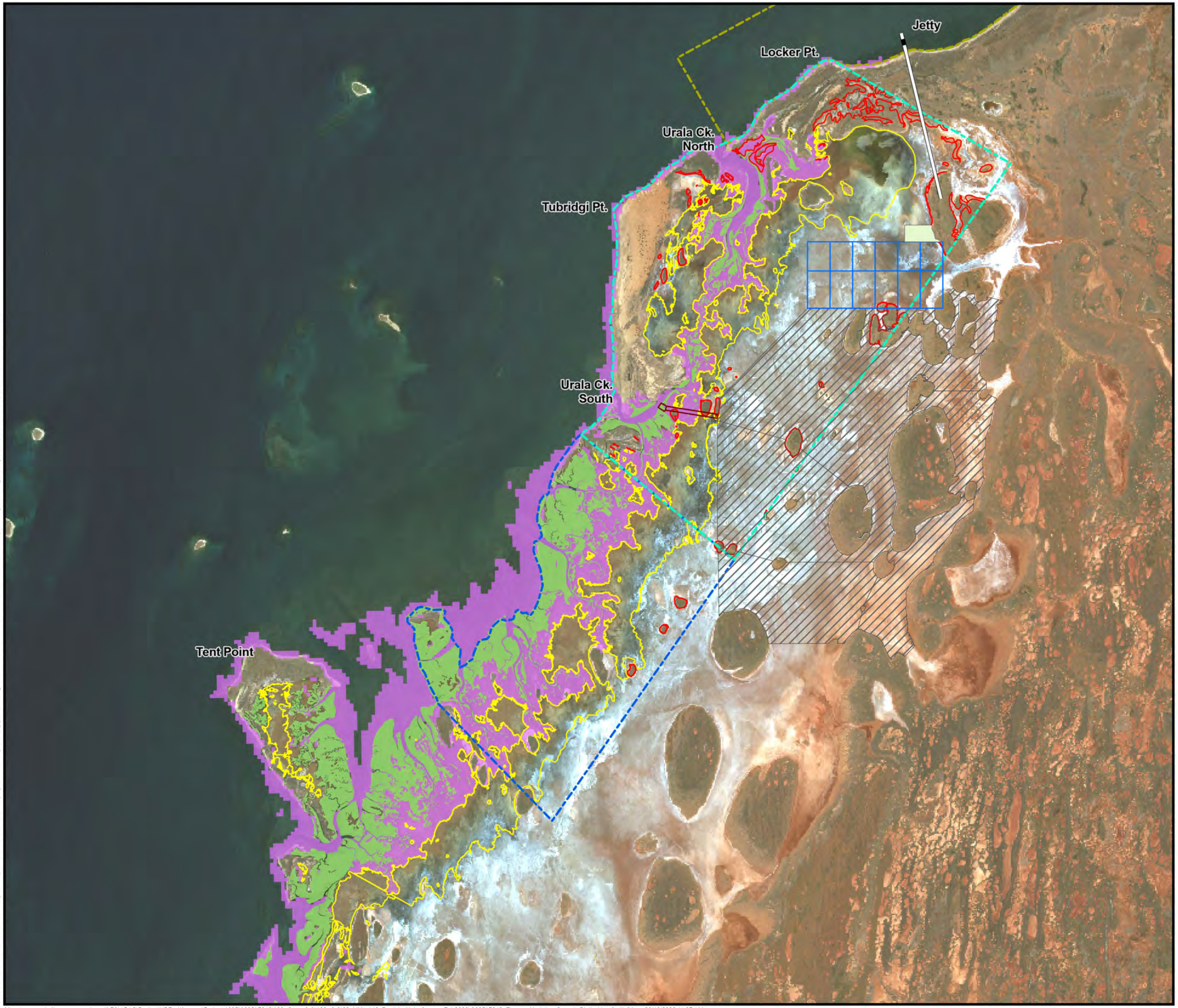
8.5.3.2 SAMPHIRE

Samphires are halophytic succulent herbs and small shrubs from the genus *Tecticornia* within the family Chenopodiaceae. Samphires are able to tolerate both prolonged waterlogging and drought. They are also highly salt-tolerant once established. Samphire species are physiologically adapted to live in very dry conditions, or areas that are "physiologically dry" because the water present is predominantly saline. Many samphire species occur in areas that only receive occasional or no tidal inundation and infrequent freshwater inputs, due to their ability to tolerate both saline conditions and prolonged drought (DPIRD, 2021), (Coleman, 2016). Samphire vegetation communities mapped by Biota (2022a) occur in various settings including within intertidal areas, at the base of supratidal slopes such as those fringing mainland remnant islands, and in claypans and drainage lines water emanating from the hinterland debouches.

The Biota (2022a) mapping identified large areas of samphire vegetation adjacent to the eastern and north-eastern sections of the study area that are not subject to tidal influences but would receive infrequent inundation from terrestrial sources via ephemeral drainage lines. As a result, the Biota (2022a) vegetation mapping outputs have been refined further to only show the distribution of those samphire areas that are potentially located within the intertidal zone of the defined Local Assessment Units (LAUs) This mapping unit shown is referred to as "intertidal samphires" in Figure 87 and combines the three samphire vegetation communities (Units S1 – S3) described below.

- Unit S1 - *Tecticornia doliiformis*, (*T. indica, T. halocnemoides, Frankenia ambita*) low shrubland over *Sporobolus mitchellii, Eragrostis falcata* very open grassland.
- Unit S2 - *Tecticornia doliiformis*, (*T. indica, T. halocnemoides, Frankenia ambita*) low shrubland over *Sporobolus mitchellii, Eragrostis falcata* very open grassland.
- Unit S3 - *Tecticornia auriculata*, (*T. indica, T. halocnemoides*) low shrubland over *Eragrostis falcata* scattered grasses.

Samphire identified by Biota were considered to be of local rather than regional significance, and of "somewhat elevated conservation significance". The samphire vegetation within the study area did not contain any significant flora species, other than two *Tecticornia* species that were not able to be identified (Biota, 2022a).



PROJECT ID 60597242
CREATED BY SmithS9
APPROVED BY ABougher
LAST MODIFIED 26 OCT 2022

AECOM
www.aecom.com

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LEGEND

- Bittens Pond (Option 8)
- Crystalliser (Option 8)
- Pond Layout (Option 8)
- Intake and Channel
- Jetty Alignment
- Conveyor
- Intertidal LAU North
- Intertidal LAU South
- Locker Pt. Nearshore LAU
- Intertidal Samphires
- Algal Mat Mapping
- Mangrove Mapping
- Transitional Mudflat mapping

Data sources:Prelimanary Mangrove and Algal Mat: (Biota 2005 and 2016)

Sentinel Imagery Oct 2022

Base Data: (c) Based on information provided by and with the permission of the Western Australian Land Information Authority trading as Landgate (2010)

Intertidal Habitat Mapping

K PLUS S SALT AUSTRALIA PTY LTD

ASHBURTON SALT PROJECT

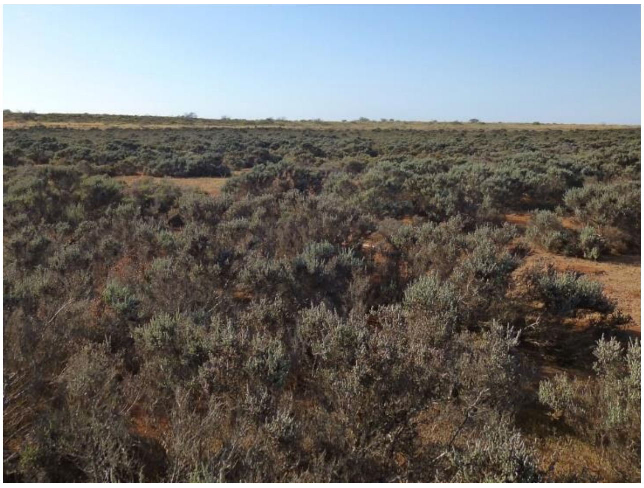
Map Document: (\\na.aecomnet.com\LFS\APAC\Perth-AUPER1\Legacy\Projects\605X\60597242\900_CAD_GIS\920_GIS\02_MXDs\10_Benthic_Hab_Survey_Feb2020\G60597242_Figures_Update_v2.aprx) Plotted by: SmithS9 on 26/10/2022 11:27 AM

A3 size

Figure 87: Intertidal BCH Mapping

Unit S1 (ASHC04, Phase 1)

Unit S1 (ASH55, Phase 2).



Unit S2 (ASH21, Phase 1)

Unit S2 (ASH35, Phase 1)

Unit S3 (ASH09, Phase 2).

Unit S3 (ASH54, Phase 2).

Figure 88: Samphire Recorded by Biota (2022a)

8.5.3.3 SALT FLATS

Immediately abutting the intertidal mudflat environment to the east, the tidal flats grade into supratidal salt flats (Figure 89). These salt flats are inundated only on rare occasions by extreme spring high tides, cyclone-induced storm surges or by freshwater during heavy rainfall and flood events. Extensive areas, up to 10 km wide, of salt flats occur in the study area and the majority of the proposed solar salt pond system would be located within the salt flats. Salt flat is not considered to be a benthic community, given it is bare salt crust with no living benthic communities detected within or on it (AECOM, 2022a).

Supratidal mud flats in the Pilbara bioregion are highly saline and are referred to here as salt flats. High surface temperatures and evaporation rates lead to hypersaline groundwater and the crystallisation of salt in surface sediments. The extreme conditions result in salt flats being devoid of marine or intertidal biota (no vegetation, algae or invertebrate fauna) and hence this habitat is not considered to support any benthic communities (AECOM, 2022a).

The hydrogeology within salt flat areas is characterised by the presence of hypersaline groundwater that is thought to have formed over time from combined actions of seawater submersion, evaporitic concentration of salts supplied periodically by tidal inundation and storm surge, and contribution from the regional groundwater throughflow from east to west. These create a dense hypersaline waterbody underneath the salt flats which is more dense than incoming groundwater from inland areas to the east or groundwater from tidal (ocean) influences to the west (GHD, 2021c).

Salt flat – Eastern Proposal area.

Surface salt crust overlaying the brown mudflat

Figure 89: Salt Flat Recorded by AECOM (2022a)

8.5.4 INTERTIDAL HABITATS

8.5.4.1 SURVEY AND MAPPING METHODS

A survey of intertidal habitats in the vicinity of the Proposal was undertaken AECOM in May 2019 to:

- Document intertidal habitats at selected localities within the study area.
- Ground truth preliminary mapping of mangrove and algal mat distribution to facilitate an assessment of the extent of potential Project-related impacts.
- Collect cores from algal mat and salt flat areas to confirm the presence/absence of algal mats and determine algal mat, structure, species composition and concentration of chlorophyll and phaeophytin (indicators of photosynthetic activity) (AECOM, 2022a).

Existing mangrove mapping from Biota (2005a) was overlaid onto recent high-resolution satellite imagery to ascertain the accuracy of the mapping boundaries. The boundaries of habitats identified from the preliminary mapping and any adjustments from post fieldwork (ground-truthing) analysis of imagery were delineated and recorded into an updated spatial dataset using ArcGIS software. Fine-scale adjustments of the resultant 'habitat' polygons were made on-screen in ArcGIS by using the rectified digital imagery as background mapping and correcting any local spatial inaccuracies. The polygons were cross-referenced to the habitat type codes and total areas for each habitat were calculated using ArcGIS (AECOM, 2022a).

Algal mat communities were mapped using remote sensing methods that exploit the characteristics of multispectral imagery and spectral signatures established for algal mats in the Proposal area. The multispectral imagery data were used to derive a spectral profile using red and infrared bands across known algal mat areas and then apply this spectral profile or signature to map algal mat areas. This was achieved by first calculating the Normalised Difference Vegetation Index (NDVI) to highlight the difference between the red and near infrared bands and a threshold applied to classify the algal mat using an automated classification method in the ArcGIS software package. The classified image was then further processed to remove artefacts of the image analysis procedures and manually edited to refine the mapping of algal mat areas. The field survey information related to the presence/absence and species composition of algal mats was also used as additional information to help confirm algal mat boundaries (AECOM, 2022a).

Transitional mudflats were mapped using high resolution aerial imagery (Fugro, 2018b) and the Lidar DEM (Fugro, 2018a) to digitise the mudflat areas which form a transition between the mangroves and other habitats. Sandy beaches were mapped using the fauna habitat mapping provided by Biota (2022b) and high resolution aerial imagery (Fugro, 2018b). Tidal creeks were mapped using the WA Coastline GIS dataset (Landgate, 2021) and high resolution aerial imagery (Fugro, 2018b).

8.5.4.2 MANGROVES

Mangroves occur within a range of local scale geomorphic settings: either forming the coastal shoreline (i.e., between Urala Creek South and Tent Point), fringing tidal creeks or on tidal flats extending landward from the coastal shoreline and tidal creek areas (Figure 90). Six species of mangroves were recorded:

- *Avicennia marina* – grey mangrove
- *Rhizophora stylosa* – spotted-leaved red mangrove
- *Bruguiera exaristata* – ribbed mangrove
- *Ceriops australis* – spurred mangrove
- *Aegialitis annulata* – club mangrove
- *Aegiceras corniculatum* – river mangrove (AECOM, 2022a).

A. marina was a widespread and dominant species that occurred within the majority of mangrove associations present including thickets and low forests. *R. stylosa* occurred mostly as monospecific stands but in some areas was mixed with taller *A. marina*. Furthermore, *C. australis* was less common than the above two species and typically occurred in association with *A. marina* to form open scrub along the landward margin of the mangrove zone (AECOM, 2022a).

Mangroves in the study area occupied the section of the intertidal gradient that was approximately between MSL (0 m AHD) and an elevation of approximately (0.7 m AHD), a level between MHWN (0.3 m AHD) and MHWS (0.9 m AHD) (Seashore Engineering 2021). The relationship between tidal elevation and frequency of tidal inundation plays a central role in controlling the distribution of mangrove species and assemblages by developing salinity gradients across the tidal zone. Data obtained from similar mangrove habitats on the Pilbara coast show that salinities increase from approximately 40-55 ppt at the more seaward areas (e.g. seaward and taller *Avicennia* zone and *Rhizophora* zone) to approximately 70-90 ppt in the more landward sections of the mangrove zone where low open *Avicennia* shrubland occurs (Semeniuk, 1983), (LDM, 1998), (Biota, 2005a). The dominant species in the study area (*A. marina*) has the greatest salinity tolerance of the Pilbara mangrove species and occurs in areas where groundwater salinity reaches up to 90 ppt (approximately 2.5 times seawater) (Gordon, 1987). With increasing tidal elevation through landward sections of the mangrove zone, the reduction in tidal inundation in combination with high evaporation rates results in groundwater and soil water conditions (mainly salinity) that are beyond the threshold tolerated by mangroves. In these areas the mud flats become devoid of mangrove vegetation and grade into a zone of bioturbated mud flat or algal mat habitat (AECOM, 2022a). This zonation in response to salinity gradient is represented schematically in Figure 91.

Low *Avicennia* mangrove forest fringing Urala Creek South.

Open *Avicennia* shrubland fringing the upper reaches of a tidal creek.

Tidal creek near the mouth of Urala Creek South that supports a mixture of mangrove species in foreground (*Aegialitis, Aegiceras, Avicennia* and *Ceriops*) and low dense *Rhizophora* forest in background.

Bruguiera exaristata mangrove in flower. This species was observed in a few isolated stands near the mouth of Urala Creek South (Site KS64).

Figure 90: Mangroves Recorded by AECOM (2022a)

8.5.4.3 TRANSITIONAL MUD FLATS

Seaward and landward of the mangrove zone exists a mosaic of “transitional mud flats” or mud flats which form a transition zone between the mangroves and other habitats. These have been termed “low tidal mud flats” and “high tidal mud flats” as described below (AECOM, 2022a).

8.5.4.3.1 LOW TIDAL MUDFLATS

Seaward of the mangrove zone and fringing some tidal creeks, is a zone of mostly bare or bioturbated mudflats which are submerged during higher tides and exposed lower tides. These low tidal mudflats contain high densities of crabs, molluscs and polychaetes which provide a food source for shorebirds when the mudflats are exposed at lower tides. The high density of crab holes which occur in the bioturbated zone acts as a conduit for recharging shallow groundwater with tidal water flows (AECOM, 2022a).

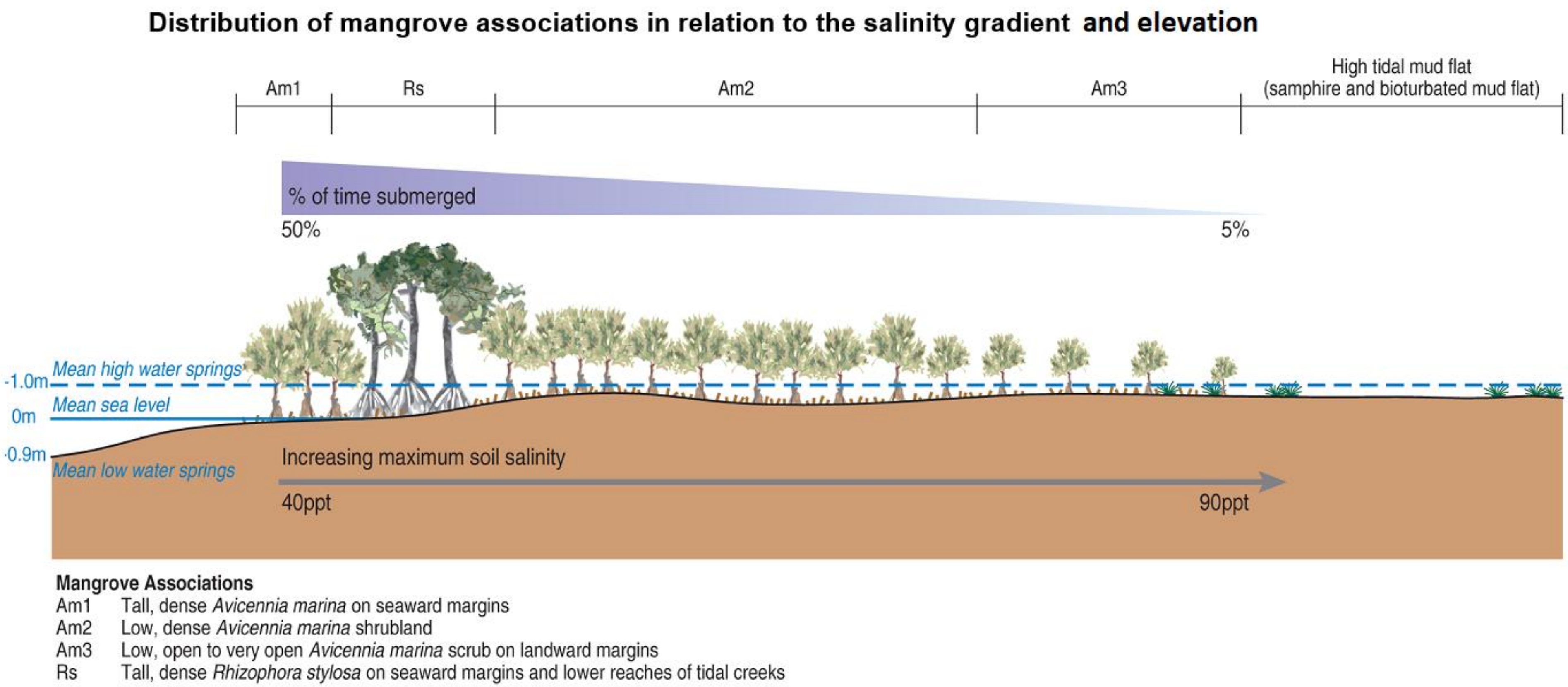


Figure 91: Zonation of Mangroves in Response to Salinity Gradient and Elevation

(AECOM, 2022a)

8.5.4.3.2 HIGH TIDAL MUD FLATS

Landward of the mangrove zone, large areas of mud flats extend approximately to the algal mat zone. These mud flat areas occur in the upper or higher sections of the intertidal zone and hence this habitat type is mapped as "high tidal mud flats". They are not regularly inundated by tides and often consist of a complex zonation or "mosaic" of the following sub-habitats:

- Bioturbated mud flats - areas devoid of macro-vegetation but heavily worked-over by burrowing crabs.
- Patches of sparse halophytic shrubs but with some crab burrows.
- Bare mud flats (AECOM, 2022a).

Landward edge of the mangrove zone. Low scattered *Avicennia* shrubs amongst salt tolerant halophytic shrubs (non-mangrove species).

Bioturbated mudflat occurring landward of the mangrove zone.

Figure 92: Transitional Mudflats Recorded by AECOM (2022a)

8.5.4.4 ALGAL MATS

Algal mats are comprised of a dense mass of individual filaments of cyanobacteria, formerly known as blue green algae and hence the term algal mat. They occur on the surface of mud flats which are infrequently tidally inundated. Algal mats fill an important ecological function in coastal arid zone systems, fixing atmospheric nitrogen into biologically available forms (Paling et al., 1989). In the study area, algal mats occur on mudflats landward of the mangroves and typically at elevations approximating Mean High Water Springs and slightly higher (Figure 93). Hence only on greater tides will the algal mats normally be inundated, and it is estimated that they are submerged for an average of 3% per month or less (Biota, 2005a). While algal mats extend over large spatial areas (~6,000 ha in the Tubridgi Point – Tent Point area), the elevation range over which they occur is very small (~ 10-20 cm). Factors that are thought to influence the distribution of algal mats are:

- Grazing pressure by invertebrates and too frequent tidal inundation (causing less stable substrates and destabilising tidal currents) contribute to maintaining the lower elevation limit of algal mat occurrence. Studies in the Onslow and Exmouth Gulf area document an area of high bioturbation activity (mostly from fiddler crabs, *Uca* sp.) on predominantly bare mud flat areas between the landward edge of the mangrove zone and algal mat areas (URS, 2010a), (Lovelock et al., 2010).
- Very low frequencies of tidal inundation and flushing at the upper elevation limits of mat occurrence would impose extreme salinities and dehydration (AECOM, 2022a).

8.5.4.4.1 SAMPLING METHODS

Algal mat communities were mapped using remote sensing methods that exploit the characteristics of multispectral imagery and spectral signatures established for algal mats in the survey area. Remote sensing techniques are increasingly being applied in the mapping of vegetation. Such techniques can provide data on both vegetation distribution and health and have capability to monitor vegetation communities over a wide geographic area. Vegetation contains chlorophyll which absorbs red energy and a leaf structure which reflects near infrared energy. The difference in the intensity of reflected red and near infrared energy can indicate the presence, as well as relative vigour and density, of vegetation.

The multispectral imagery data were used to derive a spectral profile using red and infrared bands across known algal mat areas and then apply this spectral profile or signature to map algal mat areas. High resolution (30 cm) multispectral imagery captured by manned aircraft was used to derive a spectral profile using red and infrared bands across known algal mat areas and then apply this spectral profile or signature to map algal mat areas. This was achieved by first calculating the Normalised Difference Vegetation Index (NDVI) to highlight the difference between the red and near infrared bands and a threshold applied to classify the algal mat using an automated classification method in the ArcGIS software package.

The mapping was supported by ground truthing a series of transects and helicopter flyovers that extended from the seaward edge of the algal zone, through the core algal mat area to the landward edge where peripheral or fragmented algal mats intergraded with salt flats. A series of mini-cores were collected along the transects to:

- Confirm the presence/absence of algal mats.
- Determine species composition by microscope examination.
- Analyse for chlorophyll ‘a’ and phaeophytin.

Factors that that may potentially influence the accuracy of algal mat mapping via the above remote sensing technique and other techniques previously used along the Pilbara coast include: tidal wetting/drying regimes and periods of rainfall; development of thin salt crusts on the tidal flat surface; and the presence of pooled water on the landward sections of the tidal flats.

It is considered that the mapping technique (analysis of multi-spectral imagery) used for the Proposal provides a more scientifically robust and systematic method of mapping algal mat distribution by comparison with that used previously for mapping algal mats along the Pilbara coast. That being, one based of the human interpretation of aerial imagery involving identifying possible algal mat areas on the basis of photo-tones displayed on aerial imagery (i.e. attempting to allocate “algal mat” polygons around areas of “greyness on tidal flats” of differing degrees that are spatially and temporally variable due to the influencing factors listed above).

8.5.4.4.2 RESULTS

Table 49 below summarises the cyanobacterial taxa and chlorophyll-a and phaeophytin (indicators of photosynthetic activity) recorded from the algal mat cores. The sampling shows that more species were present in the core algal mat area compared to the peripheral area (6 species versus 4 species), core areas were approximately 2 mm thicker than peripheral areas, chlorophyll-a concentration was around 4 times higher in core areas compared with peripheral areas, whilst phaeophytin was only marginally higher in core areas (AECOM, 2022a).

Table 49: Summary of Data Recorded from Algal Mat Cores

Algal Taxa	Core mat area	Peripheral mat area
Anabaena sp.	Common	Not detected
Caltothrix sp.	Rare	Not detected
Cyanothece sp.	Not detected	Rare
Lyngbya sp.	Abundant	Rare
Microcoleus sp.	Abundant	Common
Oscillatoria sp.	Abundant	Common
Schizothrix sp.	Common	Not detected
Diversity	6	4
Mat thickness	2-5 mm	1-3 mm
Chlorophyll-a (mg/m^2)	414 ± 77	137 ± 22
Phaeophytin (mg/m^2)	166 ± 29	133 ± 27

	
Core algal mat showing the crenulate mat structure that was most prevalent in the Proposal area.	Close up view of the crenulate algal mat structure.

Figure 93: Algal Mat Recorded by AECOM (2022a)

8.5.4.5 SANDY BEACHES

Sandy beaches occur along the western and northern shorelines of Tubridgi Point and extend east along the coast from Urala Creek South, including the Locker Point area and the proposed location of the export jetty (Figure 94). The beaches are comprised of fine, well sorted sand with a near-horizontal supratidal ramp and a steep intertidal beach slope. The surface of the beach slope was very smooth, without bioturbation except for occasional crab burrows. There was no mid-lower littoral sand flat, the beach simply sloping into the sublittoral zone. Sandy beaches, composed of medium to coarse-grained calcareous sands and shelly sands, are widespread along the coastline. The beaches are backed by low foredunes (vegetated by coastal species, e.g., *Spinifex longifolius, Rhagodia preissii* and *Ipomea brasiliensis*) which front parabolic dune blowouts or vegetated parallel dune systems (AECOM, 2022a).

8.5.4.6 TIDAL CREEKS

Tidal creeks form a dendritic channel system through the intertidal environment. Their key role is to provide import and export of tidal water flows, nutrients and biota which form the intertidal environment. They range in size from large estuary like waterways (such as Urala Creek North and South) to much smaller dendritic channels branching off the main channels (Figure 94). Tidal creeks are interspersed throughout the mangrove, mudflat and algal mat systems. Tidal creeks are a major part of the intertidal system, with parts of the creeks becoming exposed mudflats at low tide (therefore being intertidal), although the deeper parts of the creeks are predominantly subtidal (always submerged by water). It is therefore subjective whether the tidal creeks are included as intertidal or subtidal habitat (AECOM, 2022a).

8.5.4.7 SALT FLATS

As indicated in Section 2.9 of AECOM (2022a; Appendix M), salt flats are subject to high surface temperatures and evaporation rates leading to the crystallisation of salt in surface sediments. A similar process occurs in salt pans and salt lakes through inland areas of WA. The extreme conditions result in salt flats being devoid of marine or intertidal biota (no vegetation, algae or invertebrate fauna). This habitat does not support any benthic communities and, for that reason, salt flats were not mapped as a BCH type (i.e. given the bare salt crust with no living benthic communities detected within or on it).

Sandy beach in the Locker Point area near the proposed jetty location

Narrow sub-creek located near the proposed intake channel alignment

Figure 94: Sandy Beach and Narrow Tidal Sub-Creek Recorded by AECOM (2022a)

8.5.5 SUBTIDAL HABITATS

8.5.5.1 SURVEY AND MAPPING METHODS

A survey of subtidal habitats in the vicinity of the Proposal was undertaken by AECOM and their sub-contractor Geo Oceans in February 2019 to:

- Document subtidal habitats at selected localities within the study area.
- Ground truth to confirm preliminary mapping of subtidal habitat distribution and facilitate an assessment of the extent of potential Project-related impacts.

A review of existing subtidal habitat data of relevance to the study area (primarily that from the Yannarie Solar Salt proposal and the Wheatstone project) along with recent satellite imagery and LiDAR data, was undertaken. Ground truthing transects across target areas were completed using a high definition towed video camera. In total, 73 transects spanning 5.9 km of seafloor were completed. Subtidal habitat boundaries were delineated using a combination of towed video data, aerial imagery and satellite imagery, with additional cross referencing against LiDAR and sonar data acquired specifically for the Proposal (AECOM, 2022a).

8.5.5.2 REGIONAL SUBTIDAL HABITATS

The subtidal benthic habitats of the north eastern side of the Exmouth Gulf, and the area further north east towards Onslow, is characterised by predominantly soft and often silty sediment habitats which extend for kilometres offshore to the 10 m isobath (Oceanica, 2006) (URS, 2010c). Waters in the area are typically turbid owing to their shallow depth (<5 m), the silty substrate, complex tidal movements and dominant west, south westerly and southerly winds which achieve considerable fetch across the Exmouth Gulf, resulting in raised sea state, thus causing resuspension of the silty substrate in shallow sandy habitats (DHI, 2010).

Subtidal habitats that support complex epibenthic faunal biota are often limited to the fringes of nearby islands, shoals and shallow limestone pavement reef (URS, 2010b). The benthic subtidal biota are typical of the shallow Pilbara coastal areas and the communities are generally dominated by macroalgal genera in areas of harder substrate, with mixed assemblages of sponges, soft corals, hydroids, bryozoans and ascidians, as well as the occasional hard coral. The area also supports several tropical ephemeral seagrass species which colonise the shallow unconsolidated (often described as 'soft') sediment habitats; however, meadows are generally transitionary with significant variation in temporal and spatial biomass Vanderklift et al. (2017).

8.5.5.3 LOCAL SUBTIDAL HABITATS

It was found that three habitat types occurred locally as described below (AECOM, 2022a) (Figure 95 and Figure 96).

8.5.5.3.1 SOFT SEDIMENT (POTENTIAL SEAGRASS HABITAT)

The majority of the study area was found to be unconsolidated sediment consisting of predominantly sand and silt (supporting no epibenthic faunal communities). This habitat is typical of the Pilbara region where a combination of unconsolidated sediment in shallow depths and high energy water movement impedes the establishment of epibenthic faunal communities. However, soft sediment does have the potential to support ephemeral seagrasses in the future. As a result, all unconsolidated sediment habitats in the nearshore LAU are viewed as potential seagrass habitats (AECOM, 2022a). Of the soft sediment habitats observed and subsequently mapped by surveys undertaken by Geo Oceans (2019), seagrasses were observed at a number of locations, typically in densities of less than 5% cover, making remote sensing methods unreliable for mapping these habitats over large areas. Due to this, seagrass cover was extrapolated to regions surrounding actual observations to produce estimated seagrass presence based on the available ground truthing data.

Areas of seagrass were observed at two locations offshore (to the east and west) of the proposed jetty location and at a number of locations in shallow waters, extending offshore at the western end of the Nearshore LAU. Small areas of seagrass were identified in similarly low densities along single transects between the proposed jetty and mouth of Urala creek North. BCH comprising greater than 10% seagrass was only mapped along a section of one transect outside the mouth of Urala Creek South.

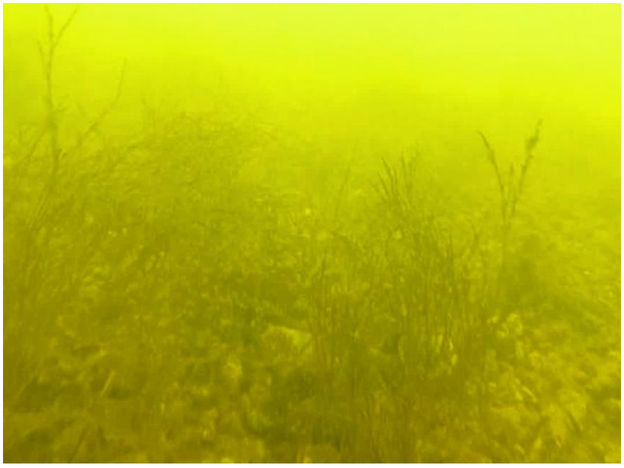
8.5.5.3.2 MACROALGAE

Macroalgae inhabited reef was found to occur nearshore on the reef pavement extending from the beach along the coast. In this habitat type, mixed assemblages of macroalgae were prominent with *Sargassum* the most dominant genus; lobed brown algae, *Caulerpa* and *Halimeda* species also occur in this habitat type (AECOM, 2022a).

8.5.5.3.3 MACROALGAE AND SPARSE CORAL

Reef dominated by macroalgae, interspersed with sparse scattered coral was found to occur on the seaward edge on the reef pavement extending offshore along the coast and within a patchy area approximately 2 km offshore locally. Mixed assemblages of macroalgae are dominant in this habitat type with *Sargassum* the most dominant genus; lobed brown algae, *Caulerpa* and *Halimeda* species also occur in this habitat type. Other benthic species observed in this habitat include scattered corals, sponges, hydroids and ascidians (AECOM, 2022a).

Habitat 1: Soft sediment



Habitat 2: Macroalgae (sparse brown algae)

Habitat 2: Macroalgae (reef with *Sargassum* sp., *Halimeda* sp., *Caulerpa racemosa*) | Habitat 3: Macroalgae and sparse coral (reef with *Sargassum sp.* sparse coral and sponge sp.)

Figure 95: Subtidal Habitats Mapped by AECOM (2022a)

8.5.6 INTRODUCED MARINE PESTS

Introduced Marine Species (IMS) are animals, plants, algae and other biota existing in a region beyond their natural geographical range, to which they have generally been translocated by human activity. Australia currently has over 250 known IMS but only a small proportion have become Introduced Marine Pests (IMPs). IMPs are IMS that harm the marine environment, social amenity or industries that use the marine environment, or have the potential to do so if they were to be introduced, established, or spread in Australia's marine environment (DAWR, 2018).

In 2008, Huisman *et al.* reported on 102 marine and estuarine species that were known to be introduced and established in WA at the time. Sixty species were considered to have been introduced by anthropogenic activity. Three of these species introduced to WA were listed on the Australian National IMS list (NIMPCG (2009a, 2009b): the dinoflagellate *Alexandrium minutum*, the bivalve *Musculista senhousia* and the polychaete *Sabella spallanzanii* (Wells, 2018)).

Over the last 20 years, the Pilbara coastline has been the most intensively surveyed area for Introduced Marine Pests (IMP) in the world. The Department of Fisheries undertook surveys using the National Introduced Marine Pests Coordination Group (NIMPCG) methodology between 2010 and 2015 in Dampier and Port Hedland (AECOM, 2022b). Wells (2018) developed an extensive database of 5,532 shallow water marine species that have been recorded in the Pilbara. Only 17 of these are believed to have been introduced and only one, the ascidian *Didemnum perlucidum* (white colonial sea squirt), is listed as an IMP (Wells, 2018). *Didemnum perlucidum* was first detected in the Fremantle marine area in 2010. Following this it was rapidly found throughout WA from Esperance on the southeast coast, along the west coast, to the Kimberley in the northeast and in Darwin, Northern Territory. It is widespread in the Pilbara and is expected to colonise artificial structures constructed by the Proposal (AECOM, 2022b).

8.5.7 LOCAL ENVIRONMENTAL VALUES

Local environmental values related to benthic habitat and communities have been identified as follows:

- Local intertidal BCH in particular mangroves and algal mats.
- Local subtidal BCH in particular soft sediment (with potential for ephemeral seagrass), macroalgae and sparse coral.

These local values have been mapped overlayed by the Proposal in Figure 97 and Figure 96 using GIS data from the Proposal BCH study (AECOM, 2022a).

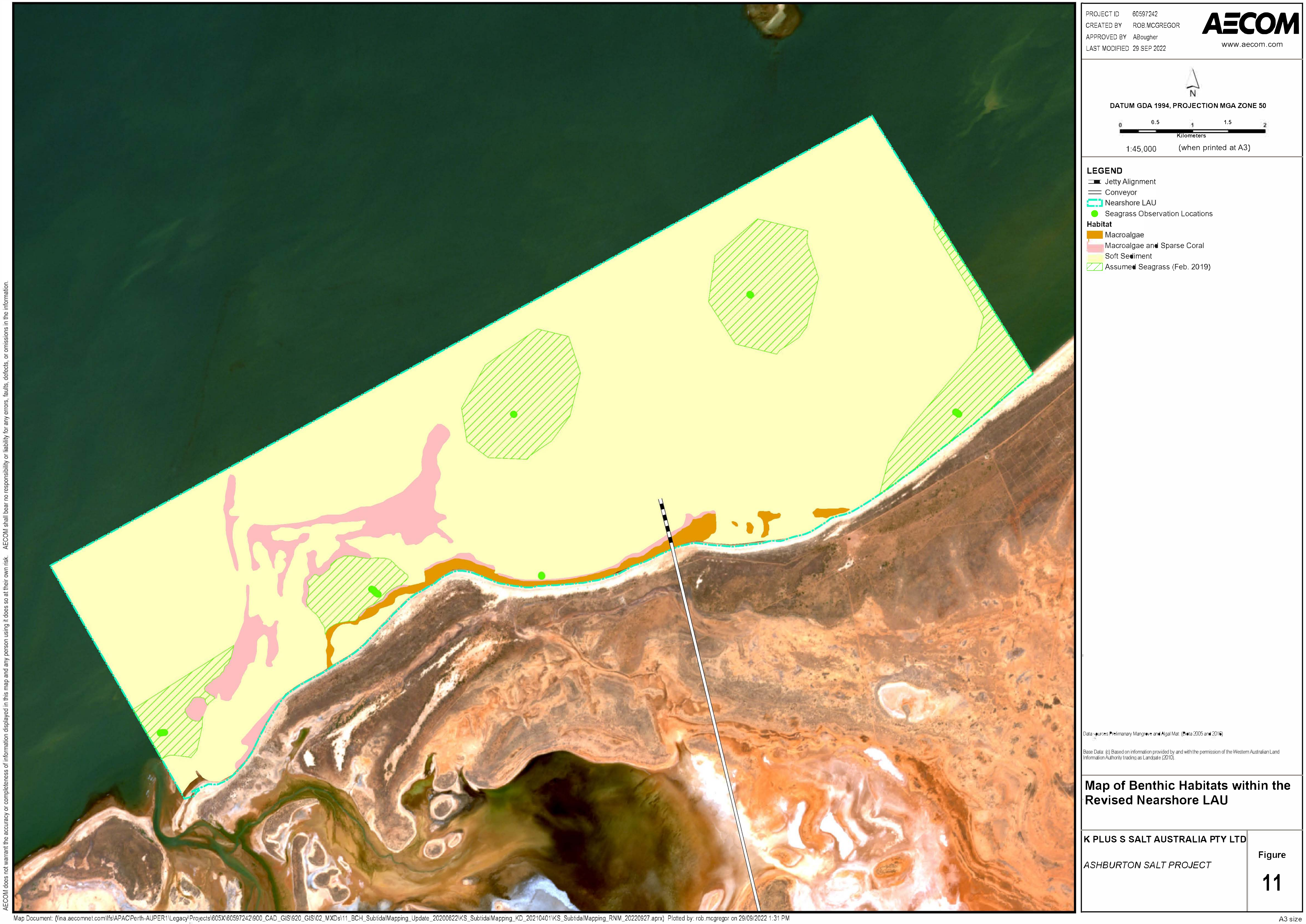


Figure 96: Subtidal Habitats Mapped by AECOM (2022a)

8.5.8 REGIONAL ENVIRONMENTAL VALUES

Regional environmental values related to benthic habitat and communities have been identified as follows:

- Regional intertidal BCH in particular mangroves and algal mats of Exmouth Gulf eastern coast.
- Regional subtidal BCH in particular nearshore subtidal habitats of Exmouth Gulf and Onslow Coast.

These regional values have been mapped overlayed by the Proposal in Figure 98 using GIS data of habitat from the BCH study (AECOM, 2022a) and regional marine charts.

8.6 POTENTIAL IMPACTS

The following potential impacts have been identified for this Proposal:

- Direct disturbance to BCH.
- Indirect impacts to intertidal and supratidal BCH due to:
    - Altered tidal movements
    - Reduced inundation as a result of pumping of seawater
    - Pond seepage modifying the shallow groundwater
    - Increased groundwater salinity
    - Increased sediment deposition during construction
    - Modified rainfall related surface water inputs
    - Modified nutrient pathways
    - Introduction of marine pests
    - Hydrocarbon or chemical leaks or spills.
- Indirect impacts to subtidal BCH due to:
    - Dredging and tailwater release
    - Bitterns discharge
    - Introduction of marine pests
    - Hydrocarbon or chemical leaks or spills.

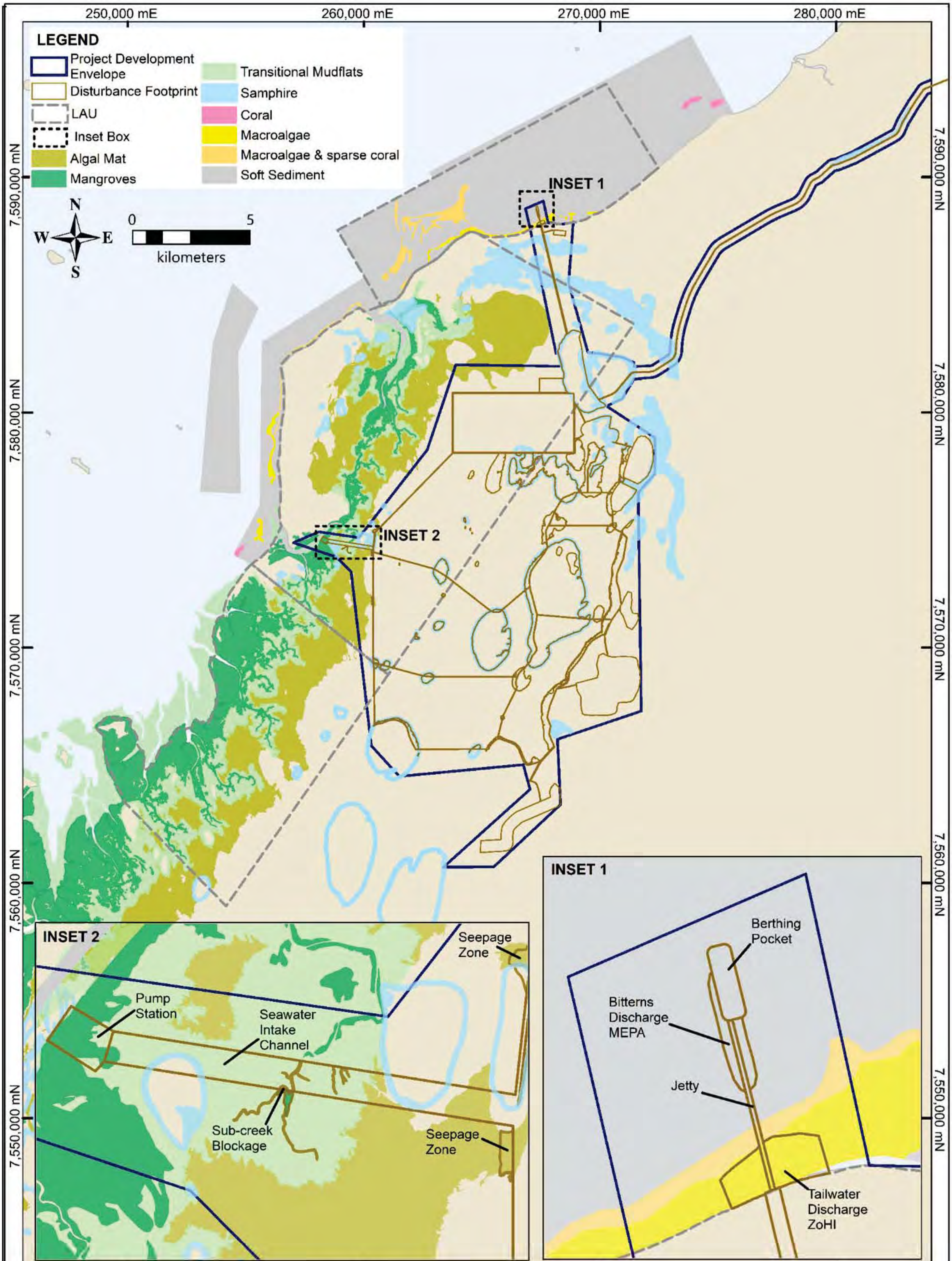
In addition, the Proposal will modify the predicted response of intertidal and supratidal BCH to SLR.

The above potential impacts are discussed in the sub-sections below.

8.6.1 LOCAL ASSESSMENT UNITS

EPA (2016f) requires proponents to present cumulative residual loss or significant impact to BCH in the context of spatially based areas referred to as LAUs. Both Intertidal and Subtidal LAUs have been nominated to reflect the Proposal layout, with a pond system and related infrastructure being located within supratidal and intertidal areas, and the jetty, berthing pocket and diffuser located in the subtidal area near Locker Point. These LAUs are shown in Figure 97.

Consultation occurred with DWER Marine Ecosystems Branch in order to designate these proposed LAUs. A specific LAU has not been defined for supratidal habitats given the geographic scope of the EPA technical guidance is to the high water mark of the intertidal zone (EPA, 2016f). However, impacts to supratidal samphire vegetation have been assessed locally and regionally in Sections 8.6.2 to 0 to provide context.



Date: 25/09/2021 | Paper: A4 P | GDA94, MGA50
Data Source: 4A, 4E, 13D, 17A
File Info: K04_J10_Local_BCH_20210707.WOR

Figure 97: Local Values Benthic Habitats and Communities

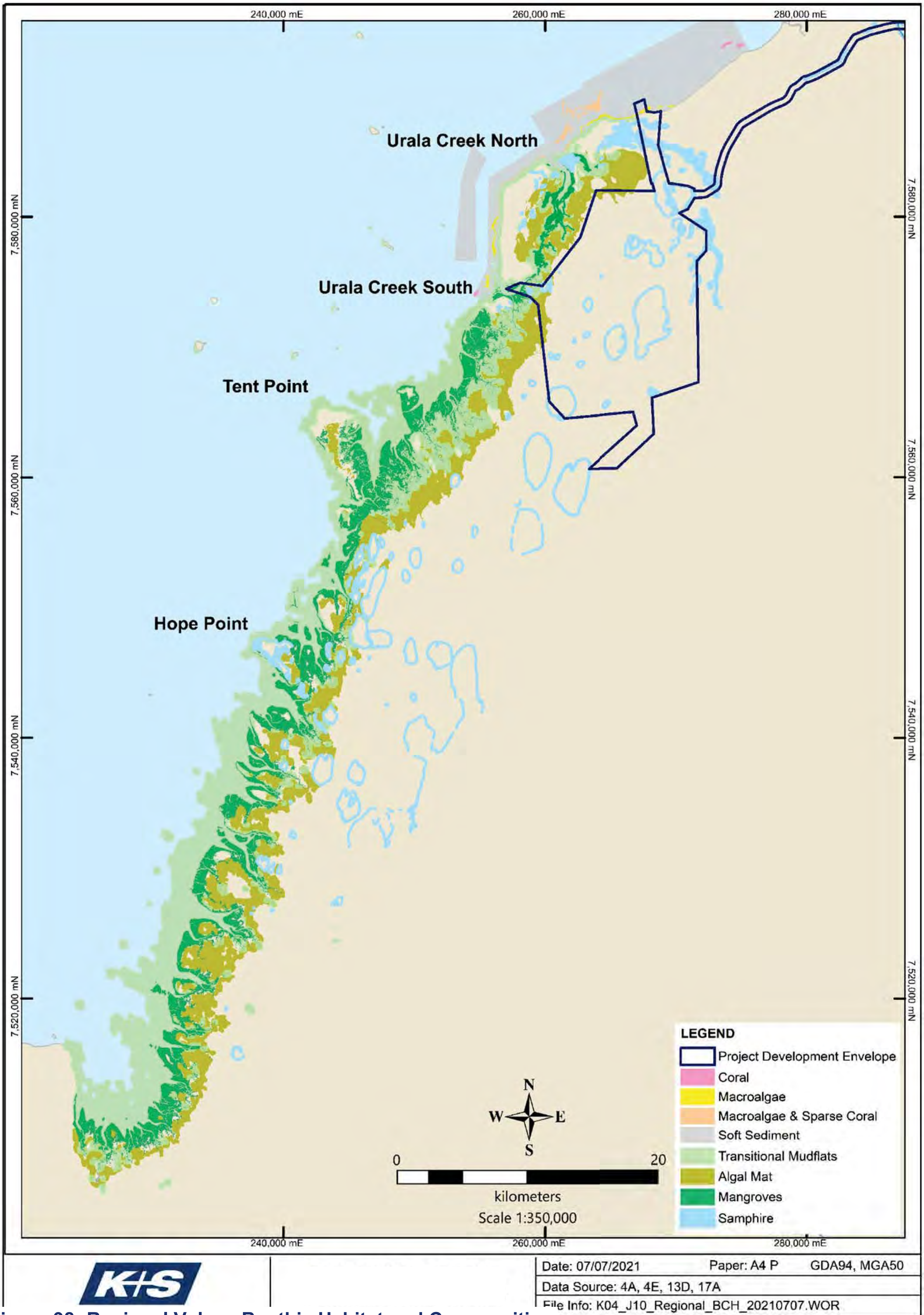


Figure 98: Regional Values Benthic Habitat and Communities

8.6.2 DIRECT IMPACT TO INTERTIDAL AND SUBTIDAL BCH

Construction and filling of the concentration and crystalliser ponds, seawater intake channel (including pump station), jetty and berthing pocket will result in the direct loss of approximately 36 ha of intertidal BCH and approximately 2.6 ha of subtidal BCH. The direct loss estimates derived from overlaying the predicted direct disturbance footprint are provided in Table 50 and shown in Figure 97.

Table 50: Direct BCH Loss within each LAU

BCH	Intertidal LAU South		Intertidal LAU North		Subtidal LAU		Total (ha)
	ha	%	ha	%	ha	%	
Intertidal							
Mangroves	0	0	3.94	0.73%	0	0	3.94
Samphires	0.17	2.83	36.19	7.88%	0	0	36.36
Transitional mudflat (high tidal mudflats)	0	0	17.81	0.90%	0	0	17.81
Transitional mudflat (low tidal mudflats)	0	0	0	0	0	0	0
Algal mat	0	0	12.74	0.38%	0	0	12.74
Sandy beaches	0	0	0.99	0.77%	0	0	0.99
Tidal creek	0	0	0.30	0.10%	0	0	0.30
Subtidal							
Soft sediment (potential seagrass)	0	0	0	0	2.3	0.08%	2.3
Recorded seagrass	0	0	0	0	0	0	0
Macroalgae	0	0	0	0	0.22	5.62%	0.22
Macroalgae & sparse coral	0	0	0	0	0.1	0.04%	0.1

8.6.1 INDIRECT IMPACTS TO INTERTIDAL AND SUBTIDAL BCH

The assessment of potential indirect impacts to BCH has been considered in Appendix M (AECOM, 2022a) for a range of Project-related factors as summarised below in Table 51.

Table 51: Potential Indirect Impacts to Intertidal and Subtidal BCH

(AECOM, 2022a)

Impact	Assessment	Outcome
Altered Tidal Movements	In general, the modelling outputs show that, due to the alignment of salt pond outer levees being located well landward (> 800 m) of the mangrove zone and above MHWS elevations, there is not expected to be any significant modifications to tidal flows to/from mangrove and algal mat areas that are likely to cause impacts. There are no predicted changes to percentage submergence time (over one year) for all mangrove habitats surrounding Urala Creek North and South, due to the large setback between the seaward embankments and the mangrove zone (with the exception of a small area of mangroves near the intake channel, as discussed below) (AECOM, 2022a). The modelling indicates: • Minimal impacts to water levels or duration of tidal inundation. • Localised areas adjacent to the pond and seawater intake channel embankments may experience minor temporary ponding due tidal water during the higher tides. • A small area of scattered mangroves and minor tidal sub-creek upstream of the seawater intake may be impacted due to the barrier effect of the seawater intake channel (AECOM, 2022a) (Water Technology, 2022b).	Impact to 0.34 ha of scattered mangroves 2.6 ha of a small tidal sub-creek upstream from the intake channel.
Reduced inundation as a result of pumping of seawater	Modelling of changes to tidal inundation patterns within mangrove and algal mats undertaken by (Water Technology, 2022b) was based on the conservative pumping requirements; it was assumed that the seawater intake as continuous pumping in both low and high tide conditions (however pumping will not occur during low tide). The modelled output did not indicate any detectable pumping-related changes to the percentage of time that mangrove and algal mat areas are inundated (AECOM, 2022a) (Water Technology, 2022b). Samphire vegetation communities occur above the elevation range of the mangroves and no changes are predicted to tidal inundation time above the mangrove elevation range and therefore there is no predicted impacts to samphires from seawater pumping within Urala Creek South (AECOM 2022a).	No impacts to mangroves or algal mat due to pumping of seawater.
Pond seepage modifying the shallow groundwater	Modelling indicates that groundwater seepage and subsequent evaporation has the potential to form a crystallised salt layer (salt crust) on the ground surface on localised areas of tidal flats immediately next to the pond levees. The predicted distribution of seepage water and salt crusts is immediately adjacent (within 50 m) of the pond embankments and is not predicted to impact mangroves which are > than 800 m away. However, the predicted seepage zones do coincide with some small areas of algal mats and samphire adjacent to the western pond embankments and given these algal mats may become permanently submerged, it is assumed on conservative basis that these algal mats may be impacted (AECOM, 2022a) (GHD, 2021c).	Impact to 3.94 ha of algal mat and 0.09 ha of samphires.

Impact	Assessment	Outcome
Increased groundwater salinity	The downward seepage of fresher pond water is predicted to displace existing hypersaline groundwater beneath the ponds. Over time, salts from existing hypersaline groundwater and seepage water are predicted to accumulate in the groundwater outside the salt ponds, resulting in the formation of more saline and denser groundwater. Predictive simulations indicate that over time a halo of increased groundwater salinity will propagate laterally around the perimeter of the pond complex (GHD, 2021c). Given the shallow root structure of mangroves, further analysis was undertaken to account for the salinity stratification where tidal flushing results in less saline groundwater at the surface of the water table which is tapped by mangrove roots. Salinity increases were estimated for the top 0.2 m of the water table to correlate with the zone of the water table (approximately 0.3-0.5 m below ground level (BGL)) into which mangrove roots would tap. The result of this analysis is a contour of maximum salinity increase of 15 kg/m^2 in the top 0.2 m of the water table after 50 years. The analysis suggests that there will not be any impacts to mangroves from Project-related salinity increases given they are likely to be less than the salinity increase trigger levels (10-15 kg/m^2) used in mangrove monitoring programs in the Pilbara that are designed to correlate changes in mangrove health with changes in shallow groundwater conditions (URS, 2010a), (Chevron, 2015) (AECOM, 2022a). Increases in groundwater salinity are not likely to result in impacts to algal mats as the mat structures occur as a 2-3 cm veneer on the ground surface and salinity conditions in that layer are regulated by surface water flows from either tidal inundation or rainfall events, rather than by connectivity to groundwater approximately 1.5 m below the ground surface. The model results and subsequent interpretation are considered conservative due to assumptions and limitations in the modelling, as detailed in (AECOM, 2022a) (GHD, 2021c).	No impacts to mangroves or algal mat due to increased groundwater salinity.

Increased sediment deposition during construction	Potential sources of Proposal-related sediment deposition in mangrove and algal mat areas are likely to be very localised and limited to (AECOM, 2022a):
	• A temporary and localised increase in the turbidity of tidal waters of Urala Creek South during construction of the seawater intake inlet well. Background turbidity concentrations along the Onslow coastline are high under existing conditions and intertidal environments in the area already cope with periods of very high turbidity during flood events. In this context, it is unlikely that any temporary increases to turbidity from the seawater intake construction works would result in additional sedimentation at a scale that could threaten the tidal creek habitat or mangrove communities. Spoil from the excavation of the inlet well will be contained within the seawater intake channel embankments and managed in accordance with the ASSSMP (GHD, 2021b). Any water within the spoil will be retained on land, treated, and evaporated, and sediment used in construction works (i.e., there will be no tailwater discharge into the creek).
	• Construction of the outer or western levees for the pond system and intake channel. Prior to the containment of the levee fill materials by the placement of rock armour on sides of levees, there is the potential for some fill material to be washed into intertidal areas. Localised sediment run-off during construction works within sensitive areas can be managed by employing appropriate sediment run-off measures and erosion control measures. These include the following:
	  ○ Incorporate a buffer area between the outer disturbance boundary and the outer construction boundary (e.g., toe of the perimeter bund).
	  ○ Containment of sediment within perimeter levee walls in sensitive areas by use of geofabric and rock armour.
		No impacts to mangroves or algal mat due to sediment deposition.

Increased sediment deposition during vessel movements	The Proposal may increase sedimentation around active vessels due to propeller churn. This will predominantly occur within and around the dredged berth pocket. All sedimentation impacts from vessels manoeuvring around the berth pocket are likely to fall within areas predicted to already be impacted by dredging (ZoHI) and bitterns discharge (the LEPA). Once away from the berth pocket the vessels will follow a generally straight path to deeper water, which will result in much lower sediment lift than manoeuvring activities.	Limited impacted to sub-tidal BCH from propeller churn

Impact	Assessment	Outcome
Modified rainfall related surface water inputs	Water Technology (2021c) conducted modelling to simulate rainfall flooding extent and duration for the Proposal area and found that rainfall related flooding of the area occurs approximately 5 – 10% of the time, with long periods of drought between relatively short duration rainfall flooding events. This concurs with Geoscience Australia (2021) Water Observations from Space data which also shows rainfall related flooding occurs between 5-10% of time. Hence, freshwater input to Pilbara mangroves is very irregular and only occurs after significant rainfall events. Groundwater salinities become very high beneath the extensive arid zone salt flats (GHD, 2021c). Under the Pilbara arid conditions, there is no sustained dilution of the hypersaline groundwater conditions by freshwater input (as occurs in the tropics) and therefore no freshwater dependent hinterland fringe of intertidal BCH has developed within the arid Pilbara (Semeniuk, 1983). Rather the intertidal BCH habitats in the arid Pilbara are predominantly reliant on tidal flushing which promotes a reduction in salinity of shallow groundwater, which is not maintained by infrequent freshwater inputs (AECOM, 2022a). Semeniuk (1983) recognises that at the small scale there can be freshwater seepage influencing mangrove distribution at localised areas within the Pilbara coast such as in tidal flat areas immediately next to limestone terrain or in alluvial fans. These scenarios either do not occur in the Proposal area or the very localised seepage (e.g., next to limestone terrain) would not be modified due to the alignment of the ponds (AECOM, 2022a). The salinity conditions required for the survival of mangroves and algal mat along the arid Pilbara coast and within the Proposal area, are maintained by regular tidal inundation and not by infrequent freshwater sources such as the fluvial input from the hinterland. Modelling of coastal hydrodynamics predicts that there will be no significant changes to tidal inundation patterns within mangroves and algal mats (Water Technology, 2022b). Hence, no impacts to mangroves or algal mat are predicted to occur due to Proposal related modification to infrequent freshwater input from the hinterland to intertidal areas. This predicted outcome is supported by monitoring and observations from other salt fields in the Pilbara that have been in operation for several decades and which have similar pond alignments to the Proposal (AECOM, 2022a).	No impacts to mangroves or algal mat due to modified rainfall related surface water inputs.
Modified nutrient pathways	Detailed modelling of nutrient pathways predicted small impacts to nutrient pathways in proportion to the total estimated nutrient flows into the Proposal catchment and Exmouth Gulf (Water Technology, 2021d). It was estimated that: • A local post-development proportional reduction in nitrogen flows into the Proposal catchment of 0.8% of land and ocean sources. • A regional post-development proportional reduction in nitrogen flows into the Exmouth Gulf of 0.24% of land and ocean sources (Water Technology, 2021d). Based on this highly conservative assessment, it can be concluded that the proposed development will not significantly alter nutrient exports or pathways due to the small scale of the predicted reductions and their infrequent nature, particularly when compared to the overall nitrogen budget of the Exmouth Gulf. Impacts related to nutrient pathways are not predicted to compromise existing environmental values including intertidal or subtidal BCH primary or secondary productivity (AECOM, 2022a).	No impacts to mangroves or algal mat due to modified nutrient pathways.
IMPs	The Proposal will utilise vessels during construction and operation that will be brought to local marine waters from other ports within Australia and overseas. These vessels have the potential to transport IMPs which can potentially impact intertidal and subtidal BCH through: • Out-competition with native species for resources; • Predation on native species; and	With appropriate mitigation measures in place the Proposal is unlikely to

Impact	Assessment	Outcome
	• Alteration of trophic interactions and food-webs. There will be limited potential for IMP introduction resulting from the Proposal due to the relatively small number of vessels involved, The proposed vessels required as part of the construction and operation of the Proposal have two potential introduction nodes for IMPs: ballast water and biofouling. Both ballast water and biofouling have Australian and WA Government protocols for managing their risks (AECOM, 2021). These protocols will be followed for all vessels mobilised for the Proposal to avoid and minimise the environmental impacts to intertidal and subtidal BCH.	increase IMP risks.
Hydrocarbon or chemical leaks or spills	Potential sources of hydrocarbon spills to the intertidal and subtidal BCH from the Proposal include: • Vessel collision or grounding resulting in vessel damage and breach of fuel tanks. • Equipment failure resulting in unplanned release of fuel from a vessel or construction equipment. • Failure to properly contain an onshore spill resulting in runoff into the marine environment. • Failure of stormwater control and / or treatment systems resulting in contaminated runoff entering the marine environment. It is noted that no bunkering or vessel refuelling will take place at the Proposal during construction or operation. While the likelihood of occurrence ins very low, any such release of hydrocarbons from these sources may result in the release of varying volumes and / or types of hydrocarbons. Potential impacts associated with hydrocarbon release will depend on the location of the spill in relation to sensitive receptors, volume and type of material released, environmental conditions at the time of the spill (i.e., current direction) and whether the material reaches the shoreline or is contained offshore. The spill of hydrocarbons and subsequent contact with subtidal habitats may be mitigated by the typically buoyant nature of such hydrocarbons. A buoyant plume is less likely to come into prolonged contact with benthic habitats in deeper waters. Where a spill occurs in, or is carried into, shallower waters, greater impacts would be expected. Shallow subtidal reefs and sandy beaches are particularly susceptible to hydrocarbon spills. Loss of macroalgae and sparse hard coral habitats may occur and areas of bare sediment and / or potential seagrass habitat may be impacted. Should a spill occur in, or be carried into Urala Creek North or South, there is a risk of impacts to BCH in the creek mouths, and mudflat, samphire and mangrove habitats further up the creeks. The nature of this environment is such that the spill may be dispersed across mudflats, where containment and removal can be difficult. Depending on the volume and type of material spilled, the impacts may result in reduced health or mortality of mangrove and samphire vegetation and impacts to mudflat environments. Mitigation measures will be in place to prevent spills and undertake corrective action should they accidentally occur. They include: • No bunkering of construction or operational vessels on site • Refuelling of machinery only within designated areas • Fuel storage and refuelling areas designed with appropriate spill prevention and containment mechanisms and equipment in place • Spill kits present on site where any machinery is operating and on all Proposal vessels. • Personnel trained in the spill response and use of spill kits to a level appropriate for their role and activities in which they are engaged.	With appropriate mitigation measures in place hydrocarbon or chemical spills are unlikely to significantly impact intertidal and subtidal BCH.

Impact	Assessment	Outcome
	• Vessel speed limits in place to prevent collisions Based on the above, hydrocarbon spills are considered highly unlikely after mitigation measures are applied and it is therefore anticipated that the outcome will be no loss of BCH resulting from hydrocarbon spills. Should a spill occur, the outcome could potentially (depending on the location and type and volume of hydrocarbon released) result in decreased health and possible mortality of areas of macroalgae and sparse hard coral and / or potential seagrass habitat. Given the small areas of these BCH types in the vicinity of the Proposal it is considered that there is no credible risk that these impacts would represent a significant impact to BCH on a regional level.	
Dredging and tailwater release	• Detailed sediment transport modelling has been undertaken to predict three zones of impact on the basis of coral tolerance limits: ZoHI, ZoMI, and ZoI. Model outputs predict that the ZoHI and ZoMI, in both summer and winter, will not impinge upon macroalgal or coral habitats. If tailwater discharge occurs in winter, it is predicted that the ZoHI will impact macroalgae habitat around the base of the jetty. Any impact within the ZoMI is considered to be recoverable and does not represent an area of BCH 'loss'. While the predicted ZoI from dredging and tailwater discharge (if these were to occur in winter) does impinge upon the fringing macroalgal and coral communities and habitat around the base of the jetty, the suspended sediment levels within the ZoI are predicted to be below those which may lead to adverse effects (Water Technology, 2022b) (AECOM, 2022a). With regards to soft sediment (potential seagrass habitat), the ZoHI, ZoMI and ZoI model outputs are defined on the basis of coral tolerance limits which are not directly applicable to seagrasses. The dredging campaign is planned to be of short duration (less than one month), and turbid plumes are predicted to be no longer detectable within a week after activities are completed. As recovery could reasonably be expected to occur within five years of completion of dredging and tailwater discharge, it is considered that there is no credible risk of 'loss' of seagrass habitat (outside of the berthing pocket) due to these activities (Water Technology, 2022b) (AECOM, 2022a). • GHD (2021a) undertook a geochemical assessment of the material to be dredged. The UCL for metals and radionuclides in all samples were below the screening levels contained within the National Assessment Guidelines for Dredging (NAGD, Commonwealth of Australia 2009) and organic contaminants were not detected. A risk of acid sulfate sediment occurring was identified, to mitigate this dredge spoil is to be disposed and treated on land and an ASSSMP has been developed (GHD 2021b). • AECOM (2022c) undertook a Marine Ecotoxicology Assessment which found dredged material is likely to present a very low risk of ecotoxicity or bioaccumulation in the marine environment, given none of the NAGD (Commonwealth of Australia, 2009) and ANZG (2018) screening criteria were exceeded in sample tests and land disposal of dredged material is proposed.	Impact to 4.57 ha of macroalgal habitat due to tailwater discharge (if in winter), with recovery potentially >5 years.
Bitterns discharge	• Modelling has been conducted based on representative WET testing results to predict LEPA and MEPA mixing zones around the bitterns diffuser. The outer boundary of the MEPA indicates the area which will remain a HEPA. Mixing zone contours were generated to determine the predicted size of the LEPA and MEPA zones for the yearly average, best case (June) and worst case (November) bitterns discharges. For the worst-case scenario, the predicted size of the LEPA zone was approximately 3,000 m in width, extending approximately 1,500 m from the end of the jetty. The MEPA was predicted to be approximately 4,300 m in width to approximately 2,000 m from the end of the jetty. • It is noted that the LEPA and MEPA are predicted to impinge upon a very small area of the macroalgal and sparse coral communities fringing the shoreline at the base of the jetty; however, they are not predicted to reach these BCH types offshore from Locker Point. Rather, they overlie 'soft sediment' habitat which may or may not, at certain times of the year in some years, support ephemeral seagrass communities. • In considering the area of potential seagrass habitat that may be affected by the bitterns discharge, it is important to recognise that it is predicted (from modelling) that the LEPA encompasses the berthing pocket, which is predicted to be rendered unsuitable habitat for seagrasses by the dredging works. Therefore, only soft sediment (potential seagrass habitat) outside the berthing pocket should be considered potentially impacted by the bitterns, given the berthing pocket will be unsuitable seagrass habitat after dredging.	Impact to 217 ha of soft sediment habitat (with the potential to support seagrass), 0.18 ha of macroalgae and 2.2 ha of macroalgae and sparse coral habitat within the

Impact	Assessment	Outcome
	• It has been assumed that the “soft sediment” habitat with the LEPA worst case zone will be permanently impacted and this area is unlikely to be conducive to the establishment of ephemeral seagrass communities. Whilst the soft sediment in the worst case MEPA may experience reduced water quality (relative to baseline/existing) this area is likely to be able to still support future seagrass habitat which might establish there in some years, given the worst case reduced water quality will only occur for a few months of the year (summer) and the worst case increase above background of between 2.2 and 1.6 PSU in salinity falls within the natural salinity variation for the site. While there may be detectable alterations to water quality within the MEPA during the periods of bitterns discharge, in accordance with water quality guidelines it is predicted that these will be of insufficient magnitude to result in irreversible changes to BCH that may be present within it. Hence, the area within the MEPA is not included within the ‘area of loss’ calculations (AECOM, 2022a).	worst case LEPA zone.

8.6.2 RESPONSE TO SEA LEVEL RISE

8.6.2.1 OVERVIEW

Predicting coastal response to SLR is not straightforward, as much of the understanding of coastal systems is based on observations from the 20th Century, or inference from recent millennia, which has involved a period of relative sea level stability. This limits available local evidence of processes active under rising sea levels, instead using of a global continuum of situations to guide a trajectory for the system's response, specifically through literature describing tidal network dependence on tidal prism.

Recognising the complexity of these factors, and to assess how they may apply to the Tubridgi Point to Tent Point area, K+S commissioned a study by Seashore Engineering (2021) to understand the potential influence of the Proposal on BCH response to SLR. The study by Seashore Engineering (2021) provides an interpretation of anticipated changes to the adjacent coastal system from SLR and an evaluation of how these changes may be influenced by the Proposal.

It should be noted that predictions regarding the areas of BCH habitat which may be prevented from expanding by the Proposal have not been included with the cumulative loss calculations presented in preceding Sections due to the extent of complexities involved and the uncertainties in the predictions regarding habitat migration and potential constraints of new habitat development.

8.6.2.2 IMPACT ASSESSMENT

The Proposal has the potential to limit the landward expansion of habitats such as mangroves and algal mat as environmental conditions suitable for recruitment and establishment into new areas become available due to SLR. A morphometric approach (assessment of the relationship between creek morphology and water flow) has been used by Seashore Engineering (2021) to assess potential response of mangroves and algal mats to SLR. As samphire habitats are topographically controlled, future behaviour has been inferred from analysis of spatial distributions, tidal dynamics and SLR, including anticipated changes to the landforms occupied by samphire (Seashore Engineering, 2021).

Evaluation of SLR impacts has been undertaken using the summary of projected SLR developed for coastal planning in WA (DoT, 2010). This recommends a single forecast curve for sea level allowances, based on IPCC model projections:

- Allowance for 0.4 m of SLR over the next 50 years (by ~2070).
- Allowance for 0.9 m of SLR over the next 100 years (by ~2110).
- SLR is projected to accelerate, with a rate of 0.008 m/yr reached by 2040-2050 and 0.012 m/yr reached by 2070-2080 (DoT, 2010).

The Proposal is not expected to substantially affect the health or distribution of existing intertidal habitats. However, it is expected to modify the development of new potential habitat areas that would otherwise be expected to occur in response to low rates of SLR (before ~2050) (Seashore Engineering, 2021).

With the Proposal in place, it is estimated that 40 to 250 ha of new potential mangrove habitat and 450 to 560 ha of potential new algal mat habitat will not develop between 2021 and 2050. However, this potential new habitat is expected to be impermanent, as accelerating SLR will place increasing stress on these habitats from 2055, with progressive habitat loss expected after 2075. Habitat stress and loss is expected to occur with or without the Proposal in place (Seashore Engineering, 2021).

Samphire along the base of supratidal slopes near the Proposal area will be unaffected by the Proposal and are anticipated to contract under SLR at the same rate as they would without the Proposal, with a reduction in samphire of 50% by 2050 and ongoing loss as sea level rates accelerate beyond this. Samphire habitat in supratidal basins and channels at the salt flat hinterland fringe will be affected by increased tidal flooding in the eastern basin of Urala Creek North due to the proposed Proposal. The predicted change is approximately 0.1 m higher peak tidal level, which suggests that the incidence of salt water flows into this samphire area will approximately double due to the Proposal. This will accelerate the process of wetland salinisation anticipated to occur due to SLR, bringing forward the approximate period of substantial ecosystem change which may cause samphire decline from 2070 without the Proposal in place, to 2055 with the Proposal in place (Seashore Engineering, 2021).

Figure 99 and Section 8.6.2.3 below summarise predicted morphodynamic and habitat responses to SLR with or without the Proposal in place, arrived at by assessing and inferring relationships between tidal creek structure, tidal exchange and habitat response along the Tubridgi coast (Seashore Engineering, 2021).

8.6.2.3 PROJECTION OF FUTURE HABITAT AREAS AND POTENTIAL CONSTRAINT BY PROPOSAL

Seashore Engineering (2022) has used conceptual models developed for the response of mangrove and algal mats to SLR to estimate projections of habitat change related to the Proposal. Area estimates were derived for SLR up to 2120 for scenarios both with and without the Proposal. While substantial mangrove habitat loss due to SLR is predicted to occur beyond 2060 (with or without the Proposal) the Seashore Engineering (2022) evaluation provided data on the relative extent of potential constraint from the Proposal on habitat development at the scale of the study area (i.e., combined area occupied by both Intertidal LAUs) and the broader Exmouth Gulf East area over both shorter (next 50 years) and longer (next 100 years) timeframes.

Data on mangrove and algal mat BCH area estimates for the study area provided in Seashore Engineering (2022) have been extrapolated on a proportional basis to derive estimates for Exmouth Gulf East. The area estimates for the study area and Exmouth Gulf East provided are:

- Areas (ha) of mangrove and algal mat BCH from 2010-2120 both with and without the Proposal, the reduction in habitat area due to the Proposal and the percentage reduction due to the Proposal (Table 52 for mangroves; Table 55 for algal mats).
- Net change (ha) and percentage net change in mangrove areas since 2010 both with and without the Proposal, and the difference in percentage net change since 2010 due to the Proposal (Table 53).

The 2010 BCH areas used in the assessment align with the “Pre-European Extent” and “Current Extent” presented earlier in this section, and represent baseline areas against which SLR related habitat area changes and Proposal-related constraint on BCH development are compared.

In addition to the assessment based on spatial metrics, consideration is also given to the impact on productivity from SLR and the potential Proposal-related constraints on new habitat development. Table 54 provides an assessment of changes to mangrove primary productivity in the study area and Exmouth Gulf East over the period 2010-2120 using primary production estimates for the mangrove *Avicennia marina* (2,350 g C m^{-2} $year^{-1}$ from Alongi et al. 2003) and the habitat areas shown in Table 52.

Seashore Engineering (2022) note that the projections of BCH change are sensitive to assumptions, including the forecast sea level curve and that the “estimates have been developed using a combination of observational and conceptual models, incorporating behavioural patterns that although based on best available knowledge identified, have limited scientific support, and should be applied correspondingly. The most significant limitation is associated with reduction of mangrove habitat resulting from excessive rates of SLR – although there is geomorphic evidence of this process, it has not been experienced in the modern period”.

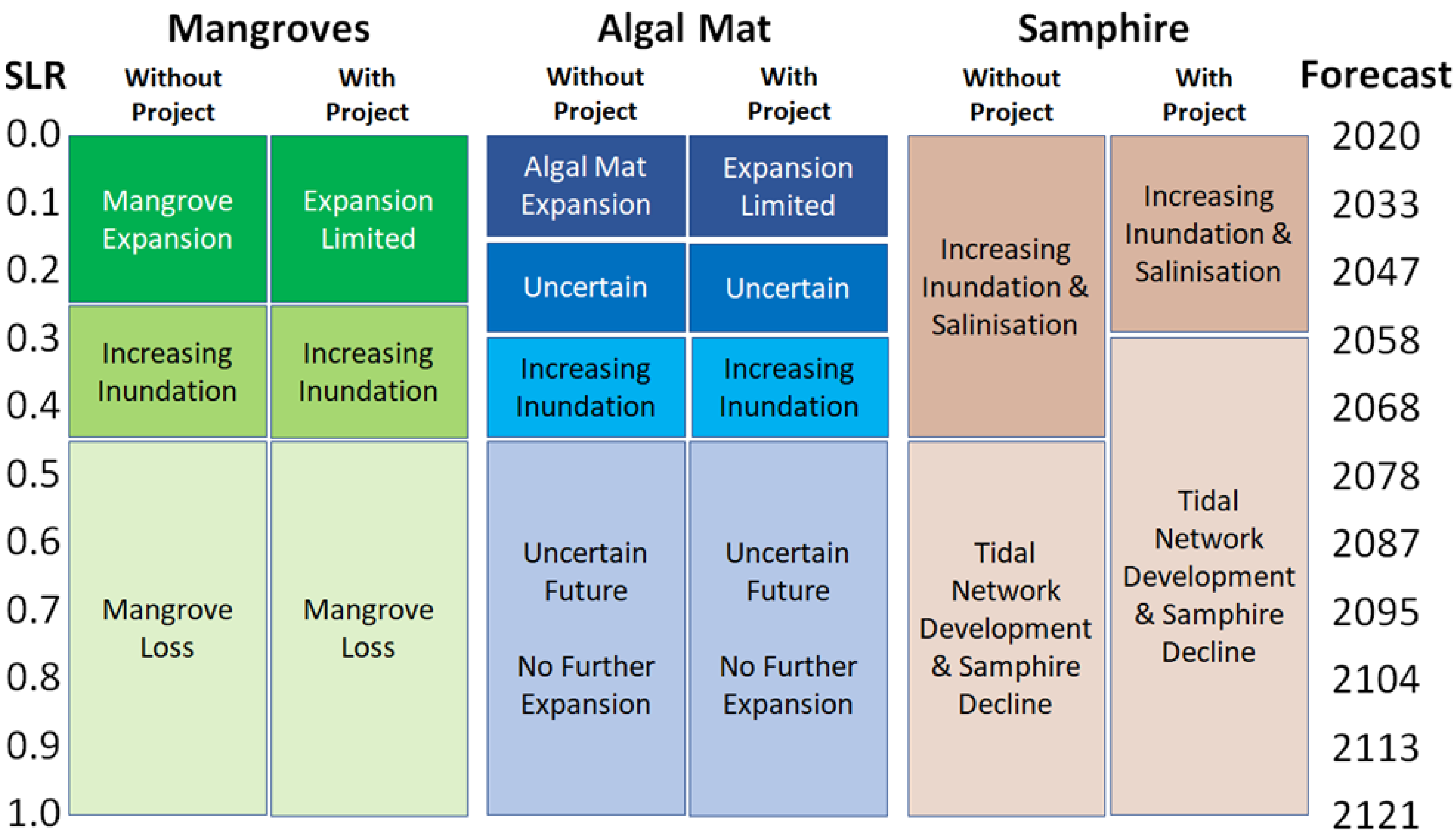


Figure 99: Mangrove and algal mat response to sea level rise with and without the Proposal
(Seashore Engineering, 2021)

Key findings related to the predicted areas of mangrove and algal mat BCH are:

Mangroves

For the study area, mangrove habitat will expand from 2,185 ha to 2,468 ha by 2050 (an expansion of 283 ha (13%) and then decrease to 1,394 ha (reduction of 36.2%) by 2120. Constraint on new habitat development due to the Proposal will reduce these areas by 140 ha (-5.6%) in 2050 and 40 ha (-2.9%) in 2120 (Table 52). Mangrove primary productivity will increase from 51,348 to 57,998 t C m^{-2} yr^{-1} ha by 2050 and then decrease to 32,759 t C m^{-2} by 2120. Constraint on new habitat development due to the Proposal will reduce productivity by 3,267 t C m^{-2} (-5.6%) in 2050 and 940 t C m^{-2} (-2.9%) in 2120 (Table 54).

For Exmouth Gulf East, mangrove habitat will expand from 11,742 ha to 13,263 ha by 2050 (an expansion of 1,521 ha (13%)) and then decrease to 7,491 ha (reduction of 4,251 or 36.2%) by 2120. Constraint on new habitat development due to the Proposal represents -1.0% in 2050 and -0.5% in 2120 (Table 52). Mangrove primary productivity will increase from 275,937 to 311,676 t C m^{-2} yr^{-1} ha by 2050 and then decrease to 176,044 t C m^{-2} by 2120. Constraint on new habitat development due to the Proposal will reduce productivity by -1.0% in 2050 and -0.5% in 2120 (Table 54).

Table 52: Changes in mangrove areas due to sea level rise and potential constraint from Proposal

Year	Sea Level Rise (m)	Mangrove area (ha) without Proposal		Mangrove area (ha) with Proposal		Reduction in area (ha) due to Proposal	% Reduction in area due to Proposal	
		Study Area	East Exmouth Gulf	Study Area	East Exmouth Gulf		Study Area	East Exmouth Gulf
2010	0.00	2,185	11,742	2,185	11,742	0	0.0	0.0
2020	0.04	2,261	12,150	2,224	12,113	-37	-1.6	-0.3
2030	0.09	2,341	12,580	2,265	12,504	-76	-3.2	-0.6
2040	0.15	2,420	13,005	2,305	12,890	-115	-4.8	-0.9
2050	0.22	2,468	13,263	2,329	13,124	-139	-5.6	-1.0
2060	0.31	2,408	12,940	2,291	12,823	-117	-4.9	-0.9
2070	0.41	2,277	12,236	2,210	12,169	-67	-2.9	-0.5
2080	0.52	2,104	11,307	2,064	11,267	-40	-1.9	-0.4
2090	0.64	1,924	10,339	1,884	10,299	-40	-2.1	-0.4
2100	0.76	1,744	9,372	1,704	9,332	-40	-2.3	-0.4
2110	0.88	1,567	8,421	1,527	8,381	-40	-2.6	-0.5
2120	1.00	1,394	7,491	1,354	7,451	-40	-2.9	-0.5

Table 53: Net changes to mangrove areas due to sea level rise and constraint from Proposal

Year	Sea Level Rise (m)	Mangrove area (ha) without Proposal		Mangrove area (ha) with Proposal		% Net change in area since 2010 without Proposal	% Net change in area since 2010 with Proposal		Difference in % net change since 2010 due to Proposal	
		Study Area	East Exmouth Gulf	Study Area	East Exmouth Gulf		Study Area	East Exmouth Gulf	Study Area	East Exmouth Gulf
2010	0.00	0	0	0	0	0	0	0	0	0
2020	0.04	76	408	39	371	3.5	1.8	3.2	-1.7	-0.3
2030	0.09	156	838	80	762	7.1	3.7	6.5	-3.5	-0.6
2040	0.15	235	1,263	120	1,148	10.8	5.5	9.8	-5.3	-1.0
2050	0.22	283	1,521	144	1,382	13.0	6.6	11.8	-6.4	-1.2

Year	Sea Level Rise (m)	Mangrove area (ha) without Proposal		Mangrove area (ha) with Proposal		% Net change in area since 2010 without Proposal	% Net change in area since 2010 with Proposal		Difference in % net change since 2010 due to Proposal	
		Study Area	East Exmouth Gulf	Study Area	East Exmouth Gulf		Study Area	East Exmouth Gulf	Study Area	East Exmouth Gulf
2060	0.31	223	1,198	106	1,081	10.2	4.9	9.2	-5.4	-1.0
2070	0.41	92	494	25	427	4.2	1.1	3.6	-3.1	-0.6
2080	0.52	-81	-435	-121	-475	-3.7	-5.5	-4.0	-1.8	-0.3
2090	0.64	-261	-1,403	-301	-1,443	-11.9	-13.8	-12.3	-1.8	-0.3
2100	0.76	-441	-2,370	-481	-2,410	-20.2	-22.0	-20.5	-1.8	-0.3
2110	0.88	-618	-3,321	-658	-3,361	-28.3	-30.1	-28.6	-1.8	-0.3
2120	1.00	-791	-4,251	-831	-4,291	-36.2	-38.0	-36.5	-1.8	-0.3

Table 54: Changes in mangrove areas due to sea level rise and potential constraint from Proposal

Year	Sea Level Rise (m)	Mangrove area (ha) without Proposal		Mangrove area (ha) with Proposal		Reduction in productivity due to Proposal	% Reduction in productivity due to Proposal	
		Study Area	East Exmouth Gulf	Study Area	East Exmouth Gulf		Study Area	East Exmouth Gulf
2010	0.00	51,348	275,937	51,348	275,937	0	0.0	0.0
2020	0.04	53,134	285,535	52,264	284,665	-870	-1.6	-0.3
2030	0.09	55,014	295,638	53,228	293,852	-1,786	-3.2	-0.6
2040	0.15	56,870	305,614	54,168	302,912	-2,703	-4.8	-0.9
2050	0.22	57,998	311,676	54,732	308,410	-3,267	-5.6	-1.0
2060	0.31	56,588	304,099	53,839	301,349	-2,750	-4.9	-0.9
2070	0.41	53,510	287,555	51,935	285,981	-1,575	-2.9	-0.5
2080	0.52	49,444	265,708	48,504	264,768	-940	-1.9	-0.4
2090	0.64	45,214	242,976	44,274	242,036	-940	-2.1	-0.4
2100	0.76	40,984	220,244	40,044	219,304	-940	-2.3	-0.4
2110	0.88	36,825	197,892	35,885	196,952	-940	-2.6	-0.5
2120	1.00	32,759	176,044	31,819	175,104	-940	-2.9	-0.5

Algal mats

- For the study area, algal mat habitat will expand from 5,384 ha to 11,197 ha (108%) by 2060 and then not expand any further. Constraint on new habitat development due to the Proposal will reduce this area by 563 ha (-5.0%) (Table 55).
- For Exmouth Gulf East, algal mat habitat will expand from 11,617 ha to 24,160 ha by 2060 and then not expand any further. Constraint on new habitat development due to the Proposal will reduce this area by 563 ha (-2.3%) (Table 55).

Table 55: Changes in algal mat areas due to sea level rise and potential constraint from Proposal

Year	Sea Level Rise (m)	Algal mat area (ha) without Proposal		Algal mat area (ha) with Proposal		Reduction in area (ha) due to Proposal	% Reduction in area due to Proposal	
		Study Area	East Exmouth Gulf	Study Area	East Exmouth Gulf		Study Area	East Exmouth Gulf
2010	0.00	5,384	11,617	5,384	11,617	0	0.0	0.0
2020	0.04	6,384	13,775	6,287	13,678	-97	-1.5	-0.7
2030	0.09	7,500	16,183	7,295	15,978	-205	-2.7	-1.3
2040	0.15	8,755	18,891	8,429	18,565	-326	-3.7	-1.7
2050	0.22	10,383	22,403	9,899	21,919	-484	-4.7	-2.2
2060	0.31	11,197	24,160	10,634	23,597	-563	-5.0	-2.3
2070	0.41	11,197	24,160	10,634	23,597	-563	-5.0	-2.3
2080	0.52	11,197	24,160	10,634	23,597	-563	-5.0	-2.3
2090	0.64	11,197	24,160	10,634	23,597	-563	-5.0	-2.3
2100	0.76	11,197	24,160	10,634	23,597	-563	-5.0	-2.3
2110	0.88	11,197	24,160	10,634	23,597	-563	-5.0	-2.3
2120	1.00	11,197	24,160	10,634	23,597	-563	-5.0	-2.3

8.6.2.4 CONCLUSION

Substantial changes are predicted to occur to intertidal BCH due to SLR both in the study area and broader Exmouth Gulf East area (i.e., with or without the Proposal). Net changes to mangrove BCH include an expansion of 13% by 2050 and a decrease of 36.2% by 2120. Net changes to algal mat BCH are an expansion of 108% by 2060 and then stabilisation. For Exmouth Gulf East these changes related to SLR represent large areas (several thousand hectares) of mangrove and algal mat BCH.

Seashore Engineering (2022) has identified that some areas of new BCH associated with SLR may potentially be constrained from developing due to Proposal infrastructure by either modification to SLR related increases in tidal exchange (in the case of mangroves) or from the presence of the salt ponds being in areas that algal mats may expand into.

For mangroves the constraint of new habitat development from the Proposal is 140 ha in 2050 and 40 ha in 2120, this representing net changes of -6.4% and -1.8% respectively for the study area and -1.2% and -0.3% for Exmouth Gulf East. For algal mats, the maximum constraint of new BCH development from the Proposal is 563 ha in 2050, this representing a potential reduction of 5.0% for the study area and 2.3% for Exmouth Gulf East.

Given the magnitude of changes to BCH distribution that are predicted to occur from SLR (i.e., the extent of changes that will occur without the Proposal) and the small proportions of BCH that maybe potentially constrained by the Proposal at either the scale of the study area or Exmouth Gulf East, it is unlikely that they represent significant potential impacts or constitute a significant threat to the integrity or overall productivity of the intertidal and marine ecosystem.

8.6.3 CUMULATIVE IMPACTS TO INTERTIDAL AND SUBTIDAL BCH

Predicted cumulative proportional impacts to intertidal and subtidal BCH have been summarised in Table 56 and Table 57 as a percentage of:

- Intertidal and subtidal BCH mapped within the LAU's.
- Intertidal BCH mapped from Tubridgi Point to Tent Point.
- Intertidal BCH mapped for the Eastern Exmouth Gulf.

- Subtidal BCH mapped within the study area (AECOM, 2022a).

Given there is no existing development on the Eastern Exmouth Gulf (including within the LAUs) the BCH mapping represents the pre-European extents (that is 100% of the pre-European extent is assumed to be remaining) (AECOM, 2022a).

Table 56: Intertidal BCH Proportional Cumulative Loss

BCH Type	Areas (ha)					Proportional Loss (%)			
	Cumulative Loss	Intertidal LAU North	Intertidal LAU South	Tubridgi -Tent Pt	East Exmouth Gulf	Intertidal LAU North	Intertidal LAU South	Tubridgi - Tent Pt	Exmouth Gulf
Mangroves	4.28	540	1,645	3,724	11,742	0.79%	0%	0.11%	0.04%
Transitional Mud Flats	17.81	1,980	2,040	7,990	20,747	0.44%	0%	0.22%	0.09%
Algal Mats	16.68	3,350	2,034	6,199	11,617	0.50%	0%	0.27%	0.14%
Samphires	36.36	459	6	879	2,141	7.88%	2.83%	4.14%	1.70%
Sandy Beaches	0.99	127.5	5.3	298	1,040	0.78%	0%	0.33%	0.10%
Tidal Creeks	0.54	297	206	876	2,710	0.18%	0%	0.06%	0.02%
TOTAL	76.66	**6,754**	**5,936**	**19,966**	**49,577**	**1.14%**	0.05%	0.38%	0.15%

Table 57: Subtidal BCH Proportional Cumulative Loss

BCH Type	Areas (ha)				Proportional Loss (%)		
	Cumulative Loss	Subtidal LAU	Study Area	Regional Note1	Subtidal LAU	Study Area	Regional
Soft Sediment	219.3	4,674	8,966	112,500	4.69%	2.45%	
Macroalgae	4.79	82	147		5.84%	3.26%	
Macroalgae & Sparse Coral	2.3	244	325		0.94%	0.71%	
TOTAL	**226.39**	**5,000**	**9,438**	**112,500**	**4.52%**	**2.40%**	**0.20%**

Table Note 1: Regional subtidal habitat has been estimated as a spatial area 5 km from coast along 225 km of coastline from Ashburton River to North West Cape.

8.6.3.1 CUMULATIVE IMPACTS FROM SEA LEVEL RISE

The maximum predicted impacts of the Proposal on mangroves and algal mat extents associated with sea level rise (discussed in Section 8.6.2) has been added to the cumulative loss in Table 58.

Table 58: Intertidal BCH Proportional Cumulative Loss (inclusive of sea level rise impacts)

BCH Type	Areas (ha)			Proportional Loss (%)
	Cumulative Loss	Max. Sea Level Rise Impacts	East Exmouth Gulf	Exmouth Gulf
Mangroves	4.28	139 (in 2050)	13,263 (in 2050)	1.1%

BCH Type	Areas (ha)			Proportional Loss (%)
	Cumulative Loss	Max. Sea Level Rise Impacts	East Exmouth Gulf	Exmouth Gulf
Algal Mats	16.68	563 (from 2060 onwards)	24,160 (from 2060 onwards)	2.4%

8.6.4 WEST PILBARA REGIONAL IMPACT ASSESSMENT

In its recent assessment of the Mardie Project, the EPA advised that all future salt proposals on the West Pilbara Coast (defined as the area from the bottom of the Exmouth Gulf to Karratha) should include an assessment of the West Pilbara cumulative regional impacts to mangrove, algal mat and samphire habitat (EPA, 2021). To meet this requirement AECOM (2022a) has undertaken a review of relevant EIA documents and mapping sources to provide a cumulative loss assessment for the West Pilbara Coast and place the relative scale of potential impacts from the Proposal within the regional context.

The AECOM (2022a) estimates of the extent of mangroves, algal mat and samphire occurring along the West Pilbara Coast were derived from:

- Detailed mapping from EIAs where available.
- Less detailed remote sensed mapping that could be sourced.
- Extrapolation of habitat distribution where the above sources were not available.

The AECOM (2022a) cumulative loss estimates for mangroves, algal mat and samphire were conservatively derived from:

- Historical and potential future losses as reported in EIA's and other sources.
- Where loss data was unavailable, inferred historical losses were estimated by the extrapolating 50% of known losses along other parts of the West Pilbara Coast (a conservative assumption given parts of the coastline where data is unavailable, are largely undeveloped).

The estimates provided in Table 59 indicate that within the West Pilbara region, mangrove loss would increase by 0.02%, algal mats loss would increase by 0.06% and samphire loss would increase by 0.5% as a result of the Proposal (AECOM, 2022a).

Table 59: West Pilbara Regional Impact Assessment

Habitat	Method of Calculation	Coastal sector	EIA / Data Source	Coastline Length (km)	Total Area (ha)	Cumulative Loss (ha)	% of Total Area With Proposal	% of Total Area Without Proposal	% Difference with & without Proposal
Mangroves	Detailed mapping	Exmouth Gulf East	Ashburton Salt (AECOM, 2022a)	100	11,742	4.6			
		Ashburton Delta-Onslow-Coolgra Point	Onslow Salt and Wheatstone LNG (URS, 2010a)	50	1,450	6			
		Robe River Delta- Fortescue River Delta	Mardie Salt (Stantec, 2018), (EPA, 2021)	80	7,849	17			
		Cape Preston	Cape Preston Causeway (URS, 2008)	10	502	1			
		Detailed Mapping Sectors Total		*240*	*21,543*	*29*			
	Course mapping	Cape Preston East to Karratha	Dampier Salt Ponds (Gordon, 1987)	70	2,942	1,120			
		Global Mangrove Watch Data and satellite imagery Interpolation	Global Mangrove Watch (GMW, 2010)	40	4,384	-			
		Mangroves West Pilbara Coast Total		**350**	**28,869**	**1,149**	**3.98%**	**3.96%**	**0.02%**
Algal Mats	Detailed mapping	Exmouth Gulf East	Ashburton Salt (AECOM, 2022a)	100	11,617	17.8			
		Ashburton Delta-Onslow-Coolgra Point	Onslow Salt and Wheatstone LNG (URS, 2010a)	50	2,012	432			
		Robe River Delta- Fortescue River Delta	Mardie Salt (Stantec, 2018), (EPA, 2021)	80	4,544	880			
		Detailed Mapping Sectors Total		*230*	*18,173*	*1,330*			
	Inferred	Remaining coastline - extrapolated from mapped sectors		120	9,482	347			
		Algal Mat West Pilbara Coast Total		**350**	**27,655**	**1,677**	**6.06%**	**6.00%**	**0.06%**
Samphire	Detailed mapping	Exmouth Gulf East (Mid-North Portion)	Ashburton Salt (Biota, 2005b), (Biota, 2022a)	60	2,141	158.7			
		Wheatstone Plant Area	Onslow Salt and Wheatstone LNG (Biota, 2010)	8	2,449	686			
		Robe River Delta- Fortescue River Delta	Mardie Salt (Phoenix, 2020a) (EPA, 2021)	32	4,111	346			
		Detailed Mapping Sectors Total		*100*	*8,701*	*1,191*			
	Inferred	Remaining coastline – extrapolated from mapped sectors		250	21,753	1,488			
		Samphire West Pilbara Coast Total		**350**	**30,454**	**2,679**	**8.80%**	**8.28%**	**0.52%**

8.6.5 EXTREME EVENTS

There is the potential for discharges of contaminants associated with extreme events such as cyclones or tsunamis. Such an event could cause overtopping or breaching of the bitterns, salt, or crystalliser pond embankments and/or flooding of the salt stockpiles.

However, the current engineering design requirements for these structures require that the embankment crest to be designed to such a level as to accommodate a 1 in 50-year flood event (~ 2% AEP). This includes inclusion of freeboard above the predicted design water level. Stockpiles will also be elevated above this level. The embankments are also designed with rock armouring to limit the potential for breaching due to wind and wave erosion.

Exceedance of these flood levels have a low (~2%) annual probability of occurring (i.e., ~ 2% AEP). If a major cyclone or tsunami occurred which exceeded these 1 in 50-year flood levels, the volume of water that would be deposited onto the site due to storm surge, rainfall or tsunami would be proportionally overwhelming of any contaminants and cause dilution of the bitterns/pond water/salt that was released, to such an extent it would be insignificant and undetectable. Therefore, this is likely to have a negligible impact on benthic habitats, which would be much more likely to be severely damaged by the natural forces of wind and wave action, than from any contamination resulting from product stockpiles or bitterns being released by the Proposal.

For example, large scale destruction resulted from TC Vance in 1999 when approximately 5,700 ha of mangrove habitat was damaged on the eastern side of Exmouth Gulf. The authors of a paper documenting the extent of mangrove change caused by TC Vance noted that the scale of damage "exceeds any anthropogenic impact that has ever taken place in WA by several orders of magnitude" (Paling et al., 2008). Regeneration and recovery of mangroves occurred in the years subsequent to TC Vance and it was estimated that by five years post-TC Vance, approximately 68% of mangrove habitat had returned to its former coverage.

8.6.6 IMPACTS TO 'EXMOUTH GULF EAST WETLAND' AND 'EXMOUTH EAST SHORE MANGROVE MANAGEMENT AREA'

In addition to providing the direct loss estimates for BCH within the proposed LAUs, Table 56 provides the loss estimates in the context of the overall eastern section of Exmouth Gulf, a similar area to that encompassed within Area 2 - Exmouth East Shore of GS No. 1 (EPA 2001) and the Exmouth Gulf East wetland (WA007) listed in ANCA (1993).

When considering the assessment undertaken in previous sections, the following key points support the conclusion that the Proposal does not threaten ecological function, biodiversity, productivity or conservation significance on a local or regional basis:

- The majority of the Proposal is located outside of the mangrove and algal mat zones.
- The location and design of the Proposal is predicted to result in a very low scale of impacts to mangroves (<0.1%) and algal mats (<0.2%) within the eastern Exmouth Gulf area.
- Tidal flows that are predominantly responsible for mangrove ecosystem maintenance are not impacted in either the Tubridgi Point - Urala Creek area or broader eastern Exmouth Gulf area.
- Sedimentation patterns are also likely to be maintained, so erosion and deposition within mangrove and tidal flats habitats is predicted to be within natural variation.
- Significant impacts to nutrient pathways, sources or sinks in the context of the local catchment or Exmouth Gulf are not predicted.
- Key geomorphic features within the eastern Exmouth Gulf, such as the Yanrey River Delta and the barrier islands of Tent Point and Tubridgi Point, will not be impacted.

- Overland flows from the Yanrey River Delta to the tidal flats and estuarine wetland system of eastern Exmouth Gulf will not be modified by the Proposal.

The functioning and ecological productivity of ‘Exmouth Gulf East wetland (WA007)’ and ‘Area 2 – Exmouth East Shore’ is reliant on expansive areas of mangroves and algal mats that are predicted to be subject to substantial changes in habitat area (both increases and decreases) in the future due to SLR. These changes that will occur with or without the Proposal, represent several thousand hectares of mangrove and algal mat BCH and, in the case of mangroves, includes a loss of approximately 4,000 ha (or -36%) predicted to occur by 2120.

Seashore Engineering (2022) has identified that some areas of new BCH associated with SLR may potentially be constrained from developing due to Proposal infrastructure by either modification to SLR related increases in tidal exchange (in the case of mangroves) or from the location of salt ponds in areas that algal mats may expand into. Given the magnitude of changes predicted to occur from SLR (i.e., the extent of changes that will occur with or without the Proposal) and the small proportions of BCH that maybe potentially constrained by the Proposal, it is unlikely that they represent significant potential impacts or constitute a significant threat to the integrity or overall productivity of the intertidal and marine ecosystem.

In the long term, man-made salt pond habitats have the potential to augment the existing natural intertidal wetland and mangrove habitats within the ‘Exmouth Gulf East wetland (WA007)’ and ‘Area 2 – Exmouth East Shore MMA’, some of which are predicted to be lost due to SLR (Biota, 2022). This potential outcome is aligned with GS No. 1, which promotes providing the Exmouth East Shore MMA the highest degree of protection with respect to geographical distribution, biodiversity, productivity and ecological function.

8.7 ASSESSMENT OF IMPACTS

The location and design of the Proposal results in a small scale of impacts to BCH:

- Proportional impact to intertidal BCH is predicted to be:
  - Within East Exmouth Gulf 0.04% of mangroves, 0.09% of transitional mudflats, 0.14% of algal mats, 1.7% of samphires, 0.1% of sandy beaches and 0.02% of tidal creeks.
  - Within the LAU’s 0.79% of mangroves, 0.44% of transitional mudflats, 0.5% of algal mats, 7.82% of samphires, 0.78% of sandy beaches and 0.18% of tidal creeks.
- Proportional impact to subtidal BCH is predicted to be:
  - Within the Exmouth Gulf less than 0.2% of similar subtidal habitats.
  - Within the study area 0.71% of macroalgae and sparse coral, 2.45% of soft sediment and 3.26% of macroalgae.
  - Within the LAU 0.94% of macroalgae and sparse coral, 4.69% of soft sediment and 5.84% of macroalgae.
- Estimated cumulative proportional losses for the West Pilbara taking into account historical and projected future losses from other developments is very small. With the Proposal developed:
  - Mangrove loss would increase by 0.02%.
  - Algal mats loss would increase by 0.06%.
  - Samphire loss would increase by 0.5%.

In terms of the functioning and ecological productivity of the ‘Exmouth Gulf East wetland (WA007)’ and ‘Area 2 – Exmouth East Shore’ MMA, impacts to these are not considered to be significant because (AECOM, 2022a):

- The majority of the Proposal is located outside of the mangrove and algal mat zones.
- Tidal flows that are predominantly responsible for mangrove ecosystem maintenance are not impacted in either the Tubridgi Point - Urala Creek area or broader eastern Exmouth Gulf area.

- Sedimentation patterns are also likely to be maintained, so erosion and deposition within mangrove and tidal flats habitats is predicted to be within natural variation.
- Significant impacts to nutrient pathways, sources or sinks in the context of the local catchment or Exmouth Gulf are not predicted to occur.
- Key geomorphic features within the Eastern Exmouth Gulf, such as the Yanrey River Delta and the barrier islands of Tent Point and Tubridgi Point, will not be impacted.
- Overland flows from the Yanrey River Delta to the tidal flats and estuarine wetland system of eastern Exmouth Gulf will not be modified by the Proposal.

The functioning and ecological productivity of 'Exmouth Gulf East wetland (WA007)' and MMA 'Area 2 – Exmouth East Shore' is reliant on expansive areas of mangroves and algal mats, which are at risk in the long term due to the effects of SLR. The natural loss of mangroves and algal mats from these areas is predicted to occur progressively after approximately 50 years due to SLR without the Proposal in place (Seashore Engineering, 2021).

However, the Proposal is uniquely positioned to consider the creation of ongoing habitat for algal mat, mangroves and associated fauna as a part of Proposal closure. K+S's preferred post-closure land use is to leave the evaporation ponds in situ so that they become "wetland" habitat for mangroves, algal mats and associated fauna. This is discussed further in Section 11.5.2.8 and in AECOM (2022a).

Based on the assessment detailed in above it is concluded that the Proposal does not threaten BCH ecological function, biodiversity, productivity, or conservation significance on a local or regional basis, including that of 'Exmouth Gulf East wetland (WA007)' and MMA 'Area 2 – Exmouth East Shore'.

8.8 MITIGATION

8.8.1 AVOID

The Proposal has undertaken significant design optimisation to avoid environmental impacts to BCH including:

- Eight iterations of the pond design to minimise the footprint. Alignment of the western boundary of concentration ponds was moved further east to minimise direct loss of algal mats and provide a setback from mangroves areas (>800 m) to avoid seepage-related impacts to mangroves and longer-term impacts related to salinity increases. As a result, the spatial extent of loss from the Proposal is less than that from existing and proposed solar salt projects, and from other major infrastructure projects constructed within similar settings on the Pilbara coast.
- Detailed analysis of seawater intake options and locations reducing the seawater intake locations from two (Urala Creek North and South), to only one (Urala Creek South).
- Detailed analysis of dredging options and spoil disposal. Proposing transhipment with low draft barges to avoid the need for dredging a long shipping channel to deeper water (avoiding significant disturbance of the seafloor via dredging). The dredged berthing pocket is proposed in a location away from sensitive benthic habitats (such as coral reefs) thereby avoiding impacts to sensitive habitats.
- There is no requirement for disposal of dredged material at sea avoiding much larger impacts to subtidal BCH from elevated turbidity.
- There is no requirement for dredged material to be used for coastal land reclamation avoiding potential impacts to intertidal BCH through direct disturbance or sedimentation.
- It is proposed that bitterns will be discharged via a diffuser positioned such that the mixing zone is in an area of existing high disturbance (dredged berthing pocket) and away from sensitive benthic habitats (coral reef and seagrass) thereby avoiding impacts to sensitive habitats.
- Throughout the salt production process, no chemicals will be added at any stage of the process avoiding ecotoxicity risk for BCH.

8.8.2 MINIMISE

As the design progressed, the following modifications were made to minimise impacts to BCH:

- Appropriate culverts and drainage diversions were designed to minimise impacts to tidal and surface water flows and nutrient pathways, therefore minimising related impacts to intertidal habitats.
- Detailed analysis of bitterns disposal options including:
    - Lengthening and realignment of the jetty and bitterns discharge pipeline into deeper water to minimise impacts of bitterns discharge, reducing mixing zone size and therefore minimising related impacts to subtidal habitats;
    - Prior to discharge, the bitterns flowing out of the crystalliser ponds will flow into a bitterns dilution pond. Washwater (ocean water) will be used to wash the harvested salt to get rid of the adherent bitterns and the possible KCl-crystals which could be grown during transport. No additional chemicals or organics are added to the washwater. The bitterns would be diluted 1:1 with an equal amount of seawater before being combined with the washwater and discharged from the diffuser. Bitterns will be discharged through an upward facing diffuser which will force the bitterns to the surface, thereby facilitating enhanced mixing and diffusion with faster moving surface waters and minimising the impacts to subtidal habitats;
- The area and volume of sediment to be dredged is minimised to 0.7 ha and 17,000 m^3, minimising impacts to subtidal habitats.
- The dredging methodology (cutter suction dredge) typically results in only very localised areas of elevated turbidity. Modelling predicts that the localised plumes of elevated turbidity will not persist for more than a week following cessation of the dredging activity, thereby minimising impact to subtidal habitats.

The following mitigation measures are proposed to ensure that direct and indirect impacts to BCH are minimised:

- Obtain and comply with the following approvals:
    - Ministerial Statement to be issued under Part IV of the EPA Act;
    - Works Approval and Licence to be issued under Part V of the EP Act for solar salt manufacturing (including bitterns disposal) and bulk material loading;
    - Mining proposal to be approved under the *Mining Act 1978* for activities on *Mining Act 1978* tenure;
    - MCP to be approved under the *Mining Act 1978* for activities on *Mining Act 1978* tenure. The MCP will describe the rehabilitation and closure of the Proposal, and associated management and monitoring proposed during the closure phase. An Interim MCP has been provided in Appendix BB; and
    - Development Application to be approved under the *Port Authorities Act 1999* for activities within PPA-managed lands and waters.
- Implement the Introduced Marine Pest Monitoring and Management Plan (IMPMMP; Appendix BB).
- Implement the DSMP (Appendix BB).
- Implement the MEQMMP (Appendix BB).
- Develop and implement a Mangrove, Samphire and Algal Mat Management Plan (MSAMMP). Further detail about the content of the MSAMMP is provided in Section 8.8.2.1.;
- Undertake the following monitoring measures to minimise residual groundwater impacts to BCH:
    - Installation of monitoring bores to allow water level and quality investigations;
    - Pumping tests of test bores within the aquifer to quantify aquifer parameters;
    - Numerical modelling to estimate potential for environmental impacts from groundwater mounding or seepage from evaporation ponds;

    - Collection of water level and quality data, and analysis in conjunction with other datasets to investigate nature of groundwater/surface water interaction and effects on GDEs;
    - Acquisition of water level, water samples and conductivity profiles from all monitoring bores to characterise natural variation and ongoing variations which may be due to effects of the Proposal;
    - Development of trigger and threshold criteria for groundwater quality from the baseline groundwater quality data;
- Given the annual variability of seagrass extent, conduct baseline seagrass surveys at least 12 months prior to any disturbance within the marine environment, annually during construction, and ongoing monitoring to be determined pending the results of the baseline surveys. The monitoring will be used to inform appropriate management measures if seagrass is identified within potential impact zones.
- Develop and implement an Oil Spill Response Plan. This Plan will be developed in consultation with PPA and will include:
    - Refuelling procedures;
    - Response equipment requirements;
    - Response procedures and action plans for various spill scenarios; and
    - Reporting and responsibilities.

  The following controls will be used to minimise the risk of hydrocarbon spills:
    - No bunkering of Proposal vessels on site
    - Refuelling of machinery only within designated areas
    - Fuel storage and refuelling areas designed with appropriate spill prevention and containment mechanisms and equipment in place
    - Spill kits present on site where any machinery is operating and on all Proposal vessels
    - Personnel trained in the spill response and use of spill kits to a level appropriate for their role and activities in which they are engaged.
- The following controls will be used to minimise the risk of impact from unintentional brine pipeline spills:
    - Pipelines will be fitted with leak detection;
    - Water flows will be shut off if leaks are detected;
    - Pipelines will be inspected regularly, especially during extreme heat or fire events;
    - Pipelines will be located off access road surfaces;
    - If pipelines have to cross access roads, then they will be buried;
    - Investigations will be conducted into the cause of any spills, and remedial actions will be taken to minimise the chance of reoccurrence; and
    - Spill response training to mitigate damage for site-based personnel.
- Ensure product infrastructure wash down water is captured and not released to the surrounding environment.
- Monitor erosion and install erosion protection (i.e., rock armouring and dune vegetation) if required (refer to Section 2.3).

8.8.2.1 MANGROVE, SAMPHIRE AND ALGAL MAT MANAGEMENT PLAN

A MSAMMP will be developed and implemented that integrates the monitoring of mangrove, samphire and algal mat health/status with the monitoring of shallow groundwater conditions (including salinity), and mapping showing Proposal-related changes in habitat distribution. This MSAMMP is currently being developed with the intention for this plan to address public review comments and be provided at the response to submissions stage of the assessment, or as a condition of approval (if approved). Further detail about the content of the MSAMMP is provided in the sections below, which has been generally informed by the draft BCH Monitoring and Management Plan developed for the Mardie Project.

8.8.2.1.1 MONITORING PROGRAM

K+S will implement a monitoring program to achieve the initial monitoring and management objectives and outcomes outlined in Table 61 and Table 62, respectively.

Each sub-program discussed below will be integrated into a set of transects, comprising control and impact areas, that commence at the seaward pond wall and will traverse generally in an east-west direction to the western margin of mangrove stands. The transect locations are being determined and will be defined in the MSAMMP.

Each sub-program will comprise of:

- On-ground monitoring for samphire health applied annually in an appropriate season (summer), or following a trigger event such as:
  - A wall breach, spill or cyclone;
  - An early warning trigger from the GWMMP; or
  - Where quarterly remote sensing data identifies values which fall below a specified trigger value;
- On-ground monitoring for algal mat health, dormancy and distribution annually in an appropriate season (see specific methods for algal mat monitoring in Section 8.8.2.1.1.2), or following a trigger event described above;
- On-ground monitoring for mangrove health using conventional methods conducted annually for five years (see specific methods for Mangrove monitoring in Section 8.8.2.1.1.3), or following a trigger event described above; and
- Continuous inundation/sea level monitoring via a tide gauge to determine:
  - Actual tidal inundation changes associated with the Proposal (i.e., due to the presence of the causeway, pond walls or due to seawater abstraction);
  - Actual freshwater inundation changes associated with the Proposal (i.e., due to drainage diversions and rainfall capture within the ponds); and
  - Sea level monitoring to record changes in sea water levels due to climate change.

A series of other monitoring and management plans will be implemented for the Proposal, including:

- GWMMP;
- IMPMMP;
- DSMP; and
- MEQMMP.

Findings from these monitoring programs may be used to inform the analysis of results from the MSAMMP monitoring and management actions or may trigger additional monitoring requirements.

8.8.2.1.1.1 INUNDATION/SEA LEVEL MONITORING

The monitoring information will be used to inform whether boundary changes to BCH are occurring as a result of changes to inundation or SLR. Inundation will be monitored by tide gauges as described in Table 61 and Table 62.

Inundation monitoring results will be used to assist in the investigation of any impacts identified from routine health monitoring of intertidal BCH.

8.8.2.1.1.2 ALGAL MATS

The spatial extent of algal mat BCH will be assessed quarterly using remotely sensed multi-spectral data. Analysis will be undertaken to determine the area of decline or expansion, as well as any seasonal or annual photosynthetic trends.

Pre-disturbance algal mat surveys will be undertaken within the monitoring program transects that contain algal mats to establish permanent monitoring transects and record baseline health, dormancy and distribution. Algal mat samples will be taken at evenly spaced intervals along the transect and will include active and dormant mat areas. Parameters to be measured include algal mat health, dormancy and distribution.

Algal distribution will be ground-truthed by foot searches with the boundary of the mat, within transects, traced by GPS. In subsequent survey events the previous survey tracks will be used to detect any change to the boundary.

Annual surveys of algal mat transects will be undertaken following construction to monitor for any change in algal mat health and/or distribution in accordance with methods above. Annual monitoring results will be compared with baseline data to determine if there has been any deleterious change including:

- Decrease in health;
- Changes to dormancy; and
- Decrease in distribution.

Results will be compared between control and impact transects. Where impacts are determined then additional surveys will be undertaken to attempt to establish the extent of any perceived impact.

Further detail related to the health monitoring of algal mat is included in Table 61 and Table 62.

8.8.2.1.1.3 MANGROVES

Conventional on-ground mangrove health monitoring will be conducted over an initial period with relevant metrics (canopy cover and tree health observations) correlated against remote sensing data collected concurrently over the same period. If remote sensing is determined to be an accurate method to detect change in mangrove community health, then routine mangrove health monitoring may be conducted remotely.

The routine monitoring program will include impact and reference transects, with quadrats utilised for on-ground health monitoring. Transects will be positioned to ensure assessment of impacts across the entire gradient for mangroves at each location.

The spatial extent of mangrove assemblages will be mapped from aerial photographs. A new dataset will be created every five years for spatial comparison with previous years. The spatial extent of the mangrove communities along the transects will be assessed using remotely sensed multi-spectral aerial imagery. GIS analysis will be used to determine temporal reduction or expansion of mangrove communities. Analysis will be undertaken quarterly to ensure early detection of any impacts related to mangrove health. The entire mangrove extent within the spatial bounds of each transect will be assessed.

Reactive on-ground health monitoring of mangrove assemblages will be undertaken after a trigger event, typically employing the same methods as routine health monitoring. The monitoring program is described in detail within Table 60.

8.8.2.1.1.4 INTERTIDAL SAMPHIRE

The spatial extent of intertidal samphire will be assessed on a quarterly basis using remotely sensed multi-spectral data along the integrated monitoring transects. Analysis will be undertaken to determine the area of decline or expansion / improvement, as well as any seasonal or annual photosynthetic trends.

Further detail related to the health monitoring of coastal samphire is included in Table 61 and Table 62.

Monitoring will be conducted using quadrats spaced evenly along permanent linear belt transects in accordance with EPA (2016) methods. Transect lengths are likely to vary between monitoring locations dependent on the width of the samphire community at each location. Samphire distribution will be ground-truthed by foot searches. In subsequent survey events the previous GPS survey tracks will be reviewed such that any change to the boundary is immediately detected during the on-ground survey. The phenological state of the plants will be recorded including evidence of flowering and recent new growth.

Following the establishment of baseline data all subsequent monitoring data will be compared to this baseline data to determine whether there has been any deleterious change including:

- Decrease in species diversity;
- Decrease in total plant numbers or numbers of individual species;
- Decrease in total foliage cover of all shrubs or for individual species;
- Increase in proportion of dead foliage to living foliage in any species; and/or
- Decrease in vegetation health measures.

Any apparent deleterious change in indirect impact areas will be compared to control sites to establish whether impact may be attributed to operations and require further investigation.

Where impacts are determined, foot and/or helicopter surveys will be undertaken to attempt to establish the impact extent.

Table 60: Monitoring of Intertidal BCH

Methods	Parameters	Location of monitoring sites	General timing + additional/other	Other parameters to be measured
BCH Mapping Sampling Method Aerial photography for the extent of the LAUs. Data Analysis 1. Map and calculate the spatial area of mangrove assemblages, algal mats and samphire communities. 2. Calculate loss/increase in mangrove spatial areas.	• Spatial extent. • Areas (ha) of BCH distribution.	Intertidal BCH areas within the LAUs.	Every five years.	N/A
Mangrove Health Monitoring A number of BCH transects will be established (including reference transects and impact transects). 1. Select locations along each transect which represent seaward edge, centre closed canopy and landward edge assemblages. 2. Survey flora quadrats at each location. 3. Collect data for qualitative, quantitative and general observations Data Analysis 1. Insect damage and tree health data averaged across each transect. 2. Assess impact sites against trigger criteria. 3. Calculate average canopy density. 4. Compare site averages for canopy cover against trigger criteria and trigger thresholds. 5. Determine net increase/decrease for impact sites against the trigger criteria and threshold.	• Insect damage. • Tree health / leaf health classification. • Canopy density. • No. of trees per quadrat. • Estimate average canopy height. • No. dead/dying limbs. • Presence of disease. • Damage. • Site photographs.	BCH Monitoring Transects	Annually. After significant incident or weather event Review at end of five years to direct ongoing monitoring.	N/A
Algal Mat and Samphire Monitoring Pre-disturbance baseline survey of intertidal BCH transects. Samples collected at evenly spaced intervals along each transect. Subsequent annual monitoring of transects in accordance with methods above. Annual monitoring results will be compared with baseline data to determine if there has been any deleterious change including: • Decrease in health; • Changes to dormancy; and • Decrease in distribution.	• Health; • Dormancy; and • Distribution	BCH Monitoring Transects	Annually. After significant incident or weather event Review at end of five years to direct ongoing monitoring.	Water depth, soil pH, water salinity, soil salinity.

8.8.2.1.2 OBJECTIVE-BASED MANAGEMENT ACTIONS

Table 61: Objective-based Management Actions

Management Targets	Management Actions	Monitoring	Timing/frequency of actions
Changes to surface water and groundwater levels associated with the Proposal are detected as early as possible.	N/A	Monitoring of groundwater as described in Section 13.7.2.1. Sampling at inundation monitoring points. Analysis of Inundation levels relative to model predictions across full tidal range and mean trend relative to known land benchmarks and past yearly assessments.	Continuous real-time sampling.
Losses of intertidal BCH as a result of the Proposal are accurately recorded	N/A	Algal Mat, Mangrove and Samphire BCH extent within the spatial bounds of each applicable transect (refer to Section 8.8.2.1.1)	Refer to Section 8.8.2.1.1
Proposal-attributable adverse impacts to intertidal BCH are addressed using best-practice available management mitigation and contingency measures.	Undertake investigation into the cause of the impact. Investigate and reengineer design, groundwater management, pollution controls, tidal flow regimes or other measure as determined by investigation to ensure no further impacts are likely.	Algal Mat, Mangrove and Samphire BCH extent within the spatial bounds of each applicable transect (refer to Section 8.8.2.1.1)	If the Proposal-attributable adverse impacts to intertidal BCH are detected. Post-incident monitoring to continue as described in Section 8.8.2.1.1.

8.8.2.1.3 OUTCOMES-BASED MANAGEMENT ACTIONS

Table 62: Outcomes-based Management Actions

• Trigger Criteria • Trigger Thresholds	Response actions	Monitoring	Timing/frequency of actions	Reporting
Outcome 1: **No direct impacts to intertidal BCH that exceed the maximum impact areas proposed in this ERD.**				
Trigger criterion 1 Final Proposal design would result in direct impacts to mangroves,	**Trigger level actions / timing to implement:** 1. Proposal is to be re-designed to ensure the extent of final direct impacts to mangroves, algal mats and intertidal samphires do not exceed the	Proposal design footprint to be monitored against mapped mangroves, algal mats and intertidal samphire extent on a monthly basis	On a monthly basis during intertidal clearing activities or after any major Proposal design revision.	Refer to Section 8.8.2.1.4.5

• Trigger Criteria • Trigger Thresholds	Response actions	Monitoring	Timing/frequency of actions	Reporting
algal mats and intertidal samphires that exceed the maximum areas proposed in this ERD. **Trigger criterion 2** Clearing of mangroves, algal mats or intertidal samphires occurs outside of final Proposal design footprint. **Threshold criterion 1** Final Proposal footprint has resulted in direct impacts to mangroves, algal mats and intertidal samphires that exceed the maximum areas proposed in this ERD.	maximum areas proposed in this ERD. Demonstrate that the outcome can be achieved with a revised design within 1 month. 2. Proposal design is reviewed to determine if the additional clearing would result in direct impacts that exceed the maximum areas proposed in this ERD. If yes, then the Proposal is to be re-designed to reduce the extent of final direct impacts accordingly. Demonstrate that the outcome can be achieved with a revised design within 1 month. **Threshold Contingency Actions (and timing to implement):** 1. Identify areas of mangroves, algal mats or intertidal samphires that were cleared that are available and suitable for an attempted reinstatement of communities. Areas are to be equivalent or greater than the unauthorised area cleared. 2. Liaise with DBCA and relevant BCH experts to determine the best available methods for rehabilitation. 3. Undertake rehabilitation until it can be demonstrated that the affected BCH has become established.	during intertidal clearing activities or after any major Proposal design revision. Ground disturbance permit system to be used to monitor any clearing of mangroves, algal mats and intertidal samphires outside the final Proposal design footprint.	Mangrove, algal mat and intertidal samphire boundaries will be monitored prior to ground disturbing activities, and annually thereafter. Monitoring will also be triggered where a potential impact on these communities is identified.	
Outcome 2: **No adverse impact on mangroves, algal mats and intertidal samphires outside the predicted indirect impact areas presented in this ERD.**				
Trigger criterion 1 No decline in cover / density outside the predicted indirect impact areas presented in this ERD that is	**Trigger level actions / timing to implement:** Implement reactive monitoring programs and assessment against Threshold Criteria. **Threshold level actions / timing to implement:** 1. Investigate to determine the cause of the threshold criteria being exceeded.	Monitoring to be conducted in accordance with detailed management plans.	If monitoring determines a breach of trigger or threshold criteria	Refer to Section 8.8.2.1.4.5

• Trigger Criteria • Trigger Thresholds	Response actions	Monitoring	Timing/frequency of actions	Reporting
greater than reference sites. **Threshold criterion 1** Proposal results in a reduction in spatial extent outside the predicted indirect impact areas presented in this ERD.	2. Implement multiple lines of evidence approach to determine if other health indictors have declined (e.g., disease, dying canopy, storm impacts (cyclone), yellowing leaves etc). Where exceedance is attributed to Proposal activities or Proposal infrastructure, investigate and reengineer design or other action as determined by investigation to ensure source of the impact is removed and no further impacts are identified. Investigate remediation or restoration to return BCH to baseline condition and spatial area.			

8.8.2.1.4 ADAPTIVE MANAGEMENT AND REVIEW

8.8.2.1.4.1 ADAPTIVE MANAGEMENT

K+S is committed to improving environmental results and management practices throughout the implementation of the Proposal and therefore will use an adaptive management approach for the MSAMMP. Adaptive management practices will include:

- Annual review and comparison of monitoring data and information gathered against established baseline data;
- Annual evaluation of monitoring and management outcomes against management targets and the objectives of the MSAMMP; and
- Review of management actions and identification of potential new management measures and technologies that may be more effective.

8.8.2.1.4.2 REVIEW REQUIREMENTS

The MSAMMP will be reviewed annually through the construction phase and every two years during operation. It will also be updated based on review outcomes. The review will take into account whether best practice and management targets are being achieved or are likely to be achieved and will identify any updates required to realise the targets.

8.8.2.1.4.3 ROUTINE AND REACTIVE MONITORING

Reactive monitoring and management is proposed in response to a trigger event, which may include but is not limited to:

- A wall breach or other brine spill;
- Monitoring data that suggests a significant change;
- Confirmed reports of significant BCH impacts; and
- After cyclones, if warranted.

Implementation of reactive monitoring and management will allow K+S to respond to unforeseen potential impacts and therefore have improved success in achieving the management targets.

8.8.2.1.4.4 EARLY RESPONSE INDICATORS, CRITERIA AND ACTIONS

The MSAMMP will include early response indicators and actions regarding inundation and groundwater impacts, with the intent of making design or operational changes as soon as practicable, before significant BCH impacts occur. Early response indicators include review of quarterly remote sensing data to identify any measurable changes to BCH.

8.8.2.1.4.5 REPORTING

In the event that monitoring or investigations at any time indicate an exceedance of management targets or threshold criteria specified in the MSAMMP, K+S will report any exceedance (in writing) within seven (7) days of the exceedance being identified and implement the threshold contingency actions within seven (7) days of the exceedances being reported. K+S will continue to implement those actions until it has been demonstrated that the threshold criteria are being met and implementation of the threshold contingency actions are no longer required.

K+S will further investigate to determine the cause of the exceedance, to determine any potential environmental harm or alteration of the environment. Within 21 days of the exceedance being reported, K+S will provide a report, detailing:

- Implemented threshold contingency actions;
- Their effectiveness against management targets and threshold criteria;

- Investigation findings;
- Measures to prevent the threshold criteria being exceeded in the future;
- Measures to prevent, control or abate impacts which may have occurred; and
- Justification (where relevant) of the threshold criteria remaining or being adjusted based on better understanding.

Monitoring reports will also be provided to DWER on an annual basis.

8.8.3 REHABILITATE

At the completion of the Proposal the site will be rehabilitated to reinstate BCH. A MCP will be required under the *Mining Act 1978* for the majority of the Proposal. Temporary disturbance of BCH areas due to construction will not occur (i.e., all disturbance is permanent for the life of the operation), therefore there will be no rehabilitation of BCH during the life of the operation.

The natural loss of mangroves and algal mat after approximately 50 years, due to SLR is predicted occur with or without the Proposal in place (Seashore Engineering, 2021). However, the Proposal is uniquely positioned to consider the creation of ongoing habitat for algal mat and mangroves as a part of Proposal closure and this will be explored as part of closure planning for the site. The effect of SLR will be considered during the closure planning process, and it may be possible to create a “niche” environment for mangroves and/or algal mats which may enable them to continue to exist beyond the currently anticipated timeframe of SLR induced mangrove/algal mat loss, by providing physical protection from the effects of SLR behind rock armoured embankments.

An Interim MCP (Appendix BB) has been developed for the Proposal and will continue to evolve during the life of the Proposal. K+S preferred post closure land use is to leave the evaporation ponds in situ so that they become a “wetland” habitat for mangroves, algal mats and associated fauna (including migratory birds which require “wetland areas” for migratory stop over). This will also likely create habitat opportunities for the survival of mangroves and/or algal mats beyond the currently anticipated timeframe of sea level rise induced mangrove/algal mat loss.

At the completion of operations, all buildings and structures on land will be removed from the site and the pond areas may be selectively reconnected to the existing tidal flat system. The bitterns discharge infrastructure will be removed from site; however, the jetty may be transferred to the ownership of another user. Alternatively, it could be decommissioned and removed. If ponds are to be reconnected, the MCP will establish which embankments to breach that will enable inwards tidal movement bringing sediments and allowing tidal channels to expand naturally. Natural tidal flows will allow movement of mangrove propagules (seeds) which will passively revegetate the reconnected tidal areas. This will enhance the habitat values of the ponds to BCH and fauna post closure. The effect of SLR will be considered during the closure planning process.

If the Proposal receives Ministerial Approval under Part IV of the EP Act as well as under the EPBC Act, the Interim MCP will be developed in more detail and submitted to DMIRS for approval as required by the *Statutory Guidelines for MCPs under the Mining Act 1978* - DMIRS (2020b).

8.8.3.1 REHABILITATION EXPERIENCE, KNOWLEDGE GAPS AND OUTCOMES

K+S has conducted a review of rehabilitation experience and identified knowledge gaps as follows:

- Mangrove recolonisation is proven in other projects (AECOM, 2022a). Therefore, encouraging establishment of mangroves in intertidal areas should be readily achievable.
- Very few solar salt projects have entered the closure and rehabilitation phase, with most solar salt projects having long operational lifetimes. However, many solar salt projects are considering “tidal reconnection” of ponds on closure to be a potential end land use in recognition of the important intertidal, benthic and fauna habitat that salt ponds create (AECOM, 2022a). One example is the Dry Creek Salt field which is in closure stage after operating in Adelaide since the late 1930s. The Dry

- Creek Salt field has recently demonstrated a successful tidal reconnection trial for one of its salt evaporation ponds - Mosley et. al (2019).
- Knowledge gaps exist regarding the viability of tidal reconnection of the ponds at the Ashburton Salt site, including detailed modelling to determine which pond walls to breach to create a functioning tidal wetland system, which is ideally resilient to SLR, longer than the existing surrounding habitat. These knowledge gaps will be addressed during the closure planning process.

With regards to rehabilitation and closure outcomes, K+S aims to achieve:

- Site-specific rehabilitation and closure outcomes consistent with the end land use that are realistic and achievable based on a thorough closure risk assessment.
- Completion criteria that are specific, measurable, achievable, relevant and time-bound, and will demonstrate the achievement of the closure outcomes and monitoring.

8.9 PREDICTED OUTCOME

The EPA objective in relation to BCH is to *protect benthic communities and habitats so that biological diversity and ecological integrity are maintained*.

K+S has incorporated extensive avoidance and minimisation measures into the Proposal design and operational processes. A key measure was to focus the disturbance footprint further inland on the unvegetated Supratidal salt flats, which has resulted in only a small proportion of the total Proposal footprint occurring within mangrove, algal mat and samphire BCH. With the implementation of these measures the Proposal will result in the loss of 76.66 ha of intertidal BCH and 226.39 ha of subtidal BCH.

It is concluded that the EPA's objective can be met by the Proposal with the implementation of appropriate management measures and plans. Key findings supporting this are:

- The scale of impacts to BCH are very low (typically <1% loss in LAUs and <0.2% loss in Exmouth Gulf) (apart from samphires). Habitat losses of those magnitudes do not constitute a significant threat to the integrity or overall productivity of the intertidal and marine ecosystem (AECOM, 2022a).
- Potential indirect impacts to mangroves from the modification to tidal flows, pond-related seepage and modified groundwater conditions are largely avoided due to the location of the pond system and sufficient setback between the ponds and mangrove zone. This finding is supported by both the modelling studies and experience gained from other salt fields within similar settings on the Pilbara coast (AECOM, 2022a).
- While large areas of salt flat are to be covered by the Proposal footprint, the relative nutrient contribution from the salt flats is very low at local and regional scales. In addition, overland flows reaching coastal ecosystems via the salt flats can be maintained by incorporating measures (e.g., spillways, diversion channels) designed to re-direct overland flows around the pond system. The Proposal is predicted to have very minor impact on nutrients flowing into Exmouth Gulf which predominantly originate from ocean-based sources. Impacts related to nutrient pathways are not predicted to compromise existing environmental values including intertidal or subtidal BCH primary or secondary productivity (Water Technology, 2021d) (AECOM, 2022a).
- In terms of biodiversity, when considering the regional distribution of BCH and marine biogeography, the diversity of mangrove species, algae species (within either algal mats or in subtidal habitats) and marine invertebrate fauna are likely to be well represented along the Pilbara coast and, as such, biodiversity is not expected to be impacted at either local or regional scales (AECOM, 2022a).

Modelling of impacts is based on highly conservative assumptions (Water Technology, 2022b) (Water Technology, 2021d) (Water Technology, 2021c) and has been peer reviewed (DHI, 2021) and a detailed thorough assessment of BCH has been undertaken (AECOM, 2022a). Therefore, the level of confidence in the predicted outcome is high.

While the loss of BCH is considered unlikely to be significant from a broader biological diversity and ecological integrity perspective, this loss of BCH is considered to be significant given it occurs within BIAs or is considered critical habitat for several significant marine fauna species. The Proposal is therefore predicted to result in the following residual impacts that are considered significant, as reflected in the Marine Fauna and Terrestrial Fauna sections:

- The loss of up to 226.2 ha of nearshore BCH, which may be utilised by species such as turtles, dugong, green sawfish and other elasmobranchs;
- The loss of the following BCH which may be utilised by Migratory Shorebirds:
    - 0.99 ha of Sandy Beaches BCH;
    - 4.28 ha of Mangroves BCH, which may also be utilised by green turtle juveniles;
    - 17.81 ha of Transitional Mudflat BCH;
    - 16.68 ha of Algal Mats BCH.
- The loss of 0.54 ha of tidal creek BCH, which may be utilised by green sawfish and green turtle juveniles.

Offsets are proposed to counterbalance these significant residual impacts (refer to Section 17).

Based on the above the Proposal is expected to be able to meet the EPA's objective for this factor. The implementation of the proposed mitigation and offsets are expected to minimise and counterbalance any significant residual impacts to BCH.

8.9.1 POTENTIAL BENEFITS

There are a range of environmental benefits to the local coastal ecosystem that may develop due to the presence and operation of the salt ponds as outlined below.

- At both the Dampier and Port Hedland solar salt fields a biological system has developed within the ponds composed of a sub-set of species from adjacent tidal creeks and nearshore waters:
    - Seawater pumped from adjacent tidal creeks passes through a screen mesh which allows small crustaceans, plankton and the eggs, larvae and juveniles of fish to pass into the ponds.
    - Due to the large areas of the concentration ponds and volumes of water pumped, the abundance of biota such can be considerable. Fisheries WA (2002) has estimated the fish populations to range in mass up to 105 t.
- Within the concentration ponds at the Port Hedland and Onslow salt fields, deltas have formed from the accumulation of fine sediments transported into the ponds by the pumping of tidal waters:
    - The deltas support high densities of infauna and thereby attract a large number and diversity of migratory shorebirds (regularly up to 27 shorebird species) (LDM, 1998),(WABN, 2021).
    - Shorebird surveys conducted periodically since the early 1980s have identified the salt ponds as an important stop-over point for migratory shorebirds on the East Asia – Australian Flyway (AECOM, 2022a).
    - It is therefore likely, that if developed, the Proposal would form additional valuable habitat for shorebirds to that existing at the nearby Onslow Salt operation (AECOM, 2022a)
    - Mangrove seeds (propagules) have also been entrained within the seawater and settled out within the sedimentary deltas and become established. As part of the mangrove monitoring and rehabilitation studies undertaken for the Port Hedland saltworks (LDM, 1998), mapping of mangrove recruitment into the deltas (based on aerial photographs) calculated that approximately 19 ha of mangroves had colonised the deltas in the period between the commissioning of the concentration ponds in 1966 and 1993.
- Mangrove recruitment and algal mat expansion has also been observed to occur in seepage zones adjacent to pond embankments at other solar salt operations:
    - The low salinity conditions from the seepage of water from a primary concentration pond can provide conditions conducive for natural mangrove seedling recruitment and algal mat expansion.
    - This has been observed to occur next to the Port Hedland salt ponds (AECOM, 2022a). Salinities in the Proposal ponds CP1 and CP2 will be approximately 40 ppt and 60 ppt and hence the seepage from these ponds is likely to provide much lower salinity conditions than those currently experienced in adjacent algal mat and salt flat areas which may encourage the development of algal mats in peripheral seepage areas and mangrove recruitment in permanently inundated seepage areas (AECOM, 2022a).

9 MARINE FAUNA

9.1 EPA OBJECTIVE

To protect marine fauna so that biological diversity and ecological integrity are maintained.

9.2 POLICY AND GUIDANCE

- *A Directory of Important Wetlands in Australia* (ANCA, 1993).
- *Approved Commonwealth Conservation Advice on Pristis clavata (Dwarf sawfish)* (TSSC, 2009a).
- *Approved Conservation Advice for Aipysurus apraefrontalis (Short-nosed Sea Snake)* (DSEWPaC, 2011a).
- *Approved Conservation Advice for Dermochelys coriacea (Leatherback Turtle)* (DEWHA, 2008a).
- *Approved Conservation Advice for Megaptera novaeangliae (humpback whale)* (TSSC, 2015a).
- *Approved Conservation Advice for Pristis zijsron (Green Sawfish) (TSSC, 2008)*.
- *Australian and New Zealand Guidelines for Fresh and Marine Water Quality* (ANZG, 2018)
- *Australian Ballast Water Management Requirements* (DAWR, 2017).
- *Biofouling Biosecurity Policy* (DoF, 2017a).
- *Commonwealth Listing Advice on* Aipysurus apraefrontalis *(Short-nosed Seasnake)* (TSSC, 2011b).
- *Commonwealth Listing Advice on Pristis* clavate *(Dwarf Sawfish)*. (TSSC, 2009b).
- *Conservation Advice Rhincodon typus whale shark* (TSSC, 2015c).
- *Conservation Management Plan for the Blue Whale - A Recovery Plan under the Environment Protection and Biodiversity Conservation Act 1999* (Commonwealth of Australia, 2015).
- *Environmental Assessment Guideline 5 – Protecting Marine Turtles from Light Impacts* (EPA, 2010).
- *Environmental Factor Guideline: Marine Fauna* (EPA, 2016g).
- *EPBC Act Environmental Offsets Policy* (Commonwealth of Australia, 2012).
- *EPBC Act Policy Statement 2.1 - Interaction between offshore seismic exploration and whales: Industry guidelines (DOEWHA, 2008).*
- *Light Pollution Guidelines: National Light Pollution Guidelines for Wildlife Including Marine Turtles, Seabirds and Migratory Shorebirds (DotEE, 2020).*
- *Marine Bioregional Plan for the North-West Marine Region* (DSEWPaC, 2012).
- *National Assessment Guidelines for Dredging* (Commonwealth of Australia, 2009)
- *National Strategy for Mitigating Vessel Strike of Marine Mega-fauna* (DotEE, 2017b)
- *Recovery Plan for Marine Turtles in Australia* (Commonwealth of Australia, 2017b).
- *Recovery Plan for the Grey Nurse Shark* (*Carcharias taurus*) (DoE, 2014)
- *Sawfish and River Sharks Multispecies Recovery Plan* (DotE, 2015a)
- *Significant impact guidelines for 36 migratory shorebird species (EPBC Act Policy Statement 3.21)* (DEWHA, 2009a).
- *Technical Guidance - Environmental Impact Assessment of Marine Dredging Proposals* (EPA, 2016d).
- *Threat abatement plan for predation by feral cats* (DotE, 2015b).
- *Threat abatement plan for predation by the European red fox* (DEWHA, 2008c).
- *Threat abatement plan for predation, habitat degradation, competition and disease transmission by feral pigs (Sus scrofa)* (DEE, 2017).
- *Threat Abatement Plan for the Impacts of Marine Debris on Vertebrate Marine Life* (DEWHA, 2009b).
- *Threat Abatement Plan for the impacts of marine debris on the vertebrate wildlife of Australia's coasts and oceans (DEE, 2018)*.
- *Vessel Check: Biofouling Risk Assessment Tool* (DoF, 2017b).
- *WA Environmental Offsets Guidelines* (Government of Western Australia, 2014).
- *WA Environmental Offsets Policy* (Government of Western Australia, 2011).

9.3 MARINE FAUNA STUDIES

Studies to assess impacts to marine fauna have been conducted as summarised in Table 63.

Table 63. Marine Fauna Studies

Report	Reference	Appendix
Marine Fauna Impact Assessment	AECOM, 2022	N
Light Spill Modelling	Pendoley Environment, 2020	N
Underwater Sound Modelling	Talis, 2021	N
Sawfish Survey	Morgan et. al., 2020	N
Ecotoxicology Assessment	AECOM, 2022c	L
Assessment of Benthic Communities and Habitats	AECOM, 2022a	M
Shorebird Survey	Biota, 2021	O
Marine and Coastal Assessment and Modelling	Water Technology, 2022b	A
Nutrient Pathways Assessment and Modelling	Water Technology, 2021d	J
Marine, Surface Water and Nutrient Modelling Peer Review	DHI, 2021	F
Prawn Assessments	Water Technology, 2022c	P
Updated Artificial Light Monitoring and Modelling Report	Pendoley Environment, 2023	DD

9.3.1 MODELLING

Specific modelling studies (Talis, 2021), ((Pendoley Environmental, 2020), Pendoley Environmental, 2023), (Water Technology, 2021d), (Water Technology, 2022b) have been conducted to assess potential impacts of the Proposal regarding:

- Underwater sound.
- Anthropogenic light spill.
- Dredging sediment release.
- Bitterns discharge.
- Nutrient pathways.

9.3.2 MODELLING PEER REVIEW

A peer review of the above water related modelling studies have been conducted. The peer review process was undertaken in a comprehensive, rigorous and iterative manner. It is the opinion of the nutrient and marine peer reviewer that the models constructed by Water Technology (2021, d; e) can be considered suitable for the purpose of identifying potential environmental impacts (DHI, 2021).

9.4 EXISTING ENVIRONMENT

9.4.1 LITERATURE REVIEW, GAP ANALYSIS AND STUDY METHODS

The marine fauna baseline assessment is based on an extensive review of available literature and Proposal specific survey data. A literature review was undertaken, comprising not only a review of publicly available literature, but also liaison with technical specialists, including sawfish and prawn specialists from Murdoch University and DPIRD, to understand current and past research into potentially affected marine fauna species and identify knowledge gaps that exist (AECOM, 2022b).

An assessment was undertaken of the 'likelihood of occurrence' for threatened marine species identified through the database search and desktop review. The results of the likelihood of occurrence assessment are provided in full in Appendix N (Marine Fauna Assessment) and summarised in Table 64 below (AECOM, 2022b).

The literature review and gap analysis identified a number of focus areas for the marine fauna study that required further investigation to enable adequate assessment of potential impacts. The results of the gap analysis are summarised in Table 65 whilst the methods employed for all studies are summarised in Table 66 (AECOM, 2022b).

Table 64: Threatened Marine Fauna Species Likelihood of Occurrence Locally
(AECOM, 2022b)

Common name	Scientific name	Threatened Status			Likelihood of occurrence
		EPBC Act	BC Act	IUCN	
Elasmobranchs - Sharks, fish and rays					
Whale shark	*Rhincodon typus*	V, MM	OS	E	May occur
White shark	*Carcharodon carcharias*	V, MM	V	V	Unlikely to occur
Grey nurse shark (west coast)	*Carcharias taurus*	V	V	V	May occur
Green sawfish	*Pristis zijsron*	V, MM	V	CE	Likely to occur
Dwarf sawfish	*Pristis clavata*	V	P1	E	May occur
Narrow sawfish	*Anoxypristis cuspidata*	MM	-	E	May occur
Shortfin mako	*Isurus oxyrinchus*	MM	-	V	Unlikely to occur
Longfin mako	*Isurus paucus*	MM	-	E	Unlikely to occur
Reef manta ray	*Manta alfredi*	MM	-	V	May occur
Giant manta ray	*Manta birostris*	MM	-	V	May occur
Giant Guitarfish	*Glaucostegus typus*	-	-	CE	Likely to occur
Nervous Shark	*Carcharhinus cautus*	-	-	LC	Likely to occur
Bottlenose Wedgefish	*Rhynchobatus australiae*	-	-	CE	Likely to occur
Marine mammals					
Sei whale	*Balaenoptera borealis*	V, MM	E	E	Unlikely to occur
Fin whale	*Balaenoptera physalus*	V, MM	E	V	Unlikely to occur
Humpback whale	*Megaptera novaeangliae*	V, MM	CD	LC	Likely to occur
Blue whale	*Balaenoptera musculus*	E, MM	E	E	Unlikely to occur
Southern right whale	*Eubalaena australis*	E, MM	V	LC	Unlikely to occur
Antarctic minke whale	*Balaenoptera bonaerensis*	MM		NT	Unlikely to occur
Bryde's whale	*Balaenoptera edeni*	MM		LC	Unlikely to occur
Sperm whale	*Physeter macrocephalus*	MM	V	E	Unlikely to occur
Killer whale	*Orcinus orca*	MM	-	DD	Unlikely to occur
Spotted bottlenose dolphin	*Tursiops aduncus*	MM	-	NT	May occur
Australian humpback dolphin	*Sousa sahulensis*	MM	P4	V	Likely to occur
Dugong	*Dugong dugon*	MM	OS	V	Likely to occur
Marine reptiles					
Hawksbill turtle	*Eretmochelys imbricata*	V, MM	V	CR	Likely to occur
Flatback turtle	*Natator depressus*	V, MM	V	DD	Likely to occur
Green turtle	*Chelonia mydas*	V, MM	V	E	Likely to occur
Loggerhead turtle	*Caretta*	E, MM	E	CR	Likely to occur
Leatherback turtle	*Dermochelys coriacea*	E, MM	V	CR	May occur
Short-nosed sea-snake	*Aipysurus apraefrontalis*	CE	CR	CR	May occur
Leaf-scaled sea snake	*Aipysurus foliosquama*	CE	CR	DD	May occur

Table Key: * - Species identified during field surveys, CE / CR – Critically Endangered, E – Endangered, V/VU – Vulnerable, MI – Migratory, MM – Migratory Marine, CD – Conservation Dependent, P4 – Priority 4, OS – Other specially protected fauna, LC – Least Concern, DD – Data Deficient, NT – Near Threatened

Table 65: Marine Fauna Knowledge Gap Analysis
(AECOM, 2022b)

Summary of baseline gap analysis	Gaps identified	How the gaps have been addressed
Sawfish		
• The closest known research into sawfish distribution and abundance was undertaken in the Ashburton River, as well as surrounding creeks, as part of the Chevron Wheatstone Project. • A review of the Exmouth Gulf Prawn Resource Status Report by Kangas et. al (2019), revealed that 15 sawfish were caught in commercial fishing activities during 2017 indicating that sawfish are present in the vicinity of the Proposal area.	• There is no information on the use of the nearshore area surrounding the Proposal area by sawfish. • It is believed that both Urala Creek North and South contain suitable habitat for sawfish; however, the importance of this habitat is unknown (i.e., pupping ground and/or nursery area). • Benthic habitat mapping to determine Proposal specific habitat associations has not yet been undertaken. • Proposal specific potential effects of sound, light, vessel movement, seawater intake and water quality changes are not yet well understood.	• The use of the creeks and nearshore environment by sawfish species and the importance of these creeks as pupping/nursery areas for juvenile sawfish was investigated in February 2019 (Morgan et al. 2020). • Benthic habitat survey and mapping (AECOM, 2022a) was undertaken in to identify areas of habitat to assist in minimising potential Proposal related impacts. • Water quality and ecotoxicity studies were undertaken to minimise the potential for impacts from changes in water quality due to bitterns discharge, sedimentation and nutrient flows from the catchment. • Modelling of the seawater intake was undertaken including potential impacts to assist in quantifying the potential impact on important sawfish habitat (Water Technology, 2022b) • Underwater sound modelling was undertaken to determine the potential zones of impact of pile driving and other Proposal generated sound sources, and to determine suitable observation and management zones (e.g., for application of soft start procedures) (Talis, 2021). • Light modelling was undertaken to understand the potential impacts of artificial light spill on ontogenetic changes in behaviour (e.g., predator-prey relationships) (Pendoley Environmental, 2020). Updated and additional site light monitoring and modelling was completed in 2023 (Pendoley Environmental, 2023).
Whales, dolphins and dugong		
• The abundance, distribution and habitat associations of cetaceans and dugongs known to occur in the Exmouth Gulf region are well understood. • It can be assumed that species that have been recorded, or are known to occur, in the Exmouth Gulf region have the potential to pass through the Proposal area. • Habitat associations are well known, and detailed habitat mapping can assist in determining the use of the Proposal area by certain species, such as dugong distribution being closely related to seagrass distribution. • Mitigation measures associated with Proposal related activities (such as piling and vessel	• Benthic habitat mapping to determine Proposal specific habitat associations has not yet been undertaken. • Proposal specific potential effects of sound, light, vessel movement and water quality changes are not yet well understood.	• Benthic habitat survey and mapping (AECOM, 2022a) to determine areas of important habitat and to assist in implementing management measures to minimise the potential for impact to important habitat associations. • Water quality and ecotoxicity assessments were undertaken to minimise the potential for impacts from changes in water quality due to bitterns discharge, sedimentation and nutrient flows from the catchment (Water Technology, 2022b) (AECOM, 2022c). • Underwater sound modelling was undertaken to determine the potential zones of impact of pile driving and other Proposal generated sound sources, and to determine suitable observation and management zones (e.g., for application of soft start procedures) (Talis 2021). • Light modelling was undertaken to understand the potential impacts of artificial light spill on ontogenetic changes in behaviour (e.g., predator-prey relationships) (Pendoley Environmental 2020). Updated and additional site light monitoring and modelling was completed in 2023 (Pendoley Environmental, 2023).

Summary of baseline gap analysis	Gaps identified	How the gaps have been addressed
activities) are well understood and therefore can be applied to the Proposal.		
Marine turtles		
• Previous surveys have recorded low density nesting of flatback and green turtles on Urala Beach in front of Urala Homestead. • Aerial surveys have recorded a number of turtles around the mouth of Urala Creek North, indicating that this area may be important foraging habitat; however, the importance of the creeks to juvenile turtles is not well understood.	• No dedicated nesting track census survey has been undertaken between Urala Creek North and South. • Use of Urala Creek South by foraging juveniles is unknown. • Benthic habitat mapping to determine Proposal specific habitat associations has not yet been undertaken. • Proposal specific potential effects of sound, light, vessel movement and water quality changes are not yet well understood.	• A turtle nesting survey of the Proposal area and surrounding beaches was undertaken in December 2018 and 2019. Opportunistic observations were made of the use of Urala Creek South for foraging juveniles. Together, these enable a reduction in the risk of potential impacts to key habitats, and the evaluation and mitigation of the risk of entrapment in the seawater intake. • Benthic habitat survey and mapping was undertaken (AECOM, 2022a) to determine areas of important habitat and to assist in implementing management measures to minimise the potential for impact to important habitat associations. • Water quality and ecotoxicity assessments were undertaken to minimise the potential for impacts from changes in water quality due to bitterns discharge, sedimentation and nutrient flows from the catchment (Water Technology, 2022b) (AECOM, 2022c). • Underwater sound modelling was undertaken to determine the potential zones of impact of pile driving and other Proposal generated sound sources, and to determine suitable observation and management zones (e.g., for application of soft start procedures) (Talis 2021). • Light spill modelling was undertaken to determine the impacts of lighting on beaches and nearshore areas surrounding the proposed jetty location (Pendoley Environmental 2020) Updated and additional site light monitoring and modelling was completed in 2023 (Pendoley Environmental, 2023).
Prawns		
• All waters adjoining the Proposal development footprint are included in the EGPMF footprint whilst waters to the North of the Proposal area are included in the OPMF. • The primary species associated with the EGPMF are brown tiger prawns (*Penaeus esculentus*), western king prawns (*P. latisulcatus*) and blue endeavour prawns (*Metapenaeus endeavouri*). • It is understood that the primary area for prawn recruitment is towards the southern end of Exmouth Gulf in the area south of Tent Point and away from Urala Creek South (AECOM, 2022b).	• Little is known about juvenile prawn abundance and distribution within the tidal creeks of the eastern Exmouth Gulf (including Urala Creek South, where the seawater intake will be located). • Benthic habitat mapping to determine Proposal specific habitat associations has not yet been undertaken. • Proposal specific potential effects of sound, light, vessel movement, pests, entrainment and water quality changes are not yet well understood.	• The abundances of post-larval and juvenile prawns in Urala Creek North, in Urala Creek South, within the predicted nursery area at the mouth of Urala Creek South, and in the vicinity of the proposed bitterns discharge location was investigated in 2019 (AECOM, 2022b). • K+S commissioned Water Technology to undertake an ABM study to assess the potential impacts of the intake and outfall on prawn populations in Exmouth Gulf (Water Technology, 2022c). This study is a collaborative effort with extensive stakeholder engagement with participants from DPIRD, MG Kallis and Murdoch University. The results of this prawn modelling exercise are intended to be provided to DPIRD as the managers of the fisheries.

Table 66: Summary of Marine Fauna Surveys and Modelling Methods

Type	Details	Methods
Survey	Sawfish Survey	Morgan et al. (2020) undertook targeted sawfish surveys in Urala Creek North and South in February 2019. Nets were set in the afternoon and removed in the evening. Sampling of a variety of creek habitats occurred for between 1.5 and 5 hours using two 60 m lengths of 152 mm (stretched mesh) monofilament gill nets. Nets were most often set perpendicular to the bank, fishing from the shallows (0–0.1 m) to deeper water (down to 2 m). Walking surveys were also conducted along the shoreline or along straight transect lines in shallow areas at different times of the day. Boat surveys were also conducted in a 3.75 m vessel along straight transect lines throughout the mouth and shallow areas of both creeks (AECOM, 2022b).
	Turtle Nesting Survey	Two turtle nesting surveys were undertaken by an experienced AECOM turtle biologist in December 2018 and December 2019 (peak nesting period of flatback turtles). The survey area comprised mainland beaches from Ashburton River to the mouth of Urala Creek South and nearshore islands. Surveys were undertaken from dawn until midday and completed using an R44 Helicopter flown at slow speeds at a height of approximately 100 m to allow any recent turtle activity to be identified. All turtle activity was recorded on an electronic tablet with the location of the activity recorded on a handheld GPS and photographs taken. Where possible, the species of turtle was identified from the track. It was also recorded whether the turtle activity occurred before, during or after high tide (AECOM, 2022b).
	Prawn Post-larval Survey	Field work was conducted in January, February, October, November and December 2019 to sample post-larval and juvenile prawns in Urala Creek North, Urala Creek South, the prawn nursery area adjacent to the mouth of Urala Creek South, and in the vicinity of the bitterns discharge area. Sampling included a plankton net (177 µm mesh) to capture post-larval prawns in the upper half of the water column and a benthic trawl net (26 mm diamond mesh) to capture juvenile and adult prawns from the seabed. All plankton and prawns were identified to species level where possible under a dissecting microscope (Murdoch University, 2020) (AECOM, 2022b).
	Benchmark Light Survey	Pendoley Environmental (2020) undertook a benchmark light survey from 3 beach locations (LM1 4 km south of Turbridgi Point, LM2 3 km north of Tubridgi Point and LM3 1 km north of Locker Point) to establish a baseline to assess the potential changes to the light environment from the Proposal. Four survey locations were selected for benchmark light data collection, three situated on the mainland and the one on the south side of Locker Island. Light data were collected for three monitoring nights between 22–25 May 2019 using a Sky42™ light monitoring camera to acquire low-light images of the entire night sky.
	Updated Light Survey	Pendoley Environmental (2023) updated the benchmark light program conducted at Locker Island and the mainland (LM3) monitoring sites to address comments received by the EPA. Furthermore, to ensure compliance with the guidance and recommendations of the NLPGW which were released after the initial benchmark light program, Pendoley Environmental undertook artificial light monitoring and modelling at additional sites situated at potential sensitive nesting habitat within a 20 km buffer of the Proposal infrastructure (including offshore transhipment areas and mainland jetty). This buffer area is a specific recommendation made in the NLPGW and within which, marine turtle species-specific impacts need to be considered from artificial light generated from the Proposal and associated vessel movements (Commonwealth of Australia, 2020).
	Migratory Shorebird Survey	A Shorebird Assessment for the Proposal has been undertaken in accordance with *Industry guidelines for avoiding, assessing and mitigating impacts on EPBC Act listed migratory shorebird species* (Commonwealth of Australia, 2017a) and is included as Appendix O (Biota, 2022c).
	BCH	Refer to Section 8.5.5.1 (AECOM, 2022a).
Modelling	Light Spill	A line-of-sight (LOS) assessment was completed to identify the potential visibility of artificial light associated with the Proposal site at sensitive locations (i.e., turtle nesting beaches). The analysis was undertaken using 3D Analyst in ESRI ArcGIS and involved analysing areas of land that are visible from the Proposal site. An artificial light model was developed which considered the location of light sources, total lumens, type of artificial lights, and height of light placement used as part of the proposed development. Of the four locations surveyed in the benchmark light survey, two were selected to be used in the artificial light modelling (Locker Island and LM3) given their close proximity to the Proposal location and marine turtle nesting habitat. The model considered both 'Worst case' (with all jetty and conveyor lights switched on at all times) and 'Best case' (with all jetty and conveyor lights switched off when not in use both other lighting remaining on) (Pendoley Environmental, 2020) (AECOM, 2022b).

Type	Details	Methods
	Updated Light Modelling	Light modelling was undertaken at previously monitored sites and at five additional sites in 2022 (Pendoley Environmental, 2023). A whole of sky (WOS) and horizon sky brightness assessment was completed to analyse all suitable images.
	Underwater Sound	Underwater sound modelling was undertaken of ambient sound levels, concurrent emission sources, as well as cumulative effects from existing emission sources, and considered the area of impact in relation to sensitive environmental receptors (i.e., marine mammals and marine turtles). The objective of the modelling was to inform the development of appropriate mitigation and management measures for marine fauna, for application during the construction and operational phases of the Proposal (e.g., observation and exclusion zones around piling and dredging activities) (Talis, 2021) (AECOM, 2022b).
	Prawn	K+S commissioned Water Technology to undertake an ABM study to assess the potential impacts of the intake and outfall on prawn populations in Exmouth Gulf (Water Technology, 2022c). This study has been a collaborative effort with extensive stakeholder engagement with participants from DPIRD, MG Kallis and Murdoch University. The results of this prawn modelling exercise are intended to be provided to DPIRD as the managers of the fisheries.
	Dredge Sediment, Bitterns, Nutrient	Refer to Sections 7.5.1, 7.5.2, 7.5.3.1, 8.6.1 and Appendices D and E (Water Technology, 2022b) (Water Technology, 2021c)
	Peer Review	Refer to Section 7.3.2 and Appendix F (DHI, 2021)

9.4.2 REGIONAL OVERVIEW

9.4.2.1 NORTHWEST MARINE REGION

The Proposal sits within the southern part of Northwest Marine Region of WA, which extends from the WA – Northern Territory border to Kalbarri, south of Shark Bay. The marine environment of the region is characterised by shallow-water tropical marine ecosystems, subject to extreme tidal regimes and a high incidence of cyclones. It is influenced by a complex system of ocean currents that change seasonally and between years, generally resulting in surface waters that are warm, nutrient-poor and of low salinity. The southern part of the region transitions between tropical and temperate waters (Director of National Parks, 2018).

9.4.2.2 EXMOUTH GULF AND NINGALOO MARINE PARK

The Proposal is located northeast of the Exmouth Gulf and Ningaloo Marine Park. The Exmouth Gulf is one of the largest embayment's (about 3,000 km^2) on the Western Australian coast. The Exmouth Gulf is enclosed by the Cape Range Peninsula to the west and the Yannarie Coastal Plain to the east and marks the start of the shallow Pilbara waters region. At its deepest, the Gulf is 21 m in depth and the relatively narrow entrance between Point Murat and the Muiron Islands is approximately 19 m. The shallow waters of the Exmouth Gulf provide a stark contrast to the waters of Ningaloo Reef which, outside the reef line, are exposed to the open ocean and rapidly drop off into the waters approximately 1,000 m deep. The Exmouth Gulf is strongly influenced by the Leeuwin Current being in the region where it forms and starts to head south down the coast (AECOM, 2022b).

9.4.3 SIGNIFICANT MARINE FAUNA SPECIES

The literature review and field survey have identified a range of significant marine fauna species that are likely to occur locally as summarised in the sub-sections below (AECOM, 2022b). Distribution and inferred habitat for species likely to occur is mapped in Figure 106 and Figure 107 (AECOM, 2022b).

Species which "may occur" have not been summarised below however information on these species is provided in the Marine Fauna Impact Assessment Appendix N (AECOM, 2022b).

9.4.3.1 ELASMOBRANCHS

The desktop review and corresponding field surveys identified a total of 13 elasmobranchs that have the potential to occur locally. Of these, four species are considered likely to occur (Figure 100), and six may occur near the Proposal. Key species are discussed in further detail in the following sub-sections (AECOM, 2022b).

9.4.3.1.1 GREEN SAWFISH – PRISTIS ZIJSRON

The green sawfish is listed as Critically Endangered on the IUCN Red List and as Vulnerable under both Commonwealth and State legislation. Green sawfish are most common in shallow coastal and estuarine areas but can occur in depths up to 70 m. The species inhabits inshore marine waters, estuaries, river mouths, embankments and along sandy and muddy beaches.

The green sawfish is primarily under threat from fishing, as the large, toothed rostrum is easily entangled in nets and other fishing gear (IUCN 2020). Other threats to green sawfish include habitat loss (particularly loss of intertidal areas, and coastal development), pollution, loss of genetic diversity and climate change (IUCN 2020). *The Sawfish and River Sharks Multispecies Recovery Plan* has been adopted to manage this species (DotE, 2015a).

The green sawfish was recorded in Urala Creek North during targeted sawfish surveys conducted in 2018. Ashburton River mouth, located approximately 30 km north of Urala Creek North, has been identified as an important nursery area for green sawfish (AECOM, 2022b). It is likely that sawfish are pupped just outside the river mouth and use the Ashburton River as a nursery for their first several months (AECOM, 2022b). When the river floods following storms in summer, acoustic tracking has shown that the young-of-year sawfish leave the river, and while some return after flooding has subsided, others do not (AECOM, 2022b).

It is hypothesised that these sawfish begin to use other nearby tidal creeks along the coastline when the freshwater pulse pushes them out of the Ashburton River mouth. As the second and third major creeks found south of the Ashburton, it is likely that Urala Creek North and South are important secondary nurseries for sawfish, which was confirmed in the present work by the sighting of at least three individuals ranging in size from approximately 1.2 to 1.4 m in Urala Creek North. These individuals are likely less than one year old, based on age-growth curves (AECOM, 2022b).

9.4.3.1.2 DWARF SAWFISH – PRISTIS CLAVATA

The dwarf sawfish is listed as Migratory and Vulnerable under the EPBC Act and Endangered under the IUCN Red List. The dwarf sawfish usually inhabits shallow (2 – 3 m) coastal waters and estuarine habitats. A study in north-western WA found that estuarine habitats are used as nursery areas by dwarf sawfish, with immature juveniles remaining in these areas up until three years of age (AECOM, 2022b). This species is known to occur in northern Australia, from Cairns to 80 mile beach in WA (AECOM, 2022b). As the closest confirmed occurrence of this species is located over 600 km away, and targeted surveying of sawfish in Urala Creek North and South in 2018 did not record any dwarf sawfish, this indicates that the Proposal is not within the home range of this species (AECOM, 2022b).

9.4.3.1.3 GIANT GUITARFISH – GLAUCOSTEGUS TYPUS

The giant guitarfish is listed as critically endangered on the IUCN Red List and typically occurs from close inshore (including tidal creeks) to depths of at least 100 m on the continental shelf of northern Australia (AECOM, 2022b). Although juveniles and adults are known to co-occur within inshore coastal habitats, embayments and coral reef atolls, neonates and juveniles more common in shallow areas. Globally, giant guitarfishes are subject to fishing pressures including gillnet, trawl, hook, line, and trap fishing, however, these pressures are relatively low within Australian waters (IUCN 2020).

This species was recorded in both Urala Creek North and Urala Creek South during targeted sawfish surveys, and ranged in size from neonates to juveniles, with aggregations of neonate giant guitarfish (~400-500 mm total length) observed in both creeks (> 31 individuals recorded). The high number of neonates and juveniles recorded in both creeks suggest that these habitats may be pupping locations and nursery areas for this species (AECOM, 2022b).

9.4.3.1.4 NERVOUS SHARK – CARCHARHINUS CAUTUS

The nervous shark occurs on continental and insular shelves in shallow tropical and subtropical waters to depths of 20 m. In Australia the distribution of this species extends from Moreton Bay in QLD to Shark Bay in WA. The species prefers inshore sandy habitats, estuaries and mangrove fringed coastlines. Aggregations of neonate nervous sharks (~400 mm total length) were observed in both Urala Creek North and South during the targeted sawfish surveys (>46 individuals recorded). An aggregation of 23 nervous sharks was observed in an area of approximately 1000 m^2 and a total of 16 nervous sharks were caught in gillnets (ranging in size from 718-1180 mm total length). The high number of neonates and juveniles recorded in both creeks suggest that these creek habitats may by pupping locations and nursery areas for this species (AECOM, 2022b).

9.4.3.1.5 BOTTLENOSE WEDGEFISH – *RHYNCHOBATUS AUSTRALIAE*

Bottlenose wedgefish are listed as critically endangered on the IUCN Red List and occur across the northern part of Australia. *Rhynchobatus* spp. are caught throughout their range as target and bycatch in demersal trawl, net, and long-lining fisheries for their fins and flesh (AECOM, 2022b). The species inhabits shallow soft substrate inshore areas, to depths of at least 60 m across the continental shelf. A single male, measuring 1420 mm (total length), was recorded in Urala Creek South during the targeted sawfish surveys conducted in 2018, indicating that Urala Creek South supports suitable habitat for this species (AECOM, 2022b).

9.4.3.1.6 WHALE SHARK – *RHINCODON TYPUS*

Whale Sharks are listed as Migratory and Vulnerable under the EPBC Act, listed as other protected fauna under the Biodiversity Conservation Act 2016 (WA) (BC Act) and Endangered under the IUCN Red List. Whale sharks inhabit oceanic and coastal waters of 124 countries worldwide (AECOM, 2022b), however, a population of approximately 300-500 individuals aggregate seasonally (March–June) to feed in coastal waters off Ningaloo Reef, WA (AECOM, 2022b).

Whale Sharks are migratory and under threat from a range of anthropogenic impacts, such as commercial and illegal fishing, disturbance to important habitat and tourism (AECOM, 2022b). While residing at Ningaloo Reef, Whale sharks spend approximately 40% of their time in the upper 15 m of the water column and routinely move between the sea surface and deep water, up to 1000 m (AECOM, 2022b). There is no adopted recovery plan for the species, however Whale sharks are included in the *Marine Bioregional Plan* for North-west and East Marine Regions.

The Proposal is not within the declared foraging BIA for this species; however, the transhipping route and offshore anchorage site are within proximity to the BIA (AECOM 2022b). Aerial surveys of Exmouth Gulf conducted by Irvine and Kent (2018) revealed 153 individual shark sightings however, these were not recorded to species level.

Green Sawfish: 6 recorded in Urala Creek North

Nervous Shark: > 46 recorded in Urala Creek North & South

Giant Guitarfish: > 31 recorded in Urala Creek North & South

Bottlenose Wedgefish: 1 recorded in Urala Creek South

Figure 100: Significant Elasmobranchs Recorded in Urala Creek North and South
Morgan et. al. (2020)

9.4.3.2 MARINE MAMMALS

The desktop review and baseline surveys identified three marine mammal species considered likely to occur near the Proposal, these have been discussed in further detail in the following sub-sections.

9.4.3.2.1 HUMPBACK WHALE – MEGAPTERA NOVAEANGLIAE

Humpback whales are listed as Migratory under the Commonwealth EPBC Act 1999 and Conservation dependant under the BC Act. Current threats to humpback whales include climate change, noise interference, habitat degradation, marine debris, and vessel strike (IUCN 2020). Humpback whales are protected by a number of measures, including sanctuaries and a moratorium on commercial whaling. In Australia, there are no current recovery plans in place for this species, however humpback whales have been identified as a conservation value in three Marine Bioregional Plans. The Proposal intersects with the BIA for this species (AECOM 2022b).

The largest global population breeds along the coast of WA, with a number of locations along this coastline identified as critical habitat. These areas are known to support significant seasonal aggregations of humpback whales, during key life processes (such as migrating, calving and resting). Exmouth Gulf is located within the humpback whale migration (north and south) BIA and has been identified as one of four important resting areas along the WA coast during the southern migration (AECOM, 2022b). It is utilised between July and November each year, with peak numbers in September and October (AECOM, 2022b). Exmouth Gulf is considered critical habitat for the survival of humpback whales as mothers and their calves utilise the sheltered waters of the Gulf for resting and nursing, allowing calves to grow and build sufficient energy reserves for the long southwards migration to their Antarctic feeding grounds (AECOM, 2022b). Aerial surveys conducted by:

- Irvine and Salgado Kent (2018) recorded the number of Humpback whales using Exmouth Gulf with nine aerial transect surveys conducted between August and November 2018. Peak numbers were recorded in September and October. The aerial survey area included the marine waters adjacent to the Proposal area. This survey indicated more concentration of whales and calves on the western and southern portions of the Exmouth Gulf with very few sightings in the shallow waters immediately off the eastern coast of the Exmouth Gulf or the Proposal area for a distance of approximately 5 – 10 km.
- Jenner et. al. (2010) recorded the number of Humpback whales using the waters from the mouth of Exmouth Gulf to Barrow Island with 26 aerial transect surveys conducted between May 2009 and April 2010. Peak numbers were recorded in September and October. This survey indicated waters proposed to be used for transhipment operations have a high density of whales including calves utilising the area.

Figure 101 provides the distribution of humpback whales recorded during these aerial surveys (Irvine and Salgado Kent, 2018) (Jenner et. al., 2010).

9.4.3.2.2 AUSTRALIAN HUMPBACK DOLPHIN (SOUSA SAHULENSIS)

Australian humpback dolphins are widely distributed along the northern Australian coastline from approximately the Queensland/New South Wales border to Western Shark Bay, found mainly in coastal waters and often sighted within waters 5 km from the coast (Parra and Cagnazzi , 2016). Australian humpback dolphins are listed as Migratory under the EPBC Act and Vulnerable in the IUCN Red List. The humpback dolphin is primarily under threat due to habitat loss from coastal developments, however there are no adopted recovery plans for this species (IUCN 2020).

Across Australia, humpback dolphins have been observed feeding in a wide range of inshore-estuarine coastal habitats including rivers and creeks, exposed banks, shallow flats, rock and coral reefs as well as over submerged reefs in waters at least up to 40 m deep (Parra and Cagnazzi 2016).

This species has been recorded throughout Exmouth Gulf and has been sighted in coastal waters close to the Proposal, therefore due to the highly mobile nature of this species it is likely that individuals may occasionally pass adjacent to the Proposal (AECOM, 2022b).

The aerial surveys described above for humpback whales also recorded dolphins (although not to species level) as depicted in Figure 101 below. These surveys indicate a wide distribution of dolphins in the region (Irvine and Salgado Kent, 2018) (Jenner et. al., 2010).

9.4.3.2.3 PYGMY BLUE WHALE (BALAENOPTERA MUSCULUS BREVICAUDA)

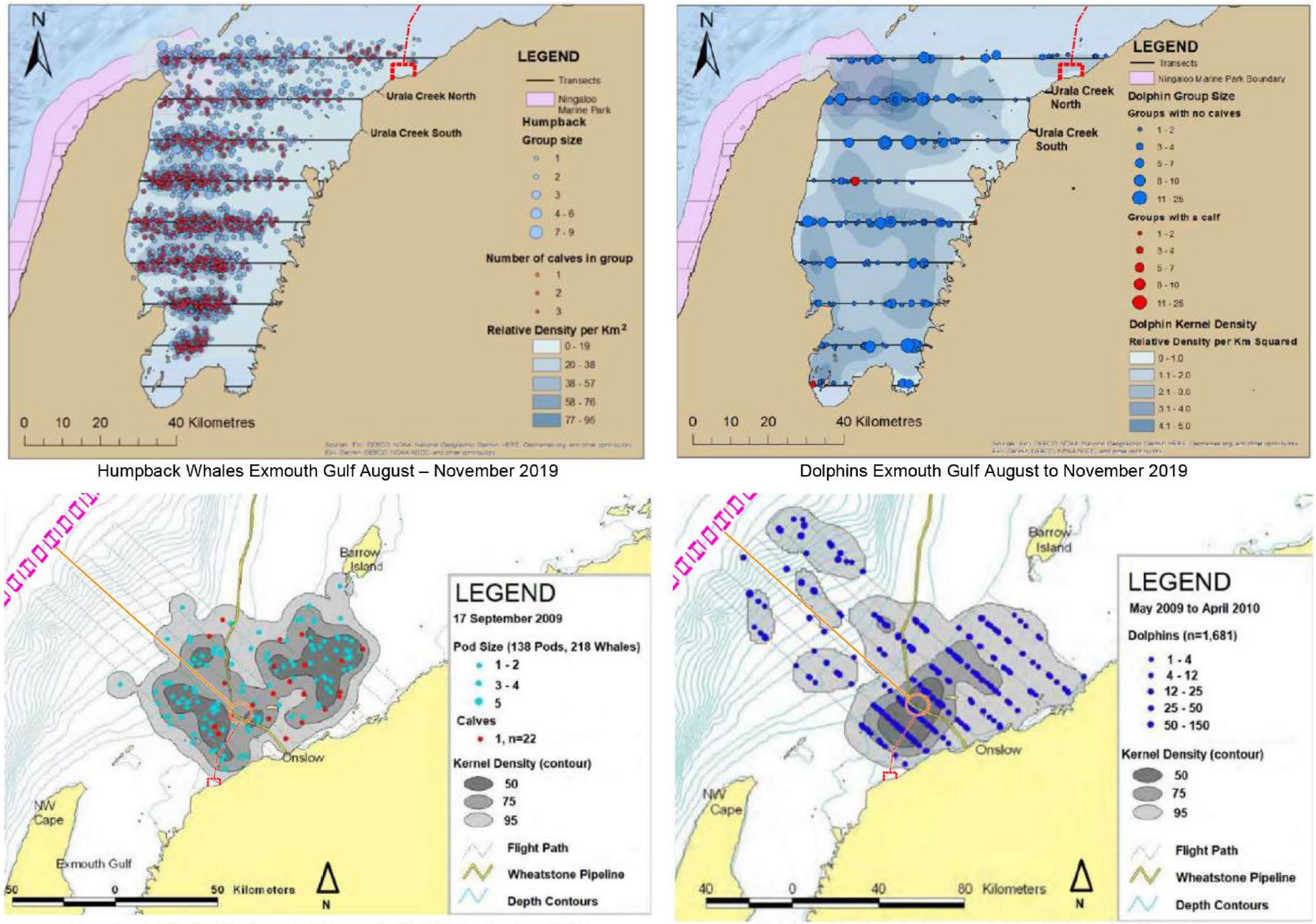
Pygmy Blue Whales are listed as Endangered and Migratory under the EPBC Act and Endangered under both the BC Act and IUCN Red List. These whales are under threat from climate change, underwater noise, and vessel disturbances. Pygmy blue whales are generally restricted to the Southern Hemisphere including the Indian Ocean. Double et al. (2014) satellite tagged 11 pygmy blue whales over a two-year period and found that they travelled northward from the Perth Canyon towards Indonesia from March to June. The Proposal intersects with the Blue Whale BIA (AECOM, 2022b); however, research suggests that this species primarily favours deeper waters (AECOM, 2022b).

9.4.3.2.4 DUGONG – DUGONG DUGON

Dugongs are listed as migratory under the EPBC Act, other specially protected fauna under the BC Act and as Vulnerable on the IUCN Red List. Dugongs are under threat from several anthropogenic factors including coastal development, pollution, entanglement, and vessel strike (AECOM, 2022b). This species inhabit coastal and island waters from Shark Bay in WA across north Australia to Moreton Bay in QLD and spend most of their time in the neritic zone, especially near tidal and subtidal seagrass meadows (AECOM, 2022b). There are currently no recovery plans for this species, however dugongs are considered a priority for conservation and therefore included in the Marine Bioregional Plan for the North-west and North Marine Regions. The Proposal intersects with critical habitat for this species (AECOM, 2022b).

Dugongs are seagrass community specialists, and the range of the dugong is broadly coincident with the distribution of seagrasses in the tropical and sub-tropical waters in their Australian range (AECOM, 2022b). Exmouth Gulf is recognised as a specific area that supports dugong populations.

Dugongs were observed, during 2018 field surveys undertaken by AECOM (2020b), with regular sightings in the nearshore area to the southwest of Urala Creek South. The aerial surveys described above for humpback whales and dolphins also recorded dugong as depicted in Figure 102 below. Surveys show significant concentration of dugong (including calves) in the nearshore area approximately 5 km southwest of the mouth of Urala Creek South and in the vicinity of transhipment operations (Irvine and Salgado Kent, 2018) (Jenner et. al., 2010).



Humpback Whales Exmouth Gulf August – November 2019

Dolphins Exmouth Gulf August to November 2019

Humpback Whales Northeast of Exmouth Gulf 17 September 2009

Dolphins Northeast of Exmouth May 2009 to April 2010

Figure 101: Humpback Whale and Dolphin (all species) Regional Distribution

Edited from: (Irvine and Salgado Kent, 2018) (Jenner et. al., 2010). Red lines represent transhipment loading and vessel route. Orange lines represent OGV anchorage / loading area and export route. Purple lines represent existing shipping pathways.

9.4.3.3 MARINE REPTILES

The desktop review and baseline surveys identified seven reptile species (five marine turtle species, and two sea snake species) that have the potential to occur locally. Four marine reptile species are considered likely to occur, and three may occur near the Proposal. These species and the results of the AECOM (2022c) 2018 and 2019 turtle nesting surveys are discussed in the following sub-sections and mapped in Figure 106. The aerial surveys described above for humpback whales and dolphins also recorded turtles (although not to species level) as depicted in Figure 102 below. Surveys show turtles are widespread in the region, along the eastern Exmouth Gulf and in the vicinity of transhipment operations (Irvine and Salgado Kent, 2018) (Jenner et. al., 2010).

Figure 102 provides the distribution of turtles (although not to species level) recorded during 2018 and 2010 aerial surveys. These surveys show turtles are widespread in the region, along the eastern Exmouth Gulf and to the northeast of the Gulf in the vicinity of proposed transhipment operations (Irvine and Salgado Kent, 2018) (Jenner et. al., 2010). The results of the AECOM (2022c) 2018 and 2019 turtle nesting surveys indicate that:

- The beaches from Urala Creek South to Ashburton River (including the proposed Jetty location) support low density nesting for flatback turtles (no green turtle nesting was recorded) and are considered 'low quality nesting habitat'.
- Locker Island supports a higher density of nesting for both flatback and green turtle. Locker Island has a density of nesting similar to that recorded on other Pilbara Islands.
- The Proposal intersects with the internesting buffer for Flatback and Hawksbill turtles.

9.4.3.3.1 HAWKSBILL TURTLE – ERETMOCHELYS IMBRICATA

Hawksbill turtles are listed as vulnerable and migratory under the EPBC Act, vulnerable under the BC Act and critically endangered on the IUCN Red List. In Australia the main threats to hawksbill turtles include disturbances to critical habitat, by-catch, nest predation, entanglement, and marine pollution. Subsequently, the species is included in the *Recovery Plan for Marine Turtle in Australia* (Commonwealth of Australia 2017b).

No hawksbill nesting was recorded by AECOM (2020b) during snapshot surveys undertaken in 2018 and 2019 and the coastal beach in close proximity to the Proposal footprint appears to only support low density nesting of flatback turtles (discussed below). While the species may pass through the Proposal area of influence it is believed that this would be transitory in nature (AECOM, 2022b).

9.4.3.3.2 FLATBACK TURTLE – NATATOR DEPRESSUS

The flatback turtle is listed as vulnerable and migratory under the EPBC Act, vulnerable under the BC Act and as data deficient on the IUCN Red List. Flatback turtles face a number of threats within Australia, including light pollution, by-catch, marine debris, vessel strike, and climate change. Due to this, the species is included in the *Recovery Plan for Marine Turtle in Australia* (Commonwealth of Australia 2017b). Flatback turtles are endemic to the northern Australian continental shelf and no nesting is known to occur outside of Australia.

No breeding sites for this species are known on the eastern side of Exmouth Gulf, however Exmouth Gulf is within the internesting BIA for the species and the northern half of Exmouth Gulf (including the Proposal) is contained within the area declared as critical habitat for the species (AECOM, 2022b). The coastal area north of the Proposal, from Urala Creek North, is included within the nesting BIA for the species; however, snapshot turtle surveys conducted in 2018 and 2019 indicated that the mainland coastal area between Urala Creek North and Ashburton River supported low density nesting, with three flatback turtle nests recorded on the beach adjacent to Urala Station during both the 2018 and 2019 surveys. The closest nest to the proposed jetty location was 3.5 km to the north east of the jetty. One false crawl was recorded in both 2018 and 2019 surveys approximately 1.8 km and 3.2 km (respectively) north east of the proposed jetty location. No turtle activity was recorded or evident in the immediate vicinity of proposed jetty.

The nesting habitat recorded on the mainland beach, in proximity to the jetty and conveyor location, typically comprised a shallow limestone rock platform in the nearshore area and exposed areas of rock platform with large broken slabs evident in the intertidal area, these broken slabs may present an obstacle to nesting turtles and deter those turtles emerging at low tide. A small sand escarpment <0.5 m was present along the high tide line and the area of beach between the high tide line and the vegetation line was flat, approximately 25 m wide and comprised predominantly medium coarse sand with shell and rock fragments, vehicle tracks were present. The incipient dune was relatively flat and comprised sparse vegetation hummocks. There was no significant dune present behind the vegetation line. This habitat assessment classified the nesting habitat as low quality turtle nesting habitat.

Flatback turtle nesting was recorded on Locker Island during the snapshot survey conducted in 2018, and the density of nesting activity recorded was consistent with other offshore islands in the Pilbara, such as Ashburton Island. The Proposal (including transhipment channel and offshore anchorage site) intersects with the internesting buffer for this species from October to March (Commonwealth of Australia 2017b).

9.4.3.3.3 GREEN TURTLE – CHELONIA MYDAS

Green turtles are listed as vulnerable and migratory under the EPBC Act, Vulnerable under the BC Act and Endangered on the IUCN Red List. In Australia, the main current threats to green turtles are coastal development, by-catch, predation on nests, boat strikes, marine debris and climate change. As a result, the species is included in the *Recovery Plan for Marine Turtle in Australia* (Commonwealth of Australia 2017b).

Green turtles, nest, forage and migrate across tropical northern Australia. No green turtle nesting was recorded on the beach between Urala Creek North and Ashburton River by AECOM (2022b) in 2018 and 2019. Nesting was recorded on Locker Island in 2018. Juvenile and sub-adult green turtles were recorded foraging in the nearshore coastal areas and juvenile, sub-adult and adult turtles were recorded in both Urala Creek North and South during field surveys in 2018 (AECOM, 2022b). The presence of juvenile and sub-adult turtles within Urala Creek suggest the system is used as an important food source and nursery for the species (AECOM, 2022b).

9.4.3.3.4 LOGGERHEAD TURTLE – CARETTA

The Loggerhead turtle is listed as endangered and migratory under the EPBC Act, endangered under the BC Act and critically endangered on the IUCN Red List. In WA, nesting is known to occur from Shark Bay (including the mainland near Steep Point) to the North West Cape with major nesting sites located at Dirk Hartog Island, Gnarloo Bay, Muiron Island and the beaches of the North West Cape. In Australian waters, Loggerhead turtles are threatened by coastal infrastructure, nest predation, by-catch and climate change. Due to this, the species is included in the *Recovery Plan for Marine Turtle in Australia* (Commonwealth of Australia 2017b).

No loggerhead turtles were recorded during field surveys conducted as part of the Proposal and any presence of Loggerhead turtles in the Proposal area of influence is considered likely be transitory in nature (AECOM, 2022b).

9.4.3.3.5 LEATHERBACK TURTLE – DERMOCHELYS CORIACEA

The leatherback turtle is listed as Endangered and Migratory under the EPBC Act and Vulnerable under the BC Act and IUCN Red List of Threatened Species. The leatherback turtle has been found feeding in all coastal waters of Australia, however no major nesting has been recorded on Australian beaches (AECOM, 2022b). Due to this, there are fewer anthropogenic impacts to leatherback turtles in Australian waters, however by-catch, marine debris and vessel strike remain considerable threats. As a result, the leatherback turtle is included in The *Recovery Plan for Marine Turtle in Australia* (Commonwealth of Australia 2017b). Leatherback foraging habitat is known to occur locally, therefore the species may pass through the transhipping channel and offshore anchorage site; however, it is believed that this would be transitory in nature.

Sea Snakes

9.4.3.3.6 SHORT-NOSED SEASNAKE – AIPYSURUS APRAEFRONTALI

The short-nosed seasnake is listed as Critically Endangered under the EPBC Act, the BC Act and IUCN Red List due to their apparent disappearance from their known habitat of Ashmore Reef and Hibernia Reef (AECOM, 2022b). However, recent surveys and distribution modelling conducted by D'Anastasi et al (2016) have identified previously unknown breeding populations in Exmouth Gulf and Ningaloo Reef.

The short-nosed seasnake is a true sea snake, giving birth to live young and spending their whole lifecycle at sea. This species resides in shallow coral reefs to depths of 10 m and will often rest during the day under coral overhangs in water depths of 1-2 m (AECOM, 2022b). The species is under threat from anthropogenic activities such as commercial fishing, climate change, increased boat traffic and pollution. A recovery plan is not in place for this species as research is ongoing to determine management strategies.

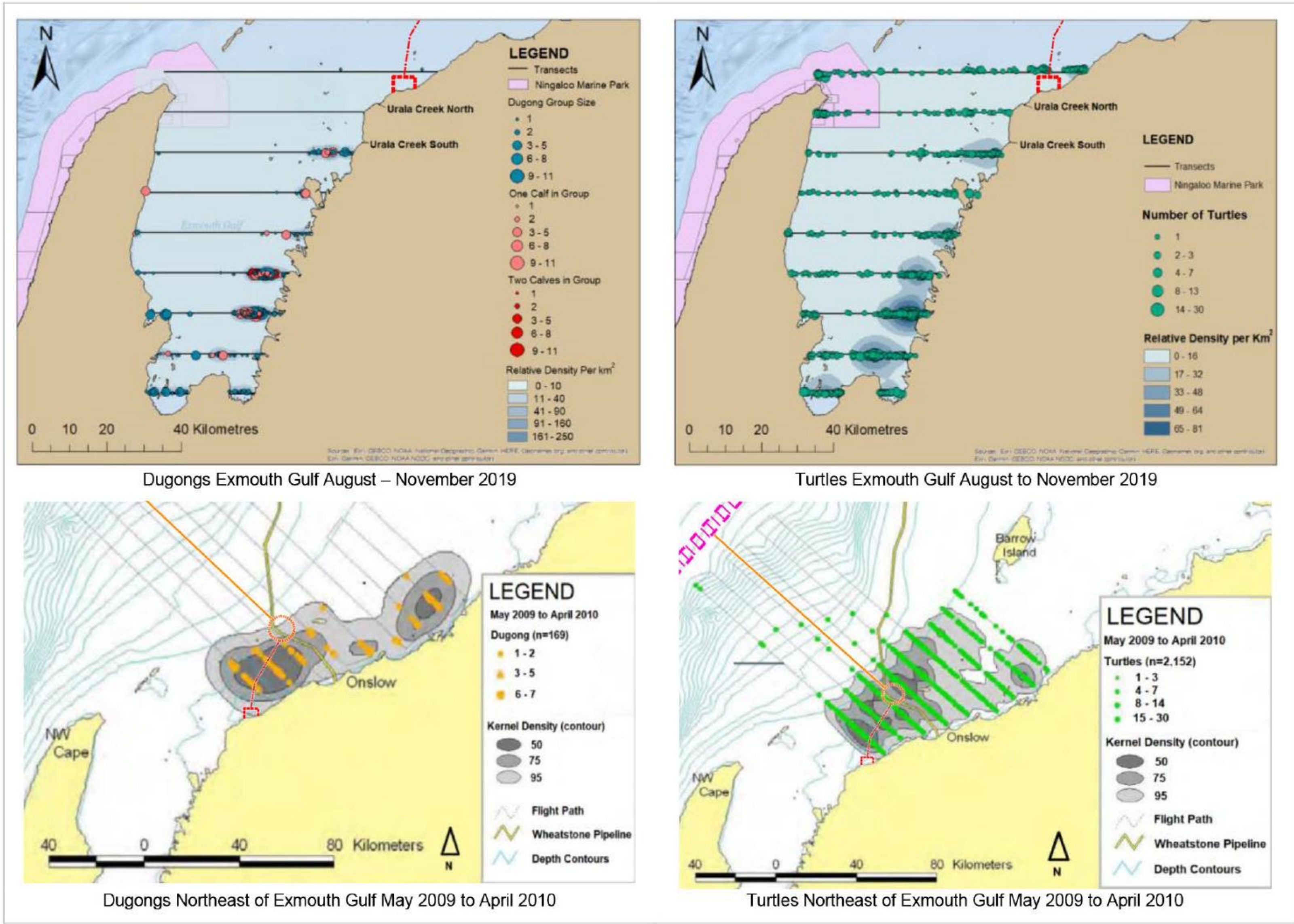
Little is known about the abundance or dynamics of the Exmouth Gulf population; however suitable habitat can be found in proximity to the Proposal. Therefore, this species is considered as potentially occurring in the vicinity of the Proposal.

9.4.3.3.7 LEAF SCALED SEA SNAKE – AIPYSURUS FOLIOSQUAMA

The leaf-scaled sea snake is listed as Critically Endangered under the EPBC Act and the BC Act, however, is Data Deficient on the IUCN Red List. Threats to this species include incidental catch from commercial fish and prawn trawling, increasing vessel traffic and climate change.

The leaf-scaled sea snake is a true sea snake, the species is known to inhabit coral reefs and lagoons to depths of 10 m, with their whole lifecycle occurring at sea. Like the short-nosed seasnake, the leaf-scaled sea snake was once thought to be endemic and abundant at Ashmore Reef and Hibernia Reef, however the population experienced drastic declines since 1998 (AECOM, 2022b). Recent research conducted by D'Anastasi et al (2016) have identified a previously unknown breeding population as far south as Shark Bay, suggesting the species restricted geographic range is no longer valid. New distribution modelling by Udyawer *et al* (2020) has suggested this species may be present in locations close to seagrass meadows and coral reefs, similar to those found along the Ningaloo coast and Exmouth Gulf.

More research is required to understand the distribution and population dynamics of this species, however suitable habitat can be found in proximity to the Proposal. There are currently no recovery plans for this species, though they are listed in the *Marine Bioregional Plan for the North-west Marine Region* (AECOM, 2022b).



Dugongs Exmouth Gulf August – November 2019

Turtles Exmouth Gulf August to November 2019

Dugongs Northeast of Exmouth Gulf May 2009 to April 2010

Turtles Northeast of Exmouth Gulf May 2009 to April 2010

Figure 102: Dugong and Turtle Regional Distribution

Edited from: (Irvine and Salgado Kent, 2018) (Jenner et. al., 2010). Red lines represent transhipment loading and vessel route. Orange lines represent OGV anchorage / loading area and export route. Purple lines represent existing shipping pathways.

9.4.3.4 OTHER LISTED MARINE FAUNA SPECIES

In addition to providing for the protection of threatened and migratory species, the EPBC Act also provides for the listing of marine species for protection. The list of species protected under this section of the Act include all Australian sea snakes, dugongs, turtles, seahorse, seabirds and a large number of cetaceans. The listed marine species that were identified in the EPBC Protected Matters Search for the Proposal have been discussed in the following sections.

9.4.3.4.1 BONY FISH

Syngnathids, an order of ray-finned fishes comprising seahorses and pipefish are widespread throughout WA, with approximately 32 species thought to inhabit shallow coastal waters. All syngnathids are listed marine species under the EPBC Act. There is limited information about the distribution of the individual species within the Pilbara region, however of the 32 species it is thought that 22 occur in the North-west Marine Region (AECOM, 2022b). No BIAs have been identified for seahorses or pipefish species in this region (DSEWPaC 2012).

Almost all syngnathids live in nearshore and inner shelf habitats, usually in shallow coastal waters, among seagrasses, mangroves, coral reefs, macroalgae-dominated reefs and sand or rubble habitats (DSEWPaC 2012). Syngnathids tend to use only certain parts of apparently suitable habitat. For example, they have been recorded occupying the edges of seagrass beds or macroalgae-dominated reefs and leaving large areas unoccupied (DSEWPaC 2012). Physical habitat modification is of potential concern for Syngnathids, with species associated with associated with soft bottom substrates particularly vulnerable to habitat loss (DSEWPaC 2012).

The EPBC Protected Matters search listed 31 species of syngnathids (22 pipefish, five seahorse and four pipehorse species) that may occur in the vicinity of the Proposal. No syngnathids were recorded during the field surveys, however if any of these species are present, then it is considered likely that they would also be present in similar shallow benthic habitats that are well represented across the broader region.

9.4.3.4.2 SEA SNAKES

All sea snakes in Australia are protected under the EPBC Act as listed marine species with ten of the 22 species of sea snakes known to occur in WA recorded in Exmouth Gulf (AECOM, 2022b). Sea snakes can be found throughout the Gulf but are most common in the shallow waters of the eastern shore (AECOM, 2022b). Most sea snake species within the Gulf are considered to be abundant or common, and populations are not known to be at vulnerable levels (AECOM, 2022b).

9.4.3.4.3 WHALES AND OTHER CETACEANS

The EPBC Protected Matters Search listed 29 whale and other cetacean species, of these five were listed as threatened and six were listed as Migratory. Marine mammals that are likely to occur in the vicinity of the Proposal have been discussed in Section 9.4.3.2 of this report.

Due to the mobile nature of cetaceans, it is possible that listed species of dolphins and whales may pass through the local area, during either migration movements or when foraging, however it is likely that these occurrences would be transitory in nature.

9.4.4 IMPORTANT HABITAT AND SEASONAL SENSITIVIES

Important habitat for the significant marine fauna species discussed above is outlined in Table 67 below.

Table 67: Important Habitat for Significant Marine Fauna

Habitat type	Significant Marine Fauna
Mangroves	Juvenile green turtles are known to forage on mangroves and were recorded in both Urala Creek North and Urala Creek South.
Soft sediment (tidal creeks)	Sawfish and other elasmobranchs are known to forage in inshore marine waters, river mouths, embankments and along sandy and muddy beaches. A number of elasmobranch species were recorded in Urala Creek North and in the nearshore shallow intertidal zone. Both Urala Creek North and Urala Creek South are believed to be nursery areas for species of elasmobranchs.
Soft sediment (including potential seagrass habitat, tidal creeks and shallow intertidal zones)	Dugongs and turtles are known to forage on seagrass beds and these species were recorded opportunistically. Seagrass is a key habitat for post-larvae and juvenile prawns. Sawfish and other are known to forage in inshore marine waters, river mouths, embankments and along sandy and muddy beaches.
Sandy beaches	The beach from Urala Creek North to Ashburton River is low quality nesting habitat. Turtles nest at low density in sandy beaches locally, with higher density nesting on local islands.
Offshore waters	Offshore waters including Exmouth Gulf and North East to Barrow Island are habitat (including critical habitat and BIAs) for marine mammals such as migrating and calving humpback whales and Australian humpback dolphins. Offshore waters are also used as transit zones for dugongs, turtles and elasmobranchs.

Periods of the year coinciding with key ecological sensitivities for significant species potentially occurring locally, are presented in Table 68. These relate to breeding, foraging or migration of the indicated fauna.

Table 68: Seasonal Sensitivities Significant Marine Fauna
(AECOM, 2022b)

Species	Jan	Feb	Mar	April	May	June	July	Aug	Sept	Oct	Nov	Dec
Elasmobranchs - Sharks, fish and rays												
Green sawfish	░	░	░	░	░	░	░	░	▓	▓	▓	░
Giant guitarfish	░	░	░	░	░	░	░	░	░	░	░	░
Bottlenose wedgefish	░	░	░	░	░	░	░	░	░	░	░	░
Nervous shark	░	░	░	░	░	░	░	░	░	░	░	░
Marine mammals												
Humpback whale – northern migration (Jurien Bay-Montebello)[3]					░	▓	▓	▓	░	░	░	
Humpback whale – southern migration (Montebello-Jurien Bay)[4]							░	▓	▓	▓	░	
Australia humpback dolphin	░	░	░	░	░	░	░	░	░	░	░	░
Dugong	░	░	░	░	░	░	░	░	░	░	░	░
Marine reptiles												
Hawksbill turtles (peak = nesting)	▓	░								░	░	▓
Flatback turtle (peak = nesting)	▓	░	░							░	░	▓
Green turtle (peak = nesting)	▓	▓	░								░	░
Loggerhead turtle (peak = nesting)	▓	░	░	░	░						░	▓

Key:
░ Species likely to be present in the region.
▓ Peak period: presence of animals reliable and predictable each year.

9.4.5 BIOLOGICALLY IMPORTANT AREAS

BIAs are spatially defined zones where aggregations of individuals of a species are known to display biologically important behaviours such as foraging, breeding, resting or migration (DAWE, 2021). They are important components of Species' Recovery Plans. A search of the Conservation Values Atlas identified BIAs within proximity to the Proposal, which are presented in Table 69 and Figures 9 – 14 of AECOM (2022b).

Table 69: Biologically Important Areas that Spatially Overlap with the Proposal

Species	Type	Marine Component
Humpback Whale	Migration and Resting	Nearshore, navigation route and Offshore
Pygmy Blue Whale	Distribution	Nearshore, navigation route and Offshore
Whale Shark	Foraging	Offshore, Southwestern boundary of the BIA
Flatback Turtle	Nesting and internesting	Nearshore, navigation route and Offshore
Hawksbill Turtle	Internesting	
Green Turtle	Internesting*	Nearshore, navigation route and Offshore
Loggerhead Turtle	Internesting*	
Dugong	Nursing and foraging	Nearshore
* Includes internesting buffer		

9.4.6 CRITICAL HABITAT AREAS

The Recovery Plan for Marine Turtles in Australia 2017-2027 (Commonwealth of Australia 2017b) identifies habitat critical to the survival of various sea turtle species. These have been identified by consensus of an expert panel of marine turtle biologists. These critical habitats are not listed on the Register of Critical Habitat under the EPBC Act; however, they are relevant for the Proposal. Relevant Critical Habitat Areas for listed species can be found in Figures 11 – 14 of (AECOM, 2022b) and Table 70.

Table 70: Critical Habitat Areas that Spatially Overlap the Proposal.

Species	Type	Marine Component
Flatback Turtle	Nesting	Nearshore and Offshore
Green Turtle	Nesting	Nearshore and Offshore
Hawksbill Turtle	Nesting	Nearshore and Offshore
Loggerhead Turtle	Nesting	Nearshore (Urala Creek South) and Offshore
Green sawfish	Pupping / nursing	Tidal Creeks

9.4.7 INTRODUCED MARINE PESTS

Over the last 20 years, the Pilbara coastline has been the most intensively surveyed area for Introduced Marine Pests (IMP) in the world. Department of Fisheries undertook surveys using the NIMPCG methodology between 2010 and 2015 in Dampier and Port Hedland (AECOM, 2022b). Wells (2018) developed an extensive database of 5532 shallow water marine species that have been recorded in the Pilbara. Only 17 of these are believed to have been introduced and only one, the ascidian *Didemnum perlucidum* (white colonial sea squirt), is listed as an IMP (Wells, 2018). *Didemnum perlucidum* was first detected in the Fremantle marine area in 2010. Following this it was rapidly found throughout WA from Esperance on the southeast coast, along the west coast, to the Kimberley in the northeast and in Darwin, Northern Territory. It is widespread in the Pilbara and is expected to colonise artificial structures constructed by the Proposal (AECOM, 2022b).

9.4.8 COMMERCIAL SPECIES

The Proposal area is adjacent to the northern section of the EGPMF and is approximately 6 km southeast of the OPMF (Figure 33).

K+S commissioned Water Technology to undertake an ABM study to assess the potential impacts of the intake and outfall on prawn populations in Exmouth Gulf. This study has been a collaborative effort with extensive stakeholder engagement with participants from DPIRD, MG Kallis and Murdoch University. The results of this prawn modelling exercise are intended to be provided to DPIRD as the managers of the fisheries and will be provided to the EPA to inform this assessment.

The following information has been sourced from Water Technology (2022c; Appendix P).

9.4.8.1 EXMOUTH GULF PRAWN MANAGED FISHERY

The EGPMF covers an area of approximately 2,790 km^2, or 70% of Exmouth Gulf, with the remaining 30% permanently closed to trawling (Figure 103). The EGPMF targets prawns using low-opening demersal otter trawl nets.

The Proposal is located adjacent to the EGPMF and the Proposal's intake at Urala Creek South is within the designated nursery area of the EGPMF. Concerns were raised by the Fishery Licensee that the development of the Proposal could impact the prawn population as juveniles can be drawn into the intake or interact with the bitterns discharge (currently under investigation).

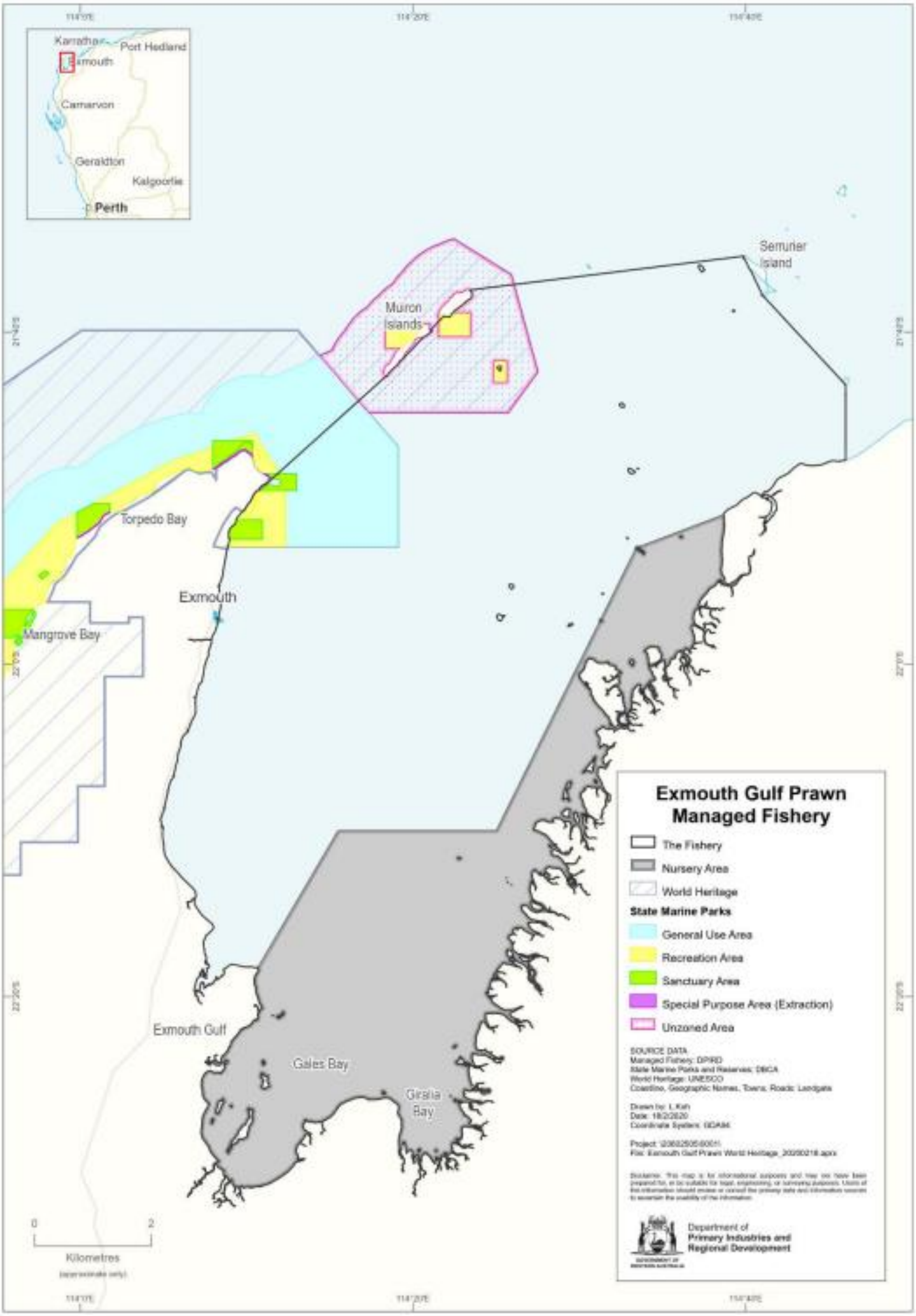


Figure 103: Exmouth Gulf Managed Prawn Fishery

(Water Technology, 2022c)

9.4.8.2 PRAWN SPECIES

The three target species of the EGPMF are Blue endeavour prawns (*Metapenaeus endeavouri*); Western king prawns (*Penaeus (Melicertus) latisulcatus*); and Brown tiger prawns (*Penaeus esculentus*). There are three key prawn species targeted by the EGPMF. A fourth prawn species prevalent in the Gulf, Banana prawns (*Penaeus merguiensis*) are only a minor species and there is also limited information on their spawning habits.

A summary of life cycle, important movements and key habitats for each species has been summarised in the sections below.

Brown Tiger Prawn

The brown tiger prawn (*Penaeus esculentus*) is a decapod crustacean of the family Penaeidae. The species is easily identified by its pattern of distinctive pale brown and darker bands. Brown tiger prawns are generally regarded as endemic to Australia and are distributed around the northern coast, from central New South Wales in the east to Shark Bay in WA.

Penaeid prawns need to move between different habitats to complete their lifecycle, which is shown in Figure 104. Dall et al. (1990) describe these migrations as a larval and postlarval migration from the spawning ground to the nursery ground; a juvenile migration out of the nursery area; and an adult migration to deeper offshore water to spawn.

Although spawning female brown tiger prawns are found in WA between July and the end of summer, the main spawning season of this species in Exmouth Gulf is between August and October. Approximately one month after mating, female prawns will release the fertilised eggs, which float and typically hatch within 24 hours (Water Technology 2022c). Active vertical migration during the pelagic larval stage, in combination with water currents, is the most probable method transporting post-larvae to the inshore nursery areas (Water Technology 2022c).

As the larval development continues through the protozoea, mysis and postlarvae stages, predators are responsible for high mortality rates of the larvae. If by this time the larvae have drifted to a suitable nursery area (e.g. beds of seagrass and algae), they will settle as post-larvae two to four weeks after eggs are released from the females (Water Technology 2022c). If settlement occurs in unsuitable habitats, they are likely to perish.

Juvenile brown tiger prawns occupy shallow waters with seagrass and algal communities, which form the main juvenile habitat for this species (Kenyon et al., 1995). In Exmouth Gulf, a main migration of juvenile prawns into deeper, more offshore waters occurs during late summer and autumn of each year, after spending approximately six months in the nursery areas (Water Technology 2022c). Prawns move by either walking or swimming, however, the speeds recorded during migration are unlikely to be achieved by walking (Water Technology 2022c).

As pre-adults, brown tiger prawns migrate out of the nursery areas into deeper waters to spawn. Adult brown tiger prawns are generally found over mud or sandy mud substrates in coastal waters less than 30 m depth, however, have been recorded as deep as 200 m (Water Technology 2022c). Most spawning females are found in water 13 – 20 m deep (Water Technology 2022c).

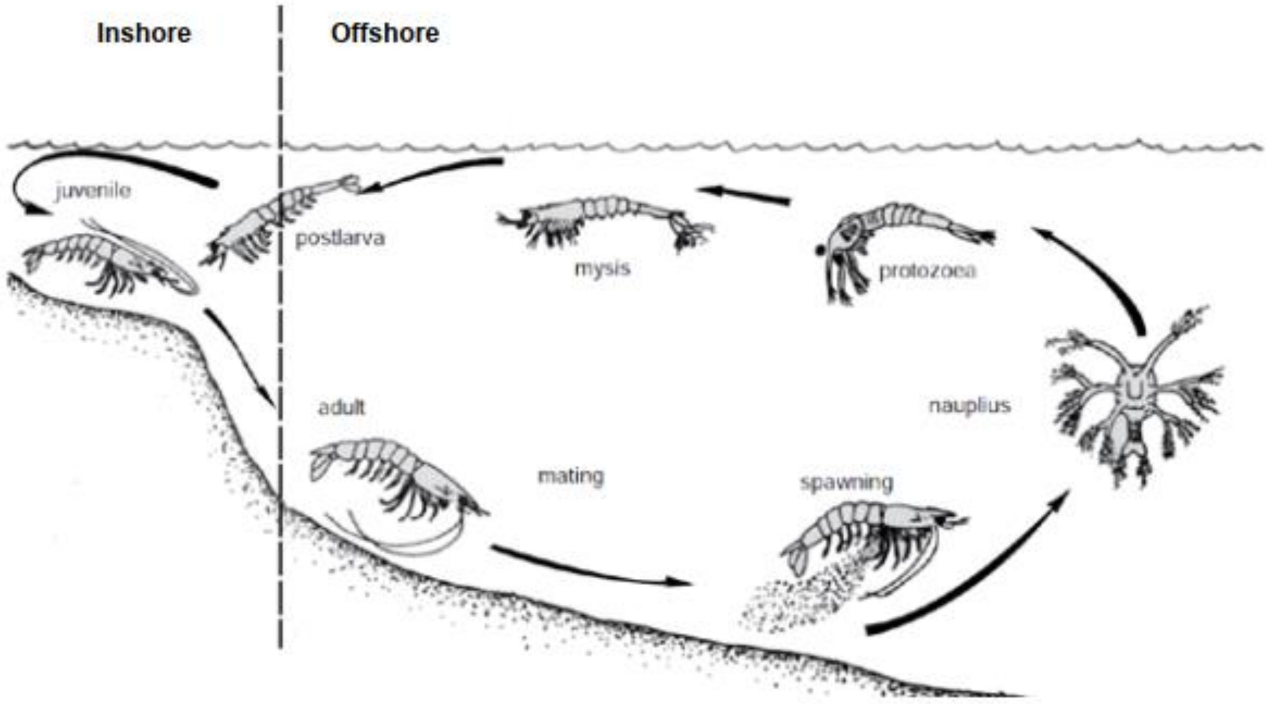


Figure 104: Life cycle of a penaeid prawn

Western King Prawns

The western king prawn (*Penaeus latisculcatus*) is a decapod crustacean of the family Penaeidae and is widely distributed throughout the Indo-West Pacific region (Water Technology 2022c). Within Australian waters, this species occurs from South Australia, WA, Northern Territory, Queensland and down the east coast to northern New South Wales (Water Technology 2022c). The species is easily distinguished by its distinctive bright blue legs and tail.

The western king prawn is a fast-growing species that grows to a maximum size of 20 cm and is a highly fecund species, reaching sexual maturity at six to nine months. Western King prawns spawn throughout the year, with a peak spawning period from May to October. The life cycle characteristics of western king prawns closely resemble those described above for brown tiger prawns.

As with other penaeid prawns, western king prawns undertake a migration from nursery areas to deeper, more offshore waters to spawn. This migration, which is likely to occur in response to either biological cues, such as size, and/or some change in their environment (such as rainfall, salinity, currents or temperature).

Post-larval and juvenile western king prawns can be found inshore on shallow tidal flats with sand or mud sediments, which are often backed by mangroves (Water Technology 2022c). Because there is very little freshwater input, such inshore areas can have salinities higher than seawater (i.e., hypersaline waters). The juveniles of western king prawns prefer this habitat, unlike most other prawn species, which prefer estuarine conditions where seawater is diluted by freshwater.

Juvenile western king prawns spend about three to six months in the nursery grounds before they reach maturity and migrate offshore, entering the trawl fishing grounds (Water Technology 2022c). Western king prawns reach maturity at six to seven months of age, at a size of around 25 mm carapace length.

Blue Endeavour Prawns

Blue endeavour prawns (*Metapenaeus endeavouri*) are a secondary target species whose distribution partly overlaps with that of brown tiger and western king prawns and are caught when fishers are targeting these two species. Blue endeavour prawns are restricted to northern Australian waters between northern New South Wales and Exmouth Gulf in WA (Water Technology 2022c) and are generally found in coastal waters down to approximately 50 m in muddy or sand/mud substrates. They are considered more resilient to fishing pressure due to their smaller size and lower catchability, as well as the lower level of targeting compared to the other target species (Water Technology 2022c).

Endeavour prawns are believed to spawn all year round and have a similar life cycle to brown tiger and western kings prawns. Post-larvae and juvenile endeavour prawns are most commonly found in seagrass beds and spend only a short time in nursery areas. Mature endeavour prawns are generally found in coastal waters down to approximately 50 m in muddy or sand/mud substrates.

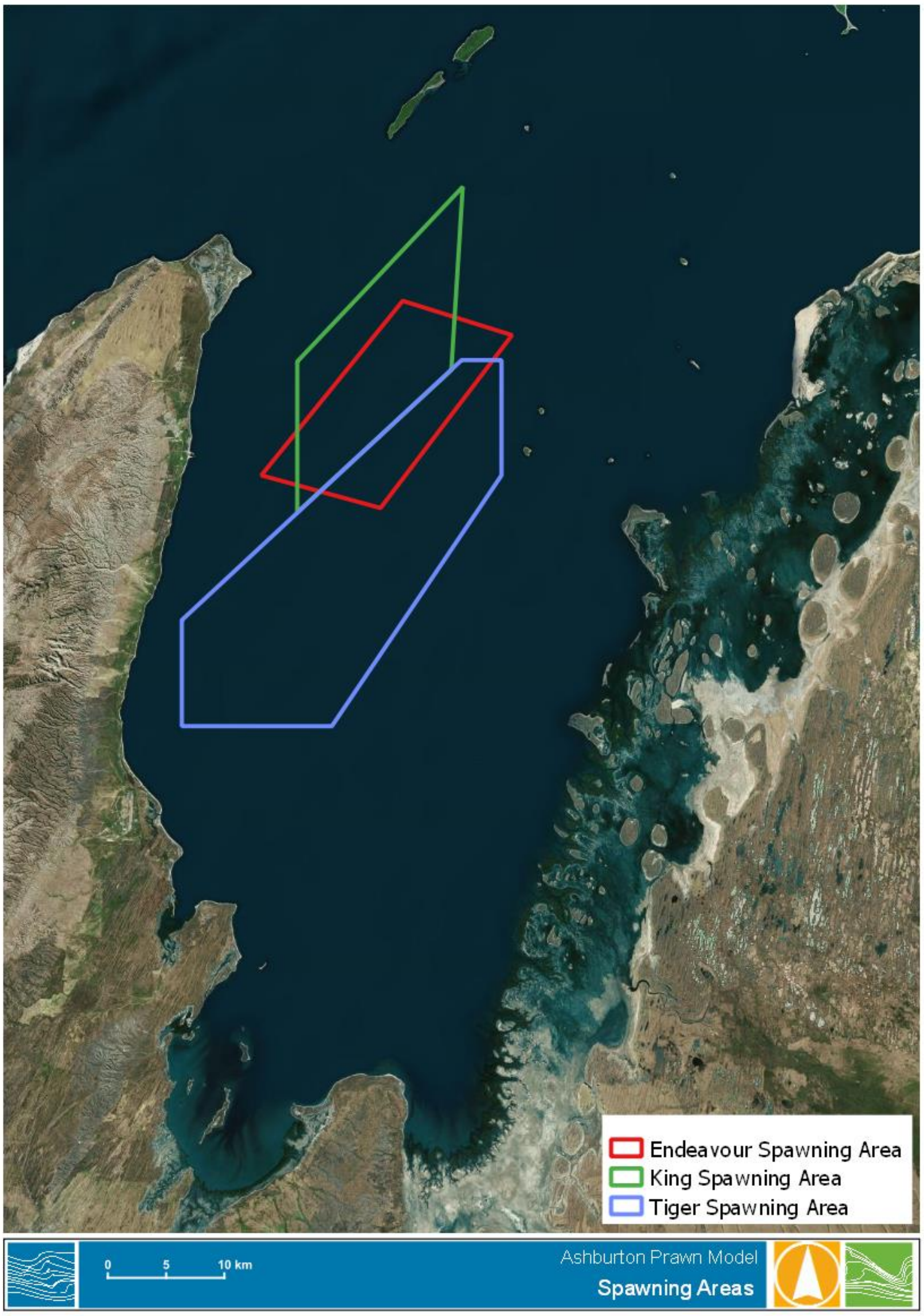


Figure 105: Spawning area by species

9.4.9 LOCAL ENVIRONMENTAL VALUES

Local environmental values related to marine fauna have been identified as follows:

- Local marine fauna habitat.
- Local significant marine fauna species.

These local values have been mapped overlayed by the Proposal in Figure 106 using GIS data from the Proposal marine fauna study (AECOM, 2022b).

9.4.10 REGIONAL ENVIRONMENTAL VALUES

Regional environmental values related to marine fauna have been identified as follows:

- Regional marine fauna habitat.
- Regional significant marine fauna populations.

These regional values have been mapped overlayed by the Proposal in Figure 107 using GIS data from the Proposal marine fauna studies (AECOM, 2022b) (Morgan et. al. 2020) and publicly available data regarding marine fauna habitat and known distribution of conservation significant marine fauna species (Irvine and Salgado Kent, 2018) (Jenner et. al. 2010).

9.4.11 PROPOSED EXMOUTH GULF MARINE PARK

A new marine park is proposed at the southern and eastern edges of Exmouth Gulf (see Section 2.4.7) and may intersect with Proposal activities; however, the exact location of the expansion has not been formalised at this stage. In light of the proposed expansion, the marine fauna impact assessment has been prepared to consider the possible impacts the Proposal may directly or indirectly impose on the key ecological values of Exmouth Gulf and the surrounding habitats.

9.5 POTENTIAL IMPACTS

The following potential impacts have been identified for this Proposal as discussed in the sub-sections below:

- Direct impacts:
    - Habitat loss.
    - Vessel collisions with marine fauna.
    - Entrainment and entrapment of marine fauna due to the seawater intakes.
    - Underwater sound (temporary or permanent threshold shift).
- Indirect impacts:
    - Dredging sediment discharge.
    - Bitterns discharge.
    - Underwater sound (behavioural changes).
    - Anthropogenic light spill.
    - Altered nutrient inputs.
    - Hydrocarbon spills.
    - IMP.

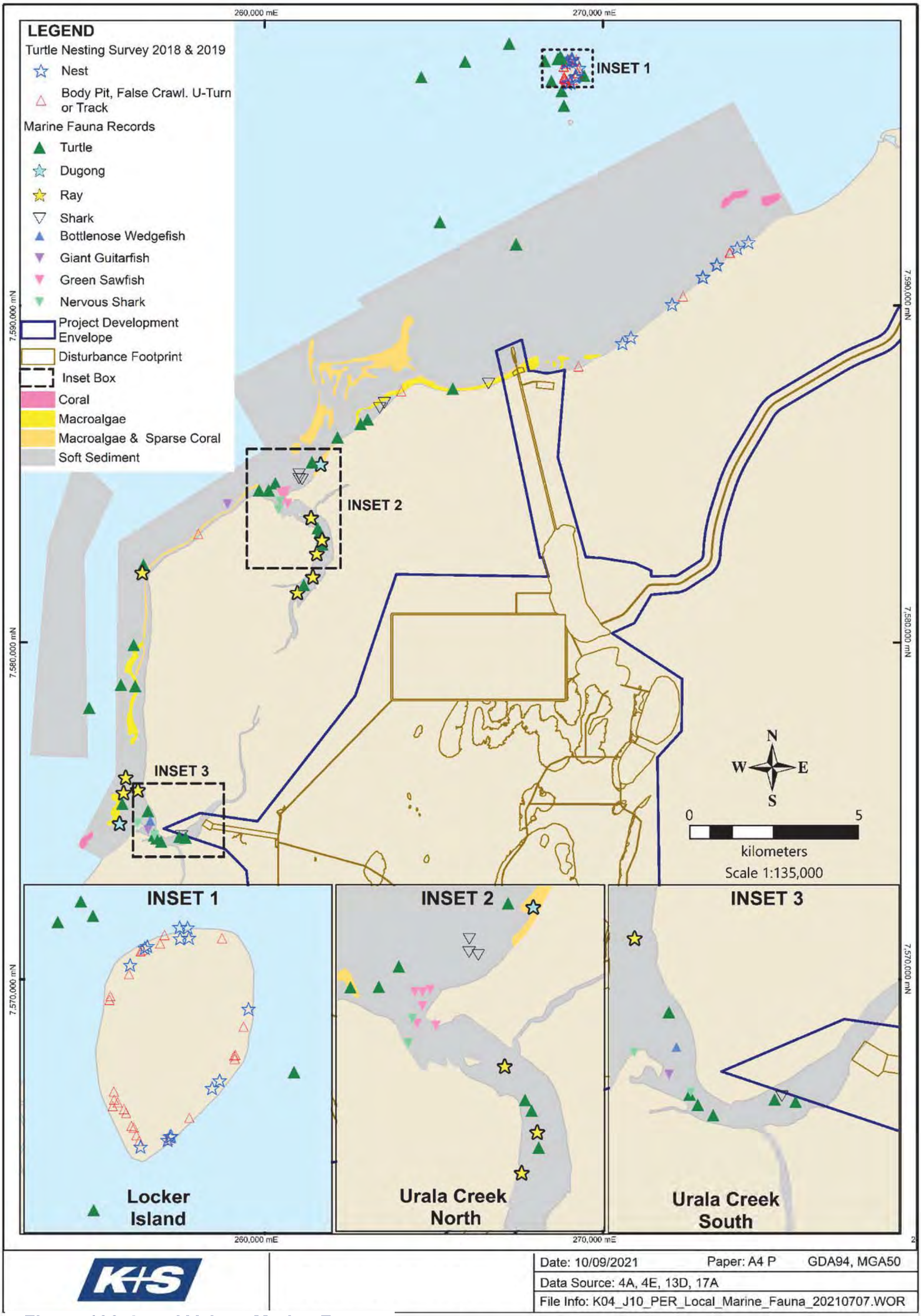


Figure 106: Local Values Marine Fauna

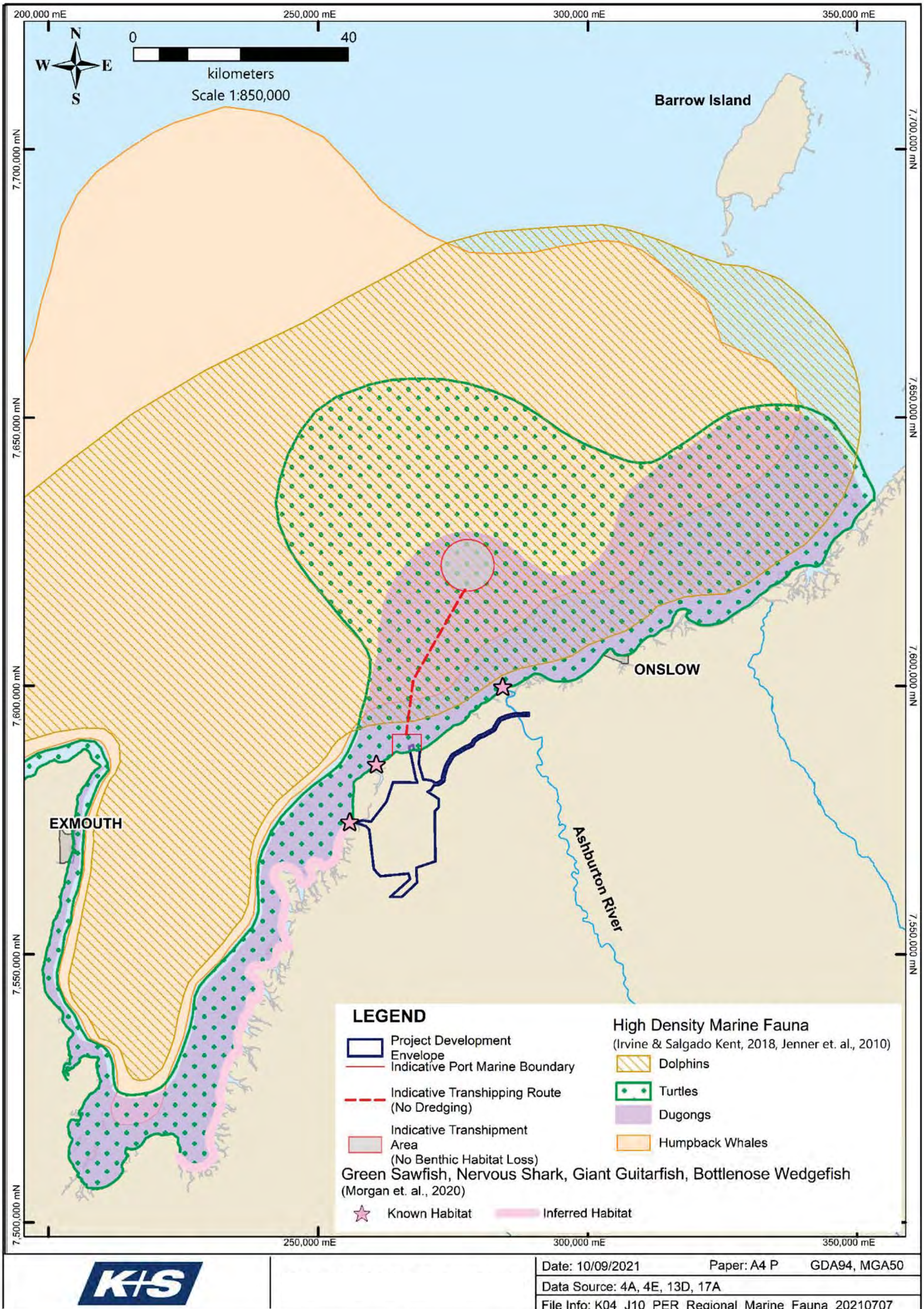


Figure 107: Regional Values Marine Fauna

9.5.1 DIRECT IMPACTS

9.5.1.1 HABITAT LOSS

A detailed assessment of habitat loss and associated mitigation measures has been included in the BCH assessment report (AECOM, 2022a) and summarised in Section 8. The Proposal will result in the direct loss of approximately 4.28 ha of mangrove, 0.54 ha of tidal creek and 226.4 ha of nearshore BCH. Direct removal of benthic habitats is required for construction of the jetty and berthing pocket, as well as the seawater intake and pumping station. Additional indirect loss of BCH is expected due to dredging plumes and ongoing bitterns discharge associated with the Proposal.

A summary of potential marine fauna habitat loss including proportional loss within LAUs and regionally within Exmouth Gulf is detailed in Table 71. This table represents the irreversible loss occurring from cumulative pressures associated with the Proposal. Based on the BCH assessment, it is considered likely that the loss of intertidal and nearshore habitat would have negligible impact on general marine fauna populations that inhabit the region, however given the area intersects with several BIAs and critical habitat areas for marine fauna this may be considered significant. For example, the presence of juvenile and sub-adult green turtles and green sawfish in both Urala Creek North and South indicates that these locations are considered habitat critical to the survival of the species, and the system is used as an important food source and nursery for these species. As such, any habitat loss or associated disturbances in these areas have the potential to negatively impact critical habitat. All habitat loss including direct disturbance and indirect impact due to creek blockage (to mangroves) and bitterns discharge (to soft sediment) is included in Table 71.

Within the transhipment area (offshore), suitable anchorage areas will be designated in sandy areas to ensure sufficient anchor holding capacity. These areas will be identified through a combination of bathymetric and side scan sonar survey. Once target locations have been selected, video footage of the seabed will be taken at each location to confirm substrate is sand, with sparse to nil vegetated benthic habitat present. Final site selection will be done in consultation with PPA. K+S is confident of achieving no loss of vegetated BCH in the anchorage area.

Table 71: Predicted area of Habitat Loss

Habitat	Significant Marine Fauna	Cumulative Loss (ha)	% of LAUs	% of Tubridgi to Tent Pt	% of East Exmouth Gulf
Mangroves	Juvenile green turtles	4.28	0.2%	0.12%	0.04%
Tidal Creeks	Green sawfish, Juvenile green turtles	0.54	0.11%	0.06%	0.02%
Soft sediment (nearshore), macroalgae, sparse coral	Turtles, dugong, green sawfish, other elasmobranchs	226.4	4.7% of soft sediment, 5.8% macroalgae, 0.9% macroalgae / sparse coral	2.2%	0.4%
Sandy beach	Turtles (nesting)	0.99	0.7%	0.33%	0.1%
Offshore waters	Humpback whales, dolphins, turtles, elasmobranchs	0	0%	0%	0%
TOTAL		**232.21**			

The Proposal may also prevent the inland movement of mangrove habitat as a result of sea level rise. As detailed in Table 58, this difference in future habitat extent is predicted to peak at 139 ha in 2050. An additional 1,382 ha of mangroves is however expected to be present within the East Exmouth Gulf area in 2050, therefore mangrove habitat extent would remain higher than current conditions.

9.5.1.1.1 POTENTIAL IMPACTS OF HABITAT LOSS

Mangrove and Tidal Creek Habitat

Typical mangrove habitat has moderately high invertebrate fauna biodiversity and high primary productivity. A wide variety of invertebrates inhabit mangroves, dominated by molluscs, crustaceans, and polychaetes. Protected marine fauna such as green sawfish, humpback dolphin, and green turtles are known to utilise mangrove and intertidal habitats (AECOM 2022b).

Juvenile and sub-adult green turtles, as well as green sawfish were recorded in both Urala Creek North and South during field surveys conducted for the Proposal. The presence of juvenile and sub-adult turtles within Urala Creek suggest the system is used as an important food source and nursery for the species. Similarly, Urala Creek North and South represent critical habitat for green sawfish as pupping/nursing environment. Some studies have suggested that there is a strong association between mangrove health and intactness, and the abundance of sawfish species (AECOM 2022b). Therefore, mangrove habitat within the Proposal area is of high conservation value.

The BCH assessments and associated modelling studies undertaken for this Proposal demonstrate a combined loss of 4.28 ha of mangrove habitat and 0.54 ha of tidal creek habitat. All efforts have been made during Proposal design to maintain maximum mangrove biomass which would be of importance to marine fauna. While 4.28 ha will be lost, this represents less than 1% of this community and will not significantly impact the integrity of the habitat in terms of contributions to local and regional ecological function and connectivity.

Impacts associated with sea level rise are likely to occur, however this is predicted to coincide with a large increase in mangrove extent in the region, which limits the affects the Proposal would have on marine fauna that utilise these habitats.

Nearshore Habitat

Nearshore habitat that supports BCH such as seagrass, coral and macroalgae provide important feeding habitat for protected marine fauna. Seagrasses, along with macroalgae, are considered key food habitats for dugongs and green turtles, as well as providing critical nursery habitats for juvenile fish and many macroinvertebrates, including commercially valuable prawn species (AECOM 2022b). Prawn post-larvae settle into shallow seagrass areas which provide shelter and food sources such as epiphytic algae and detritus. Ecologically, macroalgae perform a similar role to seagrasses and they are important contributors to primary productivity. Following observations of minimal seagrass biomass in Exmouth Gulf, McCook (1995) suggested macroalgae are also an important secondary food source for dugongs. The removal of nearshore BCH could have significant effects on the survival, fitness, distribution and feeding habitats of these key marine species.

The Proposal intersects with the critical habitat for flatback, hawksbill and green turtles (DoEE 2017a), as well as within the BIA for the pygmy blue whale and humpback whale. Additionally, the nearshore habitat within proximity to Urala Creek North and South is likely to be important foraging and migratory habitat for juvenile and sub-adult sawfish and green turtles. Disturbance to 226.4 ha of nearshore habitat is expected as a result of the combined effects of dredging, bitterns discharge, shading and shipping movements. All effort has been made during the planning phase of the Proposal to ensure minimal disturbance to nearshore BCH (as outlined in BCH report). Bare substrate has been targeted to ensure that high value nearshore habitat (such as high coral/seagrass cover) has been avoided where possible.

As a result, the total cumulative habitat loss for the Proposal is considered low when compared to the availability of similar habitat in the surrounding areas (less than 5% of available habitat), which will be easily accessible to highly mobile marine fauna species. Therefore, is it unlikely that habitat loss resulting from construction and operation of the Proposal will impact the biological diversity and ecological integrity of general marine fauna populations and their habitats. However, as the habitat loss will occur within several BIAs and critical habitat area, this habitat loss is considered to be significant.

Sandy Beach

Sandy beaches occur along the western and northern shorelines of Tubridgi Point and extended east along the coast from Urala Creek South, including the Locker Point area and the proposed location of the export jetty. The coastal area north of the Proposal, from Urala Creek North, is included within the critical habitat for flatback, hawksbill and green turtles. However, snapshot turtle surveys conducted in 2018 and 2019 indicated that the mainland coastal area between Urala Creek North and Ashburton River supported only low density nesting, with only three flatback turtle nests recorded.

The proposed disturbance of this beach is limited to a narrow section (less than 50 m) to install the trestle jetty structure, resulting in a disturbance of 0.99 ha. The nesting habitat recorded within proximity to the jetty and conveyor location, typically comprised a shallow limestone rock platform in the nearshore area and exposed areas of rock platform with large broken slabs evident in the intertidal area. As a result, this environment is considered low quality nesting habitat.

Given the poor nesting quality of the impacted beach, the low recorded nesting and extensive availability of suitable nesting habitat within the region, the direct impacts of 0.99 ha of sandy beach habitat is not expected to significantly impact local marine turtle populations.

9.5.1.2 VESSEL COLLISIONS

Moving vessels could collide with marine fauna such as marine mammals and turtles, resulting in physical injuries (e.g., corkscrew injuries), and in extreme instances mortality (AECOM 2022b). Marine fauna is most at risk from collision when:

- the level of vessel traffic is high (AECOM 2022b);
- vessels are greater than 80 m in length; and
- when vessels are travelling at speeds faster than 14 knots (AECOM 2022b).

The Proposal will have a number of vessels operating during both the construction and operational phase. During construction, vessels will include a dredge (planned to be a cutter suction dredge), a piling barge, and support vessels (e.g., crew transfer vessels, tender vessels). During operations a transhipment vessel will traverse 14 nm between the jetty and the transhipment location every day.

The main risk of physical interaction with marine fauna during construction will be in relation to the movement of support vessels for the dredge and the piling barge. These will be stationary during most of the works, with the most mobile parts of the equipment generating noise and vibration which is likely to discourage any species that may be present from approaching sufficiently close for them to be exposed to the risk of direct impact. When moving within the Proposal footprint, the dredge and barge will transit at low speeds and only over small distances during each move (typically tens of metres).

Physical interaction between marine fauna and transhipment vessels will remain a possibility throughout operations. The increase in shipping traffic may impact marine fauna, particularly turtles, dugongs, humpback whales, and whale sharks, all of which have the potential to occur within proximity to the transhipping route and offshore anchorage site. The transhipment vessel be restricted to a maximum speed of 9 knots in the navigation channel. The slow pace and predictable path will ensure the transhipment vessel will pose a low risk to marine fauna. With the implementation of additional mitigation measures presented in Section 9.7.2 and implementation of the Marine Fauna Management Plan (MFMP) and DSMP, direct impacts due to vessel movements associated with the Proposal are expected to be low.

Risks to some specific marine fauna are summarised below:

- Elasmobranch (whale sharks, fish and rays) are not known to be naturally inquisitive and are therefore not expected to approach vessels whilst in operation. They are also sufficiently mobile that there would be negligible potential for physical impacts upon them during vessel movements.
  Whale Sharks are unlikely to be impacted by nearshore construction activities for the Proposal, however there is potential for encounters to occur during operational activities along the transhipping

channel and offshore anchorage site. Whale Sharks congregate at Ningaloo Reef from March to July each year and spend a significant amount of time in surface waters, and therefore there is a possibility of vessel strike. Lester *et al* (2020) found that 38.8% of whale sharks identified in Ningaloo Reef exhibited some form of scarring from vessel strikes.

- Dugongs are distributed throughout the coastal water to the 20 m isobath, with a couple of individuals recorded foraging in nearshore areas close to the mouths of Urala Creek South and Urala Creek North. Dugongs are considered to be most vulnerable to being struck by marine vessels as they are slow moving and often found at the surface.

  It has also been suggested that sirenians are unable to avoid vessels due to a phenomenon called the Lloyd's mirror effect; this can lower the sound frequency emitted from the propeller of the oncoming vessel within surface waters to below levels detectable by sirenians (AECOM 2022b). In such instances, underwater sound no longer acts as an early warning signal alerting an individual of approaching vessels and allowing opportunity for a behavioural response which may reduce the risk of collision (i.e., movement out of the collision path).

  Dugongs have also been shown to exhibit a delayed avoidance response to fast approaching vessels, reacting only when they are approximately 20–25 m away, which is often insufficient time for avoidance (AECOM 2022b). This combination of factors renders sirenians particularly vulnerable to collisions with vessels.
- Exmouth Gulf is located within the humpback whale migration (north and south) BIA and has been identified as one of four important resting areas along the WA coast during the southern migration (AECOM 2022b). Cetaceans are agile organisms that possess quick reflexes, with fast swimming abilities and good sensory recognition which means they are capable of avoiding most vessels (AECOM 2022b). However, marine mammals which may be distracted by activities such as foraging and social interactions may not perceive the threat of moving vessels and could therefore be vulnerable to vessel strikes (AECOM 2022b). Additionally, females with a dependant calf are at higher risk of vessel strike as they spend more time resting near the surface (AECOM 2022b). The high proportion of calves and juveniles among collision victims also suggests that perception of vessels as a threat is something that is learnt later in life (AECOM 2022b).
- Unlike marine mammals, turtles are not fast or agile and may not have the ability to avoid vessels travelling faster than 4 km/h (~2 knots) (AECOM 2022b). Individuals that occur close to the sea surface to bask, mate or breathe are more vulnerable to vessel collisions or being struck by propellers. Similarly, individuals foraging, nesting or swimming in water depths insufficient to allow the draft of the vessel and propellers to pass over are also vulnerable to impacts (AECOM 2022b).

The implementation of the MFMP and DSMP, and the use of trained Marine Fauna Observers (MFOs) on construction vessels, together with the mitigation measures outlined in Section 9.7.2, will reduce the risk of marine fauna being struck by vessels throughout construction and operation of the Proposal.

9.5.1.3 SEAWATER INTAKE ENTRAINMENT/ENTRAPMENT

The seawater intake is located within Urala Creek South. It will operate throughout the year with the peak flows to occur in summer months when evaporation is highest. It will include a screened rock armoured inlet well excavated into the creek bank to reduce the risk of entrapment of floating debris and large fauna. The downward facing intake pipes within the intake well will also be screened.

Entrainment

Entrainment occurs when fauna (including zooplankton, gametes, larval, post-larval, sub-adult and adult stages of certain species) are small enough to pass through intake screens. Depending upon the resilience of the fauna, varying degrees of mortality will occur. The intake pumps mean water velocity has been calculated to operate at 0.11 m/s (Vortex Australia, 2020), potentially reducing biota passing through the intakes. However, depending upon the resilience of the fauna to the forces exerted upon them as they pass through the intake pumps, varying degrees of mortality will occur. All solar salt operations have marine biota in the salt ponds from the adjacent marine environment. In current pond designs, the biota are generally unable to leave the ponds, thus a locally unique ecosystem is created within the ponds. (AECOM, 2022b).

Fish resources within the Port Hedland concentrator ponds of Dampier Salt Limited (2006) were found to exceed 60 t throughout the year and exceeded 100 t in May 2000. Although the number of species found was lower than typically recorded in other tropical estuaries, a large number of recreational and/or commercial species were present, sometimes in large numbers. It is expected that a number of fish species will inhabit the concentrator ponds of the Proposal and become part of the pond ecosystem. This ecosystem is also expected to provide habitat for migratory waders and other shorebirds which have been observed congregating at concentrator ponds of other WA solar salt operations.

Entrapment

Entrapment refers to the trapping of fauna against intake screens due to water velocity. If fauna are unable to extricate themselves from the screens, then mortality is inevitable. The rate and degree of entrapment is a function of the large fauna present, water velocity, intake design and intake location. USEPA (2014) recommendations screen water velocity of less than 0.15 m/s, for protection of 96% of motile species (concluded from fish swim speeds). The intake pumps mean water velocity has been calculated to operate at 0.11 m/s indicating screen velocity less than 0.15 m/s should be readily achievable (Vortex Australia, 2020). Dugongs, dolphins, marine turtles (including juveniles) and sawfish are the key marine fauna of concern in relation to entrapment. The maximum swimming speed of a dugong is reported around 5.6 m/s (Huffman, 2006), which suggests that a dugong would be quite capable of swimming away from an intake screen should it find itself in the vicinity of the screen at pump start-up. Dolphins found locally are capable of swimming faster than the dugong and could also be reasonably expected to swim away from the intake screens without becoming entrapped and are unlikely to occur at the intake location.

Sawfish species are easily caught and entrapped in nets and lines due to their toothed rostrum, which is a major reason for their global decline (Dulvey et al. 2016). To avoid sawfish and juvenile turtles becoming entrapped in the seawater intake within Urala Creek South, an exclusion device is required. This device is required to be rigid and of a relatively small grid size to prevent sawfish rostra becoming entangled or suck in grid openings (Morgan et al. 2020). The screening of the intake inlet well will act as a suitable exclusion device (AECOM, 2022b).

9.5.1.3.1 STATUS OF PRAWN STUDIES

A summary of life cycle, important movements and key habitats for each species has been retrieved from DPIRD (2015) and is provided in Section 9.4.8.1.

K+S has commissioned a prawn modelling study to determine the potential losses of prawn larvae as a result of the seawater intake and bitterns outfall. The first run of modelling for this study has been completed and reviewed by relevant prawn experts from DPIRD and Murdoch University. K+S has commissioned a re-run of the model in October 2022 to address the comments from the prawn experts. The results will be provided with the Response to Submissions document (when accepted by the prawn experts).

9.5.1.4 UNDERWATER SOUND

Underwater sound modelling was undertaken to determine the distance from activities that marine fauna may experience a temporary reduction in hearing sensitivity (Temporary Threshold Shift - TTS) or permanent reduction in hearing sensitivity (Permanent Threshold Shift - PTS). Modelling and impact assessment predicts the following for marine fauna (Talis, 2021) (AECOM, 2022b). Additional assessment of potential impacts from vessel activity was undertaken by AECOM (2022b), as also described below:

Elasmobranchs:

- Dredging: Low tide TTS = 150 m, PTS = 90 m. High tide TTS = 360 m, PTS = 170 m. It is highly unlikely that elasmobranchs will be exposed to these thresholds within their creek and nearshore habitats given the dredging will occur approximately 660 m offshore. Dredging soft start procedures will allow elasmobranchs to move away from the noise source before such thresholds are reached.

- Pile driving: Low tide TTS = 450 m, PTS = 250 m. High tide TTS = 1,200 m, PTS = 550 m. It is possible that elasmobranchs will be exposed to a reduction in hearing sensitivity within their nearshore habitats during piling which will occur from the shoreline and along the 660 m length of the jetty. Elasmobranchs within creek habitats are unlikely to be impacted. Piling soft start procedures will allow elasmobranchs to move away from the noise source before such thresholds are reached.
- Vessels: Fish have been recorded to avoid approaching vessels, usually by swimming down or laterally away from the vessel's track, with these effects noted to be transitory. The persistent presence of fish adjacent to operating marine and coastal infrastructure, such as wharves and offshore petroleum production platforms, indicates that at least some species are able to habituate to radiated underwater noise. Therefore, the associated underwater noise from operational vessels is not expected to significantly impact elasmobranchs.

Whales:

- Dredging: Low tide TTS = 180 m, PTS <5 m. High tide TTS = 260 m, PTS <5 m. Given whales are unlikely to occur in the immediate vicinity of dredging activities (due to shallow water depths) it is highly unlikely they will be exposed to these thresholds. Behavioural responses may occur to lower noise levels that may be heard by whales such as increased alertness, modification of vocalisations, interruption or cessation of feeding or social interactions and alteration of movement or diving behaviour, however these will be transient.
- Pile driving: Low tide TTS = 2.7 km, PTS = 500 m. High tide TTS = 5 km, PTS = 900 m. Exposure ranges to noise levels exceeding the TTS thresholds are predicted to extend over several kilometres and likely to cause behavioural reactions (avoidance) with some acoustic masking of vocalisations. The underwater noise mitigation measures proposed will each contribute to reducing the underwater noise levels; however, reduction cannot be precisely quantified. Therefore, to minimise impacts to whales piling operations will be undertaken outside key ecological windows for humpback whales (in particular the southern migration September to November).
- Vessels: Sprogis *et al* 2020 found louder vessels approaching mother and calf humpback whales (within 100 m) resulted in increased respiration rates and reduced resting rates, suggesting that excessive vessel noise can affect the energy budgets of mother-calf pairs, resulting in decreased fitness of calves. The minimal increase of vessel noise as a result of the Proposal is likely to be limited to temporary behavioural disturbance and/or masking of other biological sounds. Additionally, transhipment vessels will not actively approach cetaceans, and thus have minimal interaction with marine mammals. As shipping and vessel noise is a continuous noise source of relatively low intensity, thresholds above which injury to marine mammal hearing could occur will not be exceeded. Bejder et al (2019) reported a reduction in vessel speed also reduces ship noise levels if the speeds are reduced to a level where cavitation is avoided; this is achievable when the transhipment vessel travels at a speed of 7-10 knots. Therefore, with mitigation measures applied, it is unlikely that vessel noise resulting from the Proposal will significantly impact cetaceans.

Dolphins:

- Dredging: no impact is predicted. Lack of impact is due to the medium frequency hearing range of dolphins.
- Pile driving: High and low tide PTS < 50 m. Exposure of dolphins to PTS is unlikely due to the low presence and mobile nature of dolphin species. Impacts of pile driving will likely be limited to behavioural responses such as avoidance of the area, increased alertness, modification of vocalisations and, interruption / cessation of feeding or social interactions.
- Vessels: Short-term changes in surface behaviour of bottlenose dolphins in response to dolphin-watching vessels were reported in Koombana Bay, WA (AECOM, 2022b). Dolphins were observed to be attracted to the vessel during 20% of cases and to have avoided it in 28% of cases. Time spent resting and feeding decreased in the presence of the tour vessels, whereas time spent travelling increased. As with whales, the minimal increase of vessel noise as a result of the Proposal is likely to be limited to temporary behavioural disturbance and/or masking of other biological sounds. With mitigation measures applied, it is unlikely that vessel noise resulting from the Proposal will significantly impact cetaceans.

Dugong:

- Dredging: High and low tide TTS < 50 m, PTS < 5 m. It likely that any dugongs present in the area will avoid impact from dredging activities and move away from the area during soft starts. Behavioural responses may include brief interruption of normal activities.
- Pile driving: High and low tide PTS < 50 m. It likely that any dugongs present in the area will avoid impact from piling activities and move away from the area during soft starts. Behavioural responses may range from brief interruption of normal activities to short or long-term displacement.
- Vessels: Preen (2001) reported that individual dugongs differ greatly in their response to slow and/or fast moving vessels, with some individuals showing no signs of disturbance, while others rapidly moved away from the approaching vessels. Prevailing weather conditions may also affect a dugong's response to fast vessels. It is possible, for example, that the ambient level of underwater noise during strong wind conditions may mask the sound of an approaching vessel. Vessel noise as a result of the Proposal may potentially trigger a range of temporary behavioural responses, from brief interruption of activities or masking of vocalisations. However, vessel noise is not expected to negatively impact dugong populations within the area.

Turtles:

- Dredging: Low tide TTS = 150 m, PTS = 90 m. High tide TTS = 360 m, PTS = 170 m. Due to the short duration of dredging activities and the implementation of appropriate mitigation measures, it is unlikely that dredging activities will have significant impact on marine turtles. There may be some observable behavioural responses (such as avoiding the area). Dredging will be undertaken outside of the mating and nesting season (October to January) and soft start procedures will allow turtles to move away from the noise source before such thresholds are reached.
- Pile driving: Low tide TTS = 450 m, PTS = 250 m. High tide TTS = 1,200 m, PTS = 550 m. Behavioural responses (avoidance) may be caused to turtles within the local area. Pile driving will be undertaken outside of the mating and nesting season (October to January) and soft start procedures will allow turtles to move away from the noise source before such thresholds are reached.
- Vessels: There may be some minimal behavioural responses (such as avoidance or swimming away from operational vessels) in juvenile and adult turtles as a result of Proposal construction and operation. Modelling for this Proposal suggests turtles may express behavioural responses to underwater noise from a continuous source, such as vessel movements, at a distance of 75 m. However, given the implementation of the MFMP and mitigation measures it is unlikely that vessel noise will have significant impact on marine turtles.

Piling for the bridge across Ashburton River will occur only when the river bed is dry to prevent potential impacts to sawfish species.

9.5.2 INDIRECT IMPACTS

The assessment of potential indirect impacts to marine fauna have been considered in Appendix N (AECOM, 2022b) for a range of Proposal-related factors as summarised below in Table 72.

Table 72: Potential Indirect Impacts to Marine Fauna

(AECOM, 2022b)

<table>
<tr><th>Impact</th><th>Assessment</th><th>Outcome</th></tr>
<tr><td>Dredging sediment discharge</td><td>Dredging and tailwater discharge will generate plumes of turbid water containing elevated levels of suspended sediments which can impact marine fauna through light reduction, clogging of feeding and respiratory structures and the mobilisation of nutrients and/or contaminants. Analysis of sediment indicated no toxicants exceeded screening levels (AECOM, 2022b). Modelling of suspended sediment generation has been conducted by Water Technology (2022b) as described in Section 7.5.2. Potential impacts to specific marine fauna are discussed below:
Elasmobranch nearshore and creek habitat is naturally turbid at times. The suspended sediment ZoI as described in Section 7.5.2 is not predicted to reach creek systems, with a localised short-term turbidity increase predicted in nearshore waters. Therefore, elasmobranchs present in nearshore waters potentially exposed to temporarily increased turbidity levels as a result of the Proposal are unlikely to be significantly impacted.
Marine mammals often inhabit turbid environments, and many utilise sophisticated sonar systems to sense the environment around them. Evidence that turbidity affects cetaceans or sirenians directly does not exist in the literature. Dugong forage on ephemeral seagrass beds which may be present in some years on soft sediment locally. As described in Section 8.6.1 the suspended sediment zones of influence have been defined on the basis of coral tolerance limits which are not directly applicable to seagrasses. The dredging is planned to be of short duration (less than one month), and turbid plumes are predicted to be no longer detectable within a week after activities are completed. As any impacts to local seagrass could reasonably be expected to recover within five years of completion of dredging it is considered that there is no credible risk of loss of seagrass habitat due to suspended sediment. It is therefore unlikely that dugongs will be impacted, as any loss in foraging habitat (if present) will be limited to the dredging footprint (considered under Habitat Loss in Section 9.5.1.1) and large amounts of similar soft sediment (potential seagrass) habitat exist locally.
Marine reptiles often inhabit turbid environments. Given the naturally turbid conditions of the area and localised, temporary extent of the predicted suspended sediment plume, an impact on marine reptiles in the area is unlikely. As described above (with regards to dugongs), it is considered that there is no credible risk of loss of seagrass habitat due to suspended sediment. It is therefore unlikely that marine turtles will be impacted, as any loss in foraging habitat (if present) will be limited to the dredging footprint (considered under Habitat Loss in Section 9.5.1.1) and large amounts of similar soft sediment (potential seagrass) habitat exist locally.</td><td>Significant impacts to marine fauna as a result of increased suspended sediment are considered unlikely.</td></tr>
<tr><td>Bitterns discharge</td><td>The key impact that bitterns can have on biota within the receiving environment is physio-chemical stress due to the high salinity which has osmotic effects on the cells of living organisms. Given no additives are introduced during the solar salt production process, the only toxicants that exist in the bitterns wastewater are naturally occurring elements of seawater (specifically salt and metals) which have been concentrated by the solar evaporation process. Modelling of bitterns plume generation has been conducted by Water Technology (2022b) as described in Section 7.5.1 and an ecotoxicology assessment has been conducted Appendix L (AECOM, 2022c). Potential impacts to marine fauna and their habitat are discussed below:
As outlined in Section 7.5.1.9 the predicted maximum LEPA ranges from 4,300 m in width to approximately 2,000 m from the end of the jetty. This represents an area of elevated salinity impact. Given the highly mobile nature of most marine fauna, it is unlikely that bitterns mixing zone will impact mobile marine fauna, as they will likely move away from the localised areas in which water quality is adverse prior to such impacts occurring. LEPA habitat loss is included in Section 9.5.1.1.
The ecotoxicology assessment found that the only “toxicants” within the bitterns are naturally occurring metals within seawater. The solar salt evaporation process does not lead to chemical reactions that produce substances that do not commonly occur in seawater because it is essentially an evaporation and crystallisation process for removal of sodium chloride and no additives are used in the process. This process leaves behind only naturally occurring elements within the bitterns (predominantly magnesium sulphate). Once the metals within the bitterns plume are diluted such that they meet the 99% or 95% species protection level assigned in ANZG (2018) (which is predicted to occur at the boundary of the MEPA) they present a very low risk of toxicity or bioaccumulation to marine fauna (AECOM, 2022c).</td><td>Significant impacts to marine fauna as a result of increased bitterns discharge are considered unlikely.</td></tr>
</table>

Impact	Assessment	Outcome
Anthropogenic light spill	Light spill modelling was undertaken to predict Proposal related light change at seven locations: 1) Locker Island (2019 and 2022); 2) LM3 located 1 km north of Locker Point (2019 and 2022); 3) Mainland East (2022); 4) Ashburton Island (2022); 5) Bessieres Island (2022); 6) Serrurier Island (2022); and 7) Thevenard Island (2022). Modelling considered two scenarios: 1) Worst case - the jetty and conveyor lights always switched on; and 2) Best case - the jetty and conveyor lights switched off when not in use. The potential light spill impacts on marine fauna are summarised below (Pendoley Environmental, 2020), (Pendoley Environmental, 2023), (AECOM, 2022b): • The brightest source of light on the horizon was the Wheatstone LNG Facility which appears as bright skyglow at all sites as well as a direct source from nearby Ashburton Island. Similarly, light from the Macedon LNG Facility is also visible from all monitoring sites, although it is substantially darker than the Wheatstone LNG Facility and, at some sites, both sources have an overlapping bearing. • The visibility of other sources of light at each site was dependent on the bearing of the light source and whether the source was shielded from nearby dunes or other localised topographic features. For example, artificial light from Exmouth was only visible from Locker Island and shielded elsewhere, and the Tubridgi Gas Facility was visible from all sites except Locker Island, Mainland West, and Thevenard Island. • At Ashburton Island, light emissions from the TSV and OGV at the transhipment area are visible in the model output but would be naturally shielded by the island topography meaning it is unlikely to be visible from the nesting habitat on the south and southwest sides of the island. The project jetty and infrastructure are barely visible within the modelled output and are not discernible as separate light sources in the benchmark + modelled output. • At Bessieres, light emissions from the TSV and OGV at the transhipment area are visible in the model output and are clearly visible offshore as a separate source of light in an NNE direction from the island in the benchmark + modelled output. The project jetty and infrastructure are barely visible within the modelled output and are not discernible as a separate light source in the benchmark + modelled output. • At Locker, light emissions from the TSV and OGV at the transhipment area are visible in the model output but would be naturally shielded by the island topography meaning it is unlikely to be visible from the nesting habitat on the south side of the island. The project jetty and infrastructure are visible within the modelled output and are visible as a separate source of light on the mainland in a southerly direction from the island in the benchmark + modelled output. • At Serrurier, light emissions from the TSV and OGV at the transhipment area are visible in the model output but would be naturally shielded by the island topography meaning it is unlikely to be visible from the nesting habitat on the south side of the island. The project jetty and infrastructure are barely visible in a southerly direction from the island within the modelled and the benchmark + modelled output. • At Thevenard, only light emissions from the TSV and OGV at the transhipment area are visible in the model output, with the project jetty and infrastructure not discernible as a separate source of light. The light emissions from the TSV and OGV are visible offshore in a southwest direction from the island within the benchmark + modelled output. • At the Mainland East site situated to the east of the project jetty, light emissions from the TSV and OGV at the transhipment area are barely visible in a northerly direction from the site within the modelled and the benchmark + modelled outputs. The project jetty and infrastructure are visible within the modelled output and are not discernible as a separate light source in the benchmark + modelled output due to shielding from a dune and localised topography. • At the Mainland West site situated to the west of the project jetty, light emissions from the TSV and OGV at the transhipment area appear similar to the Mainland East site and are barely visible in a northerly direction from the site within the modelled and the benchmark + modelled outputs. The project jetty is clearly visible within the modelled output and appears as a separate light source in northeast direction from the site in the benchmark + modelled output. The project infrastructure is also visible within the modelled output but is not discernible as a separate light source in the benchmark + modelled output due to shielding from a dune and localised topography. • With the inclusion of the modelled project lighting, the largest increase to benchmark light levels for both WOS and horizon areas are predicted to occur at the Mainland West site which is situated close to the jetty (+216 % WOS and +514 % horizon), and the smallest	The Proposal will increase light spill marginally compared to existing sources. With appropriate mitigation, lighting impacts to Marine Fauna from the Proposal are unlikely.

Impact	Assessment	Outcome
	increase at Ashburton Island (+8 % WOS and +6 % horizon). The second largest change is predicted for Bessieres Island with a +14 % increase in WOS brightness and +15 % increase in horizon brightness. The other monitored sites, including the Mainland East site, all experienced an +11 % increase in WOS brightness, and varying increases in horizon brightness (+9 to +11 %) due to shielding from nearby dunes and localised topographic features, and existing visible light sources on an overlapping bearing with the project location. • Under Scenario 2 when lights from the jetty are switched off, the predicted change in light emissions visible from the Mainland West site shows a +11 % increase for both WOS and horizon areas on benchmark levels which was a substantially lower increase than under Scenario 1 (+216 % WOS and +514 % horizon increase). All other sites showed no change in brightness between scenarios on benchmark levels. Predicted impact to Marine Fauna include: • Turtles (from Pendoley, 2023) - The updated modelling demonstrated that under a 'worst' case scenario with all jetty lighting switched on, light emissions from the Proposal could increase the existing WOS and horizon brightness by up to 216% and 514% respectively at the monitoring site situated closest to the project jetty (Mainland West). At this site, while the localised topography provides some natural shielding in the direction of the Proposal, the jetty extends beyond this shielding allowing both direct light and sky glow to be visible. However, under a 'best' case scenario with all jetty lighting switched off, the change in WOS and horizon brightness at the same site is predicted to be an increase of 11% indicating the importance of this lighting control. Note that the marine turtle surveys undertaken by AECOM in 2018 and 2019 recorded only one adult female turtle track to the west of the jetty indicating that this area is not likely to be significant for marine turtle nesting (AECOM 2021). At the other mainland monitoring site (Mainland East), despite being relatively close to the jetty (~4 km), the localised dune and beach headland/topography shielded the visibility of the modelled light resulting in a substantially smaller increase of 11% WOS brightness and 9% horizon brightness compared to the Mainland West site. At the monitoring sites on the offshore islands, there were detected increases in brightness from benchmark light levels with the inclusion of the modelled outputs, ranging from 8 - 14% for the WOS area and 6 - 15 % for the horizon area. The range in percentage change between the sites is likely due to a combination of factors, including the proximity of the monitoring site to the modelled light source itself, the occurrence of shielding of the modelled light from existing dunes or localised topography, or the overlapping of the modelled light source with an existing source. The predicted light emissions from the TSV and OGV vessels at the transhipment area were notably visible in the modelled outputs at the monitoring sites on Thevenard and Bessieres islands only and shielded or barely visible at all other sites. When the vessels are operating in this area, it is likely that they will be a new source of offshore light on the horizon and will appear at different bearings depending on the perspective at these two nearby islands. This means that the risk of impact from the light source on a marine turtle will change spatially across the habitat depending on where an adult turtle nests or a hatchling emerges. The risk of impact may also be counteracted by the visibility and bearing of other sources of existing light, notably the Wheatstone LNG Facility which appears notably brighter at Thevenard Island compared to the modelled vessels. • Elasmobranchs - The distance of the jetty from Urala Creek North (8 km) and Urala Creek South (19 km) will likely preclude significant light impacts from this source within the creeks. Light spill may occur in Urala Creek South if lighting is associated with the seawater intake pumpstation. Additional light spill will be introduced along the shoreline between Urala Creek North and the Ashburton River mouth from jetty operations. The effects of light pollution on sawfish are unknown, with no previous work investigating effects of changes in lighting regimes on the movement and behaviour of wild sawfish. However, considering that sawfish are largely crepuscular or nocturnal, artificial light during night-time hours has the potential to alter both the movements of sawfish around lighted areas and the timing of movements and activity, as has been suggested for other elasmobranch species. Impacts to Elasmobranchs will be considered and minimised within the LMP.	

Impact	Assessment	Outcome
	• Marine Mammals - Marine mammals are highly mobile and are not expected to occur in high densities in close proximity to the Proposal. Given the small increase in whole of sky and horizon brightness modelled at a relatively short distance from the Proposal compared with surrounding habitat for marine mammals (i.e., modelled results for Locker Island 8 km away) it is unlikely that marine mammals will be adversely affected by Proposal light spill. • Migratory Shorebirds - The migratory shorebirds near the Proposal are likely to occur within their prime foraging grounds around the intertidal mudflats and creeks during the day. However, there is the potential for attraction for shorebirds to utilise the Proposal concentration ponds. This may therefore increase the presence of shorebirds in the area and attraction to artificial light at night for foraging purposes. There is evidence that artificial lighting of migratory shorebird foraging areas may benefit the birds by allowing greater visual foraging opportunities. Impacts to shorebirds will be considered and minimised within the LMP	
Altered nutrient inputs	The assessment of nutrient pathways has been detailed in (Water Technology, 2021d) which included modelling of impacts of the Proposal on nutrient pathways into the local catchment and entire Exmouth Gulf. Details are provided in Section 7.5.3.1 and Section 14.5.2.1 with the full report in Appendix F. The impact of any predicted changes on BCH was assessed (AECOM, 2022a) and is summarised in Section 8.6.1. In summary, Water Technology (2021b) predicted: • A regional post-development proportional reduction in nitrogen flows into the Exmouth Gulf of 0.24% of land and ocean sources. • A local post-development proportional reduction in nitrogen flows into the Proposal catchment of 0.8% of land and ocean sources. Based on the modelling conservative assessments it is concluded that the proposed development will not significantly alter nutrient exports or pathways particularly when compared to the overall nitrogen budget of the Exmouth Gulf. Impacts related to nutrient pathways are not predicted to compromise existing environmental values including intertidal or subtidal BCH, primary or secondary productivity and marine fauna.	Very small changes predicted to nutrient pathways are unlikely to impact marine fauna.
Hydrocarbon spills	Potential sources of hydrocarbon spills to the marine environment from the Proposal include: • Vessel spills • Vessel collisions • Refuelling/servicing of the transhipper or seawater intake pumps. Potential impacts from spills to marine fauna may include: • Oiling of fauna (particularly seabirds) leading to injury of mortality. • Loss or disturbance to habitat • Toxic effects fauna. Mitigation measures will be in place to prevent spills and undertake corrective action should they accidentally occur.	With appropriate mitigation measures in place Proposal hydrocarbon spills are unlikely to significantly impact marine fauna.
IMP	Due to the relatively small number of vessels involved, there will be limited potential for IMP introduction resulting from the Proposal. The various vessels required as part of the construction and operation of the Proposal have two potential introduction nodes for IMPs: • Ballast water. • biofouling. There are clear Australian and Western Australian government protocols for managing the risk of both ballast water and biofouling. These protocols will be followed for all vessels mobilised for the Proposal.	With appropriate mitigation measures in place the Proposal is unlikely to increase IMP.

9.5.3 CUMULATIVE IMPACTS

From a direct habitat loss perspective, it is noted that potential impacts to the Exmouth Gulf from the Proposal are limited due to the Proposal's North Eastern Exmouth Gulf location and limited interface with the Exmouth Gulf itself. Further, there have been no past developments, there are no current developments, and there are no reasonably foreseeable future developments, in the same portion of North Eastern Exmouth Gulf to which potential Proposal impacts upon marine fauna could be considered cumulative. Hence, it is considered that the Proposal does not pose a significant risk of contributing to cumulative impacts upon marine fauna habitat within the North Eastern Exmouth Gulf (AECOM, 2022b).

There are potential cumulative indirect impacts to the marine fauna species that require consideration. The Proposal could represent a source of potential cumulative impact in addition to the Wheatstone LNG plant and accommodation village, and the Macedon gas treatment plant, all of which are some 20-25 km to the north-east of the Proposal. As discussed in Section 9.5.2, light spill from the Proposal will be additive to the light generated at the other three sources. However, given the relatively low magnitude of light spill from the Proposal, in an area that currently experiences light from the other three sources, it is considered that the Proposal will not significantly increase the overall light climate in the region, and therefore will not raise the risk of significant impacts upon marine fauna (from light spill) to a substantially greater degree than presently exists in the region.

Current activities in the vicinity of the jetty, the ocean-going vessel loading anchorages, and the transhipper route between them, primarily comprise existing recreational or commercial vessel movements. Transhipper movements and Panamax loading will add to the potential for noise disturbance to, and vessel strike upon, marine fauna. However, a MFMP will minimise impacts to marine fauna, and it is considered that the frequency of transhipper movements and ocean-going vessel loading, in conjunction with existing vessel movements, will be unlikely to pose a risk of significant impacts upon marine fauna. However, the Proposal is likely to increase local cumulative impacts due to vessel movements.

9.6 ASSESSMENT OF IMPACTS

The location and design of the Proposal results in several impacts to marine fauna as outlined in Sections 9.5.1 to 9.5.3 above:

- At a broad scale, the area of marine fauna habitat that is likely to be impacted due to the Proposal is proportionally very small when compared to the availability of similar habitat in the surrounding areas, which will be easily accessible to highly mobile marine fauna species (0.4% or less of Exmouth Gulf habitat). Therefore, is it unlikely that habitat loss resulting from construction and operation of the Proposal will impact the biological diversity and ecological integrity of marine fauna populations and their habitats. However, given the area intersects with several BIAs and critical habitat areas for marine fauna the predicted habitat loss may be considered significant. For example, the presence of juvenile and sub-adult green turtles and green sawfish in both Urala Creek North and South indicates that these locations are considered habitat critical to the survival of the species, and the system is used as an important food source and nursery for these species. As such, any habitat loss or associated disturbances in these areas have the potential to negatively impact critical habitat.
- Physical interaction between marine fauna and transhipment vessels will remain a possibility throughout operations. The increase in shipping traffic may impact marine fauna, particularly turtles, dugongs, humpback whales, and whale sharks, all of which have the potential to occur in proximity to the berth pocket, transhipping route and offshore anchorage site. However, the transhipment vessel will be restricted to a maximum speed of 9 knots in the navigation channel. The slow pace and predictable path will ensure the transhipment vessel will pose a low risk to marine fauna. With the implementation of additional mitigation measures presented in Section 9.7.2 and implementation of the MFMP, impacts due to vessel movements associated with the Proposal are expected to be low.
- With the implementation of seawater intake inlet well and pipe screens, and intake velocity to remain below the USEPA (2014) recommended 0.15 m/s, it is considered that the risk of entrapment of marine fauna is low.

- The proposed dredging is a relatively small dredging activity which is estimated to take two weeks to complete and produce relatively small, localised and temporary elevated turbidity plumes unlikely to significantly impact marine fauna.
- The risk to Marine Fauna from the bitterns discharge water quality is considered low given the likely avoidance of the area (AECOM, 2022a) and the low risk of bioaccumulation of metals (AECOM, 2022c). BCH loss as a result of the bitterns discharge is included in the BCH loss calculations discussed above.
- Underwater noise generating activities have the potential to result in behavioural responses of some marine fauna species. However, timing activities outside of key ecological windows (collectively September to January) will minimise impacts.
- Given the relatively low magnitude of light spill from the Proposal, and the presence of light from other sources, it is considered that the Proposal will not contribute significantly to the overall light climate in the region, and therefore will not raise the risk of significant impacts upon marine fauna (from light spill) to a substantially greater degree than presently exists in the region.
- The nutrient pathway modelling (Water Technology, 2021d) indicates that the nutrient-related changes are small in proportion to the total estimated nutrient flows into the local catchment and the Exmouth Gulf with impacts to primary and secondary productivity and Marine Fauna unlikely to occur.
- With appropriate mitigation measures in place, Proposal hydrocarbon spills are unlikely to significantly impact marine fauna.
- With appropriate mitigation measures in place and the government regulations surrounding IMP, the Proposal is unlikely to increase IMP risks.

9.7 MITIGATION

9.7.1 AVOID

The Proposal has undertaken significant design optimisation to avoid environmental impacts to Marine Fauna including:

- Detailed analysis of seawater intake options and locations reducing the seawater intake locations from two (Urala Creek North and South), to only one (Urala Creek South).
- Detailed analysis of dredging options and spoil disposal. Proposing transhipment with low draft barges to avoid the need for dredging a long shipping channel to deeper water (avoiding significant disturbance of the seafloor via dredging). The dredged berthing pocket is proposed in a location away from sensitive benthic habitats (such as coral reefs) thereby avoiding impacts to sensitive habitats.
- There is no requirement for disposal of dredged material at sea avoiding much larger impacts to Marine Fauna from elevated turbidity.
- It is proposed that bitterns will be discharged via a diffuser positioned such that the mixing zone overlaps with an area of existing high disturbance (dredged berthing pocket) and away from sensitive benthic habitats (coral reef), minimising impacts to marine fauna.
- Throughout the salt production process, no chemicals will be added at any stage of the process avoiding ecotoxicity and bioaccumulation risks to marine fauna.
- Uphold noise management zone distances for marine mammals and turtles to avoid the onset of injury and adverse behavioural effects.

9.7.2 MINIMISE

The following mitigation measures and management plans are proposed to ensure that direct and indirect impacts to marine fauna are minimised:

- Implementing the following engineering design and project management measures:
    - Appropriate culverts and drainage diversions designed to minimise impacts to tidal and surface water flows and nutrient pathways, therefore minimising related impacts to marine fauna habitats.
    - Detailed analysis of bitterns disposal options including lengthening and realignment of the jetty and bitterns discharge pipeline into deeper water to minimise impacts of bitterns discharge, reducing mixing zone size and therefore minimising related impacts to marine fauna habitats.

- Prior to discharge, the bitterns flowing out of the crystalliser ponds will flow into a bitterns dilution pond. Washwater (ocean water) will be used to wash the harvested salt to get rid of the adherent bitterns and the possible KCl-crystals which could be grown during transport. No additional chemicals or organics are added to the washwater. The bitterns would be diluted 1:1 with an equal amount of seawater before being combined with the washwater and discharged from the diffuser.
    - Bitterns will be discharged through an upward facing diffuser which will force the bitterns to the surface, thereby facilitating enhanced mixing and diffusion with faster moving surface waters and minimising the impacts to marine fauna habitats.
    - The area and volume of sediment to be dredged is minimised to 0.7 ha and 17,000 m^3, minimising impacts to marine fauna and their habitats.
    - Modelling predicts that the localised plumes of elevated turbidity will not persist for more than a week following cessation of the dredging activity, thereby minimising impact to marine fauna and their habitats.
    - Soft start procedures will be implemented for dredging and pile driving to move away from the noise source before hearing sensitivity loss thresholds are reached.
    - Minimise impacts of the dredge through underwater noise through proper maintenance of equipment.
- Engineering design of the seawater intake pumps mitigate any potential impacts on marine fauna. These include:
    - Dual screening of the intake structures. Firstly, screening of the inlet well from which water will be extracted. Secondly, screening of the pipe openings within the inlet well which will extract seawater. These dual screens will prevent and minimise entrapment and entrainment of marine fauna.
    - Ensuring the flow velocity of the intake pumps is less than 0.15 m/s. The inlet well screening concept design employs Johnson screens that extend from above the water line, to the bottom of the inlet well, with a total length of approximately 50 m (Vortex Australia, 2020). The mean flow velocity produced by the operating pumps has been calculated at 0.11 m/s, 25% less than the USEPA (2014) guideline of 0.15 m/s (Vortex Australia 2020).
    - When the pump stations are being commissioned the screens will be intensively monitored for the first 14 days. If there are any incidences of fauna entrapment, the pumps will be immediately shut down to allow:
        - Any entrapped fauna to swim out of the well; and
        - Improvements to the screening or the seawater intake design/operation until entrapment no longer occurs.
- Minimise the risk of fatal vessel strikes to marine fauna by implementing the following controls:
    - Operational vessels will travel no faster than 9 knots.
    - Vessel captain and crew must maintain a vigilant watch for all protected marine fauna species and slow down, or alter course, as appropriate, to avoid striking any protected species. The presence of a single individual at the surface may indicate the presence of submerged animals in the vicinity; therefore, precautionary measures should always be exercised.
    - All vessel crew members must be briefed in the identification of protected marine fauna species that may occur in the survey area and in regulations and best practices for avoiding vessel collisions.
    - Any time a vessel is underway, an observer must monitor a Vessel Strike Avoidance Zone (500 m) or greater from any sighted whales and 50 m or greater from any other marine fauna species visible at the surface, unless the marine fauna is actively approaching the vessel) to ensure detection of that animal in time to take necessary measures to avoid striking the animal.
    - Any Marine fauna indicents will be reported to both DBCA and DCCEEW as soon as possible, within 24 hours of the incident.
    - If a whale (including mother and calf pair) or whale shark are identified within 500 m of the forward path of any vessel, the vessel operator must steer a course away from the animal at

9 knots or less until the 500 m minimum separation distance has been established. Vessels may also shift to idle if feasible.

- EPBC Regulations 2000 – Part 8 Division 8.1 Interacting with cetaceans (DoEE 2017b) will be applied as follows:
  - Proposal vessels will not travel faster than six knots within 300 m of a cetacean or turtle (caution zone) and not approach closer than 100 m from a whale).
  - Proposal vessels will not approach closer than 50 m for a dolphin or turtle and/or 100 m for a whale (with the exception of animals bow-riding).
  - If the cetacean or turtle shows signs of being disturbed, Proposal vessels will immediately withdraw from the caution zone at a constant speed of less than six knots.
  - Vessels will not travel faster than eight knots within 250 m of a whale shark and will not approach closer than 30 m to a whale shark.
- Dredging operations will only be undertaken during daylight hours, where practicable.
- If a cutter suction dredge is in operation, rotation of the dredge cutter head will only start when it is positioned near the seafloor, and rotation will be stopped before the cutter is raised through the water column. This will mitigate the risk of contact between a rotating cutter head and protected marine species.
- Vessels will not approach, circle or wait in front of protected marine species for the purposes of casual viewing.
- A watch will be maintained throughout Proposal operations for stranded, injured or dead marine fauna; if observed, the DBCA Wildcare Helpline (08 9474 9055) will be contacted for advice on retrieval, treatment or post-mortem by the DBCA Parks and Wildlife Service.
- All sightings of marine fauna that occur within the operational areas of the K+S Port to be reported to operational vessels to minimise vessel strike incidents.

- Minimise potential dredging and piling noise impacts to marine fauna by implementing the following controls:
  - Piling for the bridge across Ashburton River will occur only when the river bed is dry to prevent potential impacts to sawfish species.
  - Dredging operations will be undertaken during daylight hours where practicable.
  - Pile driving activities will be undertaken only during daylight hours.
  - Where practicable, impact piling activities will be undertaken during low tide.
  - Dredging and piling operations will be undertaken outside key ecological windows for the following protected marine species;
    - Sawfish pupping window (September – November).
    - Turtle mating, nesting and hatching window (October - February).
    - Southern migration of Humpback Whales (August-December).
  - A watch, by a dedicated MFO, will be established and maintained to monitor the presence of any protected marine species, commencing ten minutes before any dredging activities and / or the "soft start" of pile driving activities. The watch will be made from an elevated position, where a clear LOS is achievable to a distance of 3,000 m from the dredging or pile driving location.
  - The dedicated MFO will be suitably trained and will have demonstrated knowledge and experience in marine fauna species observation, distance estimation and reporting. They will not have other duties while engaging in visual observations. They will adhere to the requirements of the Wildlife Conservation (Closed Season Marine Mammals) Notice 1998. MFOs must demonstrate a knowledge of marine wildlife species in the North-west region, including Threatened and Migratory Species listed under the EPBC Act, and BC Act and priority listing, including morphological and behavioural characteristics.
  - MFO observations will be undertaken from a suitable elevated point that provides appropriate vantage of the Management Zones and with unimpeded views around the noise source.
  - Implement a 3,000 m observation zone and 550 m exclusion zone for whales, dolphins, dugongs, turtles, manta rays and sawfish. The management zones have been informed using EPBC Policy Statement 2.1.

- Where protected marine fauna is observed in the exclusion zone (550 m) then dredging activities will not commence and / or piling operations shall cease until protected marine fauna have exited the management zones or have not been sighted for 30 minutes.
    - Implement a 30 minute soft start for dredging and piling operations. Dredging or piling cannot commence unless the MFO confirms that no target species were observed within the exclusion zone during the soft start period.
    - On each occasion that a dredge or pile driving equipment have been non-operational for a period exceeding 15 minutes, the soft start measures detailed above will be required to be undertaken.
    - Once dredging and / or pile driving have commenced, the MFO will maintain ongoing visual scanning of the observation and exclusion zones and, every 30 minutes, will dedicate a period of five minutes for observation (from an elevated position) for protected marine fauna. Dredging and / or piling activities will be temporarily suspended if an individual of a protected marine species encroaches within the pertinent exclusion zone. Dredging and / or piling will not recommence until no protected marine species have been sighted within the observation zones for a period of ten minutes.
- Review the measures proposed above prior to the commencement of each activity (i.e., pile driving, dredging, operations) to ensure that the measures are considered current best practice.
- If the proposed Exmouth Gulf Marine Park intersects with any Proposal activities, then review whether additional or stricter measures should be applied in these areas. Measures are to be developed in consultation with DBCA, but could include measures such as:
    - Trained MFOs on transhipment vessels.
    - Bubble curtains.
    - Increased observation and shut-down zone distances.
- Review lighting requirements during detailed design to ensure light spill impacts are minimised.
- Obtain and comply with a Works Approval and Licence under Part V of the EP Act for solar salt manufacturing (which will include the bitterns disposal) and bulk material loading. These approvals will manage the pollution risks to marine fauna associated with bitterns disposal, product spills and other emissions associated with the process and loading facilities.
- Implement the MFMP (Appendix BB).
- Implement the DSMP. The DSMP has been provided in Appendix BB and includes a comprehensive set of management actions and environmental performance measures related to marine fauna.
- Develop and implement the IMPMMP (Appendix BB).
- Develop and implement the MEQMMP (Appendix BB).
- A MSAMMP will be developed and implemented that integrates the monitoring of mangrove, samphire and algal mat health/status with the monitoring of shallow groundwater conditions (including salinity), and mapping showing Project-related changes in habitat distribution. This management plan is currently being developed with the intention for this plan to be assessed later in the assessment or as a condition of approval (if approved).

9.7.3 REHABILITATE

At the completion of the Proposal the site will be rehabilitated to reinstate the Marine Fauna. An Interim MCP (Appendix BB) for the Proposal has been developed and will continue to evolve during the life of the Proposal. If the Proposal receives Ministerial Approval under Part IV of the EP Act as well as under the EPBC Act, the Interim MCP will be developed in more detail and submitted to DMIRS for approval as required by the *Statutory Guidelines for MCPs under the Mining Act 1978* - DMIRS (2020b).

K+S preferred post closure land use is to leave the evaporation ponds in situ so that they become a “wetland” habitat for mangroves, algal mats and associated fauna (including migratory birds which require “wetland areas” for migratory stop over). This will also likely create habitat opportunities for marine fauna.

At the completion of operations, all buildings and structures on land will be removed from the site and the pond areas may be selectively reconnected to the existing tidal flat system. If ponds are to be reconnected, the MCP will establish which bunds to breach that will enable inwards tidal movement bringing sediments and allowing tidal channels to expand naturally. Natural tidal flows will allow movement of mangrove propagules (seeds) which will passively revegetate the reconnected tidal areas. This will enhance the habitat values of the ponds to marine fauna post closure.

The bitterns discharge infrastructure will be removed from site; however, the jetty may be transferred to the ownership of another user. Alternatively, it could be decommissioned and removed.

9.8 PREDICTED OUTCOME

The EPA objective in relation to marine fauna is *to protect marine fauna so that biological diversity and ecological integrity are maintained*. In the context of this objective: "ecological integrity" is listed as the composition, structure, function and processes of ecosystems, and the natural range of variation of these elements (EPA, 2016g).

K+S has incorporated extensive avoidance and minimisation measures into the Proposal design and operational processes. A key measure was to focus the disturbance footprint further inland on the unvegetated Supratidal salt flats, which has resulted in only a small proportion of the total Proposal footprint occurring within marine fauna habitat. With the implementation of these measures the Proposal will result in the loss of 232.2 ha of marine fauna habitat.

This loss of marine fauna habitat is considered to be significant for several significant marine fauna species, particularly when assessed in context with other indirect Proposal impacts. As a summary, the Proposal is therefore predicted to result in the following residual impacts that are considered significant:

- The loss of up to 226.2 ha of nearshore BCH, which may be utilised by species such as turtles, dugong, green sawfish and other elasmobranchs;
- The loss of 4.28 ha of mangroves, which may be utilised by green turtle juveniles;
- The loss of 0.54 ha of tidal creek, which may be utilised by green sawfish and green turtle juveniles;
- Significant fauna behavioural responses associated with noise, light, water quality and sedimentation; and
- Potential injury or death associated with the seawater intake, dredging or vessel strike.

Offsets are proposed to counterbalance these significant residual impacts (refer to Section 17).

The Proposal includes minimal infrastructure in the marine environment and as such rehabilitation is expected to be relatively simple. Closure planning will continue through the life of the Proposal, with the purpose of refining the closure strategies already in the MCP (Appendix BB).

Based on the above the Proposal is expected to be able to meet the EPA's objective for this factor. The implementation of the proposed mitigation and offsets are expected to minimise and counterbalance any significant residual impacts to marine fauna.

9.8.1 POTENTIAL BENEFITS

There are a range of environmental benefits to the local marine ecosystem that may develop due to the Proposal. Based on investigations into salt pond ecology, and the results of environmental monitoring at salt fields in the Pilbara (AECOM, 2022a), the following examples provide an indication of the environmental benefits that may potentially develop due to the Proposal:

- **Biological productivity within salt ponds** – At both the Dampier and Port Hedland solar salt fields, the pumping of large volumes of seawater into the primary concentration pond, and the movement and concentration (via evaporation) of seawater through a series of subsequent ponds has developed a biological system composed of a sub-set of species from adjacent tidal creeks and nearshore waters.
- **Formation of sedimentary deltas within salt ponds, forming migratory shorebird habitat** - Within the concentration ponds at the Port Hedland salt field, deltas have formed from the accumulation of

fine sediments transported into the ponds by the pumping of tidal waters. The deltas support high densities of infauna and thereby attract a large number and diversity of migratory shorebirds.

- **Increased understanding of sawfish populations in the local area** - The Ashburton River mouth, approximately 30 km north of Urala Creek North, has been identified as an important nursery area for green sawfish. As a result of studies undertaken for this Proposal, it was identified that Urala Creek North and South as potential secondary nursery areas for green sawfish as well as nurseries and habitat for several other threatened elasmobranchs.
- **Provision of pawn modelling to key stakeholders** - Independently to the ERD process, a modelling exercise is being undertaken with K+S, Water Technology, Murdoch University, DPIRD and Kailis to model potential proportional loss of prawns from the EGPMF and OPMF as a result of the Proposal. The results of this prawn modelling exercise are intended to be provided to DPIRD as the managers of the fisheries.
- **Creation of habitat from jetty structure** - Artificial structures increase habitat diversity by providing ‘hard’ surfaces in largely ‘soft’ natural habitats. There is a potential that the Proposal jetty over time will increase the habitat diversity of the surrounding area. However, it is also recognised that fish habitat created by the installation the jetty, in areas close to turtle nesting may increase the likelihood of predation of turtle hatchlings. However, as the Proposal is in an area classified as low-quality nesting habitat and low nesting density, it is not anticipated that the presence of the jetty will have a negative impact on turtle populations in the local area.
- **Marine fauna observations -** Throughout the construction phase of the Proposal, all marine based activities will have suitably trained MFOs on board vessels recording all marine fauna activity that is spotted in proximity to the Proposal area, this will include when transiting to and from site. This information will be made publicly available to allow people access to additional information regarding marine fauna activity in the local area.

10 FLORA AND VEGETATION

10.1 EPA OBJECTIVE

To protect flora and vegetation so that biological diversity and ecological integrity are maintained.

10.2 POLICY AND GUIDANCE

- *Environmental Factor Guideline: Flora and Vegetation* (EPA, 2016h).
- *Technical Guidance – Flora and Vegetation Surveys for Environmental Impact Assessment* (EPA, 2016i).
- *Checklist for documents submitted for EIA of proposals that have the potential to significantly impact on Sea and Land factors* (EPA, 2016j).
- *Environmental Protection Bulletin 20 - Protection of naturally vegetated areas through planning and development* (EPA, 2013).
- *Guidance Statement 6 – Rehabilitation of Terrestrial Ecosystems* (EPA, 2006).
- *Statutory Guidelines for MCPs* (DMIRS, 2020b).
- *A Directory of Important Wetlands in Australia* (ANCA, 1993).
- *WA Environmental Offsets Policy* (Government of Western Australia, 2011).
- *WA Environmental Offsets Guidelines* (Government of Western Australia, 2014).
- *National Recovery Plan for Olearia macdonnellensis, Minuria tridens (Minnie Daisy) and Actinotus schwarzii (Desert Flannel Flower).* Department of Natural Resources, Environment, The Arts and Sport, Northern Territory. Available from: http://www.environment.gov.au/resource/national-recovery-plan-olearia-macdonnellensis-minuria-tridens-minnie-daisy-and-actinotus. In effect under the EPBC Act from 13-Nov-2009 (Nano & Pavey, 2008). "Appendix B: Potentially contaminating industries, activities and land uses" in *Assessment and management of contaminated sites: Contaminated sites guidelines* (DER, 2014).
- *EPBC Act Environmental Offsets Policy* (Commonwealth of Australia, 2012).

10.3 FLORA AND VEGETATION STUDIES

Specific studies to assess impacts to flora and vegetation have been conducted as outlined in Table 73.

Table 73: Flora and Vegetation Studies

Study	Reference	Appendix
Detailed Vegetation and Flora Survey	Biota, 2022a	Q
Ashburton Salt Targeted Flora Survey	Biota, 2022e	R
Marine and Coastal Assessment and Modelling	Water Technology, 2022b	A
Surface Water Assessment and Modelling	Water Technology, 2022a	B
Marine, Coastal and Surface Water Data Collection	Water Technology, 2021a	C
Marine, Coastal and Surface Water Existing Environment	Water Technology, 2021b	D
Surface Water Assessment and Modelling	Water Technology, 2021c	E
Marine, Surface Water and Nutrient Modelling Peer Review	DHI, 2021	F
Acid Sulfate Soils Study	GHD, 2021a	K
ASSSMP	GHD, 2021b	BB
Materials Characterisation Study	GHD, 2021d	U
Memorandum Ashburton groundwater modelling- updated results	GHD, 2022	V
Hydrogeological Investigation	GHD, 2021c	W
Hydrogeology Modelling Peer Review	Cymod, Systems, 2022	X
Hydrogeology Modelling Peer Review	Cymod, Systems, 2021	Y

10.3.1 MODELLING

A surface water hydrodynamic modelling study (Water Technology, 2021c) and a hydrogeology modelling study (GHD, 2021c) have been conducted to assess potential impacts of the Proposal regarding:

- Surface water flows.
- Groundwater seepage and associated salt crusting.

10.3.2 MODELLING PEER REVIEWS

Peer reviews of the above modelling studies have been conducted. The peer review process was undertaken in a comprehensive, rigorous and iterative manner.

- It is the opinion of the surface water peer reviewer that the model constructed by Water Technology (2021c) can be considered suitable for the purpose of identifying potential environmental impacts for the above processes (DHI, 2021).
- It is the opinion of the groundwater model peer reviewer that the groundwater model (GHD, 2021c; 2022) is fit for the purpose of assessing groundwater related environmental impacts of the Proposal (CyMod Systems, 2021; 2022). (Water Technology, 2022a).

10.3.3 SURVEY ADEQUACY

The surveys were undertaken in accordance with *Technical Guidance – Flora and Vegetation Surveys for Environmental Impact Assessment* (EPA, 2016i). Page 23 of Biota (2020a): "Most of the vegetation types were sampled with at least the three sites recommended in EPA (2016i), with the exception of units that were extensively degraded or very small in size". Additional comments are provided in the majority of the descriptions of the vegetation types with less than three quadrats in Section 5.2 of Biota (2020a) (e.g., "Vegetation type narrow and degraded; not considered to warrant additional sampling."). These sampling decisions can only be made by an experienced botanist who is actually onsite in the survey area. The survey leaders for the Biota (2020a) study substantially exceeded this experience and are very familiar with the vegetation types of the locality, which informed such on-ground decisions.

Sampling effort was geared proportionally to the extent of the vegetation types in question – in accordance with EPA guidance. The seven vegetation types that accounted for most of the 23,000 ha survey area were sampled in excess of EPA guidance (especially unit P1). The exception was vegetation type P2, which was not sampled in excess of EPA guidance as it was largely degraded by erosion and weed invasion (as noted on p50 of Biota (2020a)). Together, these seven vegetation types represent 84% of the 23,000 ha survey area. Overall, by area, 93.5% of the vegetation types were sampled with at least three quadrats, with the remaining units being small in extent or degraded, as outlined above.

Page 16-17 of Biota (2021) clearly sets out the timing of the significant flora searches, including that an additional mobilisation aimed at improving confidence in this part of the survey was also completed under optimal conditions (p17: "Following above-average rainfall in winter 2019, it was considered opportune to undertake some additional targeted searches for conservation significant flora and annual flora that may not have been present during the two earlier surveys. Two Biota botanists undertook these targeted searches over two days (August 26 and 27, 2019).").

In recognition of optimal conditions, a further targeted flora survey was undertaken in May 2022 following good rainfall, which only added further records of the same significant taxa already recorded during the primary survey; further increasing confidence in the results.

10.4 EXISTING ENVIRONMENT

10.4.1 PRE-EUROPEAN REGIONAL VEGETATION MAPPING

The Proposal area intersects seven pre-european regional vegetation units mapped over the Cape Yannare Coastal Plain – Beard et. al. (2013). These vegetation units are widespread in the Cape Range IBRA subregion with over 90% of their original extent remaining (Figure 114).

Table 74: Pre-European Vegetation Mapping of Proposal Area
Beard et. al. (2013).

Unit	Description	Extent in Cape Range and Roebourne Subregions (ha)		% Remaining
		Pre-European	Current	
CYCP 43	Low forest; mangroves (Kimberley) or thicket; mangroves (Pilbara).	45,943.8	42,619.2	92.8%
CYCP 117	Hummock grasslands, grass steppe; soft spinifex.	63,387.3	57,809.6	91.2%
CYCP 127	Bare areas; mud flats.	278,166.4	258,814.89	93.0%
CYCP 589	Mosaic: Short bunch grassland - savanna / grass plain (Pilbara) / Hummock grasslands, grass steppe; soft spinifex.	753,492.6	749,162.4	99.4%
CYCP 670	Hummock grasslands, shrub steppe; scattered shrubs over *Triodia basedowii*. (this would now refer to *T. glabra*.)	147,810.2	147,793.6	>99.9%
CYCP 676	Succulent steppe; samphire.	39,573.3	38,769.7	98.0%
CYCP 1271	Bare areas; claypans.	18,353.6	18,353.6	100.0%

10.4.2 TERRESTRIAL VEGETATION MAPPING

Terrestrial vegetation types have been described and mapped for the study area, along with unvegetated areas, supratidal areas and intertidal areas (Biota, 2022a), (Biota, 2022b) and (AECOM, 2022a). Each terrestrial vegetation unit is summarised in Table 75 below (Biota, 2022a) (Figure 111 and Figure 114).

The samphire vegetation was largely weed-free, with only very occasional **Sonchus oleraceus* and **Cenchrus* grasses. Vegetation on sand dunes and plains generally contained at least scattered **Cenchrus* grasses, and sometimes dense patches or large infestations; condition was generally ranked as Very Good, with some areas ranked Good to Poor (e.g., within P2 and P4). Samphire is predominantly supratidal (not terrestrial) and is discussed and assessed in detail in Section 8.6 under Benthic Communities and Habitat (AECOM, 2022a).

The vegetation of the study area was generally ranked as being in Very Good to Excellent condition. A relatively small proportion of the study area had been cleared for tracks and for pastoral and gas storage infrastructure; these areas were scored as Completely Degraded (Biota, 2022a). Vegetation condition mapping is provided within Appendix Q.

Table 75: Locally Mapped Vegetation
(Biota, 2022a)

Group	ID	Description
Vegetation of Saline Mudflats and Clay Plains		
Sa.	S1	*Tecticornia doliiformis*, (*T. indica, T. halocnemoides, Frankenia ambita*) low shrubland over *Sporobolus mitchellii, Eragrostis falcata* very open grassland
	S2	*Tecticornia indica*, (*T. auriculata, T. halocnemoides*) low open shrubland over *Eragrostis falcata* scattered grasses
	S3	*Tecticornia auriculata*, (*T. indica, T. halocnemoides*) low shrubland over *Eragrostis falcata* scattered grasses
Sb.	S4	*Atriplex bunburyana* scattered low shrubs over *A. codonocarpa, Sclerolaena recurvicuspis* very open herbland with **Cenchrus* spp. scattered tussock grasses to

Group	ID	Description
		very open tussock grassland
	S5	*Acacia xiphophylla* tall open scrub over *Atriplex bunburyana* scattered low shrubs over **Cenchrus ciliaris* open tussock grassland
Vegetation of Creeklines and Drainage Areas		
C.	C1	*Eucalyptus victrix* low open woodland over **Prosopis pallida* scattered tall shrubs over **Cenchrus ciliaris,* (**C. setiger*) open tussock grassland
	C2	*Eucalyptus victrix* low woodland to low open woodland over *Acacia synchronicia, A. tetragonophylla* scattered tall shrubs to tall open shrubland over *Eriachne benthamii/flaccida,* (*Eulalia aurea, Sporobolus mitchellii*) tussock grassland
	C3	*Acacia tetragonophylla,* (*A. synchronicia*) tall shrubland over *Eriachne benthamii/flaccida* open to very open tussock grassland with *Triodia epactia* scattered hummock grasses to very open hummock grassland
	C4	*Acacia synchronicia, A. tetragonophylla* scattered tall shrubs over *Eriachne benthamii/flaccida*, (*Sporobolus mitchellii*) closed tussock grassland
Vegetation of Sand Plains		
P.	P1	*Acacia tetragonophylla, A. synchronicia, A. sclerosperma* subsp. *sclerosperma*, (*A. coriacea* subsp. *coriacea*) scattered tall shrubs to tall open shrubland over *A. stellaticeps* scattered low shrubs to low shrubland over *Triodia epactia* hummock grassland with **Cenchrus ciliaris* very open tussock grassland
	P2	*Acacia synchronicia, A. tetragonophylla* scattered tall shrubs over *Triodia epactia* very open hummock grassland with **Cenchrus ciliaris* very open tussock grassland to tussock grassland
	P3	*Acacia synchronicia, A. tetragonophylla* scattered tall shrubs over *Triodia glabra*, (*T. epactia*) hummock grassland
	P4	*Acacia tetragonophylla, A. sclerosperma* subsp. *sclerosperma* tall open shrubland over *Triodia glabra, T. epactia*, (*T. avenoides*) hummock grassland over **Cenchrus* spp. very open tussock grassland
Vegetation of Sand Dunes		
D.	D1	*Acacia coriacea* subsp. *coriacea* low open woodland over *Spinifex longifolius* very open to open tussock grassland with *Triodia epactia* scattered hummock grasses
	D2	*Acacia coriacea* subsp. *coriacea* low open woodland over *Triodia epactia* open hummock grassland with **Cenchrus ciliaris* very open tussock grassland
	D3	*Grevillea stenobotrya, Hakea stenophylla* subsp. *stenophylla*, *Acacia coriacea* subsp. *coriacea* tall open shrubland over *A. stellaticeps, Scaevola sericophylla, Quoya loxocarpa* low open shrubland over *Triodia epactia* open hummock grassland with **Cenchrus ciliaris* very open tussock grassland
	D4	*Grevillea stenobotrya, Hakea stenophylla* subsp. *stenophylla*, (*Acacia coriacea* subsp. *coriacea*) tall open shrubland over *Acacia stellaticeps* open shrubland over *Scaevola sericophylla* low open shrubland over *Triodia avenoides*, (*T. epactia*) hummock grassland

10.4.2.1 SIGNIFICANT VEGETATION

None of the vegetation types identified for the study area represent Threatened Ecological Communities (TEC's) listed either under the Commonwealth EPBC Act or EP Act, and no Priority Ecological Communities (PECs) were identified in the study area (Biota, 2022a).

Vegetation communities dominated by *Tecticornia* species or "samphire" were identified by Biota in the study area and are considered to be of local rather than regional significance, and of "somewhat elevated conservation significance". The samphire vegetation was in very good to excellent condition and largely weed-free, with only very occasional **Sonchus oleraceus* and **Cenchrus* grasses.

10.4.3 NATIVE FLORA

A total of 288 native vascular flora species from 126 genera and 45 families have been recorded from the study area based on all surveys to date (Biota, 2022a).

10.4.3.1 SIGNIFICANT FLORA

No species listed as Threatened flora under State legislation have been recorded in the study area to date, and none would be expected to occur. However, one species listed under Commonwealth legislation was potentially recorded during the Phase 1 survey in 2018 (Biota, 2022e: *Minuria tridens* is listed as Vulnerable under the EPBC Act. This species is listed as a Priority 1 species in WA. The location of the single record of *Minuria tridens* was re-visited and the surrounding area searched during the recent targeted survey, however no individuals were located (Biota, 2022e).

A total of five Priority flora taxa were recorded from the study area during the detailed vegetation and flora survey (Biota, 2022a). These species are described in Table 76 with regional distribution depicted in Figure 108 (Florabase, 2021).

A targeted significant flora was undertaken in May 2022, targeting the list of potential species identified in Section 4.9 of Biota (2022a). One Priority flora species was recorded during the targeted survey, *Abutilon* sp. Pritzelianum (S. van Leeuwen 5095) (Priority 3) (Biota, 2022e). This species is described below and a map of locations in the study area is provided in Figure 109 (2022 records only).

No records of *Eleocharis papillosa* (listed as Vulnerable at the Federal level, and a Priority 3 species for WA) were located during the contextual searches, undertaken targeting historical records along Onslow Road. A number of other flowering sedges were noted throughout the study area, and along Onslow Road, e.g., *Bulbostylis barbata, Cyperus bulbosus, B. rigidellus* and *C. squarrosus*. Conditions at the time of the May 2022 targeted survey were optimal for the detection of annual sedges.

The samphire vegetation within the Ashburton Salt study area did not contain any significant species, with all *Tecticornia* species identified being widespread throughout WA and not listed under legislation or as priority species (Biota, 2022a). Several *Tecticornia* species were sterile at the time of the Biota (2022) survey and therefore were unable to be unidentified, however these species were considered unlikely to be significant species (i.e., listed or potentially new species). Nevertheless, these species were conservatively considered to be significant flora in case they did represent potential new species.

10.4.4 INTRODUCED FLORA

A total of 16 introduced flora taxa (weed species) were recorded during the current surveys, one of which was only recorded outside the study area. Although weeds were widespread as scattered individuals, dense introduced species were most commonly recorded from areas of pastoral activity such as cattle pens, infrastructure areas and open grazed plains, and also in the vicinity of the Ashburton River (Biota, 2022a).

Three species recorded from the study area, *Parkinsonia aculeata* (Parkinsonia), *Prosopis pallida* (Mesquite) and *Tamarix aphylla* (Athel Pine) are declared plants under the WA Biosecurity and Agriculture Management Act 2007 (BAM Act) and are also listed as Weeds of National Significance (Biota, 2022a).

Table 76: Summary of Significant Flora Recorded (Biota, 2022a) (Biota, 2022e)

Taxon	Status	Description	Local Distribution and Counts	Regional Distribution (Florabase, 2021)
Minuria tridens	Priority 1 (WA) and Vulnerable (EPBC)	A perennial subshrub growing to 30 cm tall with pale blue flowers. Currently represented in WA by a single specimen from near Cue, approximately 720 km south southeast of Onslow. All other records are more than 1700 km east of Onslow in the Northern Territory, where it occurs over a range of more than 300 km on "dolomite, limestone and calcrete impregnated sandstone hills, rises and ranges" (Nano et al. 2012). It seems questionable that the WA populations would represent the same entity present in the Northern Territory, however genetic analysis would be required to investigate this.	1 plant recorded in Phase 1 from an island surrounded by mudflat in the northern section of the study area. Mike Hislop from the WA Herbarium provided the following advice in relation to this specimen: "I recently inspected a flowering specimen from the same area and found no reason to doubt that it was *Minuria tridens*, notwithstanding the geographical disjunction from the nearest known population. While I am fairly confident that this material is of the same species, it is totally sterile and so there is a degree of uncertainty."	Two other recorded locations in WA- on the coast near Roebourne (Mardie Project) and in the East Murchison. Five new populations of 75 individuals were found at the Mardie Project (EPA, 2021) Also ~ 20 populations in Northern Territory (DNREAS, 2008), although given the disparate habitats between the WA populations and the Northern Territory populations, which are >1,800 km southeast, it is questionable whether the taxa are the same (Biota, 2022a).
Abutilon sp. Pritzelianum (S. van Leeuwen 5095)	Priority 3 (WA)	A perennial shrub growing to 1.5 m tall with yellow-orange flowers in August. This species occurs on sand plains with orange, brown sandy loam substrate, and is distributed over a range of more than 700 km, extending from the southern Carnarvon bioregion through to Port Hedland in the Pilbara (DBCA, 2019).	Three records of scattered individuals (in total seven individuals) recorded during the 2022 survey (Biota 2022e). These records represent additional records to the 29 individuals recorded from 12 locations in the study area during the Biota 2020 survey (Biota, 2022a). A further 137 individuals recorded from 13 locations outside the study area. Most records from near coastal dune vegetation, but records also from sand plains, including in the far south of the study area.	Widespread record in WA. Recorded in the Carnarvon, Murchison and Pilbara IBRA regions.
Eremophila forrestii subsp. *viridis*	Priority 3 (WA)	A shrub growing to 1.5 m tall, with broad, deep green leaves that are covered in raised bumps and have a few branched hairs, and pale pink flowers from June to August (Brown and Buirchell 2011). Most records distributed over a range of 70 km in the area where the Carnarvon and Pilbara bioregions meet, with an outlying record over 1,000 km east on the Canning Stock Route.	935 individuals recorded from 54 locations in the study area. A further 13 individuals recorded from 2 locations outside the study area. Recorded from numerous locations on sand plains throughout the study area, including isolated islands surrounded by mudflat.	Two other recorded locations in WA - on the coast near Onslow and inland in the Great Sandy Desert.
Stackhousia clementii	Priority 3 (WA)	A dense, broom-like perennial shrub growing to 50 cm tall, with yellow tubular flowers, found on sandy plains and occasionally inundated areas (DBCA, 2019). This species has a broad distribution across the breadth of the arid zone of WA, with most records from the Carnarvon, Pilbara and Murchison bioregions, but some records also towards the Northern Territory border.	390 individuals recorded from 9 locations on an island surrounded by mudflat in the northern section of the study area, all concentrated on an area of limestone pavement ~100x300 m in size.	Widespread records in WA. Recorded in the Carnarvon, Central Ranges, Great Sandy Desert, Great Victoria Desert, Murchison and Pilbara IBRA regions.
Triumfetta echinata	Priority 3 (WA)	A low spreading shrub to 40 cm tall with grey leaves densely covered with stellate hairs, and fruit with long spines. Recorded from the area where the Carnarvon, Pilbara and Gascoyne bioregions meet, where it occurs on red sand dunes; distributed over a range of only 42 km between Onslow and Uaroo Station.	1 plant recorded during targeted searches in 2019 towards the eastern end of the road corridor, occurring on the side of a track near the crest of a sand dune.	Several other records in WA. Recorded in the Ashburton, Cape Range and Roebourne IBRA regions.

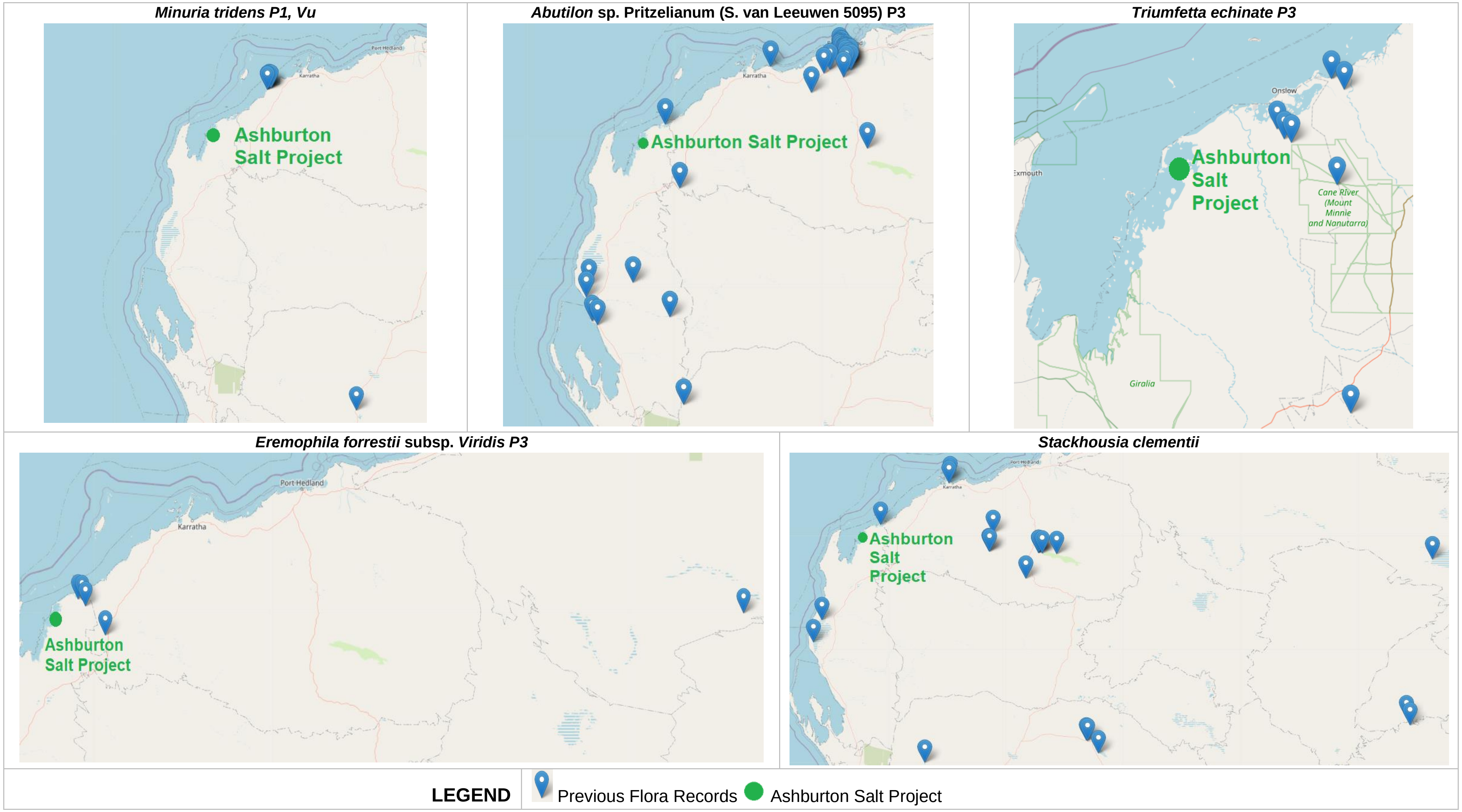
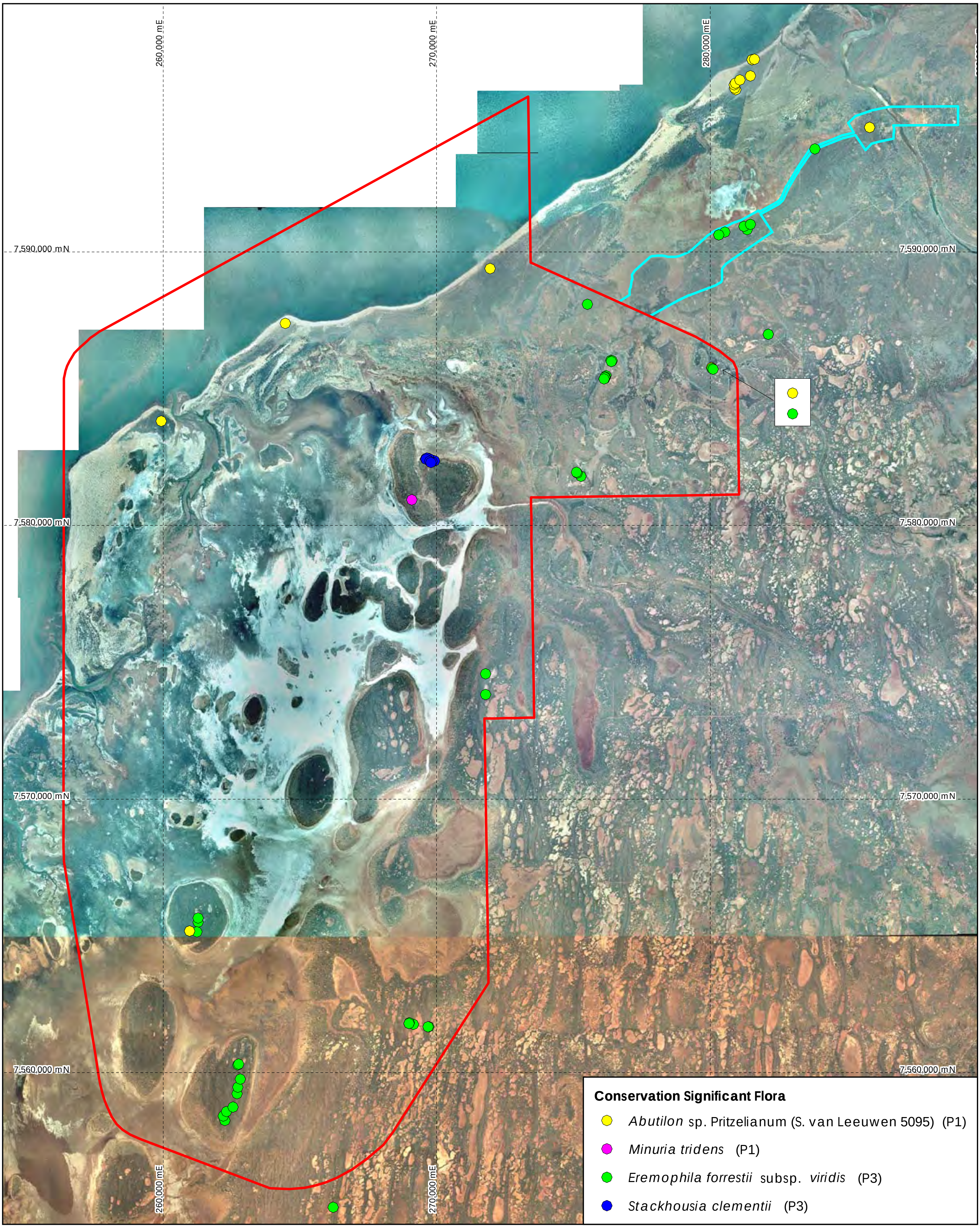


Figure 108: Regional Distribution of Conservation Signification Flora
(Florabase, 2021)



Development envelope

Road survey area

N

0 4 8

kilometres

Figure 109: Significant Flora recorded during Detailed Survey

Ashburton Salt Flora Phase 1 & 2
Conservation Significant Flora

Biota Environmental Sciences

Author: R Warner	Drawn: M Robinson	Job No.: 1261B	Date: 18 Mar 2019	Revised: 07 June 2019	Projection: MGA Z50 (GDA94)	Scale: 1:175,000

Development envelope

Priority 3 Flora Recorded

Abutilon sp. Pritzelianum (S. van Leeuwen 5095)

N

0 5
kilometres

Ashburton Salt
Significant Flora Records

Biota Environmental Sciences

Figure 110: Significant Flora recorded during Targeted Survey

Author: R Warner | Drawn: M Robinson | Job No.: 1450 | Date: 04 July 2022 | Revised: | Projection: MGA Z50 (GDA94) | Scale: 1:125,000

10.4.5 LOCAL ENVIRONMENTAL VALUES

Local environmental values related to flora and vegetation have been identified as follows:

- Vegetation communities.
- Significant flora species.

These local values have been mapped overlayed by the Proposal in Figure 111 using GIS data from the Proposal flora and vegetation study (Biota, 2022a):

- Ashburton flora survey vegetation community mapping.
- Ashburton flora survey significant flora records.

10.4.6 REGIONAL ENVIRONMENTAL VALUES

Regional environmental values related to flora and vegetation have been identified as follows:

- Vegetation communities.
- Significant flora species.

These regional values have been mapped overlayed by the Proposal in Figure 114 using publicly available GIS data including pre-European vegetation mapping by Beard et. al. (2013).

10.5 POTENTIAL IMPACTS

The following potential impacts have been identified for this Proposal:

- Direct impact through clearing for Proposal infrastructure and filling of ponds.
- Indirect impacts through:
  - Saline seepage and salt crusting.
  - Changes in surface water flows required for rainfall recharge of soil water.
  - Introduction and spread of weeds.
  - Altered fire regimes.
  - Dust.
  - Contamination due to leaching from acid sulfate soils or other contaminant spills.

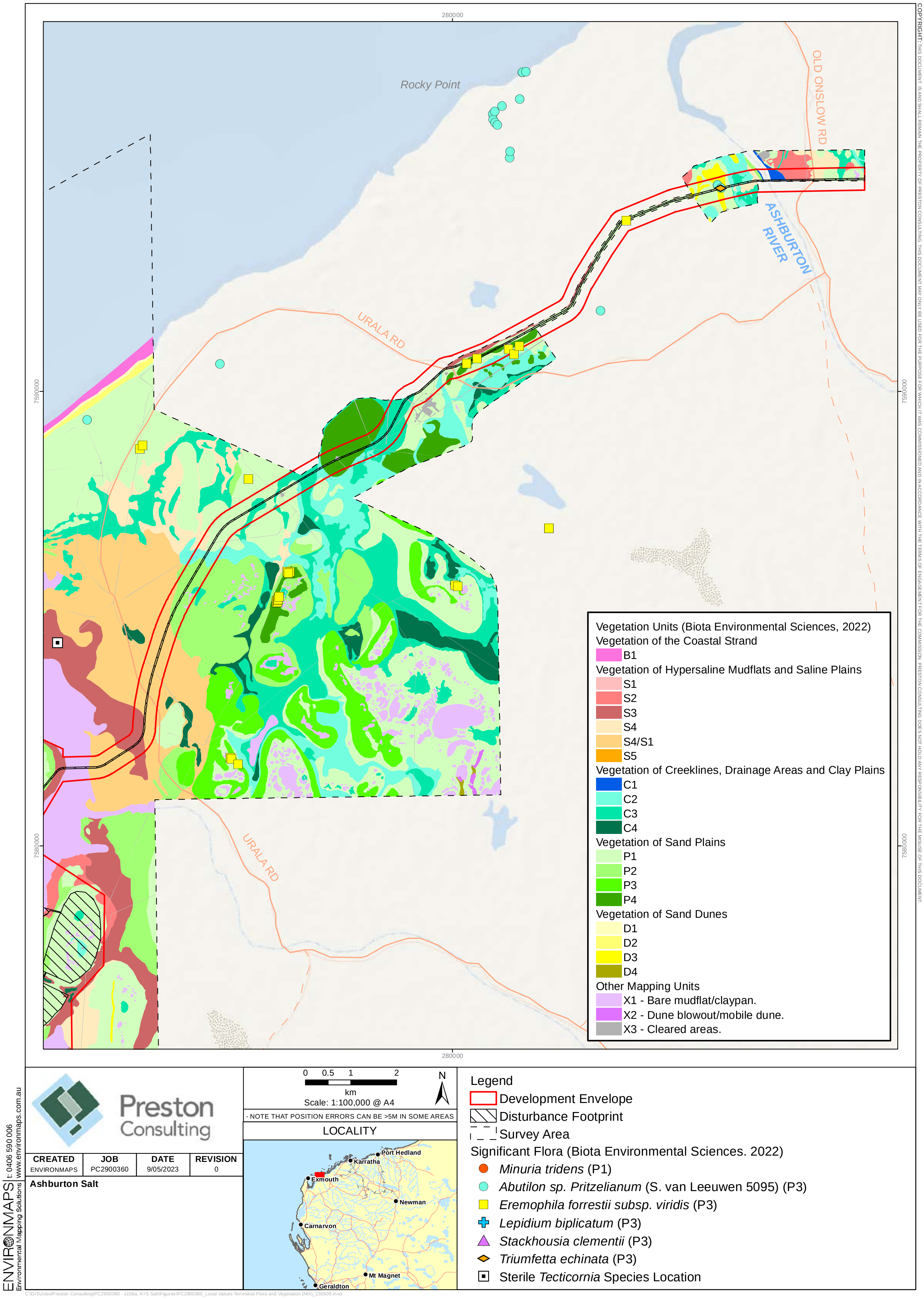


Figure 111: Local Values Flora and Vegetation (1 of 3)

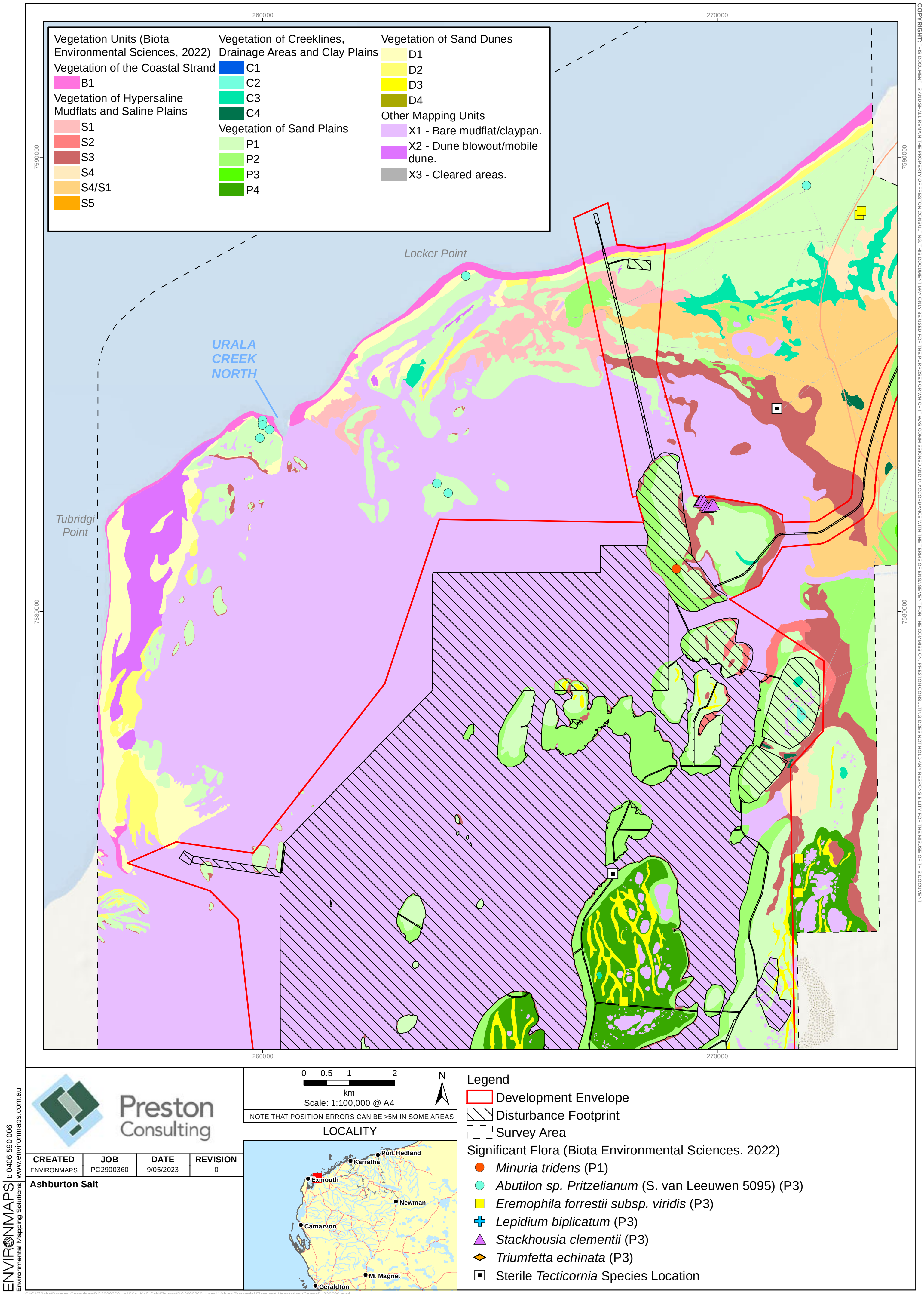
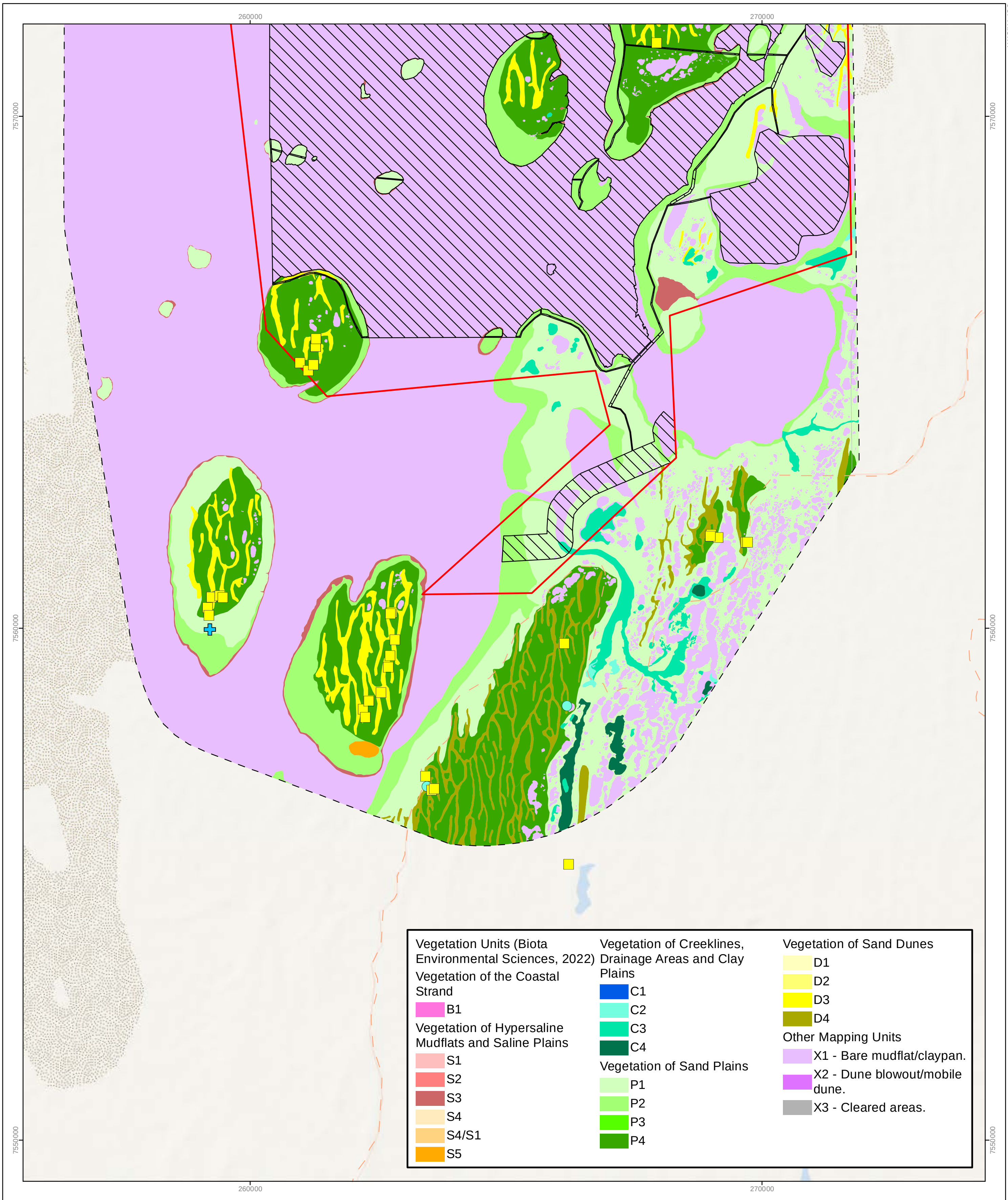


Figure 112: Local Values Flora and Vegetation (2 of 3)



Preston Consulting

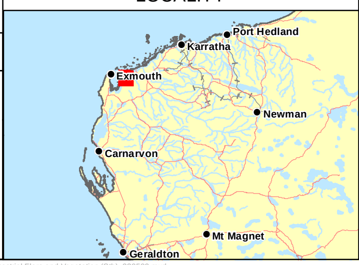
CREATED	JOB	DATE	REVISION
ENVIRONMAPS	PC2900360	9/05/2023	0

Ashburton Salt

0 0.5 1 2
km
Scale: 1:100,000 @ A4
N

- NOTE THAT POSITION ERRORS CAN BE >5M IN SOME AREAS

LOCALITY

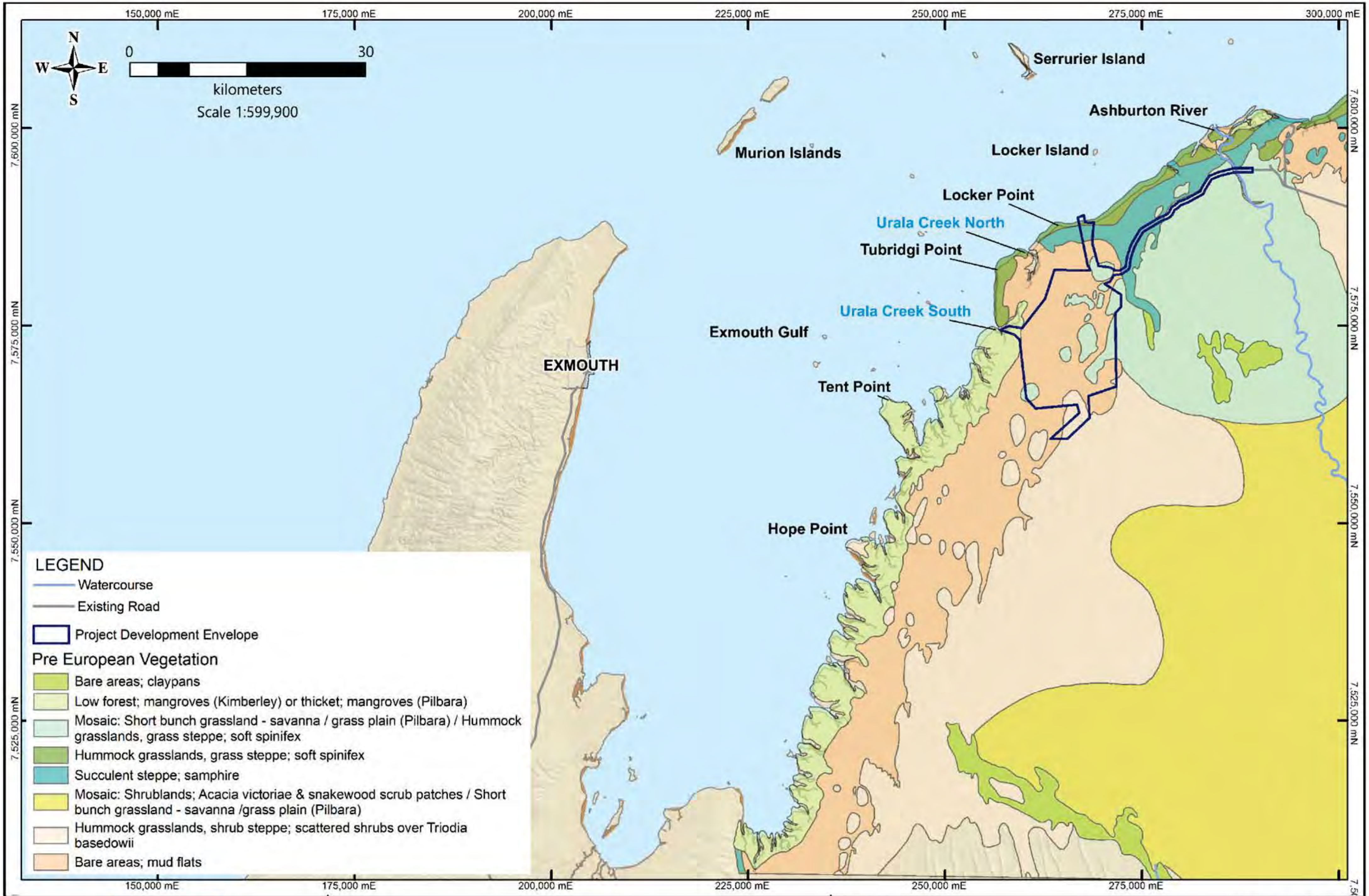


Legend
Development Envelope
Disturbance Footprint
Survey Area
Significant Flora (Biota Environmental Sciences. 2022)
Minuria tridens (P1)
Abutilon sp. Pritzelianum (S. van Leeuwen 5095) (P3)
Eremophila forrestii subsp. viridis (P3)
Lepidium biplicatum (P3)
Stackhousia clementii (P3)
Triumfetta echinata (P3)
Sterile *Tecticornia* Species Location

ENVIRONMAPS Environmental Mapping Solutions | t: 0406 590 006 | www.environmaps.com.au

C:\GIS\Jobs\Preston Consulting\PC2900360 - s156a, K+S Salt\Figures\PC2900360_Local Values Terrestrial Flora and Vegetation (5th)_230509.mxd

Figure 113: Local Values Flora and Vegetation (3 of 3)



Date: 25/08/2021	Paper: A4 L	GDA94, MGA50
Data Source: 4A, 4E, 13D, 17A		
File Info: K04_J10_PER_Regional_Flora_Veg_20210707.WOR		

Figure 114: Regional Values Flora and Vegetation

10.5.1 DIRECT IMPACTS

10.5.1.1 CLEARING

The Proposal will result in clearing of vegetation for the following infrastructure:

- Pond embankments.
- Roads.
- Levees.
- Drainage diversions.
- Dredge spoil disposal area.
- Borrow pits.
- Conveyor embankment.
- Cut and fill (levelling) of the island which contains the wash plant, administration and associated facilities.

10.5.1.2 POND FILLING

The process of importing seawater into the evaporation ponds, will cause permanent inundation of any vegetation contained within the filling footprint of the ponds. As described in Section 2.3.4.2, the pond fill heights have been determined through modelling (Water Technology, 2021c) taking into account both seawater intake volumes and predicted rainfall, so that the fill height of each pond is progressively smaller, which facilitates the gravity flow between the ponds (except for CP3 and CP4 which have a pump station between them) (Table 77).

Table 77: Pond Fill Heights

Pond	**Maximum Water level (mAHD)** (Pond fill depth plus predicted rainfall)
CP1	2.50
CP2	2.30
CP3	2.10
CP4	2.45
CP5	2.35
CP6	2.25
CP7	2.15
CP8	2.05

There are low lying areas of vegetation which occur:

- At the base of mainland remnant islands within the pond footprint.
- On the lower slopes of mainland remnant dunes which form the eastern boundary of the ponds (these dunes will be used as a natural barrier to contain water within the ponds).

Vegetation that will be permanently inundated by filling the ponds can be identified using the Lidar DEM (Fugro, 2018a) and pond fill levels above Table 77

10.5.1.3 VEGETATION DIRECTLY IMPACTED BY CLEARING AND POND FILLING

The Proposal will result in direct disturbance (clearing and pond filling) of approximately 1,265 ha of vegetation in mostly very good to excellent condition as summarised in Table 78 below. This represents approximately 5% of the vegetation within the study area. Note that Algal mat, Mangroves and Transitional mudflats have been assessed as BCH and are not included in Table 74. Samphires are assessed both as BCH (as a broad BCH type) and in this section (separated into vegetation types) for completeness.

Table 78: Direct Impact to Vegetation

Unit Code	Brief Description	Direct Impact (ha)	Total in Study Area (ha)	% of Total in Study Area
B1	Spinifex grassland	-	16	0.00%
S1	Samphire S1	4.07	414	0.98%
S2	Samphire S2	33.94	153	22.59%
S3	Samphire S3	117.94	1,150	10.39%
S4	Saline low shrubland/grassland S4	12.83	1,722	0.75%
S5	Saline tall shrubland/grassland S5	-	15	0.00%
C1	Eucalyptus victrix low woodland C1	0.81	11	7.54%
C2	Eucalyptus victrix low woodland C2	8.34	681	1.22%
C3	Acacia tall shrubland C3	15.48	1,447	1.07%
C4	Acacia tall shrubland C4	0.01	351	0.00%
P1	Acacia tall shrubland P1	682.09	8,535	7.99%
P2	Acacia tall shrubland P2	362.67	3,526	10.29%
P3	Acacia tall shrubland P3	-	622	0.00%
P4	Acacia tall shrubland P4	16.51	2,801	0.59%
D1	Acacia low open woodland D1	-	645	0.00%
D2	Acacia low open woodland D1	0.19	340	0.06%
D3	Grevillea, Hakea, Acacia tall open shrubland D3	9.65	564	1.71%
D4	Grevillea, Hakea, Acacia tall open shrubland D4	-	355	0.00%
Total	*Vegetated Areas*	1,264.53	23,346	5.42%

10.5.1.4 SIGNIFICANT FLORA DIRECTLY IMPACTED BY CLEARING AND POND FILLING

Table 79 summarises the potential direct impacts on the significant flora recorded during the Biota (2022) surveys.

Table 79: Direct Impact to Significant Flora

Flora Species	Total records in Biota (2022) in study area	Total in Development Envelope	Direct Impact
Minuria tridens (P1 (WA) and Vulnerable (EPBC)	1	1	0
Abutilon sp. *Pritzelianum* (S. van Leeuwen 5095) (P3)	15	4	1
Eremophila forrestii subsp. *viridis* (P3)	54	14	0
Stackhousia clementii (P3)	9	9	0
Triumfetta echinate (P3)	1	1	1
Sterile *Tecticornia* species (1)	1 quadrat, unknown number of individuals	0	0
Sterile *Tecticornia* species (2)	1 quadrat, unknown number of individuals	1 quadrat, unknown number of individuals	1 quadrat, unknown number of individuals

10.5.2 INDIRECT IMPACTS

10.5.2.1 SALINE GROUNDWATER SEEPAGE AND SALT CRUSTING

A numerical groundwater model was used by GHD (2021c) to simulate the key hydrogeological processes of the Proposal area. The key issue simulated by the modelling was the potential for seepage from the salt ponds to migrate and impact on the receiving environment. The nature of interaction between the salt ponds and groundwater is due to hydraulic, salinity (concentration) and density effects which vary over time.

Key findings from the GHD (2021c) modelling of groundwater level and salinity changes are:

- The hypersaline water table beneath the footprint of salt ponds is shallow, typically around 0.3 to 0.5 m below surface. When the salt ponds are filled, the water table will quickly equilibrate with the pond water level. The seepage of fresher pond water is predicted to displace existing hypersaline groundwater radially away from the ponds causing a "halo" of increased salinity in groundwater around the perimeter of the ponds. This displacement effect is likely to lead to waterlogging adjacent to the ponds and cause formation of a surface salt crust in some areas due to evaporation and salt crystallisation.

- As the rate of evapotranspiration is greater than the rate of seepage of pond water, the extent of potential waterlogging is largely constrained to a narrow area (~50 m wide) immediately adjacent to the ponds.
- Modelling indicates that seepage and subsequent evaporation of seepage water expressed at ground level has the potential to form a crystallised salt layer (salt crust) on the ground surface on localised areas immediately next to the pond levees and some islands within the ponds. It was assumed that salt will be crystallised on the ground surface due to capillary action when groundwater depths are less than 0.3 m BGL, based on a solubility limit of 350 g/L for precipitation (GHD, 2021c).

GHD (2021c) groundwater model outputs have been used to map all areas of vegetation which may be impacted by saline seepage and salt crusting due to the Ashburton Salt Ponds. Predicted areas of saline seepage and salt crusting intersecting with vegetation are small and localised (restricted to the perimeter of the ponds and some of the islands within the ponds).

Further detail regarding the areas of each vegetation type impacted by these processes is summarised in Table 80 and shown as "indirect impact" in Figure 111. It is predicted that saline seepage and salt crusting will impact 121 ha of vegetation in mostly very good to excellent condition as summarised in Table 80 below. This represents approximately 0.5% of the vegetation within the study area. No significant flora records occur within the areas of predicted saline seepage or salt crusting (Figure 111).

Table 80: Areas of Vegetation Impacted by Saline Seepage and Salt Crusting

Unit Code	Brief Description	Impacted by Saline Seepage & Crusting (ha)	Total in Study Area (ha)	% of Total in Study Area
B1	Spinifex grassland	-	16	0.00%
S1	Samphire S1	-	414	0.00%
S2	Samphire S2	0.64	153	0.42%
S3	Samphire S3	1.64	1,150	0.14%
S4	Saline low shrubland/grassland S4	-	1,722	0.00%
S5	Saline tall shrubland/grassland S5	-	15	0.00%
C1	Eucalyptus victrix low woodland C1	-	11	0.00%
C2	Eucalyptus victrix low woodland C2	-	681	0.00%
C3	Acacia tall shrubland C3	-	1,447	0.00%
C4	Acacia tall shrubland C4	-	351	0.00%
P1	Acacia tall shrubland P1	12.77	8,535	0.15%
P2	Acacia tall shrubland P2	101.38	3,526	2.88%
P3	Acacia tall shrubland P3	-	622	0.00%
P4	Acacia tall shrubland P4	3.60	2,801	0.13%
D1	Acacia low open woodland D1	-	645	0.00%
D2	Acacia low open woodland D1	-	340	0.00%
D3	Grevillea, Hakea, Acacia tall open shrubland D3	1.26	564	0.22%
D4	Grevillea, Hakea, Acacia tall open shrubland D4	-	355	0.00%
Total	*Vegetated Areas*	121.29	23,346	0.52%

While no indirect impacts were identified for the single record of *Minuria tridens* within the development envelope, there are indirect impacts to potential *Minuria tridens* habitat (P1 and P2 Acacia Shrubland vegetation types).

10.5.2.2 SURFACE WATER FLOWS AND RAINFALL RECHARGE

GHD (2021c) found that at the salt flat / hinterland fringe, groundwater salinity ranges from 50 to 150 PSU and rapidly reduces eastward to <20 PSU beneath the hinterland. This rapid reduction in groundwater salinity immediately east of the salt flats beneath the hinterland is indicative of freshening of groundwater and soil water via rainfall recharge. Therefore, it is highly likely that vegetation within the hinterland and at the hinterland

/ salt flat fringe, is reliant on sporadic rainfall inputs to maintain soil water conditions and salinity gradients conducive to its survival. Numerical modelling conducted by Water Technology (2021c) indicates that the area floods due to rainfall approximately 5 – 10% of the time and this is consistent with Geoscience Australia (2021) Water Observations from Space data. This frequency of rainfall related flooding (5 – 10% of the time) is likely to provide soil water conditions and salinity gradients suitable for vegetation survival. Therefore, if the Proposal modifies rainfall related surface water inputs to local vegetation, the health and survival of vegetation could be affected by reduction in surface water inputs post-development.

Water Technology (2021c) simulated rainfall related surface water flows from terrestrial areas through the Proposal area to assess potential impacts of the proposed development on those flows and determine mitigation strategies. Modelling found that without mitigation measures in place, Proposal infrastructure including pond, road and conveyor embankments would cause "backing up" of rainfall related flows on the hinterland side of the embankments with the level of flooding dependent on rainfall intensity and duration.

Figure 115 provides surface water modelling outputs showing the modelled difference in flood levels for a ~10 year ARI (10% AEP) with no mitigation measures in place and predicts a significant increase in flooding of between 1 – 3 m evident on the hinterland side of the embankments, with water unable to flow past the embankments into areas to the north-west. Therefore, modelling has been used to design appropriate mitigation measures (culverts and drainage diversions) to ensure surface flows are maintained and "backing up" of water is minimised. Modelling of surface flows with the proposed mitigation measures in place shows a significant reduction in "backing up" of water on the hinterland side of the embankments permitting water to flow to the north-western side of the road and conveyor and south of the ponds into the salt flats. The modelled mitigation produces a reduced difference in pre- and post-development flood levels to between 10 cm and 1 m, compared with 1 m to 3 m for the unmitigated scenario (Water Technology, 2021c).

These mitigation measures to maintain rainfall related surface water flows at the hinterland salt flat fringe, will ensure that vegetation communities and flora in this location receive required environmental freshwater flows. Whilst a small increase in water level after rainfall may still occur, this will be temporary and localised, and water levels will recede rapidly due to high local soil infiltration and evaporation rates (Water Technology, 2021c). Given local vegetation is already able to withstand periodic flooding typical of this landscape, the predicted temporary and localised increase in flood water levels are unlikely to negatively impact local vegetation or flora which is adapted to periodic flooding characteristic of the Pilbara and local area.

Therefore, no deleterious impacts to flora or vegetation are predicted as a result of Proposal related changes to surface water flows.

10.5.2.3 WEEDS, FIRE, DUST AND CONTAMINATION

Potential indirect impacts due to these mechanisms include:

- Earthworks, importation of construction materials, topsoil translocation and vehicle / equipment movement have the potential to introduce additional weeds to the area and to spread existing populations of weeds locally.
- Changes in local fire regimes due to Proposal related anthropogenic sources, have the potential to impact local vegetation and flora composition, density, reproduction and health.
- Proposal related dust deposition on the leaves of flora, can potentially impact photosynthetic ability leading to a decline in vegetation health.
- Soil contamination due to disturbance of ASS, or due to spillages of other potential contaminants (hydrocarbons, chemicals, salt product or bitterns) has the potential to lead to vegetation loss or degradation.

Management measures will be in place to minimise these impacts as described in Section 10.7.2. With management measures in place, it is considered unlikely that these processes will cause significant impacts to vegetation or flora.

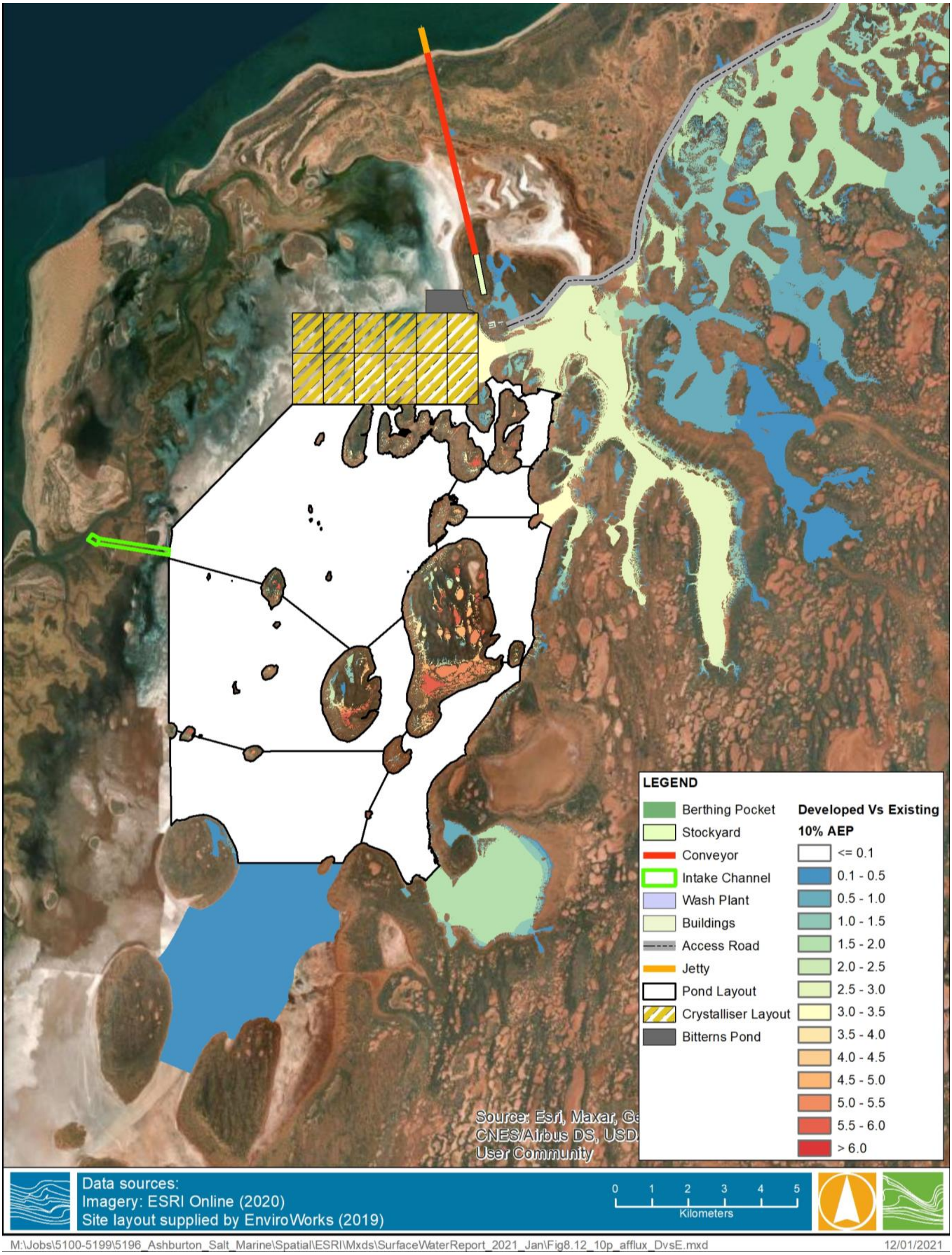


Figure 115: Modelled 10% AEP unmitigated flood depth – difference between existing vs developed

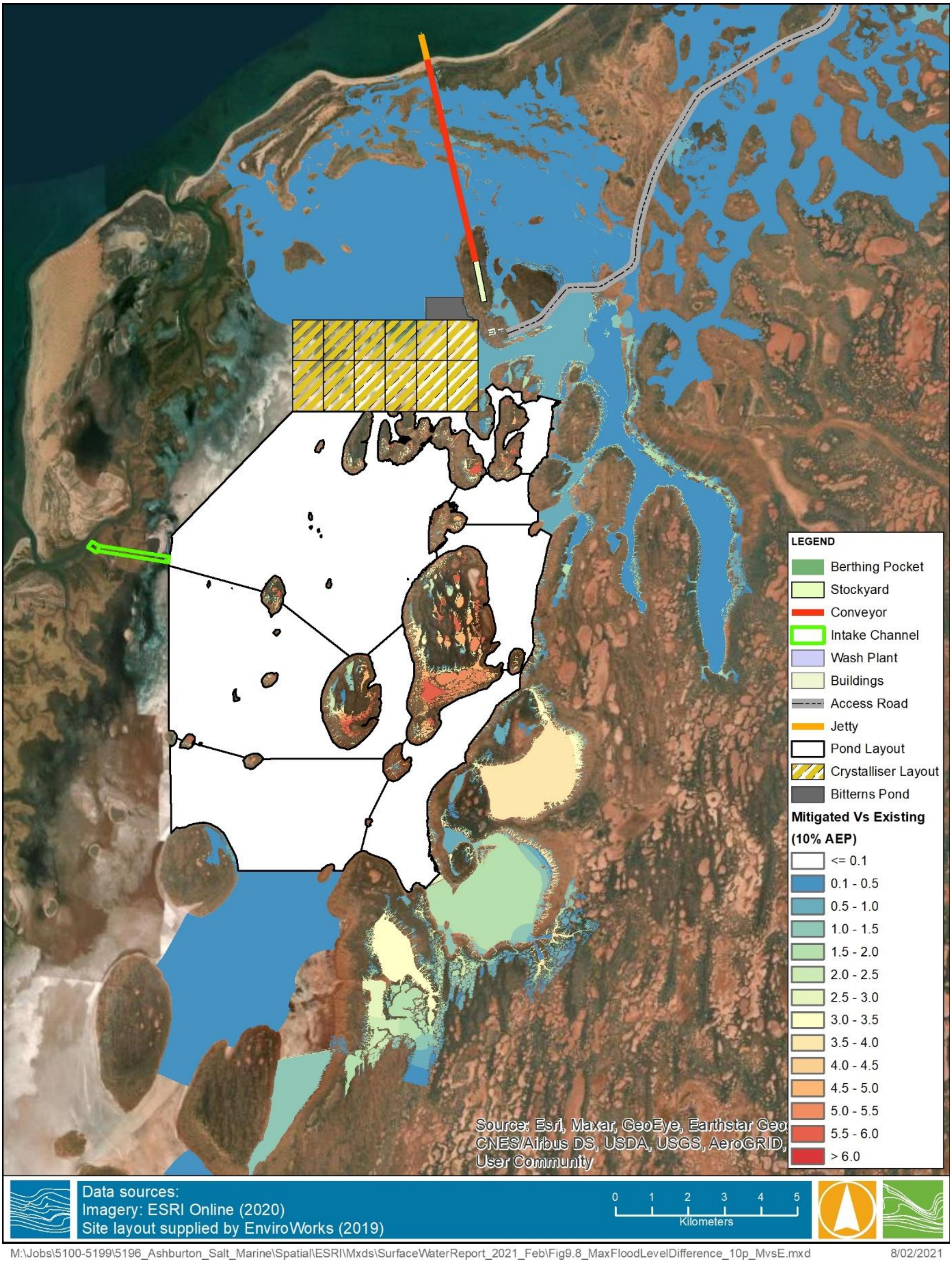


Figure 116: Modelled 10% AEP mitigated flood depth – difference between existing vs developed

10.5.3 CUMULATIVE IMPACTS

10.5.3.1 TERRESTRIAL VEGETATION

Predicted cumulative proportional impacts to vegetation have been summarised as a percentage of:

- Vegetation mapped within the study area (Biota, 2022a) in Table 81.
- Total areas of pre-European vegetation along the Eastern Exmouth Gulf mapped by Beard et. al. (2013) in Table 82.

These assessments are at different resolution and therefore the pre-European assessment does not include the same total area of vegetation impacted as the more detailed Biota (2022a) assessment, which is considered more accurate, however it does provide useful regional context.

As detailed in Section 2.3.10.1, a power line is planned to be installed to the Proposal by a power provider (subject to a separate assessment). The power provider and power line route has not yet been selected however any clearing for this power line would contribute to the cumulative impacts on flora and vegetation. Given the narrow clearing requirements for the power line however, these additional cumulative impacts are unlikely to significantly increase the proportion of impacts to any vegetation type.

A separate assessment of impacts to samphire locally and for the West Pilbara Region is presented in Section 8.6 under Benthic Communities and Habitat.

Table 81: Proportional Cumulative Impacts to Vegetation within Study Area
(Biota, 2022a)

Unit Code	Brief Description	Direct Impact (ha)	Indirect Impact (ha)	Cumulative Impact (ha)	Study Area (ha)	% of Study Area
B1	Spinifex grassland	-	-	-	16	0.00%
S1	Samphire S1	4.07	-	4.07	414	0.98%
S2	Samphire S2	33.94	0.64	34.58	153	22.59%
S3	Samphire S3	117.94	1.64	119.58	1,150	10.39%
S4	Saline low shrubland/grassland S4	12.83	-	12.83	1,722	0.75%
S5	Saline tall shrubland/grassland S5	-	-	-	15	0.00%
C1	Eucalyptus victrix low woodland C1	0.81	-	0.81	11	7.54%
C2	Eucalyptus victrix low woodland C2	8.34	-	8.34	681	1.22%
C3	Acacia tall shrubland C3	15.48	-	15.48	1,447	1.07%
C4	Acacia tall shrubland C4	0.01	-	0.01	351	0.00%
P1	Acacia tall shrubland P1	682.09	12.77	694.86	8,535	8.14%
P2	Acacia tall shrubland P2	362.67	101.38	464.05	3,526	13.16%
P3	Acacia tall shrubland P3	-	-	-	622	0.00%
P4	Acacia tall shrubland P4	16.51	3.60	20.11	2,801	0.72%
D1	Acacia low open woodland D1	-	-	-	645	0.00%
D2	Acacia low open woodland D1	0.19	-	0.19	340	0.06%
D3	Grevillea, Hakea, Acacia tall open shrubland D3	9.65	1.26	10.91	564	1.94%
D4	Grevillea, Hakea, Acacia tall open shrubland D4	-	-	-	355	0.00%
Total	*Vegetated Areas*	1,264.53	121.29	1385.82	23,346	5.94%

Table 82: Proportional Cumulative Impacts to Pre-European Vegetation on Eastern Exmouth Gulf
Beard et. al. (2013)

Unit Code	Brief Description	Direct Impact (ha)	Indirect Impact (ha)	Cumulative Impact (ha)	l East Exmouth Gulf (ha)	% of East Exmouth Gulf
117	Hummock grassland Triodia spp.	1.57	-	1.57	6143	0.03%
589	Short bunch grass savanna	1,689.73	104.20	1,793.93	78305	2.29%
670	Hummock grassland with scattered shrubs or mallee	451.09	5.91	457.00	119387	0.38%
Total	*Vegetated Areas*	2,142.39	110.11	2,252.50	203,835	1.11%

As detailed in Table 81, the Proposal will result in direct and indirect impacts to 1,386 of native vegetation. Of this, at least 333 ha of this vegetation is in Degraded – Poor condition. The remaining 1,053 ha is currently in Good – Excellent condition.

10.5.3.2 SIGNIFICANT FLORA

Minuria tridens, *Stackhousia clementii* and *Triumfetta echinate* were identified as having a high proportion of their records within the Biota (2022) Study Area within the Development Envelopes. These species are discussed below. No indirect impacts to significant flora are predicted.

10.5.3.2.1 MINURIA TRIDENS

A potential record of *Minuria tridens* (Priority 1, Vulnerable) was identified from one location within the Study Area by Biota (2022) and intersected with a proposed cut and fill area as shown in Figure 111. This record is of a single plant which was thought to be *Minuria tridens* (Priority 1, Vulnerable) although some uncertainty exists regarding the species identification given the specimen was sterile (no fruit or flowers).

A targeted significant flora survey was conducted by Biota in 2022 (Appendix R). The location of the single potential record of *Minuria tridens* from the Phase 1 survey in 2018 (Biota, 2020) was re-visited and the surrounding area searched, however no individuals were located. The original 2018 specimen was in poor condition and therefore only tentatively identified as *M. tridens* by WA Herbarium Taxonomist Mike Hislop.

Given the conservation status of this species K+S is proposing to avoid the direct disturbance of this record (with a minimum 50 m buffer), unless the record can be verified as a species other than *M. tridens*. K+S will continue to consider this record location in the Proposal design as it progresses to ensure as much surrounding habitat is maintained as practicable.

The record occurred near the boundary of the two vegetation communities P1 and P2 Acacia shrublands which are very similar and the dominant communities on the remnant mainland islands within the salt flats (Biota, 2022a). Vegetation communities P1 and P2 are extensive throughout the study area, covering a combined 12,061 ha. The combined direct (1,045 ha) and indirect (114.5 ha) impact to those communities from the Proposal is estimated to be 1,159 ha or 9.61% of the area recorded within the study area and an estimated less than 5% of those communities along the Eastern Exmouth Gulf, given the large contiguous similar habitat. Several populations totalling 75 plants of *M. tridens* has also been recently collected during surveys for the Mardie Project to the Northeast of this Proposal (EPA, 2021) (Figure 108) indicating its distribution may be wider than previously thought. Therefore, the Proposal disturbance is unlikely to lead to the long-term decrease of local habitat for this species (if the species is *M. tridens*).

10.5.3.2.2 STACKHOUSIA CLEMENTII

A total of 390 records of *Stackhousia clementii* (Priority 3) was identified from nine locations within the Study Area by Biota (2022) as shown in Figure 111. All of these records lie within the Development Envelope however none lie within the indicative disturbance area. Given this, K+S is confident that almost all (if not all) of these records will be avoided. The Proposal is therefore unlikely to significantly impact this species.

10.5.3.2.3 *TRIUMFETTA ECHINATE*

One record (single plant) of *Triumfetta echinate* (Priority 3) was identified within the Study Area by Biota (2022) as shown in Figure 111. This record lies within the Development Envelope however it currently lies on the edge of the indicative disturbance area (edge of the access road). Given the location of this record, K+S is confident that the road can be designed to avoid this record. There are also several other records in the Ashburton, Cape Range and Roebourne IBRA regions. Given this, the Proposal is unlikely to significantly impact this species.

10.5.3.2.4 STERILE TECTICORNIA SPECIES

One of the two sterile records of *Tecticornia* occurs within a quadrat within the development envelope and on the edge of the current indicative disturbance footprint (the edge of a concentrator pond). K+S intends to either attempt to identify this species to confirm it is not restricted to the development envelope or ensure that these records are not disturbed. Given this, the Proposal is unlikely to significantly impact this species.

10.6 ASSESSMENT OF IMPACTS

The area of vegetation that is predicted to be impacted as a result of the Proposal is proportionally small when compared to the amount of similar vegetation in the surrounding areas consisting of approximately:

- 5.7% of vegetation mapped within the Ashburton Salt study area.
- 1% of pre-European vegetation mapped on the Eastern Exmouth Gulf.

The vegetation communities to be disturbed are not considered threatened with over 90% of their original extent remaining (Table 74) (Beard et. al, 2013). At a local scale all of the vegetation units will have more than 77% of their local extent remaining after the implementation of the Proposal. Therefore, is it unlikely that vegetation loss resulting from the Proposal will impact the biological diversity and ecological integrity of vegetation locally or regionally.

Samphire vegetation within the Ashburton Salt study area is considered to be of local rather than regional significance, or of “somewhat elevated conservation significance” and does not contain any significant species (Biota, 2022a). Impacts to samphire as a broad unit have also been assessed under BCH in Section 8.6. The Proposal is predicted to directly or indirectly impact less than 23% of any samphire vegetation type (S1 – 3), which ensures that more than 77% of each vegetation type will remain in the local area, with samphires also predicted to occur regionally. This scale of impact is considered unlikely to be significant.

Cumulative impacts to conservation significant species are not considered to be significant. Some uncertainty exists whether the specimen collected at Ashburton Salt is indeed *M. tridens* as the specimen collected was sterile (no flowers or fruit). The location of the single record of *Minuria Tridens* was re-visited and the surrounding area searched during the recent targeted survey, however no individuals were located (Biota, 2022c). Given *M. tridens* (75 plants) has been recently recorded during surveys for the Mardie Project to the Northeast of this Proposal (EPA, 2021) (Figure 108) indicating its distribution may be wider than previously thought, the Proposal is unlikely to lead to a long term decrease in the WA population. At least 20 populations of this species also exist in the Northern Territory (DNREAS, 2008). Despite this, a 50 m exclusion zone has been incorporated into the Borrow Pit design to ensure avoidance of this record
Similarly, K+S intends to either identify the single sterile *Tecticornia* species recorded within the development envelope and confirm it is not restricted to the development envelope. If this is not able to occur, then the location of these records will be avoided (will not be flooded by the concentrator pond).

10.7 MITIGATION

10.7.1 AVOID

Impact to vegetation and flora have been avoided by placing most of the Proposal disturbance (salt ponds) on the bare salt flats which are devoid of vegetation.

K+S intends to avoid the following significant flora species records during the detailed design of the Proposal:

- *Minuria tridens* (with 50 m buffer);
- *Stackhousia clementii*; and
- *Triumfetta echinate*.

The location of sterile *Tecticornia* species will also be avoided if the single sterile *Tecticornia* species recorded within the development envelope cannot be identified and confirmed that it is not restricted to the development envelope.

10.7.2 MINIMISE

As the design progressed, the following modifications were made to minimise impacts on flora and vegetation:

- Reducing the size of the salt ponds has minimised groundwater seepage and salt crust impacts and therefore minimised these effects on vegetation to localised areas as shown in Figure 111.
- Design of surface water mitigation measures via modelling (culverts and drainage diversions) (Water Technology, 2021c) has minimised the interruption of surface water flows and will maintain required environmental flows to vegetation surrounding the embankments.

The following mitigation measures are proposed to ensure that direct and indirect impacts to flora and vegetation are minimised:

- Implement industry best-practice management measures for flora and vegetation:
    - Vegetation clearing will be managed through internal ground disturbance procedures;
    - Boundaries of areas to be cleared or disturbed will be identified by GPS coordinates and maps of boundaries will be provided to equipment operator;
    - Progressive clearing will be undertaken;
    - Raised blade disturbance will be conducted where practicable on tracks to minimise vegetation removal;
    - The disturbance footprint will be developed to the minimum required to ensure safe and adequate construction and operation, and compliance with approved limits;
    - Water or dust suppressants will be applied to disturbed areas and product transfer / storage areas as required to minimise dust generation;
    - Emergency response capabilities will be maintained to reduce fire outbreaks;
    - Weed hygiene and management measures / procedures will be implemented to prevent spread of weeds and the introduction of new weed species as a result of construction and operation; and
    - Feral animal controls will be implemented.
- Obtain and comply with the following approvals:
    - Ministerial Statement to be issued under Part IV of the EP Act;
    - Mining Proposal to be approved under the *Mining Act 1978*;
    - MCP to be approved under the *Mining Act 1978*. The MCP will describe the rehabilitation and closure of the Proposal, and associated management and monitoring proposed during the closure phase. An Interim MCP has been provided in Appendix BB; and
    - Works Approval and Licence to be issued under Part V of the EP Act for solar salt manufacturing and bulk material loading.
- Avoid any new records of Threatened or Priority Flora identified where practicable.
- Consider the *Minuria tridens* record location in the Proposal design as it progresses to ensure as much surrounding habitat is maintained as practicable.
- Minimise clearing within P1 and P2 Acacia shrublands vegetation types which may provide habitat for the EPBC Threatened Flora *Minuria tridens*.
- Maintain as large a buffer as practicable around significant flora species in order to maintain suitable surrounding habitat.
- Monitor the potential changes to tidal inundation regimes as discussed in Section 13 (Hydrological Processes). This monitoring will be conducted to verify the model and associated indirect impact assessments.
- Design and construct concentrator and crystalliser ponds to be safe and stable according to DMIRS requirements.
- Implement the following controls to further reduce the risk of impact from unintentional brine pipeline spills:
        - Pipelines will be fitted with leak detection;
        - Water flows will be shut off if leaks are detected;

- Pipelines will be inspected regularly, especially during extreme heat or fire events and after significant rainfall and storms;
- Pipelines will be located off access road surfaces;
- If pipelines have to cross access roads, then they will be buried or elevated;
- Investigations will be conducted into the cause of any spills, and remedial actions will be taken to minimise the chance of reoccurrence; and
- Spills response training for site-based personnel.

10.7.3 REHABILITATE

At the completion of the Proposal the site will be rehabilitated to reinstate the flora and vegetation. A MCP will be required under the *Mining Act 1978* for the majority of the Proposal. At the completion of construction all temporary disturbance areas (which may include temporary laydown areas and the fringes of linear infrastructure corridors) will be rehabilitated as outlined within MCP submitted to DMIRS for approval as required by the *Statutory Guidelines for MCPs under the Mining Act 1978* - DMIRS (2020b).

At the completion of operations, all buildings and structures on land will be removed from the site and rehabilitation of terrestrial vegetation will occur in disturbance area which are unaffected by SLR.

Selection of locally endemic native species will ensure that only species which are present locally are used in rehabilitation activities and the aim will be to establish a self-sustaining ecosystem with similar biological diversity and ecological integrity to that which existed prior to Proposal implementation.

An Interim MCP for the Proposal has been provided in Appendix BB and will continue to evolve during the life of the Proposal. If the Proposal receives Ministerial Approval under Part IV of the EP Act as well as under the EPBC Act, the MCP will be developed in more detail and submitted to DMIRS for approval as required by the *Statutory Guidelines for MCPs under the Mining Act 1978* - DMIRS (2020b).

10.7.3.1 REHABILITATION EXPERIENCE, KNOWLEDGE GAPS AND OUTCOMES

K+S has conducted a review of rehabilitation experience and identified knowledge gaps as follows:

- Rehabilitation of coastal and intertidal environments is undertaken regularly for other coastal development projects with stabilisation and rehabilitation techniques for coastal terrestrial vegetation well known and proven in other projects (WAPC, 2003). Therefore, rehabilitation of terrestrial vegetation should be readily achievable.
- Knowledge gaps existing regarding establishing tidal reconnection of the ponds on closure, however these knowledge gaps are relevant to intertidal habitats, not terrestrial vegetation, and are discussed in Section 8.8.3.1.

With regards to rehabilitation and closure outcomes, K+S aims to achieve:

- Site-specific rehabilitation and closure outcomes consistent with the end land use that are realistic and achievable based on a thorough closure risk assessment.
- Completion criteria that are specific, measurable, achievable, relevant and time-bound, and will demonstrate the achievement of the closure outcomes and monitoring.

10.7.4 OFFSETS

After the implementation of mitigation measures the impacts to vegetation in Good to Excellent condition are considered to remain significant and offsets are proposed to counterbalance this impact. These offsets are discussed in Section 17.

10.8 PREDICTED OUTCOME

The EPA's environmental objective for this factor is "to protect flora and vegetation so that biological diversity and ecological integrity are maintained". In the context of this objective: "ecological integrity" is listed as the composition, structure, function and processes of ecosystems, and the natural range of variation of these elements (EPA, 2016g).

K+S has incorporated extensive avoidance and minimisation measures into the Proposal design and operational processes. A key measure was to focus the disturbance footprint on the unvegetated Supratidal salt flats, which has resulted in only a small proportion of the total Proposal footprint requiring vegetation disturbance. The Proposal will result in direct and indirect impacts to 1,386 of native vegetation, however at least 333 ha of this vegetation is in Degraded – Poor condition.

The Proposal has also been designed to ensure that impacts to vegetation types are kept to a low percentage of the local extent (all <23%). The Proposal is however predicted to result in the following residual impacts that are considered significant:

- Up to 1,053 ha of Good to Excellent quality vegetation, which includes potential habitat for significant flora.

Offsets are proposed to counterbalance these significant residual impacts. Broad-scale offsets are proposed to counterbalance these impacts to Good to Excellent quality native vegetation (refer to Section 17).

The Proposal includes additional large areas of ponds that contain salts or brine and as such rehabilitation may be impeded for some time post-closure, although the majority of areas affected are salt pans that do not support vegetation. The Proposal is a long-life project with an infinite resource (seawater and solar energy) and therefore closure of the ponds may not occur this century, so consideration of altered ocean hydrodynamics and climate change will be necessary. Closure planning will continue through the life of the Proposal, with the purpose of refining the closure strategies already in the Interim MCP (Appendix BB).

Based on the above the Proposal is expected to be able to meet the EPA's objective for this factor. The implementation of the proposed mitigation and offsets are expected to minimise and counterbalance any significant residual impacts to flora and vegetation.

11 TERRESTRIAL FAUNA

11.1 EPA OBJECTIVE

To protect terrestrial fauna so that biological diversity and ecological integrity are maintained.

11.2 POLICY AND GUIDANCE

- *Significant impact guidelines for 36 migratory shorebird species (EPBC Act Policy Statement 3.21)* (DEWHA, 2009a).
- *Survey Guidelines for Australia's Threatened Bats* (DEWHA, 2010).
- *Survey Guidelines for Australia's Threatened Birds* (DSEWPaC, 2011b).
- *Survey Guidelines for Australia's Threatened Mammals* (DSEWPaC, 2011c).
- *Survey Guidelines for Australia's Threatened Reptiles* (DSEWPaC, 2011d).
- *Environmental Factor Guideline: Terrestrial Fauna* (EPA, 2016k).
- *Technical Guidance: Terrestrial fauna surveys* (EPA, 2016l).
- *Technical Guidance: Sampling methods for terrestrial vertebrate fauna* (EPA, 2016m).
- *Technical Guidance - Sampling of short range endemic invertebrate fauna* (EPA, 2016n).
- *Industry guidelines for avoiding, assessing and mitigating impacts on EPBC Act listed migratory shorebird species* (DoEE, 2017a).
- *National Recovery Plan for the Northern Quoll Dasyurus hallucatus* (Hill & Ward, 2010).
- *Approved Conservation Advice for Calidris ferruginea (Curlew Sandpiper)* (TSSC, 2015a).
- *Approved Conservation Advice for Limosa lapponica baueri (Bar-tailed godwit (western Alaskan)* (TSSC, 2016e).
- *Approved Conservation Advice* for *Limosa lapponica menzbieri (Bar-tailed godwit (northern Siberian))* (TSSC, 2016f).
- *Approved Conservation Advice for Numenius madagascariensis (Eastern Curlew)* (TSSC, 2015c).
- *Commonwealth Conservation Advice on Sternula nereis nereis (Fairy Tern)* (TSSC, 2011a).
- *Approved Conservation Advice for Calidris tenuirostris (Great knot)* (TSSC, 2016b).
- *Approved Conservation Advice for Calidris canutus (Red knot)* (TSSC, 2016a).
- *Approved Conservation Advice for Charadrius leschenaultii (Greater sand plover)* (TSSC, 2016c).
- *Approved Conservation Advice for Charadrius mongolus (Lesser sand plover)* (TSSC, 2016d).
- *Threat Abatement Plan for Predation by the European Red Fox* (DEWHA, 2008c).
- *Threat abatement plan for predation by feral cats* (DotE, 2015b).
- *Wildlife Conservation Plan for Migratory Shorebirds* (DotE, 2015c).
- *Threat abatement plan for the biological effects, including lethal toxic ingestion, caused by cane toads* (DSEWPaC, 2011e).
- *Threat Abatement Plan for the incidental catch (or bycatch) of seabirds during oceanic longline fishing operations (Commonwealth of Australia, 2018)*.
- Approved Conservation Advice *for Liasis olivaceus barroni* (Olive Python – Pilbara subspecies), (DEWHA, 2008b)
- Light Pollution Guidelines: National Light Pollution Guidelines for Wildlife Including Marine Turtles, Seabirds and Migratory Shorebirds (DotEE, 2020).
- Listing Advice on Northern quoll (*Dasyurus hallucatus*) (TSSC, 2005).
- *WA Environmental Offsets Policy* (Government of Western Australia, 2011).
- *WA Environmental Offsets Guidelines* (Government of Western Australia, 2014).
- "Appendix B: Potentially contaminating industries, activities and land uses" in *Assessment and management of contaminated sites: Contaminated sites guidelines* (DER, 2014).
- *EPBC Act Environmental Offsets Policy* (Commonwealth of Australia, 2012).

11.3 TERRESTRIAL FAUNA STUDIES

Studies to assess impacts to terrestrial fauna have been conducted as outlined in Table 83.

Table 83: Terrestrial Fauna Studies

Report	Reference	Appendix
Level 2 Seasonal Fauna Survey	Biota, 2022b	S
Shorebird Survey	Biota, 2022c	O
Claypan Invertebrate Fauna Assessment	Biota, 2021	T
Marine and Coastal Assessment and Modelling	Water Technology, 2022b	A
Surface Water Assessment and Modelling	Water Technology, 2022a	B
Marine, Coastal and Surface Water Data Collection	Water Technology, 2021a	C
Marine, Coastal and Surface Water Existing Environment	Water Technology, 2021b	D
Surface Water Assessment and Modelling	Water Technology, 2021c	E
Marine, Surface Water and Nutrient Modelling Peer Review	DHI, 2021	F
Acid Sulfate Soils Study	GHD, 2021a	K
ASSSMP	GHD, 2021b	BB
Materials Characterisation Study	GHD, 2021d	U
Memorandum Ashburton groundwater modelling- updated results	GHD, 2022	V
Hydrogeological Investigation	GHD, 2021c	W
Hydrogeology Modelling Peer Review	Cymod, Systems, 2022	X
Hydrogeology Modelling Peer Review	Cymod, Systems, 2021	Y

11.3.1 MODELLING

A surface water hydrodynamic modelling study (Water Technology, 2021c) and a hydrogeology modelling study (GHD, 2021c) have been conducted to assess potential impacts of the Proposal regarding:

- Surface water flows.
- Groundwater seepage and associated salt crusting.

11.3.2 MODELLING PEER REVIEWS

Peer reviews of the above modelling studies have been conducted. The peer review process was undertaken in a comprehensive, rigorous and iterative manner.

- It is the opinion of the surface water peer reviewer that the model constructed by Water Technology (2021c) can be considered suitable for the purpose of identifying potential environmental impacts for the above processes (DHI, 2021).
- It is the opinion of the groundwater model peer reviewer that the groundwater model (GHD, 2021c) is fit for the purpose of assessing groundwater related environmental impacts of the Proposal (CyMod Systems, 2022).

11.3.3 SURVEY EFFORT AND EXTENT

Survey methodology and approach were undertaken with consideration of the following compliance and regulatory documents:

- Technical Guidance – Sampling Methods for Terrestrial Vertebrate Fauna (EPA 2016a);
- Technical Guidance – Terrestrial Fauna Surveys (EPA 2016b);
- Technical Guidance – Sampling of Short-range Endemic Invertebrate Fauna (EPA 2016c);
- Survey Guidelines for Australia's Threatened Birds (DEWHA 2010); and
- Survey Guidelines for Australia’s Threatened Mammals (DSEWPaC 2011).

The vertebrate survey consisted of a combination of systematic trapping and non-systematic opportunistic and targeted searching. The invertebrate survey consisted of targeted searches undertaken for specific groups of invertebrates known to include SRE species.

Preliminary site selection was determined through assessment of aerial photography and thematic layers including land systems, geology and Beard's vegetation mapping. Sampling sites were located within representative land systems intersected by the study area. Further site assessments were conducted in the field while driving, flying in a helicopter and traversing on foot through the study area.

The systematic census component of the fauna survey consisted of 14 trapping transects, each located within a defined landform:

- 12 dry pitfall trapping transects consisting of a single row of ten pitfall traps arranged as alternating 20 L buckets and 150 mm diameter x 600 mm high PVC tubes, spaced at 10 m intervals and connected with a 90 m length of 300 mm high fly wire fence. These transects also included three pairs of funnel traps.
- Two trapping transect consisted of a series of medium Elliott box traps spaced at approximately 10 – 15 m intervals. Traps were baited with a universal bait mixture of peanut butter and oats.

In total, 2,905 trap days of systematic sampling were completed as part of the Biota (2022c) study. Figure 3.3 illustrates the locations of systematic trapping, remote cameras and bat sampling.

11.4 EXISTING ENVIRONMENT

11.4.1 VERTEBRATE FAUNA

11.4.1.1 VERTEBRATE FAUNA HABITAT

Five landscapes and associated landforms (fauna habitats) were determined for vertebrate fauna – refer to Table 84 and Figure 120. Based on examination of aerial imagery and land systems mapping, none of the fauna habitats identified during the survey are confined to the study area, as they are common throughout the mainland east of Exmouth Gulf (Biota, 2022b).

Table 84: Vertebrate Fauna Habitats

(Biota, 2022b)

Landscape	Landforms
LANDSCAPE 1: Mainland remnants	• Longitudinal dune • Sand plain and clay loam plain • Freshwater claypan
LANDSCAPE 2: Mud flats	• Supratidal salt flats (hypersaline mudflats) • Intertidal mudflats (including algal mats)
LANDSCAPE 3: Inland dunes and plains	• Sand plain and clay loam plain • Gilgai plain • Longitudinal dune • Freshwater claypan • River bank / creekline / drainage
LANDSCAPE 4: Coastal strand	• Coastal dune • Sandy beach
LANDSCAPE 5: Mangroves	• Mangrove

The survey recorded a total of 171 vertebrate species, comprising 54 herpetofauna species, 97 avifauna species, 13 ground-dwelling mammal species and seven bat species (Biota, 2022b).

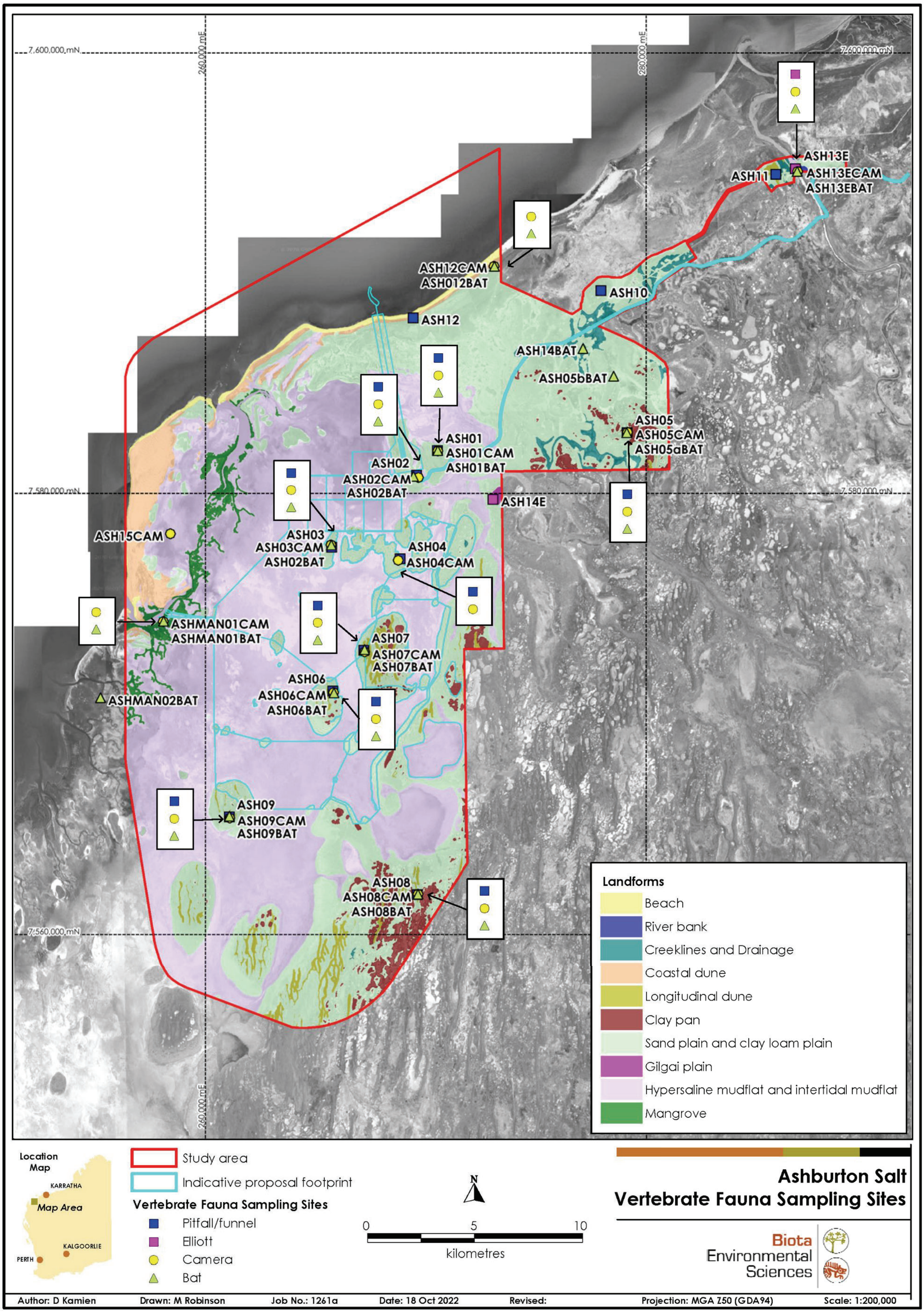


Figure 117: Vertebrate Fauna Sampling Sites

11.4.1.2 SIGNIFICANT VERTEBRATE FAUNA SPECIES

Significant fauna species either recorded or considered likely to occur locally are summarised in Table 85 (Biota, 2022b) (Biota, 2022c). Potential species recorded in the Protected Matters Search Tool (PMST) Report in Biota (2022b) were also included for reference.

Table 85: Significant Vertebrate Fauna Recorded or Potentially Occurring in Study Area
(Biota, 2022b) (Biota, 2022c)

Species Name	Common Name	Conservation Status		Occurrence Locally
		State	Commonwealth	
Herpetofauna				
Liasis olivaceus barroni	Pilbara Olive Python	Vulnerable	Vulnerable	Not recorded, lack of habitat locally, may utilise Ashburton River
Avifauna				
Apus pacificus	Fork-tailed Swift	Migratory	Migratory	Recorded Biota 2022b
Pandion cristatus	Eastern Osprey	Migratory	Migratory	Recorded Biota 2022b
Falco peregrinus	Peregrine Falcon	Other Specially Protected Fauna	–	Recorded Biota 2022b
Falco hypoleucos	Grey Falcon	Vulnerable	–	Not recorded, may occur near Ashburton River
Pluvialis fulva	Pacific Golden Plover	Migratory	Migratory	Recorded Biota 2022c
Pluvialis squatarola	Grey Plover	Migratory	Migratory	Recorded Biota 2022c
Charadrius leschenaultii	Greater Sand Plover	Migratory	Vulnerable/ Migratory	Recorded Biota 2022c
Charadrius veredus	Oriental Plover	Migratory	Migratory	Noted in PMST report
Limosa lapponica menzbieri	Bar-tailed Godwit	Critically Endangered/Migratory	Critically Endangered/Migrat ory	Recorded Biota 2022c
Numenius phaeopus	Whimbrel	Migratory	Migratory	Recorded Biota 2022c
Numenius madagascarien sis	Eastern Curlew	Critically Endangered/ Migratory/	Critically Endangered/ Migratory	Recorded Biota 2022c
Xenus cinereus	Terek Sandpiper	Migratory	Migratory	Recorded Biota 2022c
Actitis hypoleucos	Common Sandpiper	Migratory	Migratory	Recorded Biota 2022b and 2022c
Tringa brevipes	Grey-tailed Tattler	Priority 4 Migratory	Migratory	Recorded Biota 2022c
Tringa nebularia	Common Greenshank	Migratory	Migratory	Recorded Biota 20202b
Arenaria interpres	Ruddy Turnstone	Migratory	Migratory	Recorded Biota 2022c
Calidris tenuirostris	Great Knot	Critically Endangered/ Migratory	Critically Endangered/ Migratory	Recorded Biota 2022c
Calidris canutus	Red Knot	Endangered/ Migratory	Endangered/ Migratory	Recorded Biota 2022c
Calidris alba	Sanderling	Migratory	Migratory	Recorded Biota 2022c
Calidris ruficollis	Red-necked Stint	Migratory	Migratory	Recorded Biota 2022b and 2022c
Calidris acuminata	Sharp-tailed Sandpiper	Migratory	Migratory	Recorded Biota 2022c
Calidris ferruginea	Curlew Sandpiper	Critically Endangered/ Migratory	Critically Endangered/ Migratory	Recorded Biota 2022c
Limicola falcinellus	Broad-billed Sandpiper	Migratory	Migratory	Recorded Biota 2022c
Stercorarius pomarinus	Pomarine Jaeger	Migratory	Migratory	Not recorded, may occasionally use local beaches
Sternula albifrons	Little Tern	Migratory	Migratory	Recorded Biota 2022b

Species Name	Common Name	Conservation Status		Occurrence Locally
		State	Commonwealth	
Sternula nereis	Fairy Tern	Vulnerable	Vulnerable	Previously Recorded Biota 2022b, not recorded in current surveys, no breeding colonies present.
Gelochelidon nilotica	Gull-billed Tern	Migratory	Migratory	Recorded Biota 2022b
Hydroprogne caspia	Caspian Tern	Migratory	Migratory	Recorded Biota 2022b
Chlidonias leucopterus	White-winged Black Tern	Migratory	Migratory	Recorded Biota 20202b
Sterna dougallii	Roseate Tern	Migratory	Migratory	Not recorded but may occur occasionally.
Sterna hirundo	Common Tern	Migratory	Migratory	Recorded Biota 2022b
Thalasseus bergii	Crested Tern	Migratory	Migratory	Recorded Biota 2022b
Hirundo rustica	Barn Swallow	Migratory	Migratory	Not recorded, may occasionally occur locally
Mammals				
Dasyurus hallucatus	Northern Quoll	Endangered	Endangered	Not recorded, lack of habitat locally, may utilise Ashburton River and surrounding plains.
Ozimops cobourgianus	North-Western Free-tailed Bat	Priority 1	–	Recorded Biota 2022b
Leggadina lakedownensis	Short-tailed Mouse	Priority 4	–	Not recorded, may occur locally near sand dunes and cracking clay in the hinterland.

11.4.1.3 SHOREBIRDS

A Shorebird Assessment for the Proposal has been undertaken in accordance with *Industry guidelines for avoiding, assessing and mitigating impacts on EPBC Act listed migratory shorebird species* (Commonwealth of Australia, 2017a) and is included as Appendix O (Biota, 2022c).

11.4.1.3.1 SPECIES RECORDED

A total of 30 species of migratory shorebird were recorded within the shorebird study area and terrestrial fauna survey area, of which eight species are also listed as threatened or priority species as summarised in Table 86 (Biota, 2022b) (Biota, 2022c).

Table 86: Significant Shorebirds Recorded or Potentially Occurring in Study Area

Species EPBC or BC	Recorded within development envelopes?	Occurrence and significance of habitat
Asian Dowitcher (*Limnodromus semipalmatas*) – Marine/ Migratory EPBC Act and Migratory BC Act	No	The Asian Dowitcher is common in coastal mudflats further north on the Pilbara cost. Recorded in PMST Report this species is considered unlikely despite habitat availability in the study area. Nearest ALA record from offshore at Barrow Island, some 150 km north of the study area (Biota 2022b).
Barn Swallow (*Hirundo rustica*) - Migratory EPBC Act and BC Act	No	Occurs in northern Australia, near the coast. An aerial insectivore that typically inhabits open country with low vegetation, such as pasture, meadows and farmland, preferably with nearby water (Simpson and Day 2004). Nearest record located approximately 15 km east of the study area close to Onslow. Given the proximity of this record, this species may potentially occur in the study area (Biota 2022b).
Bar-tailed Godwit (*Limosa lapponica menzbieri*) – Critically	Yes	This species is a regular migrant to Australia from the northern hemisphere (mainly September to April). Some birds remain in Australia and do not migrate northward, but this species does

Species EPBC or BC	Recorded within development envelopes?	Occurrence and significance of habitat
Endangered/ Migratory EPBC Act and BC Act		not breed in Australia. It occurs throughout the Pilbara coast and several offshore islands. This species was observed using the smaller areas of algal mat habitat to the west of Urala Creek for roosting close to high tide. Bar-tailed Godwit were proportionally under-represented in the Study Area. Previous counts recorded over 1,000 Bar-tailed Godwits in the eastern Exmouth Gulf, compared to a high count of 137 for the Study Area during the current surveys (shorebird report (Biota, 2022c).
Bridled Tern (*Onychoprion anaethetus*) - Migratory EPBC Act and BC Act	No	Bridled Tern has a preferred habitat of Oceans, coasts and Islands throughout much of WA. Recorded in the PMST report, this species is considered unlikely to occur in the Study Area. It has previously been recorded approximately 13 km west of Study Area (Biota 2022b).
Broad-billed Sandpiper (*Limicola falcinellus*) - Migratory EPBC Act and BC Act	Yes	The Broad-billed Sandpiper occurs in sheltered parts of the coast, favouring estuarine mudflats but also occasionally occur on saltmarshes, shallow freshwater lagoons, saltworks and sewage farms, and in areas with large soft intertidal mudflats, which may have shell or sandbanks nearby. Occasionally they occur on reefs or rocky platforms. They have also been recorded in creeks, swamps and lakes near the coast, particularly those with bare mudflats or sand exposed by receding water. They often favour mud among, or fringed by, mangroves, particularly on the seaward side and sometimes occur in estuaries edged by saltmarsh. They are rarely recorded inland. Foraging occurs on exposed flats of soft mud or wet sand at edges of coastal and near-coastal wetlands, often around channels on mudflats or in accumulated mud in swales between shell banks. They roost on the banks of sheltered sandy, shelly or shingly beaches (Higgins & Davies 1996). They nest on the ground, frequently in the top of a tussock (Cramp 1985). The Broad-billed Sandpiper is considered to be proportionally over-represented in the Study Area compared to overall counts. Broad-billed Sandpipers were recorded on all four 'summer' surveys during the current study, with high counts in December (175) and March (129), with all records from Urala Creek North and surrounding overflow areas but was not recorded on any of the previous Exmouth Gulf surveys. It is possible that the numbers observed during the survey represent an unusual influx to the area, or they may favour the Urala Creek North area, which was not surveyed on the three previous surveys (Biota, 2022c).
Campbell Albatross (*Thalassarche impavida*) – Vulnerable/ Migratory EPBC Act and BC Act	No	Campbell Albatross is an oceanic species. It occurs in seas of south and west coast, typically as for north as 28º latitude. Recorded in the PMST report, this species is considered unlikely to occur in the Study Area as there is no habitat available. Nearest NatureMap record is over 100 km south of the Study Area in offshore waters of Perth (Biota, 2022b).
Caspian Tern (*Hydroprogne caspia*) - Migratory EPBC Act and BC Act	Yes	The Caspian Tern occurs on most coasts and many islands Australia-wide. Habitat includes shallow sheltered seas, estuaries, tidal creeks (Johnstone and Storr 1998). There was a total of 24 observations across 13 locations within the Study Area, on mudflat and beach habitat (Biota, 2022b).
Common Greenshank (*Tringa nebularia*) –	Yes	The Common Greenshank occurs on all Australian coasts, being a casual or vagrant on many islands and much of the interior (Johnstone and Storr 1998). Preferred habitat includes

Species EPBC or BC	Recorded within development envelopes?	Occurrence and significance of habitat
Migratory EPBC Act and BC Act		shallow freshwaters and salt waters such as mudflats, estuaries, mangroves, lakes and samphire flats (Biota 2020). The Exmouth Gulf shorebird area supports nationally important numbers of Common Greenshank (*Tringa nebularia*) and mangroves present are a favoured roosting habitat. Seven records were noted on the Ashburton River at site ASH13E (Biota, 2022b). This species was also recorded in four of the five surveys conducted by Biota (2020). A maximum count of 93 individuals in one flock was recorded (Biota, 2022c).
Common Noddy (*Anous stolidus*) – Migratory EPBC Act and BC Act	No	The Common Noddy has a preferred habitat of northern and western seas, south to Lancelin. It inhabits remote islands. Recorded in the PMST report, this species is considered unlikely to occur in the study area as there is no habitat available. Previously recorded on Mackeral Islands approximately 20 km northwest of the Study Area (Biota 2022b).
Common Sandpiper (*Actitis hypoleucos*) - Migratory EPBC Act and BC Act	Yes	The Common Sandpiper utilises a wide range of coastal wetlands and some inland wetlands, with varying levels of salinity, and is mostly found around muddy margins or rocky shores and rarely on mudflats. The Common Sandpiper has been recorded in estuaries and deltas of streams, as well as on banks farther upstream; around lakes, pools, billabongs, reservoirs, dams and claypans, and occasionally piers and jetties. The muddy margins utilised by the species are often narrow and may be steep. The species is often associated with mangroves, and sometimes found in areas of mud littered with rocks or snags. They prefer less dense mangrove areas for foraging habitat. Three records were noted on the Ashburton River at site ASH13E (Biota 2022b). This species was also recorded in three of the five surveys conducted by Biota (2020) with a maximum count of 10 individuals in one flock recorded (Biota, 2022c).
Common Tern (*Sterna hirundo*) – Migratory EPBC Act and BC Act	Yes	In WA, this species occurs coastally north of Carnarvon (Johnstone and Storr 1998). Inhabits sheltered seas, including estuaries (Johnstone and Storr 1998). Five individuals were recorded at three locations within the Study Area, on intertidal mudflat and beach habitat (Biota 2022b).
Crested Tern (*Thalasseus bergii*) – Migratory EPBC Act and BC Act	Yes	Occurs on most coasts and many islands, Australia-wide (Johnstone and Storr 1998). Inhabits mainly blue water seas in addition to estuaries and tidal creeks (Johnstone and Storr 1998). Ten individuals were recorded on 35 occasions at five locations within the Study Area, on mudflat and beach habitat (Biota 2022b).
Curlew Sandpiper (*Calidris ferruginea*) – Critically Endangered/ Migratory EPBC Act and BC Act	Yes	The Curlew Sandpiper is migratory from the northern hemisphere, arriving in Australia in late August–September and does not breed in Australia. The species is more abundant on the northeast Pilbara coast and Kimberley than further south (Phoenix, 2020b). Johnstone et al. (2013) reported peak numbers at the Port Hedland Saltworks (25,000) and further north at Eighty Mile Beach in the Kimberley (60,000; representing two thirds of the flyway population), with numbers decreasing rapidly southwest of Port Hedland.

Species EPBC or BC	Recorded within development envelopes?	Occurrence and significance of habitat
		Curlew Sandpipers mainly occur on intertidal mudflats in sheltered coastal areas, such as estuaries, bays, inlets and lagoons, and also around non-tidal swamps, lakes and lagoons near the coast, and ponds in saltworks and sewage farms. They are also recorded inland, though less often (Higgins & Davies 1996). The Exmouth Gulf shorebird area supports nationally important numbers of Curlew Sandpiper (*Calidris ferruginea*) (Weller et al. 2020). Curlew Sandpipers are listed as critically endangered and were recorded on all five of the surveys during the current study with a high count of 355 in March, though the remaining counts were significantly lower (≤45). Total counts from previous surveys in the broader Exmouth Gulf region ranged from 0 to 35. The high count in March may indicate that the study area is used as a migratory staging point for birds migrating north from further south. It is possible that this usage extends more broadly within Exmouth Gulf but was missed on previous surveys which were not conducted during northward migration (Biota, 2022c).
Eastern Curlew (*Numenius madagascariensis*) Critically Endangered/ Migratory EPBC Act and BC Act	Yes	The Eastern Curlew is a moderately common visitor from the northern hemisphere although some birds remain in Australia. It does not breed in Australia. They have a continuous distribution from Barrow Island and Dampier Archipelago northwards around the north of Australia. The species mainly forages on soft sheltered intertidal sandflats / mudflats that are open and without vegetation or covered with seagrass, often near mangroves, on salt flats and in saltmarsh, rock pools and amongst rubble on coral reefs, and on ocean beaches near the tideline. The species roosts on sandy spits, sandbars and islets during high-tide and amongst coastal vegetation including low saltmarsh or mangroves (Phoenix, 2020b). Most of the Western shorebird area is included within the broader Exmouth Gulf shorebird area, which has been identified as an area of international importance for migratory shorebirds as it regularly supports more than 1% of the flyway population of Eastern Curlew (Weller et al. 2020). Large species including the Eastern Curlew were considered proportionally under-represented in the Study Area with a maximum count of 13 individuals recorded compared to the 200 counted within the Study Area in 2018 (BirdLife Australia 2020). This may partly reflect variation in populations using Exmouth Gulf between years (Biota, 2022c).
Eastern Osprey (*Pandion cristatus*) - Migratory EPBC Act and BC Act	Yes	The Eastern Osprey occurs on the coast islands over much of Australia. It occasionally ranges inland along rivers, though mainly in the north of the country. The species feeds mainly on fish and breeds mainly on islands (Johnstone and Storr 1998). Recorded on ten occasions at site ASH03, ASH13E at the Ashburton River and opportunistically at five locations within the study area on clay loam plains, beach, mangrove and mudflat habitat (Biota 2022b).
Fairy Tern (*Sternula nereis*) – Migratory EPBC Act and BC Act	No	The Fairy Tern occurs on coasts and estuaries south of Port Hedland (Simpson and Day 2004). It breeds on sandy beaches and sand spits (Simpson and Day 2004). Not recorded during the recent Level 2 fauna survey (Biota 2022b) but recorded within the Study Area in 2018 on hypersaline mudflats (NatureMap record).
Fork-tailed Swift (*Apus pacificus*) – Migratory EPBC Act and BC Act	Yes	The Fork-tailed Swift occurs across much of the Australian continent from September to April, particularly in the northern

Species EPBC or BC	Recorded within development envelopes?	Occurrence and significance of habitat
		half of the continent. In general, the species is most common closer to the coast, but occurs over much of the Pilbara. The species is a non-breeding migrant to Australia and is generally present from September to April. In Australia, the species is entirely aerial in habits, foraging for flying insects and even sleeping on the wing. The species is highly mobile, often occurring in association with unsettled weather and low pressure systems (Johnstone and Storr 1998). The species was recorded opportunistically on four occasions at two locations within the Study Area in clay loam plain, and beach habitat (typically within mainland remnant and coast landscapes) (Biota 2022b).
Great Knot (*Calidris tenuirostris*) – Critically Endangered/ Migratory EPBC Act and BC Act	Yes	The Great Knot is a moderately common to common northern hemisphere visitor from August to May. It does not breed in Australia. Most of the EAAF population overwinters in Australia with greatest numbers found in northern WA and the Northern Territory. Larger counts of the species have been recorded at Barrow Island, eastern side of Exmouth Gulf and Forestier Bay (Phoenix, 2020b). Preferred habitat in Australia is sheltered coastal habitats with large intertidal mudflats or sandflats, including inlets, bays, harbours, estuaries and lagoons. The Exmouth Gulf shorebird area supports nationally important numbers of Great Knot. This species was recorded in all five phases of the migratory shorebird survey assessment. A maximum count of 126 individuals in one flock was recorded (Biota, 2022c).
Greater Sand Plover (*Charadrius leschenaultia*) – Vulnerable/ Migratory EPBC Act and BC Act	Yes	In Australia, the Greater Sand Plover occurs in coastal areas in all states, though the greatest numbers occur in northern Australia, especially the north-west. Migrating birds arrive in Australia from August and depart by March. Some, mostly first year birds, remain in Australia but the species does not breed in Australia. Most (nearly three quarters) of the EAAF population is in Australia during the non-breeding period. Greater Sand Plover occurs throughout the coastal Pilbara, including several offshore islands; however, Eighty Mile Beach and Roebuck Bay in the Kimberley are by far the most important non-breeding area for the species, supporting 90% of the Australian population (~60,000 birds). Much larger counts have been recorded at other Pilbara sites, for example 1,036 on the eastern side of Exmouth Gulf, 1,158 on Barrow Island, 323 at Forestier Bay and 303 in the Port Hedland area (Phoenix, 2020b). The species is almost entirely coastal, inhabiting littoral and estuarine habitats. They mainly occur on sheltered beaches with large intertidal mudflats or sandbanks, as well as sandy estuarine lagoons (Bamford 1988; Blakers et al. 1984; Lane 1987; Sibson 1948; Stewart et al. 2007), and inshore reefs, rock platforms, small rocky islands or sand cays on coral reefs (Abbott 1982; Morris 1989; Sedgwick 1978). They are occasionally recorded on near-coastal saltworks and salt lakes, including marginal saltmarsh, and on brackish swamps (Sibson 1953; Storr 1964, 1977; Storr et al. 1986). The Exmouth Gulf shorebird area supports nationally important numbers of Greater Sand Plover. This species was recorded in four of the five phases of the recent migratory shorebird survey assessment. A maximum count of 189 individuals in one flock was recorded (Biota, 2022c).

Species EPBC or BC	Recorded within development envelopes?	Occurrence and significance of habitat
Grey Plover (Pluvialis squatarola) – Migratory EPBC Act and BC Act	Yes	In Australia, Grey Plovers occur almost entirely in coastal areas, where they usually inhabit sheltered embayments, estuaries and lagoons with mudflats and sandflats, and occasionally on rocky coasts with wave-cut platforms or reef-flats, or on reefs within muddy lagoons. They also occur around terrestrial wetlands such as near-coastal lakes and swamps, or salt-lakes. The species is also very occasionally recorded further inland, where they occur around wetlands or salt-lakes. This species was recorded in four of the five phases of the migratory shorebird survey assessment. A maximum count of 24 individuals in one flock was recorded (shorebird report (Biota, 2022c).
Grey-tailed Tattler (*Tringa brevipes*) Migratory EPBC Act and Migratory/ Priority 4 BC Act	Yes	Migrating Grey-tailed Tattler arrive from August and depart by April; however some birds remain in non-breeding grounds in Australia. There is a marked seasonal variation between breeding and non-breeding adults. The species occurs throughout the coastal Pilbara, including offshore islands. Formally recognised internationally important areas for the species include Barrow Island and Eighty Mile Beach. Most of the Western shorebird area is included within the broader Exmouth Gulf shorebird area, which has been identified as an area of international importance for migratory shorebirds as it regularly supports more than 1% of the flyway population of Grey-tailed Tattler (Weller et al. 2020). Mangroves fringe large sections of the north and south arms of Urala Creek, and their smaller tributaries and are a favoured roosting habitat for this species (Zharikov and Milton 2009, Johnston-Gonzalez and Abril 2018). The Grey-tailed Tattler was recorded in particularly high numbers in March (229 individuals) compared to the other four survey phases, suggesting that the area may be used as a staging area for this species on northward migration (Biota, 2022c).
Grey Wagtail (*Motacilla cinerea*) - Migratory EPBC Act and BC Act	No	The Grey Wagtail has a preferred habitat of fast-flowing streams, often at high altitude. Outside of the breeding season it is found in greater variety of habitats. Recorded in the PMST report, this species would not occur in the Study Area as there is no habitat available. There is a single record approximately 500km east of the Study Area on Fortescue Marsh. Rare migrant to Australia, very rare south of Kimberley region. (Biota 2022b).
Gull-billed Tern (*Gelochelidon nilotica*) - Migratory EPBC Act and BC Act	Yes	Occurs coastally in WA but extends inland where well watered flatlands occur (e.g., Murchison and Gascoyne rivers). Habitat includes shallow sheltered seas, close to land (in the north), estuaries, tidal creeks, claypans and watercourse (Johnstone and Storr 1998). 93 observations were recorded at 21 locations on 17 occasions from sites ASH03, ASH06, ASH07, ASH09, ASH12 and ASH13E, within the study area on mudflat, mangrove, beach and clay loam plain habitat within the Study Area (Biota 2022b).
Indian Yellow-nosed Albatross (*Thalassarche carteri*) – Vulnerable/ Marine Migratory EPBC Act and Endangered BC Act	No	Indian Yellow-nosed Albatross is an oceanic species which may occur as far north as the study area. Recorded in PMST Report this species is considered unlikely to occur as there is no habitat available in the Study Area. Nearest ALA record is 300 km south of the Study Area at Carnarvon (Biota 2022b).

Species EPBC or BC	Recorded within development envelopes?	Occurrence and significance of habitat
Lesser Frigatebird (*Fregata ariel*) - Migratory EPBC Act and BC Act	No	The Lesser Frigatebird is common in tropical seas south to Dampier Archipelago. It breeds on remote islands. Recorded in the PMST report, this species is considered unlikely to occur in the Study Area as there is no habitat available. Previously recorded 100 km SW of Study Area on oceanic side of Northwest Cape (Biota 2022b).
Lesser Sand Plover (*Charadrius mongolus*) – Migratory/ Endangered EPBC Act and BC Act	Yes	The Lesser Sand Plover is an uncommon to moderately common visitor to the Pilbara from the northern hemisphere (July–late May) with odd birds overwintering. It does not breed in Australia. It occurs throughout the Pilbara coast (Yardie Creek to Madora) and offshore islands. Important Pilbara sites include Barrow Island and Port Hedland Saltworks. The species mainly feeds in freshly exposed areas of intertidal sandflats and mudflats in estuaries or beaches, or in shallow ponds in saltworks. It roosts near foraging areas, on beaches, banks, spits and banks of sand or shells and occasionally on rocky spits, islets or reefs. The Exmouth Gulf shorebird area supports nationally important numbers of Lesser Sand Plover. The Lesser Sand Plover is considered to be proportionally over-represented in the study area compared to overall counts. Lesser Sand Plovers were recorded on all four 'summer' surveys during the current study, with high counts in March (86) and April (100) (shorebird report (Biota, 2020). It is possible that the numbers observed during the survey represent an unusual influx to the area (Biota, 2022c).
Little Tern (*Sternula albifrons*) – Migratory EPBC Act and BC Act	Yes	In WA, the Little Tern occurs in coastal regions north of Shark Bay (Simpson and Day 2004). It occurs mainly in sheltered seas, estuaries and mangrove creeks (Johnstone and Storr 1998). 124 individuals were recorded on 149 occasions at 12 locations within the Study Area, on mudflat, mangrove and beach habitat (Biota 2022b).
Oriental Plover (*Charadrius veredus*) - Migratory EPBC Act and BC Act	No	The Oriental Plover is a non-breeding visitor to Australia, being widely distributed, but most records are along the north-western coast between Exmouth Gulf and Derby. Inland habitats occupied by the species include sparsely vegetated plains or recently burnt open areas. Recorded in the PMST report, this species is considered likely to occur in the Study Area. It has been recorded during previous shorebird counts in Eastern Exmouth Gulf.
Oriental Pratincole (*Glareola maldivarum*) - Migratory EPBC Act and BC Act	No	In non-breeding grounds in Australia, the Oriental Pratincole usually inhabits open plains, floodplains or short grassland (including farmland or airstrips), often with extensive bare areas. They often occur near terrestrial wetlands, such as billabongs, lakes or creeks, and artificial wetlands such as reservoirs, saltworks and sewage farms, especially around the margins. The species also occurs along the coast, inhabiting beaches, mudflats and islands, or around coastal lagoons. Recorded in the PMST report, this species is considered likely to occur in the Study Area. It has been recorded during previous shorebird counts in Eastern Exmouth Gulf.
Pacific Golden Plover (*Pluvialis fulva*) - Migratory EPBC Act and BC Act	Yes	This large charadriidae is a strict migrant in Australia where it can be found in small flocks across the coastal shoreline of every state. During the northern hemisphere summer they breed in Siberia and Western Alaska. Numbers in Australia are small (less than 10,000 individuals) and no recent data

Species EPBC or BC	Recorded within development envelopes?	Occurrence and significance of habitat
		concerning population trends are available, however in Alaska the species is declining. They can be found feeding singly or in flocks in open mudflats, salt marshes and rocky shores. This species was recorded in three of the five phases of the recent migratory shorebird survey assessment. A maximum count of four individuals in one flock was recorded (Biota, 2022c).
Pectoral Sandpiper (*Calidris melanotos*) - Migratory EPBC Act and BC Act	No	The Pectoral Sandpiper prefers shallow fresh to saline wetlands. The species is found at coastal lagoons, estuaries, bays, swamps, lakes, inundated grasslands, saltmarshes, river pools, creeks, floodplains and artificial wetlands. The species is usually found in coastal or near coastal habitat but occasionally found further inland. It prefers wetlands that have open fringing mudflats and low, emergent or fringing vegetation, such as grass or samphire. The species has also been recorded in swamp overgrown with lignum. They forage in shallow water or soft mud at the edge of wetlands (Higgins & Davies 1996). Recorded in the PMST report, this species is considered likely to occur in the Study Area. It has been recorded during previous shorebird counts in Eastern Exmouth Gulf.
Pomarine Jaeger (*Stercorarius pomarinus*) - Migratory EPBC Act and BC Act	No	An oceanic species, typically seen in the northern coast of WA and in the southwest of the state (Simpson and Day 2004). The Pomarine Jaeger breeds in the Arctic and is an uncommon visitor to Australian inshore seas and bays. It feeds on fish, carrion, smaller birds up to the size of common gull and rodents (Johnstone and Storr 1998). Recorded approximately 22 km southwest of the Study Area on a beach. This species may potentially occur in the Study Area on occasion (Biota 2022b).
Red Knot (*Calidris canutus*) – Endangered/ Migratory EPBC Act and BC Act	Yes	The Red Knot migrates from northern breeding grounds arriving in Australia from August, departing by April. It does not breed in Australia. The species is common in its main habitats around the coast of Australia. In the Pilbara, it mostly occurs along the coast from Mandora south-west to the Ashburton estuary, and also Barrow Island. In Australasia the Red Knot mainly inhabit intertidal mudflats, sandflats and sandy beaches of sheltered coasts, in estuaries, bays, inlets, lagoons and harbours; sometimes on sandy ocean beaches or shallow pools on exposed wave-cut rock platforms or coral reefs. They rarely use inland lakes or swamps (Higgins & Davies 1996). This species was recorded in all five phases of the recent migratory shorebird survey assessment. A maximum count of 89 individuals in one flock was recorded (Biota, 2022c). During the April surveys, when tides were higher than normal (likely due to the influence of Tropical Cyclone Wallace offshore to the north), smaller areas of algal mat habitat to the west of Urala Creek were inundated around high tide and were regularly used by moderate numbers of shorebirds (up to approximately 300) for foraging and roosting. Red Knots were observed foraging in small numbers.
Red-necked Stint (*Calidris ruficollis*) - Migratory EPBC Act and BC Act	Yes	The Red-necked Stint occurs on most coasts and many islands in Australia (Johnstone and Storr 1998). Preferred habitat includes edges of sheltered salt, brackish or fresh waters, predominantly estuaries, beaches and salt lakes (Johnstone and Storr 1998). The Exmouth Gulf shorebird area has been identified as internationally important habitat for migratory shorebirds as it

Species EPBC or BC	Recorded within development envelopes?	Occurrence and significance of habitat
		supports nationally important numbers of Red-necked Stint (*Calidris ruficollis*). The Onslow shorebird area also supports nationally significant numbers of Red-necked Stint (Weller et al. 2020). This species was recorded in all five phases of the recent migratory shorebird survey assessment for the Western shorebird area and three of the five phases for the Ashburton River shorebird area. A maximum high count of 681 individuals was recorded during the December phase (shorebird report (Biota, 2020). The algal mats in the northeast of the Study Area occur in a shallow basin that holds water between tide cycles and was inundated during the current survey (Geoscience Australia 2021). A small number (<50) of small shorebirds, likely comprising Red-necked Stints and Red-capped Plovers, were observed incidentally on several occasions in the north of this basin while overflying, but their occurrence was erratic. It is considered that these were likely birds using Urala Creek (North) at low tide that sometimes used this area on higher tides. During the April surveys, when tides were higher than normal, smaller areas of algal mat habitat to the west of Urala Creek were inundated around high tide and were regularly used by Red-necked Stints for foraging. Regionally, large numbers of Red-necked Stint (c. 1,000) were also observed east of the study area in 2015 (Cornell Lab of Ornithology, 2020) on flats adjacent to the Wheatstone access road that have been mapped as algal mats (URS, 2011). Recent research indicates that Red-necked Stint forage extensively by grazing on microbial mats and epibenthic biofilms (Kuwae et al. 2012, Beninger and Elner 2020) which may explain what food source these birds are using on the algal mats (shorebird report (Biota, 2022c). Six records were additionally noted on the Ashburton River at site ASH13E during the Level 2 fauna survey (Biota 2022b).
Roseate Tern (*Sterna dougallii*) - Migratory EPBC Act and BC Act	No	In WA, this species occurs in waters, islands and coasts north of Bunbury (Simpson and Day 2004). Breeds in colonies on coasts and islands and feeds on surface fish. The species inhabits rocky and sandy beaches, coral reefs, sand cays and offshore islands. Birds rarely occur in inshore waters or near the mainland, usually venturing into these areas only accidentally, when nesting islands are nearby (Higgins & Davies 1996). Recorded approximately 4 km northeast of the Study Area. It is likely to occur within the Study Area but is unlikely to breed there (Biota 2022b).
Ruddy Turnstone (*Arenaria interpres*) - Migratory EPBC Act and BC Act	Yes	The Ruddy Turnstone occurs throughout the Pilbara coast, including many offshore islands. There are several internationally important non-breeding sites in Australia, mostly in north- WA, i.e., Barrow Island, Eighty Mile Beach, Ashmore Reef, Roebuck Bay and Lacepede Islands. Preferred habitats are coastal regions with exposed rock coast lines, coral reefs or tidal mud flats as well as saltworks ponds. It mainly forages between lower supralittoral and lower littoral zones of foreshores, from strand-line to wave-zone, including amongst banks of stranded seaweed, but are also known to forage on exposed rocky platforms, coral reefs and mudflat. It has been observed to roost on beaches above the tideline, rocky islets

Species EPBC or BC	Recorded within development envelopes?	Occurrence and significance of habitat
		amongst grassy tussocks, and on mudflats and sandflats (Phoenix, 2020b). Most of the Western shorebird area is included within the broader Exmouth Gulf shorebird area, which has been identified as an area of international importance for migratory shorebirds as it regularly supports more than 1% of the flyway population of Ruddy Turnstone (Weller et al. 2020). This species was recorded in all five phases of the migratory shorebird survey assessment for the Western shorebird area. A maximum count of 95 individuals in one flock was recorded (Biota, 2022c).
Sanderling (*Calidris alba*) - Migratory EPBC Act and BC Act	Yes	Sanderlings occur in coastal areas around Australia; in the Pilbara they are present along most of the coast from Mandora to Point Cloates, as well as some islands. Breeding birds migrate from the northern hemisphere arriving in Australia from September and departing by April; non-breeding birds are present all year. They inhabit mostly on open sandy beaches exposed to open sea swell, exposed sandbars and spits, shingle banks, and less often on more sheltered sandy shorelines of estuaries, inlets and harbours (Phoenix, 2020b). The Exmouth Gulf shorebird area supports nationally important numbers of Sanderling (*Calidris alba).* This species was recorded in all five phases of the migratory shorebird survey assessment for the Western shorebird area. A maximum count of 51 individuals in one flock was recorded (Biota, 2022c).
Sharp-tailed Sandpiper (*Calidris acuminata*) - Migratory EPBC Act and BC Act	Yes	The Sharp-tailed Sandpiper spends the non-breeding season in Australia. Most of the population migrates to Australia, mostly to the south-east and are widespread in both inland and coastal locations and in both freshwater and saline habitats. Scattered records occur along the Nullarbor Plain and the southern areas of the Great Victoria Desert. They are widespread from Cape Arid to Carnarvon, around coastal and subcoastal plains of Pilbara Region to south-west and east Kimberley Division. Inland records indicate the species is widespread and scattered from Newman, east to Lake Cohen, south to Boulder and west to Meekatharra (Higgins & Davies 1996). In Australasia, the Sharp-tailed Sandpiper prefers muddy edges of shallow fresh or brackish wetlands, with inundated or emergent sedges, grass, saltmarsh or other low vegetation. This includes lagoons, swamps, lakes and pools near the coast, and dams, waterholes, soaks, bore drains and bore swamps, saltpans and hypersaline salt lakes inland. They also occur in saltworks and sewage farms. They use flooded paddocks, sedgelands and other ephemeral wetlands, but leave when they dry. They use intertidal mudflats in sheltered bays, inlets, estuaries or seashores, and also swamps and creeks lined with mangroves. They tend to occupy coastal mudflats mainly after ephemeral terrestrial wetlands have dried out, moving back during the wet season. They may be attracted to mats of algae and water weed either floating or washed up around terrestrial wetlands, and coastal areas with much beachcast seaweed. Sometimes they occur on rocky shores and rarely on exposed reefs (Higgins & Davies 1996). This species was recorded in three of the five phases of the recent migratory shorebird survey assessment for the Western

Species EPBC or BC	Recorded within development envelopes?	Occurrence and significance of habitat
		shorebird area. A maximum count of four individuals in one flock was recorded (Biota, 2022c).
Southern Giant-Petrel (*Macronectes giganteus*) – Endangered/ Migratory EPBC Act and Migratory BC Act	No	The Southern Giant-Petrel is an oceanic species. It breeds Breeds in Antarctic and Subantarctic islands. May occur as far north as the study area. Recorded in the PMST report this species is considered unlikely to occur in the Study Area as there is no habitat available. Nearest NatureMap record is 300 km south of the Study Area at Carnarvon (Biota 2022b).
Streaked Shearwater (*Calonectris leucomelas*) - Migratory EPBC Act and BC Act	No	The Streaked Shearwater has a preferred habitat of Western seas south to 28º latitude. It breeds on sub-tropical islands of northwest Pacific. Recorded in the PMST Report, this species is however considered unlikely to occur as there is no habitat available in the Study Area. The nearest record is approximately 100 km NW of the Study Area on Barrow Island. Records also exist in the Carnarvon vicinity (Biota 2022b).
Terek Sandpiper (*Xenus cinereus*) – Migratory EPBC Act and BC Act	Yes	The Terek Sandpiper is a shorebird that inhabits coastal mudflats, sheltered estuaries and lagoons. In Australia, it has a primarily coastal distribution, with occasional records inland. It is more widespread and common in northern and eastern Australia including the Pilbara and Kimberley regions. The Exmouth Gulf shorebird area supports nationally important numbers of Terek Sandpiper (*Xenus cinereus*) (Weller et al. 2020). This species was recorded in two of the five phases of the migratory shorebird survey assessment for the Western shorebird area. A maximum count of 26 individuals in one flock was recorded (Biota, 2022c).
Wedge-tailed Shearwater (*Ardenna pacifica*) – Migratory EPBC Act and BC Act	No	The Wedge-tailed Shearwater breeds on islands off the WA coast. Recorded in PMST Report, however, this species is considered unlikely to occur as there is no habitat available in the Study Area. Previously recorded approximately 25 km NW of the Study Area in the Indian Ocean and at Serrurier Island (Biota 2022b).
Whimbrel (*Numenius phaeopus*) - Migratory EPBC Act and BC Act	Yes	The Whimbrel migrates from breeding grounds to several coastal areas around Australia, although it is more common in the north. It is common and widespread in WA from Carnarvon north to the north-east Kimberley. In the Pilbara it occurs along the mainland coast and several islands. This species inhabits mainly tidal mudflats and less frequently sandy beaches and saltworks ponds (but not hypersaline ponds) in the Pilbara. The Exmouth Gulf shorebird area supports nationally important numbers of Whimbrel (*Numenius phaeopus*) (Weller et al. 2020). Mangroves, which fringe large sections of the north and south arms of Urala Creek, and their smaller tributaries are a favoured roosting habitat for Whimbrel. Few shorebirds additionally forage within tall or dense mangrove areas aside from this species (Bamford Consulting Ecologists 2009). This species was also observed using the smaller areas of algal mat habitat to the west of Urala Creek for roosting close to high tide. Whimbrel were recorded in all five phases of the recent migratory shorebird survey assessment for the Western shorebird area and four of the five phases for the Ashburton River shorebird area. A maximum count of 23 individuals was recorded during the March phase (Biota, 2022c).

Species EPBC or BC	Recorded within development envelopes?	Occurrence and significance of habitat
White-tailed Tropic Bird (*Phaethon lepturus*) – Marine Migratory EPBC Act and Migratory BC Act	No	The White-tailed Tropic Bird is an oceanic species that breeds on offshore tropical islands. Recorded in PMST Report, however, this species is considered unlikely to occur as there is no habitat available in the Study Area. Previously recorded offshore north of Exmouth, some 60 km west of the Study Area (Biota 2022b).
White-winged Black Tern (*Chlidonias leucopterus*) - Migratory EPBC Act and BC Act	Yes	In WA, this species occurs predominantly on the northern and western coasts and coastal plains south of Busselton (Johnstone and Storr 1998). Habitat in the north includes shallow sheltered seas and estuaries. In the south this species typically inhabits freshwater lakes and swamps (Johnstone and Storr 1998). A total of 19 observations were recorded at two locations within the study area, on mudflat and beach habitat (Biota 2022b).
Eastern Yellow Wagtail (*Motacilla tschutschenis*) - Migratory EPBC Act and BC Act	No	The Eastern Yellow Wagtail has a preferred habitat of paddocks, marshes and grassy wetlands. Recorded in PMST Report however this species would not occur as there is no habitat available in the Study Area. Nearest record located approximately 500 km east of the Study Area at the Fortescue Marsh (Biota 2022b).

11.4.1.3.2 ASSESSMENT AGAINST CRITERIA FOR SIGNIFICANT SHOREBIRD HABITAT

This information has been sourced from Biota (2022) provided in Appendix S.

International and National Significance

The Western shorebird area and the Ashburton River shorebird area did not meet any of the criteria for international significance at the scale of the study area.

The Ashburton River shorebird area did not meet any of the three criteria for an area of national importance for migratory shorebirds. The Western shorebird area however meets all three criteria for an area of national importance for migratory shorebirds based on both shorebird diversity and overall shorebird abundance recorded during the current counts:

- Shorebird abundance (>2,000 individuals): met the criterion for abundance during one of the five phases of the Biota (2022) survey and based on previous count data from 2018;
- Shorebird diversity (15 or more species): met the criterion for diversity during four of the five phases of the Biota (2022) survey;
- Individual species (0.1% or more of the estimated flyway population of a species): meets the criterion for national importance for ten individual migratory shorebird species. There are six species for which the study area met this criterion during the current survey, which are outlined below. In addition, a further four species met this criterion during the BirdLife Australia counts conducted within the study area in January 2018:
    - Grey-tailed tattler (*Tringa brevipes*) – Biota and Birdlife Australia surveys;
    - Sanderling (*Calidris alba*) - Biota and Birdlife Australia surveys;
    - Red-necked stint (*Calidris ruficollis*) - Biota and Birdlife Australia surveys;
    - Ruddy turnstone (*Arenaria interpres*) – Biota survey only;
    - Curlew sandpiper (*Calidris ferruginea*) - Biota survey only;
    - Broad-billed Sandpiper (Limicola falcinellus) - Biota survey only;
    - Lesser Sand Plover (*Charadrius mongolus)* - Birdlife Australia survey only;
    - Greater Sand Plover (*Charadrius leschenaultii)* - Birdlife Australia survey only;
    - Eastern Curlew (*Numenius madagascariensis)* - Birdlife Australia survey only; and
    - Common Greenshank (*Tringa nebularia)* - Birdlife Australia survey only.

Regional Significance

A complete shorebird survey of the eastern Exmouth Gulf was not feasible during the Biota (2022) study. However, several previous large-scale shorebird surveys have been undertaken in the Exmouth Gulf (Biota 2005a, BirdLife Australia 2020), which provide some broader context for the counts obtained during the survey.

An indication of the coverage of the each of the surveys in included in Figure 6.1 of Appendix S, and total counts for the three surveys are included in Table 6.3 of Appendix S. The most extensive coverage was provided by Biota's shorebird survey for the proposed Yannarie Salt Project (Biota 2005a), with surveys covering the majority of the eastern and southern Exmouth Gulf, but with little overlap of the Biota (2022) study area. Hence, an approximation for the number of shorebirds using the eastern and southern Exmouth Gulf can be obtained by combining these two counts. It should be noted that these surveys were undertaken in different years, and as such these data do not reflect a true census of shorebird populations using Exmouth Gulf and provide an indicative estimate of the Gulf population only.

Using this method, the proportion of total shorebirds recorded in the Biota (2022) study area is approximately equivalent to the spatial proportion of the eastern Exmouth Gulf occupied by the study area. However, small species appeared to be proportionally more abundant in the Biota (2022) study area, with species such as Broad-billed Sandpiper, Curlew Sandpiper, Lesser Sand Plover and Red-capped Plover proportionally over-represented compared to overall counts. The most notable of these were Broad-billed Sandpiper and Curlew Sandpiper. Broad-billed Sandpipers were recorded on all four 'summer' surveys during the Biota (2022) study, with all records from Urala Creek North and surrounding overflow areas but was not recorded on any of the previous Exmouth Gulf surveys. It is possible that the numbers observed during the current survey represent an unusual influx to the area, or they may favour the Urala Creek North area, which was not surveyed on the three previous surveys. Alternatively, they are a small species and may be overlooked amongst Red-necked Stints or Red-capped Plovers from a distance, particularly in roosting flocks, or from aerial surveys.

Curlew Sandpipers are listed as critically endangered and were recorded on all five of the surveys during the Biota (2022). Total counts from previous surveys in the broader Exmouth Gulf region ranged from 0 to 35. The high count in March may indicate that the study area is used as a migratory staging point for birds migrating north from further south. It is possible that this usage extends more broadly within Exmouth Gulf but was missed on previous surveys which were not conducted during northward migration.

Conversely, large species such as Eastern Curlew, Whimbrel and Bar-tailed Godwit were proportionally under-represented in the Biota (2022) study area. Again, this may partly reflect variation in populations using Exmouth Gulf between years.

11.4.1.3.3 IMPORTANT HABITAT

During the shorebird survey, the largest abundance and diversity of shorebirds were observed using the bare intertidal flats habitat type, particularly the intertidal mudflats of Urala Creek North, followed by the sandy beaches, while small numbers were observed in the mangroves (likely roosting). The bare intertidal mudflats have been termed "transitional mudflats" to describe their transitional nature occurring in the transition zones between other habitat types. Important shorebird habitat types adjacent to the Proposal area have been identified as follows (Biota, 2022c):

- Bare intertidal mudflats (or transitional mudflats): Preferred foraging habitat for many migratory shorebird species and are generally regarded as one of the most important habitats for migratory shorebirds. Within the study area exposed intertidal flats were used primarily for foraging, though some roosting was observed on higher intertidal mudflat areas adjacent to Urala Creek when these were inundated at high tide. During the current survey, migratory shorebirds using the extensive intertidal mudflats in the Urala Creek system followed the tidal movements across the mudflats, foraging on the low intertidal mudflats within the creeks when these were exposed at low tide, then moving to the higher intertidal mudflats nearby as the tide rose. Observations indicated that during the day they foraged throughout the tidal cycle, roosting or loafing opportunistically, rather than gathering in large flocks to roost at high tide.

- Sandy beaches: Relatively high numbers of shorebirds were observed along the coastline between Urala Creek North and South, particularly around Tubridgi Point. The majority of birds observed on the beach were roosting in small flocks at high tide, though some foraging was also observed at the tideline. Fewer shorebirds were observed using the sandy beaches along the northern coast of the study area which is possibly less preferred for roosting due to the greater distance to high-quality intertidal foraging habitat such as mudflats.

Algal Mats and Freshwater Claypans may also provide foraging habitat to shorebirds when inundated, however inundation of these habitats was not observed during the Biota (2022c) survey.

The salt flats themselves are considered to have limited value to shorebirds given:

- The low frequency of flooding.
- High salinities resulting in inhospitable habitat for invertebrate fauna which act as a food source for shorebirds (Biota, 2022c).

11.4.1.4 IMPORTANT HABITAT FOR TERRESTRIAL VERTEBRATE FAUNA SPECIES

Important habitat for the above species consists of (Figure 120) (Biota, 2022b) (Biota, 2022c):

- Migratory shorebirds: Transitional mudflats are preferred foraging habitat (Rogers et al. 2011; Commonwealth of Australia 2017a) and sandy beaches are preferred roosting habitat (Biota, 2022c; Rogers et al. 2006; Zharikov and Milton 2009) (refer to Section 11.4.1.3.3). Mangroves, Algal Mats and Freshwater Claypans habitats may also be utilised for foraging and roosting (Mangroves only).
- Northern coastal free-tailed bat: Mangroves are the key important habitat this species which is a mangrove specialist species.
- Short-tailed Mouse: Records suggest that the primary mainland habitat comprises areas of native grassland, often associated with cracking clay and adjacent habitats, although this species has also been recorded from hilltops and *Cymbopogon* sp. grassland on sandy coastal areas near Onslow. It was previously recorded 5 km southeast and northeast of the study area (Biota, 2022b). Small patches of cracking clay were observed within the sand plain and clay loam plain habitat associated with the hinterland to the east of the Proposal area which could be suitable habitat for this species.
- Pilbara Olive Python: Gorges, escarpments, rocky outcrops and water holes are preferred habitat (DotE, 2018). It has been previously recorded adjacent to Ashburton River – Figure 118 (NatureMap, 2021). A review of surface geology mapping (Geoscience Australia, 2008), topography (Geoscience Australia, 2009) and aerial imagery indicates no rocky habitat is evident in the vicinity of the Proposal area or main access roads with the surrounding environment consisting of mudflat and sand/clay plains (Table 84 and Figure 120). A review of the NatureMap record shows that the recorded location along Ashburton River is at the existing Onslow Road crossing, where a thick band (approximately 50 m wide) of riparian vegetation exists and permanent water pools exist (Figure 118). The individual Olive Python recorded at this location is considered a vagrant, utilising riparian vegetation along the Ashburton River as cover/shelter, and hunting at permanent water pools. Given the obvious lack of rocky habitat, it is highly unlikely that Pilbara Olive Pythons would exist in the plains adjacent to the Ashburton River, although they could occur in low numbers along the riparian zone of the Ashburton River. The location of the Proposal bridge is ~3 km north of the thick riparian vegetation, does not contain a large or dense riparian zone (only a few trees) and does not have permanent water pools (Figure 119).
- Northern Quoll: Prefers open, rocky habitat and commonly utilises gorges, breakaways and hills, particularly for denning purposes. It also occurs near creek lines and drainage lines, where adjacent plains and vegetated areas provide habitats for foraging and dispersal of young (van Dyck and Strahan, 2008). It has been recorded about 3 km east of Ashburton River (NatureMap, 2021) (Figure 118). A review of the NatureMap record shows that the recorded locations are about 4 km east of the same band of thick riparian vegetation of the Pilbara Olive Python record (Figure 118). It is likely that the individuals recorded at this location use the riparian vegetation

along the Ashburton River to provide cover, shelter and food resources. Given the obvious lack of rocky habitat and other cover/shelter in the area, it is highly unlikely that a large population of Northern Quoll would exist locally, although they may occur along the riparian zone of the Ashburton River and forage in adjacent plains. The location of the Proposal bridge is ~3 km north of the thick riparian vegetation, does not contain a large or dense riparian zone (only a few trees) and does not have permanent water pools (Figure 119).

11.4.1.5 FERAL ANIMALS

A number of species of introduced animals are also present at the site including the following (Biota, 2022b):

- *Canis lupus* (Dog).
- *Vulpes vulpes* (Red Fox).
- *Felis catus* (Cat).
- *Equus caballus* (Horse).
- *Bos Taurus* (European Cattle).
- *Rattus rattus* (Black Rat).
- *Rattus tunneyi* (Pale Field-rat).
- *Mus musculus* (House Mouse).
- *Oryctolagus cuniculus* (Rabbit).

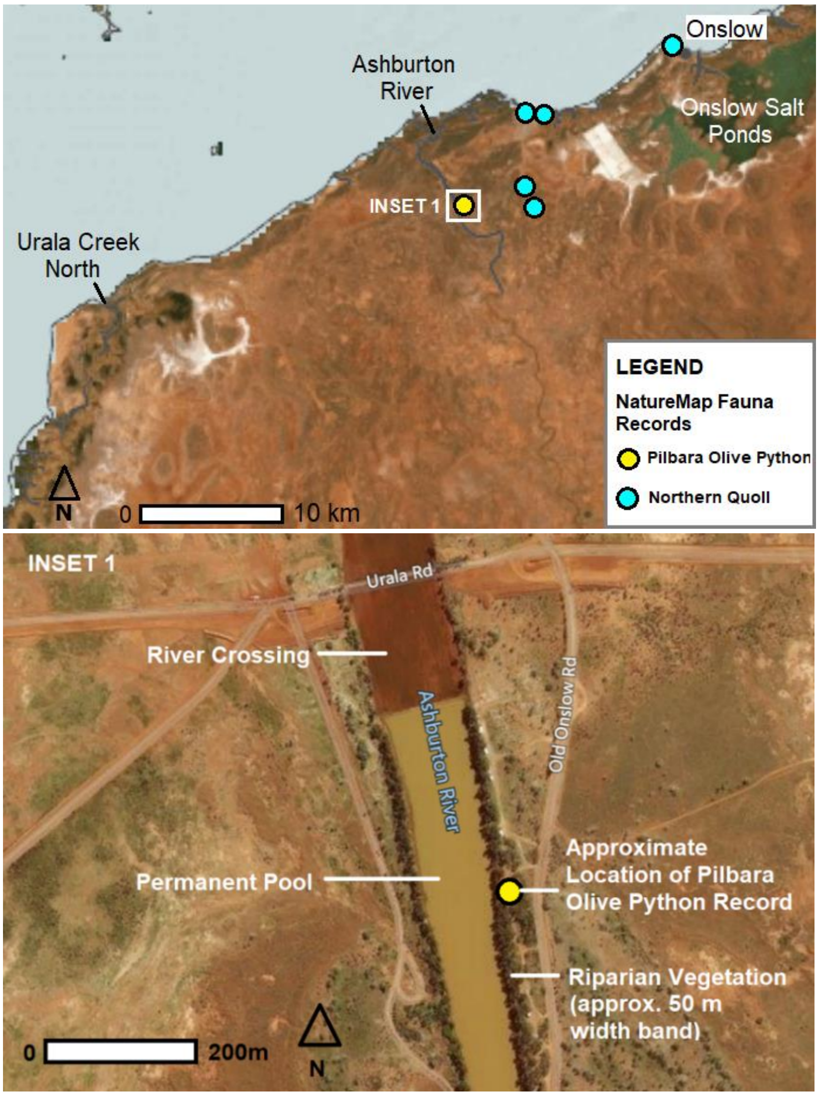


Figure 118: Records of Pilbara Olive Python and Northern Quoll Ashburton River
(NatureMap, 2021)

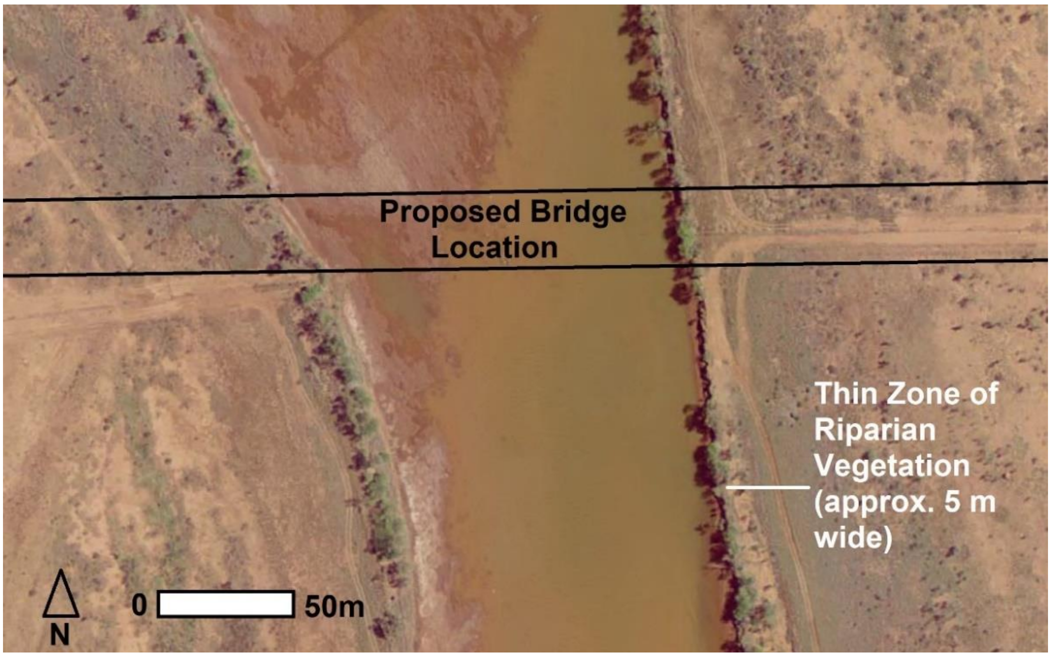


Figure 119: Location of Proposed Ashburton River Bridge with Thin Zone of Riparian Habitat

11.4.2 SHORT RANGE ENDEMICS

Short range endemic (SRE) sampling was included in the terrestrial fauna study conducted for the Proposal - Appendix S (Biota, 2022b).

11.4.2.1 POTENTIAL TERRESTRIAL SRE SPECIES

11.4.2.1.1 TERRESTRIAL SRE SPECIES RECORDED

Mygalomorph spiders and land snails were the only taxonomic groups recorded in the study area with the potential to include SRE species. Of the 12 invertebrate taxa collected during the survey, eight mygalomorph spider taxa from four families are considered to be potential SREs. The remaining taxa have been demonstrated to not be SREs (Biota, 2022b). Of these potential SREs, five are known solely from the study area, comprising: *Idiommata* sp. B38; *Conothele* sp. C26; *Conothele* sp. C27; *Aname* sp. N142; and *Aname* sp. N146. Although it is possible that these putative species exhibit highly localised distributions, they all occur on fauna habitats that are represented outside the study area. Additionally, the *Conothele* and *Aname* taxa occur in locations where analogous landscapes extend contiguously beyond the study area. Given this, it is unlikely that these taxa are restricted to the study area (Biota, 2022b).

11.4.2.1.2 IMPORTANT TERRESTRIAL SRE HABITAT

Although *Idiommata* sp. B38 was recorded on one occasion on an isolated mainland remnants “island” within the salt flats, the biogeographical history of the study area which was a connected mainland area during the evolution of this species and the distribution of other mygalomorph spiders in the study area indicate, that this taxon is likely to be widespread (Biota, 2022b). Nonetheless, isolated mainland remnants have been identified as potentially important habitat for mygalomorph spiders which are considered to be a potential SRE.

11.4.2.2 CLAYPAN INVERTEBRATE FAUNA

11.4.2.2.1 CLAYPAN INVERTEBRATE SPECIES

A Claypan Invertebrate Fauna Assessment was undertaken for the Proposal (Biota, 2021) – Appendix T. The assessment consisted of a desktop review and two opportunistic sample sites as there was no significant inundation events during the survey period. The desktop review identified 234 taxa, the majority of which comprised crustaceans, insects and rotifers. Previous work indicates that clear freshwater claypans and turbid freshwater claypans had distinct zooplankton and macroinvertebrate assemblages, but assemblages were similar between individual claypans within each of the two categories. A total of 33 claypan taxa are restricted to the Pilbara region based on available information, but most were widespread within the region. Six taxa were restricted to the Onslow locality, comprising five crustaceans and one rotifer:

- **Crustaceans**
    - *Eocyzicus* n. sp. (Class Branchiopoda, Family Cyzicidae);
    - *Ozestheria* [*Caenestheria*] n. sp. (Class Branchiopoda, Family Cyzicidae);
    - *Diaphanosoma* n. sp. (Class Branchiopoda, Family Daphniidae);
    - *Australimnadia multifasciata* (Class Branchiopoda, Family Limnadiidae); and
    - *Heterocypris* sp. PSW66 (Class Ostracoda; Family Cyprididae).
- **Rotifers**
    - *Lecane* n. sp. PSW031 (Class Monogononta, Family Lecanidae).

Overall, the desktop review indicated that the majority of claypan fauna likely to occur in the study area would be widespread taxa, but there is the potential for some range-restricted taxa, particularly crustaceans, to occur.

11.4.2.2.2 IMPORTANT HABITAT FOR CLAYPAN INVERTEBRATES

Claypans are a type of ephemeral wetland often found in arid or semi-arid regions of the world, which are flooded during rain events and dry up seasonally due to evaporation.

The fauna of claypans is usually dominated by either phyllopod crustaceans or opportunistic insects, which have developed specialised methods of coping with the unpredictability of these habitats.

Claypans are scattered through the southern and eastern parts of the study area, and on some of the supratidal mainland remnants occurring on the salt flats. Local claypans have been identified as an important habitat for invertebrate fauna.

11.4.3 LOCAL ENVIRONMENTAL VALUES

Local environmental values related to terrestrial fauna have been identified as local fauna habitat important to conservation significant fauna species including mangroves, bare intertidal / transitional mudflats, isolated mainland remnants and claypans.

These local values have been mapped overlayed by the Proposal in Figure 120 using GIS data from various Proposal studies (AECOM, 2022a), (Biota, 2022b), (Biota, 2022c) and (Biota, 2021).

11.4.4 REGIONAL ENVIRONMENTAL VALUES

Regional environmental values related to terrestrial fauna have been identified as regional fauna habitat important to conservation significant fauna species including mangroves, bare intertidal / transitional mudflats, isolated mainland remnants and claypans.

These regional values have been mapped overlayed by the Proposal in Figure 122 using GIS data from various Proposal studies (AECOM, 2022a), (Biota, 2022b), (Biota, 2022c) and (Biota, 2021) as well as publicly available GIS data regarding land systems (DPIRD, 2019).

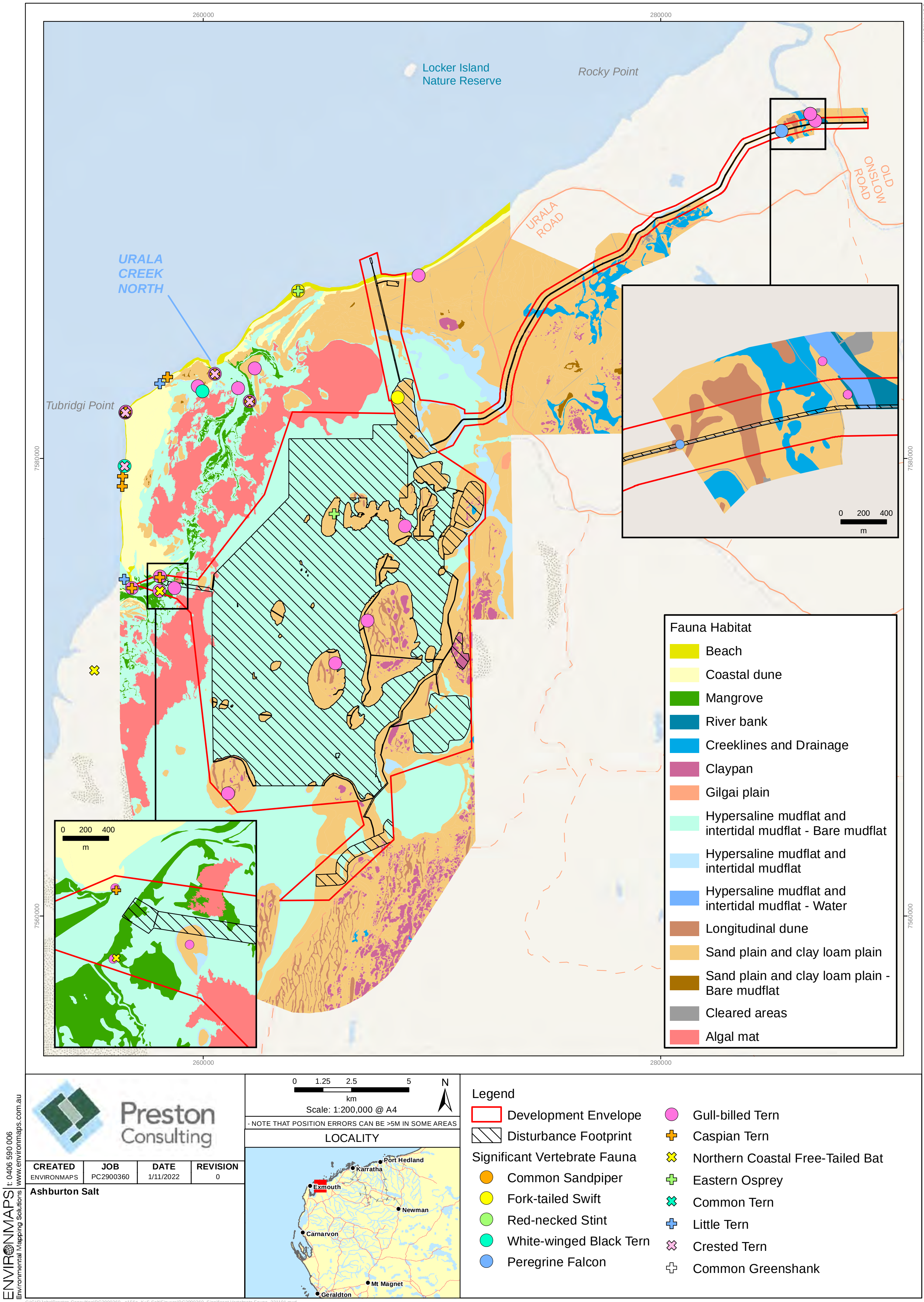


Figure 120: Local Values Terrestrial Fauna (note extent of coloured shading represents extent of survey area)

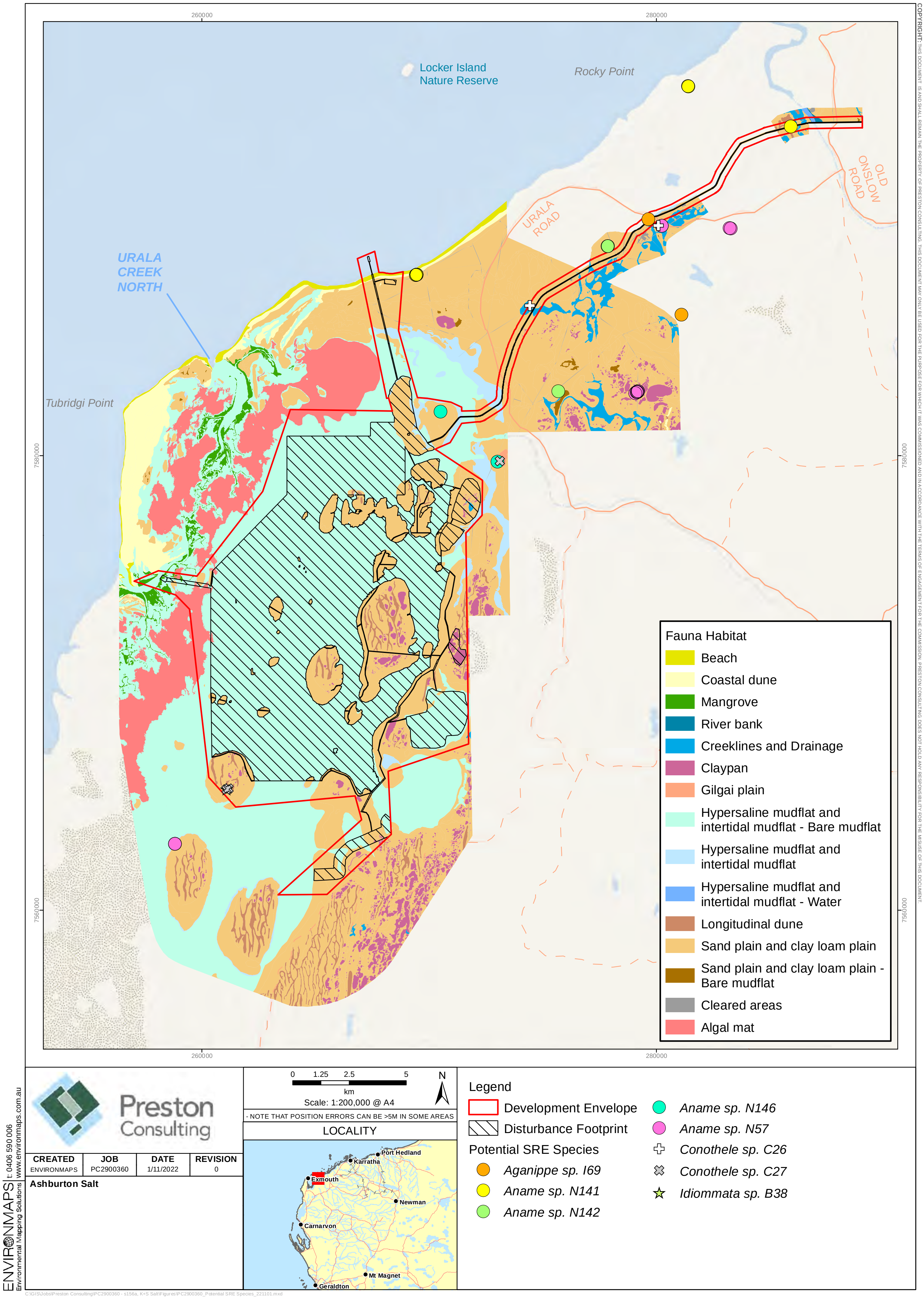
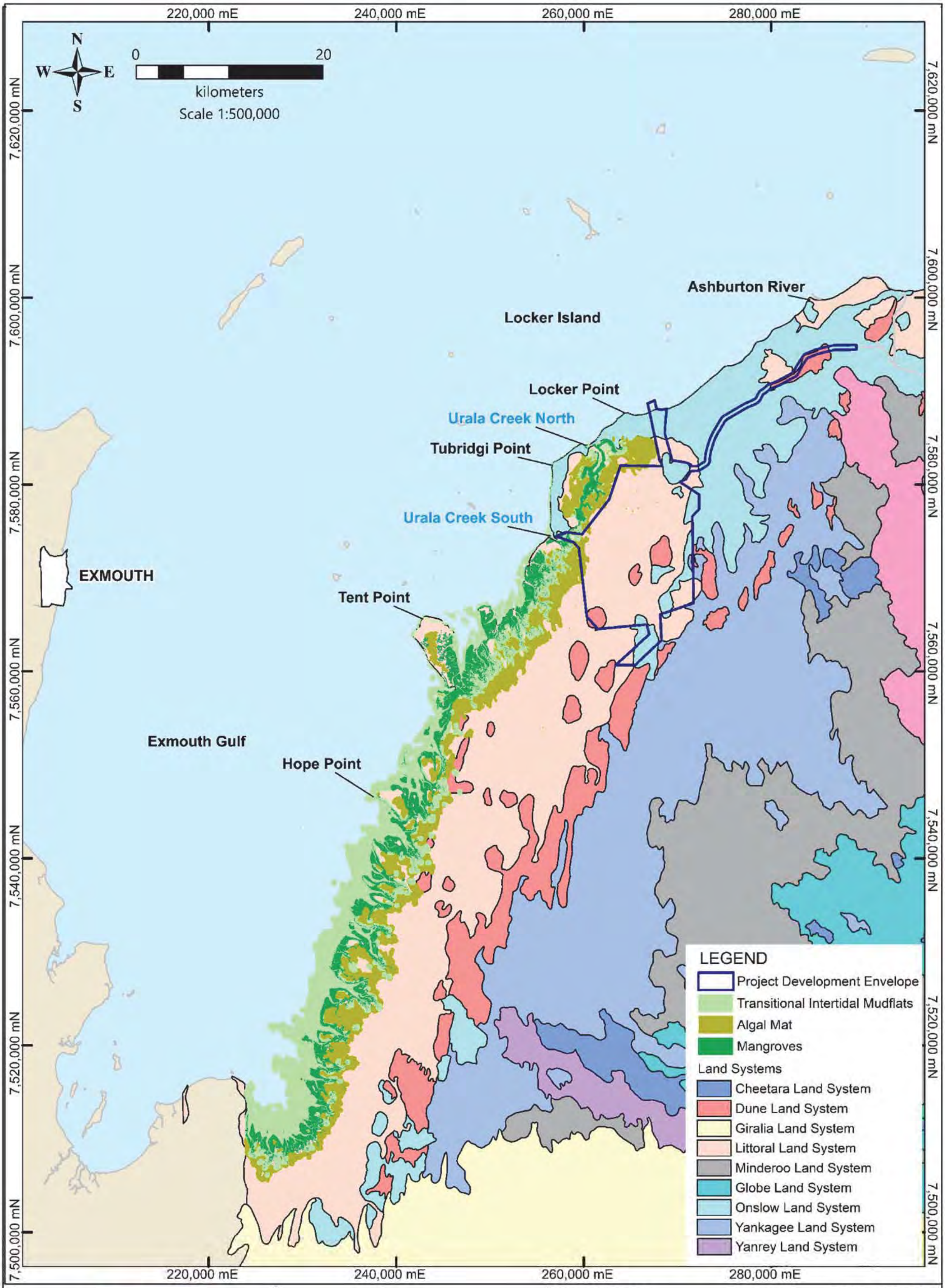


Figure 121: Local Values Potential SRE Species



Date: 25/09/2021	Paper: A4 P	GDA94, MGA50
Data Source: 4A, 4E, 13D, 17A		
File Info:K04_J10_PER_Regional_Terrestrial_Fauna_20210707		

Figure 122: Regional Values Terrestrial Fauna

11.5 POTENTIAL IMPACTS

The following potential impacts have been identified for this Proposal:

- Direct fauna habitat loss through clearing or pond filling.
- Direct mortality of fauna as a result of vehicle and/or equipment strikes.
- Indirect impacts to fauna through
    - Altered hydrological processes.
    - Habitat fragmentation.
    - Altered fire regimes
    - Feral fauna.
    - Behavioural changes due to noise and lighting.
    - Contamination due to leaching from acid sulfate soils or other contaminant spills.
    - Habitat creation

11.5.1 DIRECT IMPACTS

11.5.1.1 DIRECT HABITAT LOSS

The Proposal will result in direct loss of fauna habitat as summarised in Table 87. Included in this table are the following Proposal related direct impacts:

- Vegetation clearing.
- Permanent inundation within ponds.

Table 87: Terrestrial Fauna Habitat Direct Loss

Terrestrial Fauna Habitat Biota (2022b), (2022c), (2021) & AECOM (2022a)	Direct Impact (ha)	Local Area (ha) (see Note 1)	% of Local Area
ALL HABITAT			
Longitudinal dune	9.65	918	1.05%
Sand plain and clay loam plain	1,133.94	19,583	5.79%
Freshwater claypan	65.30	1,416	4.61%
Supratidal salt flats	10,613.75	26,665	39.80%
Mainland remnant island fringes	111.93	188	59.57%
Transitional mudflats	17.78	7,990	0.22%
Algal mats	12.77	6,199	0.21%
Mangroves	4.23	3,724	0.11%
Gilgai plain	-	24	0.00%
River bank / creekline /drainage	9.13	692	1.32%
Coastal dune	0.18	1,408	0.01%
Sandy beach	0.99	298	0.33%
Total	11,979.65	69,105	17.34%
SIGNIFICANT HABITAT AND ESTIMATED SIGNIFICANT FAUNA ABUNDANCE			
Mangroves: Northern Coastal Free-tailed Bat (Abundance Moderate), Roosting migratory birds (Abundance Low)	4.23	3,724	0.11%
Transitional mudflat: Foraging migratory birds (Abundance High)	17.78	7,990	0.22%
Sandy beaches: Roosting migratory birds (Abundance High)	0.99	298	0.33%
Ashburton riparian zone: Olive Python and Northern Quoll (Abundance Low)	0.53	266	0.20%
Plains along the Ashburton River: Foraging Northern Quoll (Abundance Low)	67.00	19,583	0.34%
Hinterland sand/clay plain: Short-tailed Mouse (Abundance Low – Moderate)	610.19		3.12%
Isolated mainland remnant islands: Mygalomorph Spiders (Abundance Low – Moderate)	751.05	5,715	13.14%
Algal mats: Foraging migratory birds (when inundated - abundance unknown)	12.77	6,199	0.21%
Freshwater claypans: Invertebrates (Abundance High After Flood), Foraging migratory birds (when inundated - abundance unknown)	65.30	1,416	4.61%
Total	1,517.07	38,992	2.59%

Table Note 1. For mangroves, transitional mudflats and sandy beaches, local area is Jetty to Tent Point, for Ashburton River local area is a 15 km radius around the proposed bridge, for other habitat types the local area is the Biota 2022b study area.

11.5.1.2 DIRECT MORTALITY

11.5.1.2.1 VESSEL AND EQUIPMENT STRIKE

The Proposal may lead to direct mortality of fauna. The most likely mortality is through vehicle and equipment strike. Vehicle and equipment strike is however likely to be rare given that:

- Vehicle speed limits will be set and enforced.
- There will be minimal vehicle traffic between ponds, jetty and coastal corridors, therefore risk of vehicle strike on fauna will be relatively low.
- Direct disturbance of significant fauna habitats such as mangroves, bare intertidal / transitional mudflats, sandy beaches and isolated mainland remnant “islands” have been minimised, with the majority of the disturbance (88.6%) occurring on unvegetated Supratidal salt flats, which provide minimal fauna habitat value.
- The Ashburton River crossing will be designed to allow fauna to pass underneath, minimising the likelihood of fauna crossing the road.

11.5.1.2.2 FAUNA ENTRAPMENT

Entrapment and collision associated with trenches, borrow pits and fences is considered unlikely given no trenches are required, borrow pit clearing will be commenced slowly in one direction allowing fauna to escape clearing activities and fencing will not be installed until the completion of construction and only around the administration and processing complex.

The concentrator and crystalliser ponds will have low embankments with shallow walls and therefore any fauna that enter the ponds are expected to be able to climb out. Mitigation measures are proposed to minimise entrapment (refer to Section 11.7).

11.5.1.2.3 COLLISION WITH POWER LINES

There is evidence of power lines presenting a collision risk for birds, with shorebirds at Rottnest Island having been observed colliding with overhead powerlines between salt lake foraging areas (Birds Australia 2010; Stevenson 2011). Power supply is to be provided by a third-party and does not form part of this Proposal, however the power line route will be inland from key shorebird habitats and therefore it is likely that shorebirds would only cross the power line route on rare occasions.

11.5.2 INDIRECT IMPACTS

11.5.2.1 HYDROLOGICAL PROCESSES

As described in Section 10.5.2.1, indirect impacts are predicted to the be localised around the ponds, due to saline groundwater seepage and associated salt crusting. As described in Section 13 hydrological impacts due to changes to rainfall related surface water flows are not expected to be significant given mitigation measures in place. If local claypans experience slightly more rainfall related flooding duration than previously this would likely benefit local invertebrate populations which rely on such flooding for survival. Some indirect impacts to intertidal BCH due to altered tidal movements have also been predicted as outlined Section 8.6.1. Therefore, the following terrestrial fauna habitat has been assessed as potentially indirectly impacted (Table 88):

- All habitat which occurs within predicted saline seepage and salt crusting zones (GHD, 2021c).
- All intertidal BCH predicted to be indirectly impacted altered tidal movements (AECOM, 2022a)

Table 88: Terrestrial Fauna Habitat Indirect Impact

Terrestrial Fauna Habitat Biota (2022b), (2022c), (2021) & AECOM (2022a)	Indirect Impact (ha)	Local Area (ha)[Note 1]	% of Local Area
ALL HABITAT			
Longitudinal dune	1.26	918	0.14%
Sand plain and clay loam plain	118.39	19,583	0.60%
Freshwater claypan	3.91	1,416	0.28%
Supratidal salt flats	20.19	26,665	0.08%
Mainland remnant island fringes	1.64	188	0.87%
Transitional mudflats	-	7,990	0.00%
Algal mats	3.92	6,199	0.06%
Mangroves	0.34	3,724	0.01%
Gilgai plain	-	24	0.00%
River bank / creekline /drainage	0.24	692	0.03%
Coastal dune	-	1,408	0.00%
Sandy beach	-	298	0.00%
Total	149.89	69,211	0.22%
SIGNIFICANT HABITAT AND ESTIMATED SIGNIFICANT FAUNA ABUNDANCE			
Mangroves: Northern Coastal Free-tailed Bat (Abundance Moderate), Roosting migratory birds (Abundance High)	0.34	3,724	0.01%
Transitional mudflat: Foraging migratory birds (Abundance High)	-	7,990	0.00%
Sandy beaches: Roosting migratory birds (Abundance High)	-	298	0.00%
Ashburton riparian zone: Olive Python and Northern Quoll (Abundance Low)	-	266	0.00%
Plains along the Ashburton River: Foraging Northern Quoll (Abundance Low)	-	19,583	0.00%
Hinterland sand/clay plain: Short-tailed Mouse (Abundance Low – Moderate)	116.85		0.60%
Isolated mainland remnant islands: Mygalomorph Spiders (Abundance Low – Moderate)	25.24	5,715	0.44%
Freshwater claypans: Invertebrates (Abundance High After Flood)	3.91	1,416	0.28%
Total	146.34	38,992	0.38%

Table Note 1. For mangroves, transitional mudflats and sandy beaches local area is Jetty to Tent Point, for Ashburton River local area is a 15 km radius around the proposed bridge, for other habitat types the local area is the Biota 2022b study area.

11.5.2.2 HABITAT FRAGMENTATION

Linear infrastructure and large developments have the potential to create a barrier effect within or between habitats which can divide fauna populations, prevent genetic transfer between populations and/or limit access to food and water resources.

11.5.2.3 FIRE

Changes in local fire regimes due to Proposal related anthropogenic sources, have the potential to cause direct mortality of fauna and impact local habitat values including shelter and food resource availability.

11.5.2.4 FERAL FAUNA

Changes to feral animal populations due to Proposal habitat modification can cause an increase in competition for resources and/or an increase in predation. Several feral animals were recorded in the study area including dogs, foxes and cats (Biota 2022b). The Proposal does not provide any significant vectors for increases in introduced fauna species; the accommodation camp will be relatively small, and there are no other Proposal activities that would either attract introduced fauna species or aid their survival in the area. With the implementation of mitigation measures the Proposal is not expected to result in additional feral species being introduced and may result in a reduction in the local feral animal population as a result of eradication programs (refer to Section 11.7.2).

11.5.2.5 CONTAMINATION

Soil contamination due to disturbance of ASS, or due to spillages of other potential contaminants (hydrocarbons, chemicals, salt product or bitterns) has the potential to lead to habitat loss or degradation. Seepage from the ponds is not expected to impact fauna habitat as only small amounts of seepage is predicted, and the groundwater is already hypersaline, therefore any seepage will either be less saline or generally equivalent to the current groundwater conditions (refer to Section 14 – Inland Waters for more detail).

A spill or leak of brine from the ponds or pipelines could result in impacts to the health of the surrounding fauna habitat. Brine is the resource for the Proposal and as such the concentrator and crystalliser ponds and brine pipelines have been designed to minimise the risk of leaks, overflows and wall breaches. Pipelines will utilise industry-standard materials to minimise the chance of leaks, and mitigation will be implemented to reduce this risk further (refer to Section 11.7). Ponds have been designed with adequate freeboard and overflow features to minimise the risk of unplanned overflows and wall breaches. If a spill was to occur, it may cause a reduction in the health of the downslope fauna habitat, however for the majority of the length of the downslope (western) walls the downslope habitat is Supratidal Salt flats, which are unvegetated and is a low value fauna habitat. These areas and their immediate surrounds are either already saline or have generally adapted to occasional saline conditions (such as during storm surge events). Brine would be expected to gradually dilute and wash away due to rainfall and freshwater and tidal inundation. The provision of drainage control and catch pits has been considered, but not adopted based on the additional clearing that would be required to manage the unlikely risk.

11.5.2.6 BEHAVIOUR CHANGES – NOISE AND LIGHT EMISSIONS

Noise can impact fauna although studies are limited and most fauna show an ability to adapt. This is considered a more significant issue for marine fauna and has been assessed under that factor separately. Lighting at night can attract shorebirds to invertebrates which are attracted to the light source.

Construction of the Proposal will result in relatively low levels of noise as most of the works will be conducted in narrow strips on soft mudflats (for the pond walls). Minimal night works are expected during pond construction given the difficult terrain.

The operation of the Proposal will result in low noise and light emissions overall as it relies on solar evaporation for the majority of the process. Noise and light emissions from the ponds are therefore unlikely to be significant enough to affect the behaviour of terrestrial fauna species.

The main source of noise and light emissions will be from the proposed salt wash plant, which covers only several hectares and is located immediately to the east of the crystalliser ponds. The Port is a simple narrow jetty structure that will export low volumes of product and not require significant lighting, apart from navigational aids. Lighting controls are proposed for the port area to minimise impacts to turtle nesting (refer to Section 9.7), and these controls will also minimise light impacts on shorebirds and other terrestrial fauna.

11.5.2.7 BEHAVIOUR CHANGES – FOOD WASTE

Inappropriate handling of food waste can attract fauna. Waste will be minimised by adopting the hierarchy of waste controls; avoid, minimise, re-use, recycle and safe disposal. Food wastes will be stored in bins that are not easily accessible to fauna and disposed of appropriately at the onsite landfill, which will be licenced under Part V of the EP Act.

11.5.2.8 HABITAT CREATION

The concentrator and crystalliser ponds will contain saline and hypersaline water, and as such they will not provide a fresh water source for terrestrial fauna. Nevertheless, shorebirds and other terrestrial fauna may be attracted and utilise the concentrator and crystalliser ponds. Shorebirds have been observed to use salt ponds as nesting, foraging and roosting nesting habitat, often preferring the ponds over nearby mudflats and occurring in great densities (Masero & Pérez-Hurtado, 2001; Rufino, 1984; Sadoul, 1998; Sampath & Krishnamurthy, 1989; Takekawa *et al.,* 2001; Velasquez, 1992, 1993; Warnock & PRBO Conservation Science). Indeed in the Pilbara, salt ponds are well known to provide important habitat for migratory shorebirds including the salt evaporation ponds that already exist near Onslow, Port Hedland and Dampier, with such salt ponds being listed as important habitats in *The National Directory of Important Shorebird Habitat* (BirdLife Australia, 2020).Houston *et al*. (2012) concluded after studying two salt fields associated with the Fitzroy River estuary, Queensland, that salt fields are "an integral component of the ecology of the landscape, providing complementary resources to that of the natural wetlands." It is likely that the Proposal if constructed will provide important new habitat for migratory shorebirds within the ponds.

11.5.3 CUMULATIVE IMPACTS

Predicted cumulative proportional impacts to terrestrial fauna habitat have been summarised in Table 89 as a percentage of:

- Habitat mapped within the study area (Figure 120).
- Habitat along the Eastern Exmouth Gulf (Figure 122).

A separate assessment of impacts to intertidal BCH for the West Pilbara Region is also presented in Section 8.6. Loss of significant fauna habitat is proportionally low locally and regionally and therefore impacts to significant fauna associated with these habitats (significant vertebrate fauna, potential terrestrial SRE species and claypan invertebrate species) are not likely to be significant on a local or regional basis.

Table 89: Proportional Cumulative Impacts to Terrestrial Fauna Habitat
Biota (2022b), (2022c), (2021), AECOM (2022a & 2022b) & DPIRD (2018)

Terrestrial Fauna Habitat	Direct Impact (ha)	Indirect Impact (ha)	Cumulative Impact (ha)	Local Area (ha) (Note 1)	Total Region (ha) (Note 1)	% Locally	% Regionally
ALL HABITAT							
Longitudinal dune	9.65	1.26	10.91	918	2,699	1.19%	0.40%
Sand plain and clay loam plain	1,133.94	118.39	1,252.33	19,583	181,427	6.39%	0.69%
Freshwater claypan	65.30	3.91	69.21	1,416	23,614	4.89%	0.29%
Supratidal salt flats	10,613.75	20.19	10,633.94	26,665	92,990	39.88%	11.44%
Mainland remnant island fringes	111.93	1.64	113.57	188	421	60.44%	27.00%
Transitional mudflats	17.78	-	17.78	7,990	20,747	0.22%	0.09%
Algal mats	12.77	3.92	16.69	6,199	11,617	0.27%	0.14%
Mangroves	4.23	0.34	4.57	3,724	11,742	0.12%	0.04%
Gilgai plain	-	-	-	24	No Data	0.00%	No Data
River bank / creekline / drainage	9.13	0.24	9.37	692	No Data	1.35%	No Data
Coastal dune	0.18	-	0.18	1,408	2,059	0.01%	0.01%
Sandy beach	0.99	-	0.99	298	1,040	0.33%	0.10%
Total	11,979.65	149.89	12,129.54	69,105	348,356	17.55%	3.48%
SIGNIFICANT HABITAT AND ESTIMATED SIGNIFICANT FAUNA ABUNDANCE							
Mangroves: Northern Coastal Free-tailed Bat (Abundance Moderate), Roosting migratory birds (Abundance Low)	4.23	0.34	4.57	3,724	11,742	0.12%	0.04%
Transitional mudflat: Foraging migratory birds (Abundance High)	17.78	-	17.78	7,990	20,747	0.22%	0.09%
Sandy beaches: Roosting migratory birds (Abundance High)	0.99	-	0.99	298	1,040	0.33%	0.10%
Ashburton riparian zone: Olive Python and Northern Quoll (Abundance Low)	0.53	-	0.53	266	580	0.20%	0.09%
Plains along the Ashburton River: Foraging Northern Quoll (Abundance Low)	67.00	-	67.00	19,583	181,427	0.34%	0.04%
Hinterland sand/clay plain: Short-tailed Mouse (Abundance Low – Moderate)	610.19	116.85	727.04			3.71%	0.40%
Isolated mainland remnant islands: Mygalomorph Spiders (Abundance Low – Moderate)	751.05	25.24	776.29	5,715	11,478	13.58%	6.76%
Algal mats: Foraging migratory birds (when inundated - abundance unknown)	12.77	3.92	16.69	6,199	11,617	0.27%	0.14%
Freshwater claypans: Invertebrates (Abundance High After Flood), Foraging migratory birds (when inundated - abundance unknown)	65.30	3.91	69.21	1,416	23,614	4.89%	0.29%
Total	1,517.07	146.34	1,663.41	38,992	250,628	4.27%	0.66%

Table Note 1. For mangroves, transitional mudflats and sandy beaches local area is Jetty to Tent Point and regional area is East Exmouth Gulf, for Ashburton River local area is a 15 km radius around the proposed bridge and regional area is a 30 km radius around the proposed bridge, for other habitat types the local area is the Biota 2022b study area and the regional area is East Exmouth Gulf.

11.6 ASSESSMENT OF IMPACTS

The area of fauna habitat that is likely to be impacted as a result of the Proposal is proportionally small when compared to the amount of similar fauna habitat in the surrounding areas consisting of approximately 17.6% of all habitat mapped locally and 3.5% of all habitat mapped on the Eastern Exmouth Gulf region.

Predicted impact to significant fauna habitat is also proportionally low locally around the Proposal area and regionally within Eastern Exmouth Gulf as follows:

- All significant habitat types: 4.27% locally and 0.66% regionally.
- Mangroves (important habitat for Northern Coastal Free-tailed Bat): 0.12% locally and 0.04% regionally.
- Sandy beaches (important roosting habitat for Migratory Birds): 0.33% locally and 0.1% regionally.
- Transitional mudflat (important foraging habitat for Migratory Birds): 0.22% locally and 0.09% regionally.
- Ashburton River riparian zone (important habitat for Pilbara Olive Python and Northern Quoll): 0.2% locally and 0.09% regionally.
- Plains along Ashburton River (potential foraging habitat for Northern Quoll): 0.34% locally and 0.04% regionally.
- Hinterland sand/clay plain (potential habitat for Short-tailed Mouse): 3.71% locally and 0.40% regionally.
- Isolated mainland remnant islands (potentially important habitat to mygalomorph spiders): 13.58% locally and 6.76% regionally.
- Freshwater claypans (important habitat to invertebrates): 4.89% locally and 0.29% regionally.

It is noted that direct and indirect impacts to important habitat for listed fauna species is considered significant. These impacts are summarised below:

- Northern Coastal Free-tailed Bat (Priority 1) – 4.57 ha of Mangroves habitat;
- Migratory Sea / Shorebirds (including Threatened Sea / Shorebirds) – 109.24 ha of known and potential habitat, including:
  - 0.99 ha of Sandy Beaches habitat;
  - 4.57 ha of Mangroves habitat;
  - 17.78 ha of Transitional Mudflat habitat;
  - 16.69 ha of Algal Mats habitat;
  - 69.21 ha of Freshwater Claypan habitat;
- Pilbara Olive Python – 0.53 ha of River bank / creekline / drainage habitat on the Ashburton River;
- Northern Quoll – 0.53 ha of River bank / creekline / drainage habitat on the Ashburton River and 67.00 ha of surrounding foraging habitat;

Hinterland sand/clay plain habitats utilised by the Short-tailed Mouse (Priority 4) (low – moderate abundance) are widespread and the Proposal is predicted to impact only 3.7% of the local extent of this habitat. This impact is therefore not considered to be significant,

Habitat for terrestrial SRE species (Isolated mainland remnant islands) are also widespread (5,715 ha local extent). Only one potential terrestrial SRE species was recorded within the development envelope. This species was also recorded outside the development envelope, which demonstrates that its local extent extends beyond the development envelope. Based on this, the potential impacts to terrestrial SRE species are unlikely to be significant.

Aquatic invertebrate habitats (Freshwater claypans habitat) are also widespread, and the Proposal is predicted to impact 4.9% of the local extent of these habitats. K+S acknowledges however that the claypans have not been extensively surveyed when inundated, and therefore there remains the potential for a species to be restricted to a portion of habitat that is intended to be disturbed. To avoid this risk K+S will undertake additional surveys within claypan areas when they are inundated prior to construction to confirm that there are no species restricted to the proposed disturbance areas (committed to in Section 11.7).

11.7 MITIGATION

11.7.1 AVOID

Impacts to fauna habitat have been avoided by placing most of the Proposal disturbance (salt ponds) on the bare salt flats which are devoid of vegetation and other valuable habitat features.

K+S will ensure that the Proposal avoids the local loss of any aquatic invertebrate species. K+S will commission additional aquatic invertebrate surveys of freshwater claypan habitat that intersects with proposed disturbance areas. These surveys will be conducted prior to construction during a period of inundation to ensure they obtain adequate results. If any aquatic invertebrate species are recorded as being restricted to only the proposed disturbance areas, then the freshwater claypan habitat(s) where the species was recorded will be avoided and alternate borrow sources will be found.

11.7.2 MINIMISE

The following mitigation measures and management plans are proposed to ensure that direct and indirect impacts to terrestrial fauna are minimised:

- Implement industry best-practice management measures for fauna:
  - Vegetation clearing will be managed through internal ground disturbance procedures;
  - Boundaries of areas to be cleared or disturbed will be identified by GPS coordinates and maps of boundaries will be provided to dozer operator;
  - Progressive clearing will be undertaken;
  - Raised blade disturbance will be conducted where practicable on tracks to minimise vegetation removal;
  - The disturbance footprint will be developed to the minimum required to ensure safe and adequate construction and operation;
  - Water or dust suppressants will be applied to disturbed areas and product transfer / storage areas as required to minimise dust generation;
  - Emergency response capabilities will be maintained to prevent fire outbreaks where possible;
  - Weed hygiene and management measures / procedures will be implemented to prevent spread of weeds and the introduction of new weed species as a result of construction and operation;
  - Feral animal controls will be implemented;
  - Pets will not be brought to site;
  - Utilise low noise equipment where available and suitable;
  - Pipeline trenches (if required) will be progressively opened and closed;
  - Fauna egress mechanisms will be installed at all trenches, turkeys nests or concentrator and crystalliser ponds;
  - The open portions of pipeline trenches will be inspected less than two hours after sunrise for the presence of trapped fauna;
  - Introduced fauna will be controlled around camps and other work areas and training will be provided to ensure that native or introduced fauna are not fed by site personnel;
  - Food wastes will be stored in bins that are not easily accessible to fauna;
  - Low noise equipment will be used where practicable;
  - All incidents resulting in fauna injury or death will be reported internally; and
  - Vehicle speed limits will be set and enforced, with lower limits imposed within shorebird habitat and potential Northern Quoll foraging habitat.
- Obtain and comply with the following approvals:
  - Ministerial Statement to be issued under Part IV of the EP Act;
  - Works Approval and Licence to be issued under Part V of the EP Act for solar salt manufacturing and bulk material loading;
  - Mining Proposal to be approved under the *Mining Act 1978*; and

- MCP to be approved under the *Mining Act 1978*. The MCP will describe the rehabilitation and closure of the Proposal, and associated management and monitoring proposed during the closure phase, An Interim MCP has been provided in Appendix BB;
- Develop and implement the WMP (Appendix BB)
- Develop and implement a BCH health monitoring program as described in Section 8. The monitoring is to be conducted over the life of the Proposal. If indirect impacts are noted to have occurred then investigate potential corrective actions, such as alterations of tidal or freshwater inundation flows;
- Verify inundation modelling results after construction to ensure potential indirect impacts to coastal habitats is within predicted outcomes (refer to Section 14.7);
- Conduct annual migratory shorebird surveys within the study area. The annual surveys will be conducted in a similar manner to the targeted survey conducted by Biota (2022c) and will provide information regarding long-term changes in the numbers, species and distributions of migratory shorebirds utilising the study area;
- Develop and implement a Migratory Shorebird Monitoring Program, including appropriate monitoring of shorebirds and management targets, as informed by the annual migratory shorebird surveys mentioned above;
- Record the usage of the concentrator and crystalliser ponds by fauna species. Incorporate these areas into the annual migratory shorebird survey if shorebird species are noted to utilise the ponds;
- Record any fauna entrapment within the ponds as an incident and review whether additional egress mechanisms should be installed;
- Concentrator and crystalliser ponds will be designed and constructed to be safe and stable according to DMIRS requirements;
- The following controls will be used to further reduce the risk of impact from unintentional brine pipeline spills:
    - Pipelines will be fitted with leak detection;
    - Water flows will be shut off if leaks are detected;
    - Pipelines will be inspected regularly, especially during extreme heat or fire events;
    - Pipelines will be located off access road surfaces;
    - If pipelines have to cross access roads, then they will be buried;
    - Investigations will be conducted into the cause of any spills, and remedial actions will be taken to minimise the chance of reoccurrence; and
    - Spills response training to mitigate damage for site-based personnel.
- Implement the Fauna Management Plan provided in Appendix BB.

11.7.3 REHABILITATE

At the completion of the Proposal the site will be rehabilitated to reinstate the terrestrial fauna. A MCP will be required under the *Mining Act 1978* for most of the Proposal At the completion of construction all temporary disturbance areas (which may include temporary laydown areas and the fringes of linear infrastructure corridors) will be rehabilitated in accordance with the MCP submitted to DMIRS for approval as required by the *Statutory Guidelines for MCPs under the Mining Act 1978* - DMIRS (2020b).

At the completion of operations, all buildings and structures on land will be removed from the site and the pond areas may be selectively reconnected to the existing tidal flat system. K+S preferred post closure land use is to leave the evaporation ponds in situ so that they become fauna habitat for shore birds (including migratory birds which require “wetland areas” for migratory stop over). If ponds are to be reconnected, the MCP will establish which bunds to breach that will enable inwards tidal movement bringing sediments and allowing tidal channels to expand naturally. Natural tidal flows will allow movement of mangrove plant and seed material which will passively revegetate the reconnected tidal areas. This will enhance the habitat values of the ponds post closure.

Selection of native species will ensure that only species which are present locally are used in rehabilitation activities and the aim will be to establish a self-sustaining ecosystem with similar biological diversity and ecological integrity to that which existed prior to Proposal implementation.

An Interim MCP for the Proposal has been provided in Appendix BB and will continue to evolve during the life of the Proposal. If the Proposal receives Ministerial Approval under Part IV of the EP Act as well as under the EPBC Act, the MCP will be developed in more detail and submitted to DMIRS for approval as required by the *Statutory Guidelines for MCPs under the Mining Act 1978* - DMIRS (2020b).

11.7.4 OFFSETS

Impacts to North-Western Free-Tailed Bat, Migratory Shorebirds, Pilbara Olive Python, Northern Quoll are considered significant, and offsets are proposed to counterbalance this impact. These offsets are discussed in Section 17.

11.8 PREDICTED OUTCOME

The EPA's environmental objective for this factor is to "protect terrestrial fauna so that biological diversity and ecological integrity are maintained". In the context of this objective: "ecological integrity" is listed as the composition, structure, function and processes of ecosystems, and the natural range of variation of these elements (EPA, 2016k).

The Proposal will result in the direct disturbance of 11,980 ha of terrestrial fauna habitat, however 10,614 ha (88.6%) of this is unvegetated Supratidal salt flats, which provide minimal fauna habitat value.

K+S has incorporated extensive avoidance and minimisation measures into the Proposal design and operational processes. A key measure was to focus the disturbance footprint on the unvegetated Supratidal salt flats, which has resulted in only 1,366 ha of vegetated fauna habitat disturbance being required for the Proposal.

The Proposal has also been designed to ensure that impacts to key fauna habitats are kept to a very small percentage of the local extent (all <6.4%). The Proposal is however predicted to result in the following residual impacts that are considered significant:

- 109.24 ha of confirmed and potential habitat for Migratory Shorebirds (including several Threatened species), including:
    - 0.99 ha of Sandy Beaches habitat;
    - 4.28 ha of Mangroves habitat (which also provides habitat for the North-Western Free-tailed Bat (Priority 1);
    - 17.78 ha of Transitional Mudflat habitat;
    - 16.69 ha of Algal Mats habitat;
    - 69.21 ha of Freshwater Claypan habitat;
- 0.53 ha of River bank / creekline / drainage habitat on the Ashburton River that provides potential habitat for the Pilbara Olive Python and Northern Quoll
- 67.00 ha of surrounding Northern Quoll foraging habitat;

Offsets are proposed to counterbalance these residual impacts. Broad-scale offsets are proposed to counterbalance the impacts to Good to Excellent quality native vegetation (refer to Section 17) and these offsets are to include $60,573 for impacts to River bank / creekline / drainage habitat on the Ashburton River and the surrounding Northern Quoll foraging habitat, based on the rates for the PEOF in the adjacent Roebourne sub-region (0.53 ha of higher rate and 67 ha of base rate). The Proposal is located in the adjacent Gascoyne Bioregion, hence the cost for recovery of the Roebourne sub-region was considered suitable. It is preferential that the offsets for the Project are within the same region, hence the PEOF was used for offset price estimation only.

The Proposal includes additional large areas of ponds that contain salts or brine and as such rehabilitation may be impeded for some time post-closure, although the majority of areas affected are salt pans that do not support vegetation. The Proposal is a long-life project with an infinite resource (seawater and solar energy) and therefore closure of the ponds may not occur this century, so consideration of altered ocean hydrodynamics and climate change will be necessary. Closure planning will continue through the life of the Proposal, with the purpose of refining the closure strategies already in the Interim MCP (Appendix BB).

Based on the above the Proposal is expected to be able to meet the EPA's objective for this factor. The implementation of the proposed mitigation and offsets is expected to minimise and counterbalance any significant residual impacts to terrestrial fauna or their habitats.

12 TERRESTRIAL ENVIRONMENTAL QUALITY

12.1 EPA OBJECTIVE

To maintain the quality of land and soils so that environmental values are protected.

12.2 POLICY AND GUIDANCE

- *Environmental Factor Guideline: Terrestrial Environmental Quality* (EPA, 2016o).
- *Acid Sulfate Soil Guideline Series: Identification and investigation of acid sulfate soils and acidic landscapes* (DER, 2015a)
- *Acid Sulfate Soil Guideline Series: Treatment and management of soils and water in acid sulfate soil landscapes* (DER, 2015b)
- *National Acid Sulfate Soils Guidance* (Water Quality Australia, 2018)
- *Draft Guidance: Materials Characterisation Baseline Data Requirements for Mining Proposals* (DMP, 2016).

12.3 RECEIVING ENVIRONMENT

12.3.1 TERRESTRIAL ENVIRONMENTAL QUALITY STUDIES

Studies to assess terrestrial environmental quality have been conducted as outlined in Table 90.

Table 90: Terrestrial Environmental Quality Studies

Report	Reference	Appendix
Marine and Coastal Assessment and Modelling	Water Technology, 2022b	A
Marine, Coastal and Surface Water Data Collection	Water Technology, 2021a	C
Acid Sulfate Soils Study	GHD, 2021a	K
ASSSMP	GHD, 2021b	BB
Materials Characterisation Study	GHD, 2021d	U
Memorandum Ashburton groundwater modelling-updated results	GHD, 2022	V
Hydrogeological Investigation	GHD, 2021c	W
Hydrogeology Modelling Peer Review	Cymod, Systems, 2022	X
Hydrogeology Modelling Peer Review	Cymod, Systems, 2021	Y

12.3.2 LAND USE

The Proposal area is situated on a region of intertidal/supratidal flats, with remnant islands and isolated sand dunes, on pastoral land associated with the Urala and Koodarrie Pastoral Leases. The Proposal area is predominately absent of any development, with the exception of an area to the northeast utilised by AGIG for the Tubridigi Gas storage operation which stores natural gas in underground geological formations. No existing anthropogenic sources of soil contamination have been identified within the Proposal area.

12.3.3 SURFACE GEOLOGY

The Proposal area encompasses eight geological units, mapped by the Geological Survey of WA and collated in Geoscience Australia (2008). Qe *Coastal silt and evaporite deposits; estuarine, lagoonal, and lacustrine deposits* is the dominant geological unit in the study area (Table 91) (Figure 125).

Table 91: Geological Units Occurring in the Development Envelope
(Geoscience Australia, 2008)

Unit	Geological Description
Czs	Sand or gravel plains; quartz sand sheets commonly with ferruginous pisolites or pebbles, minor clay; local calcrete, laterite, silcrete, silt, clay, alluvium, colluvium, aeolian sand
Qa	Channel and flood plain alluvium; gravel, sand, silt, clay, locally calcreted
Qd	Dunes, sandplain with dunes and swales; may include numerous interdune claypans; residual and aeolian sand with minor silt and clay; aeolian red quartz sand, clay and silt, in places gypsiferous; yellow hummocky sand
Qdc	Beach sand, sand dunes, coastal dunes, beaches, and beach ridges; calcareous and siliceous, locally shelly and/or cemented (beach rock); locally reworked
Qe	Coastal silt and evaporite deposits; estuarine, lagoonal, and lacustrine deposits
Qrc	Colluvium, sheetwash, talus; gravel piedmonts and aprons over and around bedrock; clay-silt-sand with sheet and nodular kankar; alluvial and aeolian sand-silt-gravel in depressions and broad valleys in Canning Basin; local calcrete, reworked laterite
Qt	Lacustrine or residual mud, clay, silt and sand, commonly gypsiferous and/or saline; playa, claypan, and swamp deposits; peat; peaty sand and clay; halitic and gypsiferous evaporites

12.3.4 SOILS

Atlas of Australian Soils mapping covers the Proposal area. Four soil units have been mapped across the Proposal Development Envelope (ASRIS, 2020). SV8 *Salt flats, tidal swamps, and coastal dune sands* is the dominant soil unit (Table 92, Figure 123).

Table 92: Soil Units Intersected by Proposal Development Envelope
(ASRIS, 2020)

Unit	Soil Description
Jw1	Low-lying coastal plains with some sand dunes: chief soils are saline clays (Uf1.41) on the flat to very gently sloping plains. Associated are (Ug5) and (Uf) soils along the inland margin of the plains; areas of saline muds (Um1) on slopes and flats submerged at high tide; and very small areas of calcareous sands (Uc1.1) and/or siliceous sands (Uc1.2) on coastal dunes.
My57	Extensive plains with parallel sand dune formations: chief soils of the plains are neutral red earths (Gn2.12) but there are also areas of acid (Gn2.11) and alkaline (Gn2.13) red earths with some hard red soils (Dr2.33) towards margins and around drainage lines. Chief soils of the dunes are red sands (Uc1.23) and (Uc5.21).
Oc58	Broad alluvial plains with a few claypans and red sand dunes; some areas of cracking clays along creek lines: chief soils are hard alkaline red soils (Dr2.33) and (Dr2.13). Associated are (Uf) soils in claypans; red sands (Uc1.23) on dunes; and areas of cracking clays (Ug5.38) along creeks. This unit grades northwards into unit Oc72.
SV8	Salt flats, tidal swamps, and coastal dune sands: chief soils are saline loams (Um1.3) and (Um1.4) with shelly sands (Uc1.11, Uc1.13). Small areas of calcareous earths (Gc) and shallow loams (Um) are associated with marls.

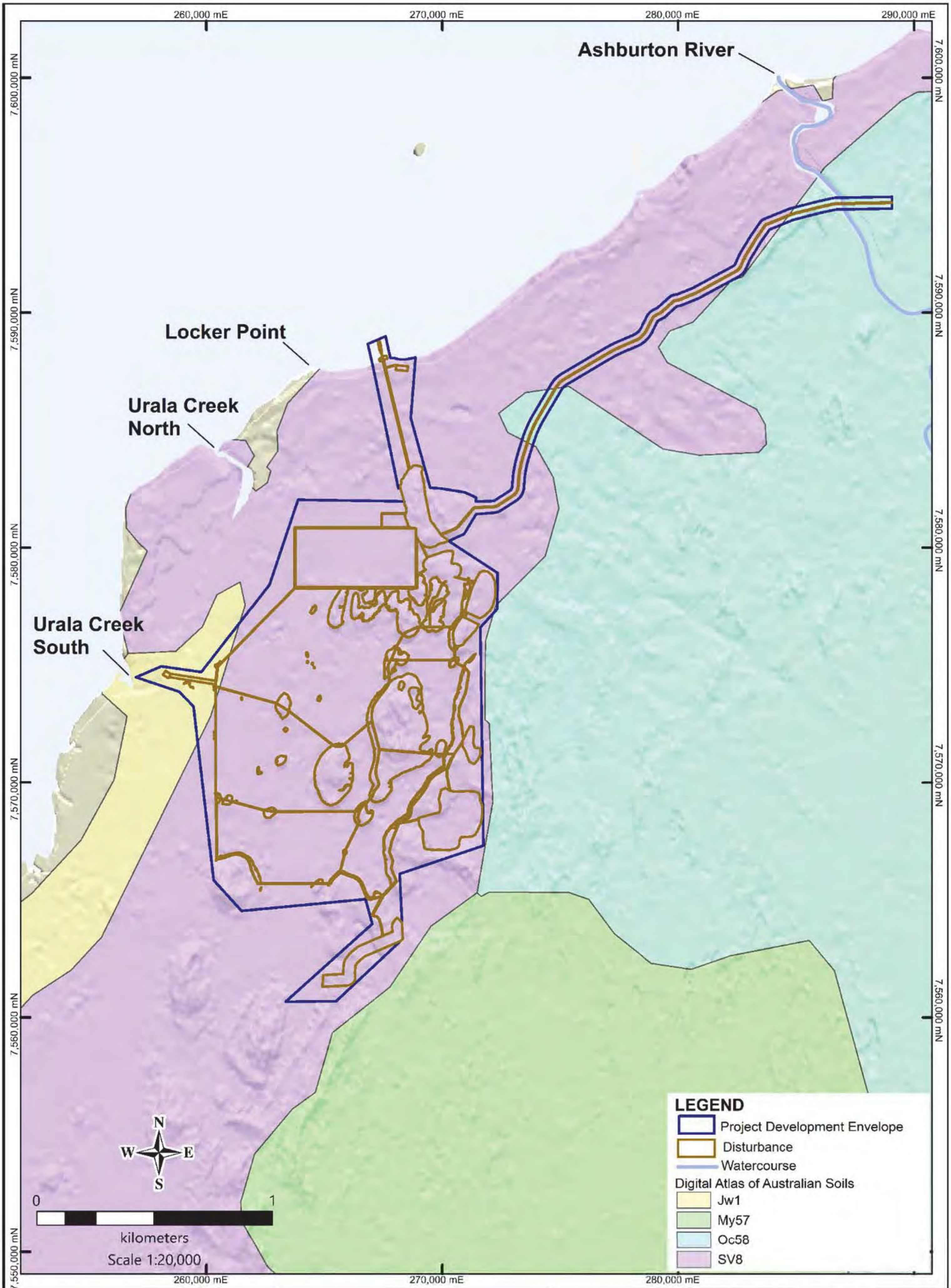


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Figure 123: Soil Types

12.3.5 SOIL RELATED RISKS

A Materials Characterisation Study identified risks related to geochemical and physical soil properties - Table 93 (GHD, 2021d).

Table 93: Soil Related Risks

Risk Type	Relevant Supporting Desktop Information	Likelihood
Environmental		
Acid Sulfate Soils	Proposal is located within an ASS risk area conducive to formation of sulfidic material (refer to Section 12.3.6	High
Saline Drainage	The geological setting (surficial sediments and tidal flats) indicates that elevated salts stored within the shallow geological profile is likely.	High
Sodic / Dispersive Material	The geological setting (surficial sediments and tidal flats) indicates that elevated salts stored within the shallow geological profile is likely, which may cause dispersive material	High
Acidic and or Metalliferous Drainage	The geological setting (surficial sediments) excludes the likelihood of sulphide derived from the weathering of basement rocks, which may form acidic conditions and mobilise metals.	Low
Workforce Health		
Heavy Metals	The geological setting (surficial sediments) indicates that metals, other than common rock forming metals (e.g., iron, manganese) are unlikely to be present at concentrations which may weather at concentrations to be a cause for concern.	Low
Fibrous Material	The geological setting (surficial sediments) excludes the likelihood of asbestos form minerals typically derived from the disturbance and exposure of basement rocks. However, silicate materials (e.g., quartz sediments) are indicated as present across the site.	High
NORMs	The geological setting (surficial sediments) is considered to exclude a radiological source (e.g., local basement granitic rocks), which may weather and be subject to mobilisation and concentration of NORMs at concentrations which may be a cause for concern. Although considered unlikely, sediments in the area may however contain naturally occurring heavy minerals (resistates) concentrated in channels systems, which may be elevated in minerals exhibiting radioactivity above generalised background concentrations.	Low / Moderate
Asbestiform Material	The geological setting (surficial sediments) excludes the likelihood of asbestos form minerals typically derived from the disturbance and exposure of basement rocks.	Low

12.3.6 ACID SULFATE SOILS

The Proposal site is located within an area of naturally occurring saline soils considered to be a consequence of primary salinity sources and is an ASSS environment. In this landscape generally, if the acid generating potential (oxidation of sulfides) exceeds the buffering capacity of the local landscape (alkalinity sources such as calcium carbonate), then acidification occurs. Additionally, disturbance (excavation, dredging and dewatering) of sulfidic materials may result in the leaching of sulfuric acids and further acidification of sulfides as well as potential liberation of other naturally occurring substances such as heavy metals (GHD, 2021a). A review of the ASS risk map of the Pilbara Coastline (Figure 124) (Australian Government, 2020) found that:

- The western portion of the site is located within an area classified predominately as 'High to moderate risk of ASS occurring within 3 m of natural soil surface (and beyond)', which may be disturbed by land development activities' and is associated with the lower lying portions of the site typically less than RL 5 m AHD and coinciding with the supratidal salt flats.
- Landside structures such as the NPI (wash plant, administration, buildings) and stockpiles are typically located on remnant dune sands 'islands' and are classified as 'Moderate to low risk of ASS occurring within 3 m of natural soil surface but high to moderate risk of ASS beyond 3 m of natural soil surface'.
- Linear infrastructure (main access road, conveyor) traverses multiple classification areas.
- The longitudinal sand dunes in the eastern portion of the site are not classified and assumed to present a negligible to low risk in regard to the presence of ASS (sulfidic material) (GHD, 2021a).

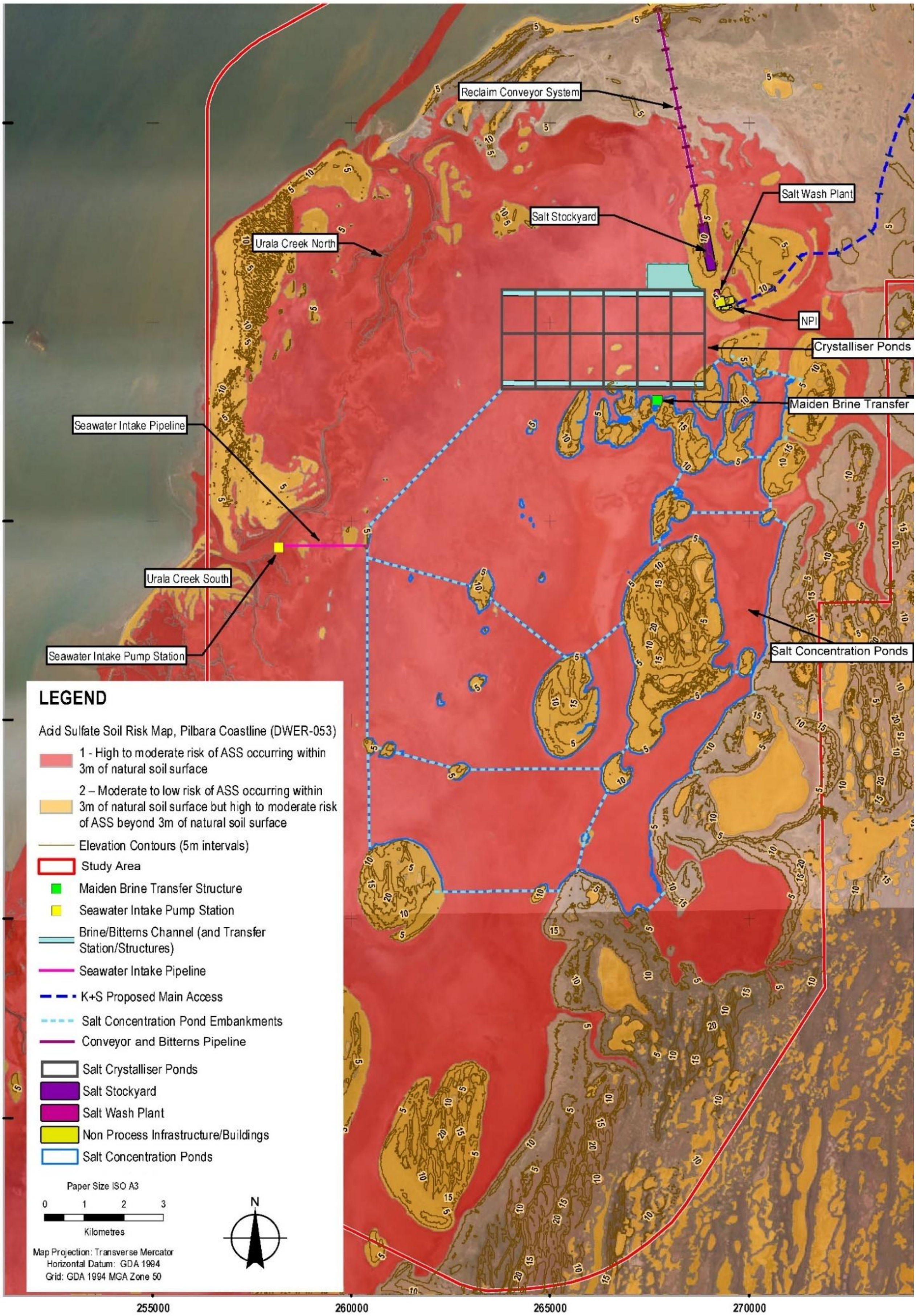

Figure 124: ASS Risk Map Pilbara Coastline - Proposal Landside Area

12.3.7 SITE SPECIFIC DATA

The site investigation regarding soils commenced on 28th October 2019 and finished on 31st March 2020. A total of 391 primary soil samples were collected throughout the Proposal area and selected samples submitted for NATA accredited laboratory analysis for soil properties including ASS, erosive materials, fibrous minerals, NORMs, heavy metals and topsoil availability. The results are summarised below (GHD, 2021a), (GHD, 2021d).

12.3.7.1 ACID SULFATE SOILS

Acid Sulfate Soils: pH Screening:

- pH_{LAB} (pH measured at the laboratory) values displayed limited variability between the samples submitted for analysis, with a population variance of 0.64 pH units. Of the samples submitted for pH screening the following were reported: maximum pH (field) of 9.9, minimum of 4.2 and average concentration of 8.5
- pH_{FOX} (pH measured in the field) values displayed limited variability between the samples submitted for analysis, with a population variance of 1.44 pH units. Of the samples submitted for pH screening the following were reported: maximum pH_{FOX} of 10.0, minimum of 2.0 and average concentration of 8.1
- Oxidised pH values were noted to be less than pH 4.0 and therefore indicative of potential acid sulphate soil (PASS) within four locations (BH03, BH05, HA12, HA19 and HA30) at variable depths (GHD, 2021a).

Chromium Reducible Sulfur Suite Analysis:

- The acid-based accounting indicated that net acidity (utilising CRS method) ranged between 670 mol H+ /t and less than the laboratory limit of reporting (i.e. 10 mol H+ /t).
- SPOCAS suite indicated slightly increased net acidity values likely due to the presence of organic sulfur forms within the sediment profile.
- ANC obtained during the standardised CRS and SPOCAS analysis program presented ANC values between 6.3 and 9500 mol H+ /tonne indicating a significant potential for neutralisation within soil and sediment fractions less than 2 mm. However, ANC calculations based on standardised methods are widely understood to significantly overestimate the buffering ability of material when subjected to laboratory procedures.
- Additional ANC analysis in the form of Total Inorganic Carbon (TIC) was completed on select sandy and silt soils within a particle size less than 0.5 mm to estimate the potential for natural buffering ability within materials particularly located within potential borrow areas and areas of excavation (GHD, 2021a).

Summary:

- The majority of the disturbance associated with infrastructure including NPI, stockyard and majority of the reclaim conveyor system will be located within the elevated regions of the site and on shallow foundations (less than 3 m depth). Typically, these higher elevated areas of the Proposal site are between 5 and 10 m AHD and consist of calcareous materials such as calcarenite gravel, coral and shells fragments and present a low risk of oxidation during disturbance. TIC analysis completed on the less than 0.5 mm fraction of samples collected indicates significant natural buffering ability would be available within the natural environment in the event of a minor acidification event.
- Sulfidic material was encountered within the supratidal flats and lower lying regions of the Proposal site. Infrastructure and assets located in these areas include the seawater intake, ponds (crystalliser and concentration ponds. The supratidal flats located at the site of the proposed Salt Processing Facility presented the highest net acidity values (670 mol H+/ t) and therefore the greatest risk of oxidation and acidification. Additionally, the material within the shallow soil profile (upper 1 m) presented no sufficient naturally available buffering capacity as ANC or the more conservative TIC (GHD, 2021a).

12.3.7.2 OTHER SOIL PROPERTIES

As described above in Table 93, other soil related moderate to high risks are saline drainage, sodic/dispersive material, fibrous (silicate) material and NORM. Studies of soils on site (GHD, 2021a), (GHD, 2021b) and (GHD, 2021d) found the following:

- Preliminary characterisation using static test data and the AMIRA (2002) Classification System indicated the soils analysed were Non-Acid Forming (NAF).
- Assessment of the material from within areas of disturbance indicates that in-situ materials may leach under circum-neutral to alkaline pH conditions.
- Soils within the supratidal flats are considered at risk of becoming dispersive under leached conditions due to the high concentration of sodium ions present.
- Soils sampled from supratidal flats and coastal dunes are considered non-sodic in nature and is likely attributed to a greater proportion of sand and silt in the samples analysed and unlikely to exhibit dispersive tendencies.
- Quaternary sediments consist of dense clayey sand and sandy clay. These clays have the potential to be sodic, and therefore dispersive.
- Although considered unlikely, sediments in the area may contain naturally occurring heavy minerals (resistates) concentrated in channels systems, which may be elevated in resistates exhibiting radioactivity above generalised background concentrations.
- Screening of heavy metals and metalloids in comparison to DGVs for Ecological Investigation Levels (EILs) available in the National Environmental Protection Measure (NEPC, 2013) indicated that exceedances of copper, nickel and zinc were recorded. The current concentrations of metals are likely to represent naturally occurring concentrations.

12.3.7.3 TOPSOIL / GROWTH MEDIA

Material sourced from remnant islands is the most likely to be suitable for topsoil or growth media during the closure phase of the Proposal. Additional soils which may be suitable for topsoil regrowth and include coastal dunes, alluvium deposits, longitudinal and network dunes over claypan-dominant terrain (GHD, 2021d).

12.3.8 LOCAL ENVIRONMENTAL VALUES

Local environmental values related to terrestrial environmental quality have been identified as local soil quality which exhibits:

- Lack of anthropogenic soil contamination.
- Several local soil types suitable for rehabilitation activities.

These local values have been mapped overlayed by the Proposal in Figure 125 using surface geology GIS data (Geoscience Australia, 2008).

12.3.9 REGIONAL ENVIRONMENTAL VALUES

Regional environmental values related to terrestrial environmental quality have been identified as Eastern Exmouth Gulf soil quality which exhibits lack of anthropogenic soil contamination.

Regional values have been mapped overlayed by the Proposal in Figure 135 using surface geology GIS data (Geoscience Australia, 2008).

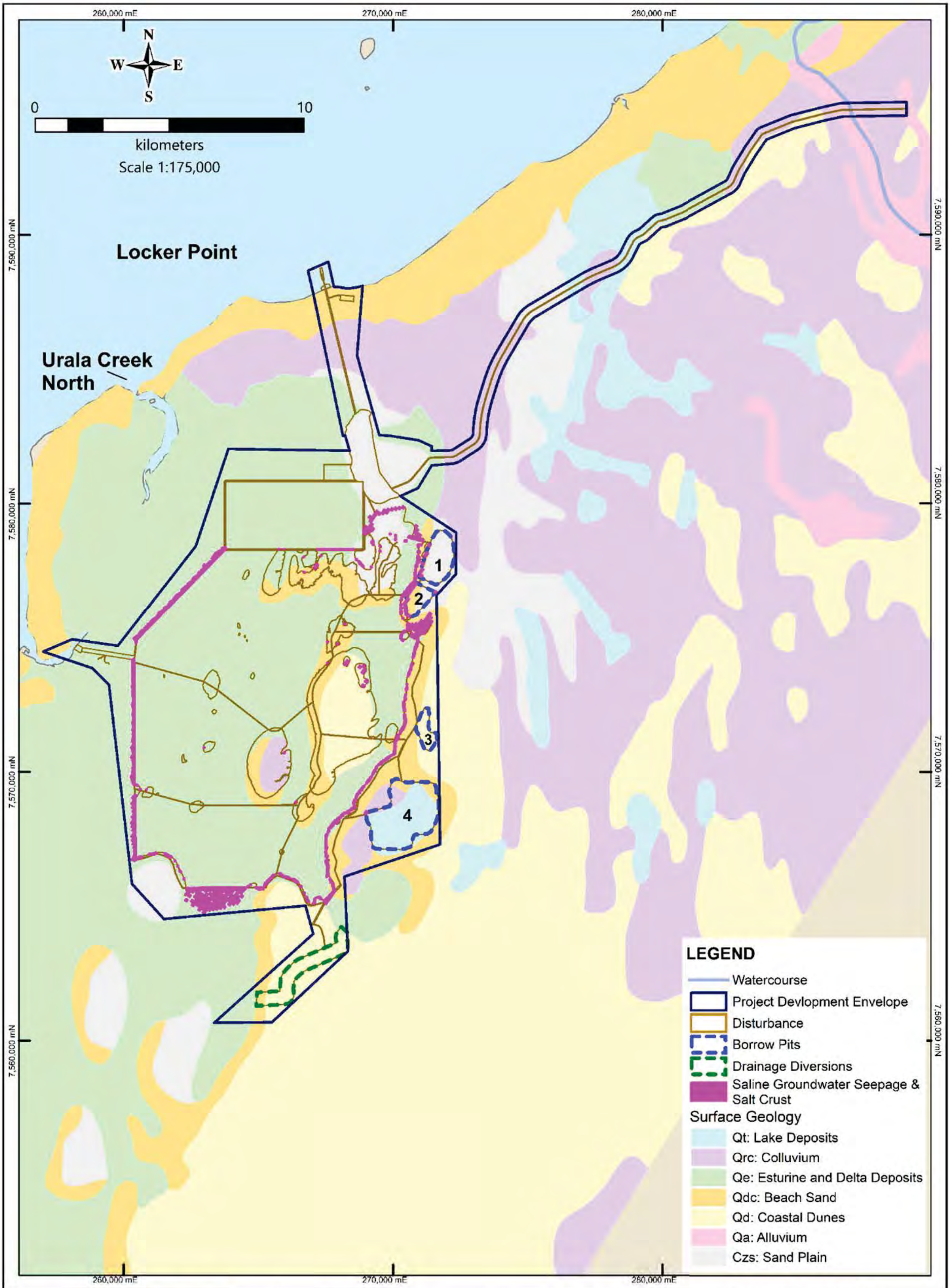

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Figure 125: Local Values Terrestrial Environmental Quality

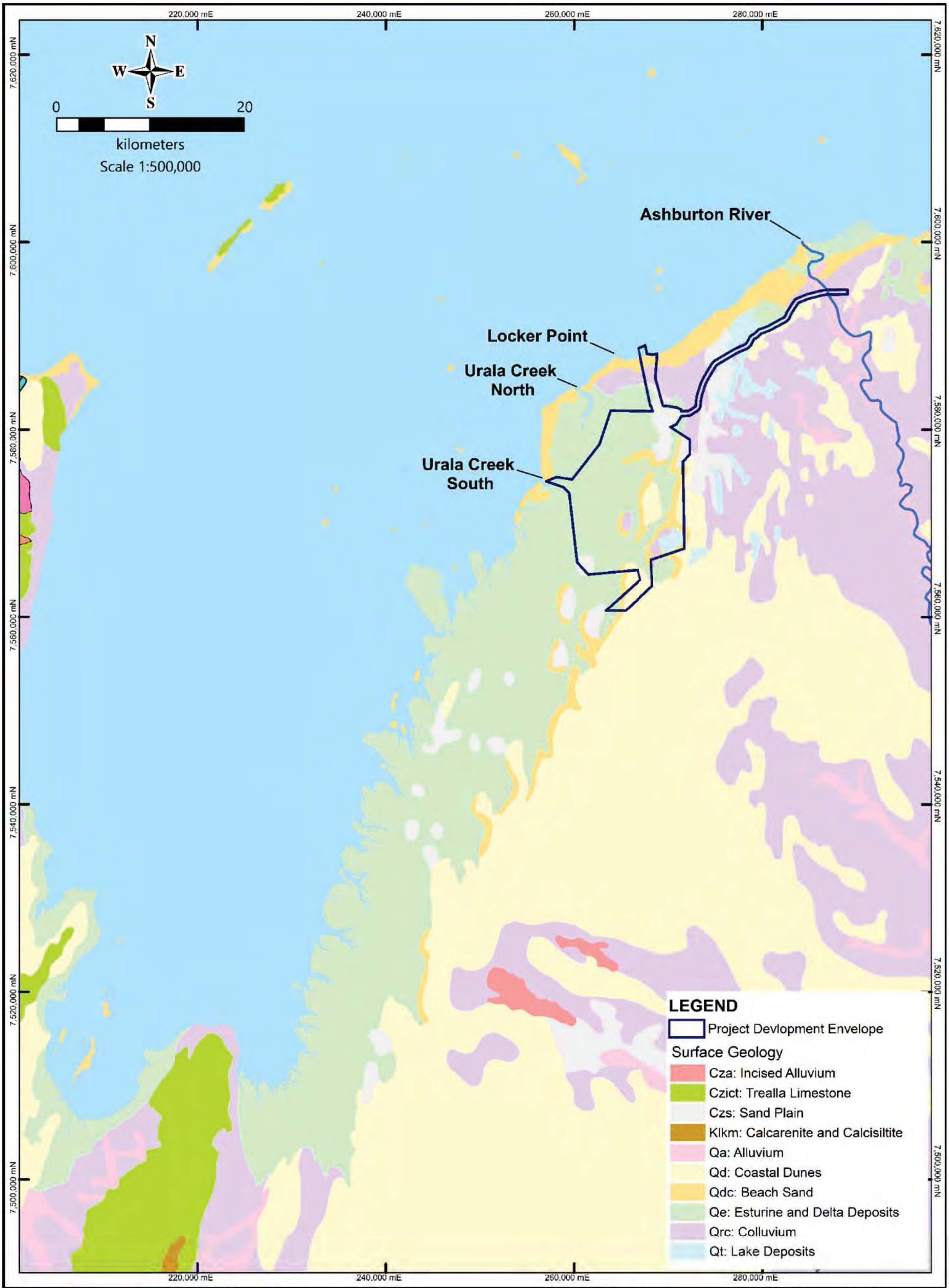

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Figure 126: Regional Values Terrestrial Environmental Quality

12.4 POTENTIAL IMPACTS

The following potential terrestrial environmental quality impacts have been identified as discussed in the sub-sections below:

- Direct impacts:
    - Spills and contamination.
    - Acid sulfate soils and sediment
- Indirect impacts
    - Saline groundwater seepage and associated salt crusting.
    - Potential Impacts of other naturally occurring soil properties including dispersive material, piping, erosive material, sodic material, topsoil/growth media, fibrous material, silicates, NORMs, heavy metals, metalloids, neutral drainage and saline drainage.

12.4.1 MODELLING

A hydrogeology modelling study (GHD, 2021c) was conducted to assess potential impacts of the Proposal regarding groundwater seepage and associated salt crusting.

12.4.2 MODELLING PEER REVIEW

A peer reviews of the above modelling was conducted. The peer review process was undertaken in a comprehensive, rigorous and iterative manner. It is the opinion of the peer reviewer that the groundwater model (GHD, 2021c) is fit for the purpose of assessing groundwater related environmental impacts of the Proposal (CyMod Systems, 2022).

12.4.3 DIRECT IMPACTS

12.4.3.1 SPILLS AND CONTAMINATION

During construction and operations there is the potential for accidental spills or inappropriate waste disposal to occur that may cause contamination of the terrestrial environment. Potential contaminants could include salt product, bitterns, hydrocarbons, dredge spoil/tailwater and general site wastes. With appropriate mitigation these impacts should not occur, therefore they are considered low risk. Spills and contamination will be prevented and mitigated through appropriate planning and management measures including the following management plans (Appendix BB) (K+S, 2021):

- DSMP.
- ASSSMP.
- WMP.

12.4.3.2 ACID SULFATE SOILS AND SEDIMENT

During the ASSS sampling program, sulfidic material was encountered on site within the supratidal flats, creek mudflats and lower lying regions of the Proposal area as well as the berthing pocket dredging location.

sulfidic material was encountered on site within the supratidal flats, creek mudflats and lower lying regions of the Proposal area as well as the berthing pocket dredging location. Table 94 below summarises areas of potential ASS risk and treatment required across the Proposal. An ASSSMP has been developed for the Proposal and is included in Appendix BB (GHD, 2021b).

Table 94: Summary of Proposal ASS Risk and Treatment Requirements

(GHD, 2021a)

Infrastructure	Excavation Required	Approx. Max. Depth of Excavation	Excavation Floor Depth mAHD	Estimated Amount of Material	ASS Risk Map Rating	Treatment Required (yes, no or specific comment)
Jetty Berthing Pocket	Dredging of Berthing Pocket	2.5 m of seabed	-7.2	17,000 m^3	N/A mapping – sampling indicates Moderate to High risk	Yes – marine sediment sampling indicates likely to be acid generating. Will be contained and treated in land disposal area.
Jetty	Piles	Assume driven with no spoil	N/A	Assume driven with no spoil	Low – Moderate	No – no excavation required.
Plant Site (NPI Infrastructure)	Shallow footings	3 m	1.1	Included in Borrow Pit A	Low – Moderate	No – elevated sandy island. ASS not identified at 6.5 m via sampling.
Borrow Pit 1	Excavation of construction material	6 m from highest point of island	0.8	10.6 million m^3	Low – Moderate	
Borrow Pit 2	Excavation of construction material	6 m from highest point of island	0.8	4.9 million m^3	Low – Moderate	
Borrow Pit 3	Excavation of construction material	2 m	2.0	1.3 million m^3	Low – Moderate	Likely to be acid generating at depth, however surface soils may have completed previous oxidation and leaching cycles resulting in lower risk or net acid generating potential. Further sampling will be conducted to confirm prior to excavation.
Borrow Pit 4	Excavation of construction material	2 m	1.0	9.8 million m^3	Low – Moderate	
Drainage Diversion A	Excavation of material for drainage diversion (to be used as fill)	2 m	5.5	330,000 m^3	Low - High	Likely to be acid generating at depth, however surface soils may have completed previous oxidation and leaching cycles resulting in lower risk or net acid generating potential. Further sampling will be conducted to confirm prior to excavation.
Drainage Diversion B	Excavation of material for drainage diversion (to be used as fill)	2 m	6.0	21,000 m^3	Low - High	
Drainage Diversion C	Excavation of material for drainage diversion (to be used as fill)	2 m	8.0	104,000 m^3	Low - High	
Evaporation Ponds External Walls	Excavation to “key” walls into clay layer	10 – 20 cm	0.75	N/A surface only	Moderate – High	Yes – materials will require confirmatory testing to ascertain acid generating potential prior to re-use.
Crystalliser Ponds External Walls	Excavation to “key” walls into clay layer	10 – 20 cm	0.65	N/A surface only	Moderate - High	
Bitterns Pond External Walls	Excavation to “key” walls into clay layer	10 – 20 cm	0.55	N/A surface only	Moderate - High	
Seawater Intake Channel	None – assumed built on top of mudflat	N/A	N/A	N/A	Moderate – High	No – no excavation required.
Seawater Intake Inlet Well and Pump Station	Excavation of creek bank required for inlet well	3 m	-2.04	Up to 20,000 m^3	Moderate - High	Yes – creek sediment sampling indicates likely to be acid generating. Will be contained and treated within intake channel.

12.4.4 INDIRECT IMPACTS

12.4.4.1 SALINE GROUNDWATER SEEPAGE AND SALT CRUSTING

A numerical groundwater model was used by GHD (2021c) to simulate the key hydrogeological processes of the Proposal area. The key issue simulated by the modelling was the potential for seepage from the salt ponds to migrate and impact on the receiving environment. The nature of interaction between the salt ponds and groundwater is due to hydraulic, salinity (concentration) and density effects which vary over time. Modelling indicates that seepage and subsequent evaporation of seepage water expressed at ground level has the potential to form a crystallised salt layer (salt crust) on the ground surface on localised areas immediately next to the pond levees and some islands within the ponds.

GHD (2021c) groundwater model outputs have been used to map all areas which may be impacted by saline seepage and salt crusting due to the Ashburton Salt Ponds. Predicted areas of saline seepage and salt crusting are small and localised (restricted to the perimeter of the ponds and some of the islands within the ponds) (Figure 125).

Saline seepage and salt crust will have no credible impact to salt flat areas which already have a thick salt crust due to naturally occurring saline seepage and evaporation as outlined in Section 8.5.3.3.

The impacts of saline seepage and salt crust to terrestrial vegetation, BCH and fauna habitat have been assessed separately under Sections 8.6.1, 10.5.2.1 and 11.5.2.1. In summary these impacts are proportionally small and localised with the following areas predicted to be affected (AECOM, 2022a) (Biota, 2022a) (Biota, 2022b):

- 3.92 ha of algal mat (0.14% of algal mat of East Exmouth Gulf).
- 2.28 ha of samphire (0.6% of samphire in West Pilbara).
- 119 ha of acacia shrubland/woodland (0.7% of similar vegetation in the study area).
- 3.91 ha of claypan (0.017% of claypan of East Exmouth Gulf).

12.4.4.2 OTHER NATURALLY OCCURRING SOIL PROPERTIES

A Materials Characterisation Study (GHD, 2021d) identified naturally occurring geochemical and physical soil properties which may have environmental or employee health impacts and made recommendations for management. Potential naturally occurring soil properties considered as summarised in Table 95 include:

- Dispersive material
- Piping
- Erosive material
- Sodic material
- Topsoil/growth media
- Fibrous material
- Silicates
- NORMs
- Heavy metals and metalloids
- Neutral or saline drainage.

Appropriate management of these soil properties during construction and operations will be documented and approval sought under other regulatory processes as follows:

- Mining Proposal and MCP to be submitted to DMIRS in accordance Statutory Guidelines for Mining Proposals (DMIRS, 2020a) and Statutory Guidelines for MCPs (DMIRS, 2020b). An Interim MCP (Appendix BB) has been developed and will continue to evolve during the life of the Proposal.

Table 95: Potential Impacts of Soil Properties and Recommended Management
(GHD, 2021d)

Material Type	Issue	Recommendation
Dispersive Material	Soils within the supratidal flats are considered at risk of becoming dispersive under leached conditions due to the high concentration of sodium ions present. These materials would be unsuitable for placement on the outer surface of constructed landforms (bunds) or any slopingsurface. Left undisturbed, these soils are unlikely to be dispersive.	Do not place any material from the supratidal flats (geologicalunit Qt) on the outer surface of constructed landforms.
Piping	Materials with high dispersibility and high permeability are most susceptible to piping). Soils within the supratidal flats are considered at risk of becoming dispersive. If placed onthe outer surface of a constructed landform, these soils may be at risk of piping due to the presence of dispersible clay and silt. Left undisturbed, these soils are unlikely to be dispersive.	As above.
Potentially Dispersive Material	Soils within the intertidal flats, mangrove swamps and claypans are considered at risk of becoming dispersive under leached conditions. These materials may be unsuitable for placement on the outer surface of constructed landforms (bunds) or any sloping surface. Left undisturbed, these soils are unlikely to be dispersive. Dispersion, a term used to describe the breakdown of clay particles into solution, is dependent uponthe interaction between sodicity, measured as Exchangeable Sodium Percentage (ESP) and salinity, measured as EC. When ESP >6 the material is sodic and potentially dispersive. The dispersion potential is quantified by the EC value.	Prior to disturbance and use in construction or rehabilitation, the following materials require further testing to confirm ESP/EC: • Intertidal Flats and Mangrove Swamps (geological unit Qw). • Claypans (geological unit Qp). Classification of these materials' dispersion characteristics should be undertaken. Only materials classified as having low dispersion risk should be placed on the outer surface ofconstructed landforms.
Erosive Material - Susceptible to Wind Erosion	The coastal dunes (Qs) are formed of unconsolidated sand and average 3m in height, but can range to a maximum height of 6 m to 7 m. In the northof the site, near the proposed jetty, the dunes are typically 500 m wide, immobile, and are generally sparsely vegetated with spinifex. Landside of the proposed jetty (BH03) the dune is characterised as extending to 7 m AHD. Observations of the surface and shallow subsurface profile presented calcareous sand with an abundance of coral, shells fragments and calcarenite gravels ranging between fine gravels to larger cobbles and occasional boulder sized particles. Disturbance of the coastal dune to construct the conveyor embankment connecting to the jetty could expose areas of the dune to wind erosion.	Appropriate erosion protection is recommended in the coastal dunes (geological unit Qs) at the site of the conveyor and jetty,such as rock armouring and dune revegetation.
Erosive Material – Susceptible to Water Erosion	Within the inland longitudinal and network dunes over claypan (geologicalunit Czp) there is up to 55% clay content, balanced by fine to medium grained quartz. The material is un-cemented with traces of fine to coarsegrained calcrete gravel. This material may not be suitable for placement on sloping surfaces due to high clay content which could facilitate water erosion.	Further testing of erosion potential of this material (geologicalunit Czp) should be conducted before any disturbance. If proposed to be used in construction or rehabilitation, it should only be placed on sloping surfaces if erosion risk is classified as low after testing.
Sodic Material	Quaternary sediments (geological unit Qsed) consist of dense clayey sand and sandy clay. These clays have the potential to be sodic, andtherefore dispersive.	Further testing of erosion potential of this material (geologicalunit Qsed) should be conducted before any disturbance. If proposed to be used in construction or rehabilitation, it should only be placed on sloping surfaces if sodicity and dispersion risk is classified as low after testing.

Material Type	Issue	Recommendation
Topsoil / Growth Media	Selection of topsoil and suitable growth media should take into consideration susceptibility to erosion (i.e. piping and dispersion) and other factors that may be prohibitive to plant growth. The following geological units within the Proposal area may be potentially suitable astopsoil/growth media: • Qs – coastal dune • Qe – mainland remnants • Cza – alluvium • Czp – longitudinal and network dunes over claypan • Qsed – quaternary sediments	Selection of topsoil and suitable growth media should take into consideration susceptibility to erosion (i.e. piping and dispersion) and other factors that may be prohibitive to plant growth such as high salinity as measured through EC/TDS andtoxicity (e.g. ASS, PASS and heavy metal toxicity typically under acidic conditions).
Fibrous Material - Silicates	A generic silicates assay has been conducted on select geological units proposed to be disturbed. Analysis identified significant quarts content inall samples presented values up to 71%, with minerals susceptible to fibrous crystal habit confined to clays/micas.	Further assessment of potential dust and workforce inhalationairborne particles should be undertaken prior to ground disturbance works. Dust suppression measures should be implemented in accordance with an appropriate CEMP during construction phase to minimise the risk of workers inhaling and ingestion of air borne particles. Appropriate dust management and monitoring will be implemented as per the CEMP and Operations Environmental Management Plan (OEMP).
NORMs	Although considered unlikely, sediments in the area may contain naturally occurring heavy minerals (resistates) concentrated in channel systems,which may be elevated in minerals exhibiting radioactivity above generalised background concentrations. Whilst these channel systems are not proposed to be excavated or disturbed as part of the Proposal, borrow pits for clay located within claypans could potentially contain such resistates due to receiving material from channel systems.	Borrow pits within claypans and drainage diversions should be further assessed prior to disturbance. Testing of material from any borrow pits within claypans (geological unit Qp) and drainage diversions for NORMs should be conducted and if present management of this material considered (including dust management and monitoring) in the CEMP and OEMP.
Heavy Metals and Metalloids	Representative samples were collected from three geological units (Qt supratidal flats, Qe mainland remnants, Czp longitudal and network dunesover claypan) and were analysed for heavy metals. Screening of heavy metals and metalloids in comparison to DGVs for EILs available in the National Environmental Protection Measure (NEPC, 2013) indicated that exceedances of copper, nickel and zinc were recorded.	The current concentrations of metals are likely to represent naturally occurring concentrations. An assessment of leachate potential and concentrations for materials proposed to be excavated (whether excavated and stored or re-used) with respect to the proposed re-use strategy should be undertaken. Materials posing a significant environmental concern, with respect to leachable metal concentrations may require to be re-used above saturated ground conditions as a minimumrequirement.
Neutral or Saline Drainage	SD and NMD within the identified areas of saline surface water and groundwater seepage around the margins of the pond embankments (GHD, 2021d) should not cause adverse impacts, given that the source seepage waters (saline ponds), and the receptor setting (salt flats) are geochemically similar in nature and that the salt flats are not considered to be a sensitive receptor to saline drainage. The saline seepage from the ponds and naturally occurring ANC within the environment is likely to have the chemical capacity to neutralise and buffer potential acid generation, whichhas been identified in the natural subsurface beneath the footprint of the ponds and seepage areas.	Follow recommendations within GHD 2021a and 2021b for acidic conditions.

12.4.5 CUMULATIVE IMPACTS

No cumulative impacts are identified as there are no other projects in the local area proposing to impact terrestrial environmental quality.

Cumulative impacts regarding BCH and vegetation which may be impacted by saline seepage and salt crusting have been discussed under Sections 8.6.2 and 10.5.3.

12.5 ASSESSMENT OF IMPACTS

Detailed investigations (GHD, 2021a) (GHD, 2021b) (GHD, 2021c) and (GHD, 2021d) have been completed to develop a comprehensive understanding of existing terrestrial environmental quality and how it may be impacted by the Proposal. The focus of these assessments has been to inform the Proposal such that the terrestrial environmental quality is maintained, and environmental values are protected.

Potential direct impacts to terrestrial environmental quality are associated with:

- Accidental spills or inappropriate waste disposal which may cause direct contamination. A range of management plans will be developed to prevent these occurrences, and if they accidentally occur ensure they are appropriately remediated.
- Disturbance of sulfidic material within the supratidal salt flats, creek mudflats and lower lying regions of the Proposal area or inappropriate management of dredge spoil leading to the generation of sulfuric acid. To prevent this an ASSSMP has been developed for the Proposal – Appendix BB (GHD, 2021b).

Indirect impacts to terrestrial environmental quality are associated with:

- The effects of saline seepage and salt crust to terrestrial vegetation, fauna habitat and BCH, are localised, proportionally small and have been assessed separately under Sections 8.6.1, 10.5.2.1 and 11.5.2.1 with these processes impacting: (AECOM, 2022a) (Biota, 2022a) (Biota, 2022b):
  - 3.92 ha of algal mat (0.14% of algal mat of East Exmouth Gulf).
  - 2.28 ha of samphire (0.6% of samphire in West Pilbara).
  - 119 ha of acacia shrubland/woodland (0.7% of similar vegetation in the study area)
  - 3.91 ha of claypan (0.017% of claypan of East Exmouth Gulf).
- Naturally occurring geochemical and physical soil properties which may have environmental or employee health impacts and will be managed and assessed under other regulatory processes.

Overall, the proposed development shows the potential for minor and manageable impacts on terrestrial environmental quality. Several Management Plans will be developed to address specific impacts.

12.6 MITIGATION

12.6.1 AVOID

The Proposal has undertaken significant design optimisation to avoid impacts to terrestrial environmental quality including:

- Detailed analysis of seawater intake options and locations reducing the seawater intake locations from two (Urala Creek North and South), to only one (Urala Creek South), reducing disturbance of PAF mudflat areas.
- Throughout the salt production process, no chemicals will be added at any stage of the process avoiding the spillage of chemical additives.
- The majority of the disturbance associated with infrastructure will be located within the elevated regions of the site. Typically, these higher elevated areas are between 5 and 10 m AHD and consist of calcareous materials such as calcarenite gravel, coral and shell fragments and present a low risk of oxidation during disturbance and have significant natural buffering ability.
- Borrow pits 1 and 2 are located in elevated areas and do not present a risk of ASS disturbance.

- No excavation will be required for the seawater intake channel. Its embankment will be built on top of mudflat areas, avoiding the disturbance of ASS.
- All access roads will be constructed on built-up embankments of imported material and therefore require no excavation or a risk of ASS disturbance.
- The conveyor system will be constructed on a built-up embankment with culverts located underneath to convey surface water flows. The embankment will be constructed on top of the natural ground surface and composed of imported material - there will be no excavation required for the conveyor or the culverts which avoids potential disturbance of ASS.

12.6.2 MINIMISE

The following measures are proposed to minimise impacts to terrestrial environmental quality:

- The area and volume of sediment to be dredged was minimised to 0.7 ha and 17,000 m^3 minimising ASS risks associated with management and disposal of dredge spoil.
- Dredged spoil will be disposed of onshore.
  - The onshore disposal area will be located immediately inshore from the jetty location;
  - Neutralising material will be added to the dredged material as necessary to treat any ASSS detected;
  - Decant water will be retained for a suitable time to allow appropriate water quality standards to be met (confirmed by monitoring) prior to release to the marine environment; and
  - Solids will be tested to ensure appropriate environmental standards are met, then will be reclaimed and used in on-site embankment construction.
- The excavation of the seawater intake inlet well, will be managed in accordance with the ASSMP (GHD, 2021b) so that spoil is contained and treated with no discharge of decant water:
  - Spoil will be delivered onshore into the proposed seawater intake channel and contained within its embankments;
  - Designated area(s) will be prepared to contain the spoil and tailwater to allow the spoil to become ‘spadable’ and enable it to be blended and neutralised prior to re-use;
  - Tailwater will be collected and contained within an impermeable lined sump and treated with neutralising material such as lime. The treated tailwater will be retained within the treatment area and allowed to evaporate; and
  - Tailwater will be monitored to meet required water quality criteria as listed in the ASSSMP prior to discharge to the marine environment.
- Further testing for ASS will be undertaken in the following proposed excavation areas to confirm acid generation potential and if acid generating potential exists, spoil will be managed in accordance with the ASSSMP:
  - Borrow pits 3 and 4;
  - All drainage diversions; and
  - Any proposed areas of salt flat disturbance (including in where any pond or other embankments may be “keyed into” the salt flats.
- Appropriate erosion protection will be implemented in the location of coastal dune disturbance (geological unit Qs) at the site of the conveyor and jetty, such as rock armouring and dune revegetation.
- Further testing of materials (soils/borrow) will be undertaken prior to disturbance of the geological units outlined in Table 95 and appropriate management plans developed for any potential impacts (to be approved by DMIRS under other regulatory processes).
- A range of management plans will be developed to prevent, mitigate and remediate accidental spills or inappropriate waste disposal, such as:
  - Pipelines will be fitted with leak detection;
  - Water flows will be shut off if leaks are detected;
  - Pipelines will be inspected regularly, especially during extreme heat or fire events;
  - Pipelines will be located off access road surfaces;
  - If pipelines have to cross access roads, then they will be buried;
  - Investigations will be conducted into the cause of any spills, and remedial actions will be taken to minimise the chance of reoccurrence; and

    - Spills response training to mitigate damage for site-based personnel.
- To manage any disturbance of sulfidic material within the supratidal salt flats, mudflats, lower lying ground and dredging area and ensure appropriate management of spoil from these areas, an ASSSMP has been developed – Appendix BB (GHD, 2021b).
- Develop and implement the DSMP (Appendix BB).
- Implement the MEQMMP (Appendix BB).
- Implement the WMP (Appendix BB).
- Management plans and measures to manage naturally occurring properties of materials which may affect the environment, workforce health or rehabilitation as required under:
  - Mining Proposal and MCP to be submitted to DMIRS in accordance Statutory Guidelines for Mining Proposals (DMIRS, 2020a) and Statutory Guidelines for MCPs (DMIRS, 2020b). An Interim MCP for the Proposal has been provided in Appendix BB and will continue to evolve during the life of the Proposal; and
  - Works Approval to be submitted to DWER.

12.6.3 REHABILITATE

At the completion of operations, all buildings and structures on land will be removed from the site and the pond areas may be selectively reconnected to the existing tidal flat system. K+S preferred post closure land use is to leave the evaporation ponds in situ so that they become fauna habitat for shore birds (including migratory birds which require "wetland areas" for migratory stop over).

If ponds are to be reconnected, the MCP will establish which bunds to breach that will enable inwards tidal movement bringing sediments and allowing tidal channels to expand naturally. Natural tidal flows will allow movement of mangrove plant and seed material which will passively revegetate the reconnected tidal areas. This will enhance the habitat values of the ponds post closure.

Selection of topsoil and suitable growth media for rehabilitation activities will take into consideration susceptibility to erosion (i.e., piping and dispersion) and other factors that may be prohibitive to plant growth such as high salinity as measured through EC/TDS and toxicity (e.g. ASS, PASS and heavy metal toxicity typically under acidic conditions) (GHD, 2021b) (GHD, 2021d). Soils suitable for rehabilitation activities have been identified (GHD, 2021d). All potential sources of ongoing contamination (bitterns, bitterns pond, crystallisers, salt stockpiles) will be removed and rehabilitated.

An Interim MCP for the Proposal has been provided in Appendix BB and will continue to evolve during the life of the Proposal. If the Proposal receives Ministerial Approval under Part IV of the EP Act as well as under the EPBC Act, the MCP will be developed in more detail and submitted to DMIRS for approval as required by the *Statutory Guidelines for MCPs under the Mining Act 1978* - DMIRS (2020b).

12.7 PREDICTED OUTCOME

The EPA objective in relation to terrestrial environmental quality is *to maintain the quality of land and soils so that environmental values are protected*.

The Proposal does not include any direct / intentional impacts to terrestrial environmental quality, however without appropriate mitigation the Proposal may result in the disturbance of ASS and spillages of product, brine, waste or hydrocarbons that could impact this factor.

K+S has incorporated avoidance and minimisation measures into five key management plans that are relevant to this factor:

1. The ASSSMP, which details how ASS will be managed during the construction phase to minimise impacts to the surrounding environment;
2. The DSMP, which details how dredged material will be managed to minimise impacts if disposed of onshore;

3. The MEQMMP, which details how product, brine and hydrocarbons will be managed to minimise impacts to the marine and terrestrial environment;
4. The WMP, which details how waste will be managed on site to minimise impacts to terrestrial environmental quality; and
5. The MCP, which details how the Proposal will be closed and rehabilitated to minimise short and long-term impacts to terrestrial environmental quality.

With the implementation of mitigation, K+S considers that the Proposal is able to be implemented without any significant residual impacts to this factor.

13 HYDROLOGICAL PROCESSES

13.1 EPA OBJECTIVE

To maintain the hydrological regimes of groundwater and surface water so that environmental values are protected.

13.2 POLICY AND GUIDANCE

- *Environmental Factor Guideline: Hydrological Processes* (EPA, 2016q).
- *Australian groundwater modelling guidelines (Waterlines Report Series No. 82)* (Barnett et al., 2012).
- *Operational Policy 5.12 - Hydrogeological reporting associated with a groundwater well licence* (DoW, 2009).
- *Rights in Water and Irrigation Act 1914*.
- *Western Australia water in mining guideline (Water licensing delivery report series: Report No. 12)* (DoW, 2013).
- *A Directory of Important Wetlands in Australia* (ANCA, 1993).
- *WA Environmental Offsets Policy* (Government of Western Australia, 2011).
- *WA Environmental Offsets Guidelines* (Government of Western Australia, 2014).

13.3 HYDROLOGICAL PROCESSES STUDIES

Studies to assess hydrological processes have been conducted as outlined in Table 96.

Table 96: Hydrological Processes Studies

Report	Reference	Appendix
Marine and Coastal Assessment and Modelling	Water Technology, 2022b	A
Surface Water Assessment and Modelling	Water Technology, 2022a	B
Marine, Coastal and Surface Water Data Collection	Water Technology, 2021a	C
Marine, Coastal and Surface Water Existing Environment	Water Technology, 2021b	D
Surface Water Assessment and Modelling	Water Technology, 2021c	E
Marine, Surface Water and Nutrient Modelling Peer Review	DHI, 2021	F
Memorandum Ashburton groundwater modelling- updated results	GHD, 2022	V
Hydrogeological Investigation	GHD, 2021c	W
Hydrogeology Modelling Peer Review	Cymod, Systems, 2022	X
Hydrogeology Modelling Peer Review	Cymod, Systems, 2021	Y

13.3.1 MODELLING

A specific hydrodynamic modelling study for surface water (Water Technology, 2021c) and a hydrogeology modelling study (GHD, 2021c) have been conducted to assess potential hydrological impacts of the Proposal regarding surface water and groundwater.

13.3.2 MODELLING PEER REVIEWS

Peer reviews of the above modelling studies have been conducted. The peer review process was undertaken in a comprehensive, rigorous and iterative manner.

- It is the opinion of the surface water model peer reviewer that the surface water model (Water Technology, 2021c) can be considered suitable for the purpose of identifying potential surface water impacts of the Proposal (DHI, 2021).
- It is the opinion of the groundwater model peer reviewer that the groundwater model (GHD, 2021c) is fit for the purpose of assessing groundwater related environmental impacts of the Proposal (CyMod Systems, 2022).

13.4 EXISTING ENVIRONMENT

13.4.1 METEOROLOGY

The climate of the Proposal area is classified as hot, semi-arid with rainfall occurring from January through to July. The dry season occurs from late August through to December. There is a tropical cyclone season that runs from the middle of December to April with a peak occurring in the wet months of February and March (Water Technology, 2021b).

Key climatic drivers are presented in Figure 126 (BOM, 2010). Along the Pilbara coast, the IOD, West Coast Troughs and Northwest Cloudbands dominate climatic conditions. In addition to this, the position of the subtropical ridge influences the seasonal change as the ridge shifts to the south in summer and to the north in winter, resulting in contrasting wet and dry seasons, respectively.

The Proposal area is located within the Australian Southern Semi-arid Pasture Region land use zone. Due to the sparse and highly variable rainfall in this region, surface runoff is usually only generated during extreme weather conditions, typically associated with tropical cyclones (Blandford and Associates, 2005).

13.4.1.1 RAINFALL

Rainfall across the inland Ashburton River catchment is spatially variable due to its large size and varying elevation. The highest area within the catchment is in the Hamersley Ranges which runs along its northern border and reaches elevations of 1,200 m and higher. The northern side of the Hamersley Ranges, which lies outside the catchment, experiences greater rainfall than that inside the catchment due to the orographic effect of the mountain range which induces precipitation around twice the magnitude experienced within the catchment. Figure 128 shows the average monthly rainfall for three locations within or near the Ashburton River catchment. Averages were calculated using the last ten years of data from 2010 to 2020. Most of the rainfall within the catchment occurs from January to March. The months of May and June experience moderate rainfall around 20 mm. The period with the lowest rainfall is August to November with less than 10 mm average monthly rainfall (Water Technology, 2021b).

13.4.1.2 EVAPORATION

The high temperatures in the region lead to high evaporation during summer months and lower rates during winter. Evaporation can impact shallow or still water bodies and cause local increases in salinity within coastal estuaries. Evaporation is measured by the BOM at the Onslow and Learmonth Airports. The Learmonth data is averaged over the period of 1975-2020 and 1966-1975 for Onslow Airport. A summary of the monthly averages can be found in Figure 35. As shown, evaporation rates are highest through the summer months (11-12 mm per daily evaporation) and peak in December and are lowest through the winter months with the lowest recorded evaporation occurring in June at 4 mm/day. In this region, the annual average rainfall is significantly exceeded by the mean annual evaporation (Water Technology, 2021b).

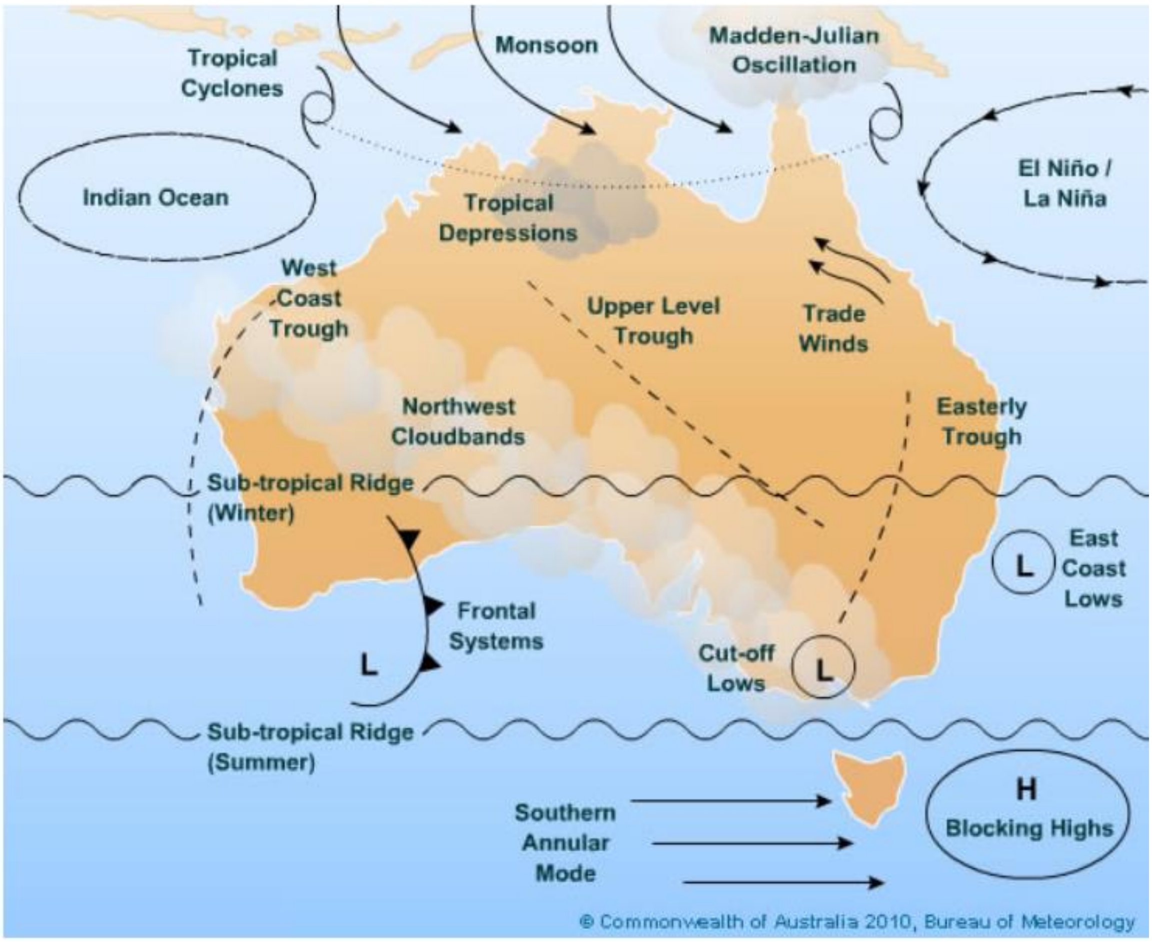

Figure 127: Australian Climate Drivers
(BOM, 2010)

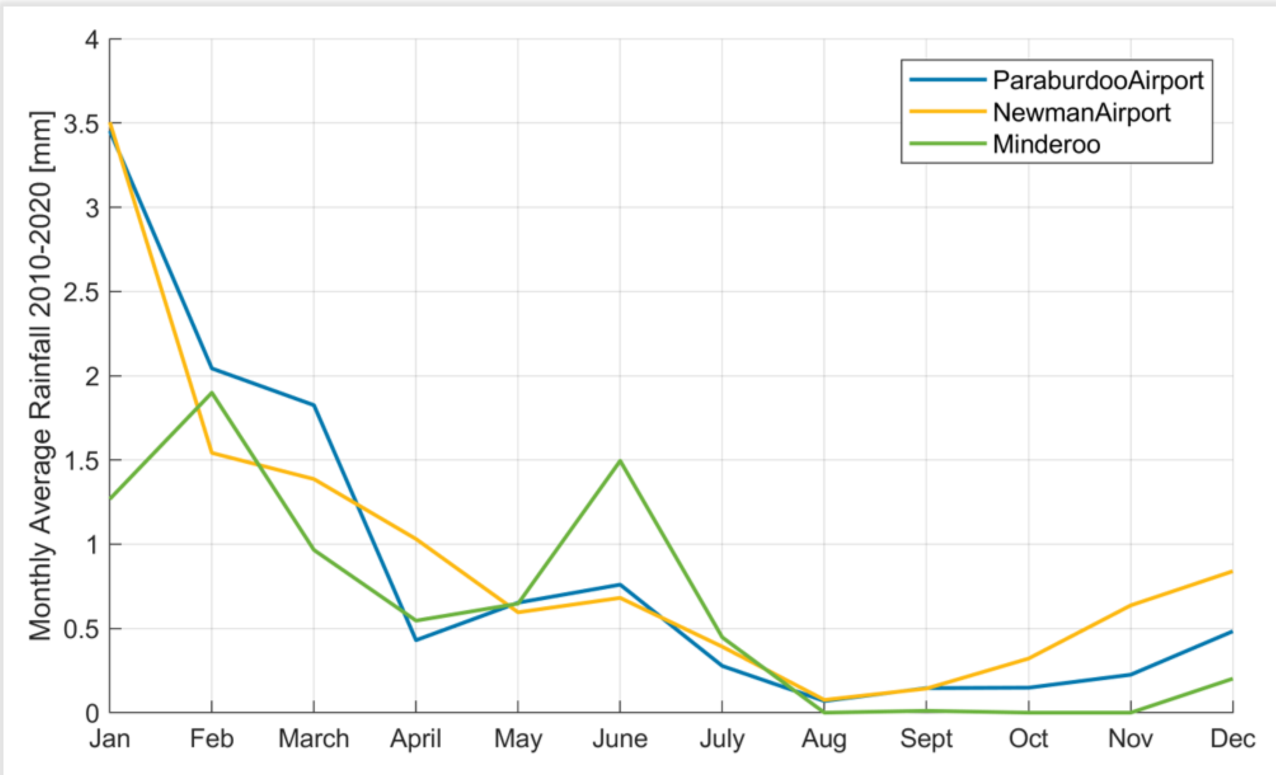

Figure 128: Average Monthly Rainfall; 3 Locations Ashburton River Catchment
(Water Technology, 2021b)

13.4.2 SURFACE WATER MANAGEMENT AREA

The Proposal occurs within the Pilbara Surface Water Area managed under the *Rights in Water and Irrigation Act 1914*. In this area it is illegal to take water from a watercourse without a licence to do so issued by DWER. No taking of surface water from a watercourse is proposed by this Proposal.

13.4.3 SURFACE WATER CATCHMENT DESCRIPTION

13.4.3.1 OVERVIEW

The Proposal is located, between the Ashburton and Yannarie Rivers. Relevant surface water catchments are shown in Figure 129.

The Ashburton River lies approximately 25 km northeast of the Proposal area. It is the largest waterway in the vicinity of the Proposal site and has a catchment area of approximately 71,000 km^2, with a defined waterway all the way to the coast. The river is perched between natural levee banks, and any flood waters that escape from the channel tend to fan out across the floodplain, both to the west and east. The floodplain comprises a range of landforms and when flood waters from the river reach the outwash plain inland of the Proposal area, they inundate interdunal basins and claypans. Much of the water that reaches these storages is eventually lost through evaporation and to a lesser extent through infiltration. There is no direct waterway connection of the Ashburton River to the Proposal site, however there are some overland flow paths across the floodplain to the west of the main Ashburton River channel, which direct flows towards the salt flats and intertidal areas, including those near the Proposal site (Water Technology, 2021c).

The Yannarie River lies approximately 50 km to southeast of the Proposal site. It has a catchment area of approximately 4,300 km^2, and a stream length of 185 km. The channel becomes poorly defined where it reaches the outwash plain inland of the Proposal site and its flood waters spread out across the outwash plain and dune field. Similarly, the adjacent Rouse Creek which has a catchment area of 1,700 km^2 and a stream length of 75 km has no defined channel once it reaches the outwash plain (Blandford and Associates, 2005). As with Ashburton River flows, when waters from these systems reach the outwash plain, they flood interdunal basins and claypans, where much of the water is eventually lost through evaporation and to a lesser extent through infiltration. During significant flood events, water from these systems can enter the salt flats and intertidal areas to the west of the Proposal area via overland flow paths (Water Technology, 2021c).

The red boundary in Figure 101 represents the local surface water catchment relevant to the Proposal which is 6,962 km^2 in size. Rainfall across the local catchment also contributes to runoff toward the Proposal area, during significant rainfall events (Water Technology, 2021c).

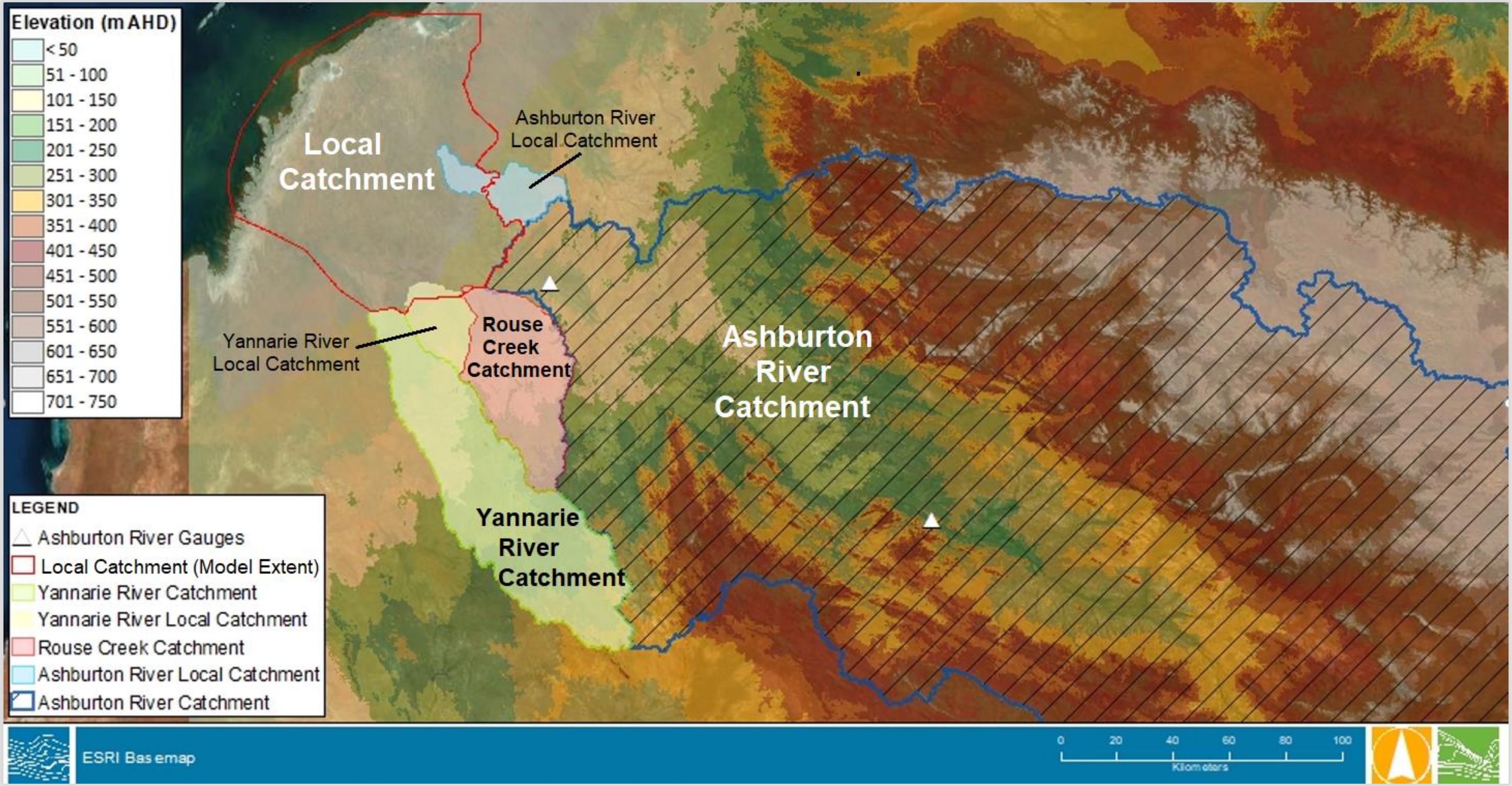

Figure 129: Surface Water Catchments
(Water Technology, 2021c)

13.4.3.2 CATCHMENT GEOMORPHOLOGY

Blandford and Associates (2005) describe the catchment geomorphology as follows:

- The Ashburton River catchment exhibits high topographic relief with waterways typically remaining channelised upstream of Nanutarra. Downstream of this location, the topography becomes much flatter, and numerous possible flow breakouts and extensive floodplains occur, with most of this depositional and erosional zone classified as outwash plains.
- The outwash plain landscape consists of alluvial and colluvial sediments. The alluvial sediments enter the plain from overland flows during flood events on the Ashburton and Yannarie Rivers, and consist of finer sediments such as clay, silt and fine sand particles. The colluvial sediments consist of coarser particles which include coarse sands and gravel.
- Further downstream, overland flows traverse the remnant dune field (Dune Land System). The dune field begins 15 km inland from the coast and runs parallel to the coastline, covering an area of approximately 3,225 km^2. The dunes are predominantly orientated north to south and were formed by aeolian transport. Vegetation cover on the dunes is abundant, indicating that they are relatively stable. The rows of dunes display longitudinal depressions or swales between them, allowing water to flow between and around the dunes, and sometimes act as significant storages where water can pond. There are also several defined overland flow paths across this area.
- Salt flats (part of the Littoral Land System) located on the seaward side of the dune field are typically inundated during extreme tide or storm events. During flood events on the Ashburton River, the area acts as an outlet for catchment flow paths. Given the low topographic gradient of the area, overland flows usually consist of shallow sheet flow across the area, with no clearly defined channels. The flats run from Sandalwood Peninsula to the mouth of the Harding River, covering an area of approximately 555km^2.
- The coastal fringe separates the salt flats and the coastline. The coastal fringe is comprised of beach systems, sand sheets and limestone outcrops, and is the final outlet for overland flows. Tidal creeks, such as Urala Creek North and Urala Creek South, are abundant over the landscape and provide mangrove habitat.

These geomorphic features have been broadly mapped in Figure 130.

13.4.3.3 SURFACE WATER FLOW PATHS

Surface water flow paths in and around the Proposal site is a complex interaction between watercourses including the Ashburton River, Yannarie River and Rouse Creek and the wide outwash plain, salt flats and dune fields adjacent to the coast.

Catchment inflows to the Proposal area have been modelled by Water Technology (2021c). The generalised flow paths identified from this modelling are mapped below in Figure 130.

Breakout overland flows from Yannarie River and Rouse Creek typically enter the coastal system 35 km to the south of the Proposal. Yannarie River itself is located 50 km southeast of the Proposal, whilst Rouse creek is located approximately 75 km to the southeast of the Proposal.

Breakout overland flows from the Ashburton River combined with local runoff create sheet flow conditions across the catchment and flows that pass through the inland dune field and claypan system. Overland flows from the hinterland dune field immediately to the east of the Proposal enter the salt flats via large local basins adjacent to the eastern boundary of the proposed salt evaporation ponds. To the immediate north and south of the Proposal local flows are conveyed along more defined local flow paths, specifically 'Chinty Creek' to the north and an unnamed flow path to the south - Figure 130 (Water Technology, 2021c).

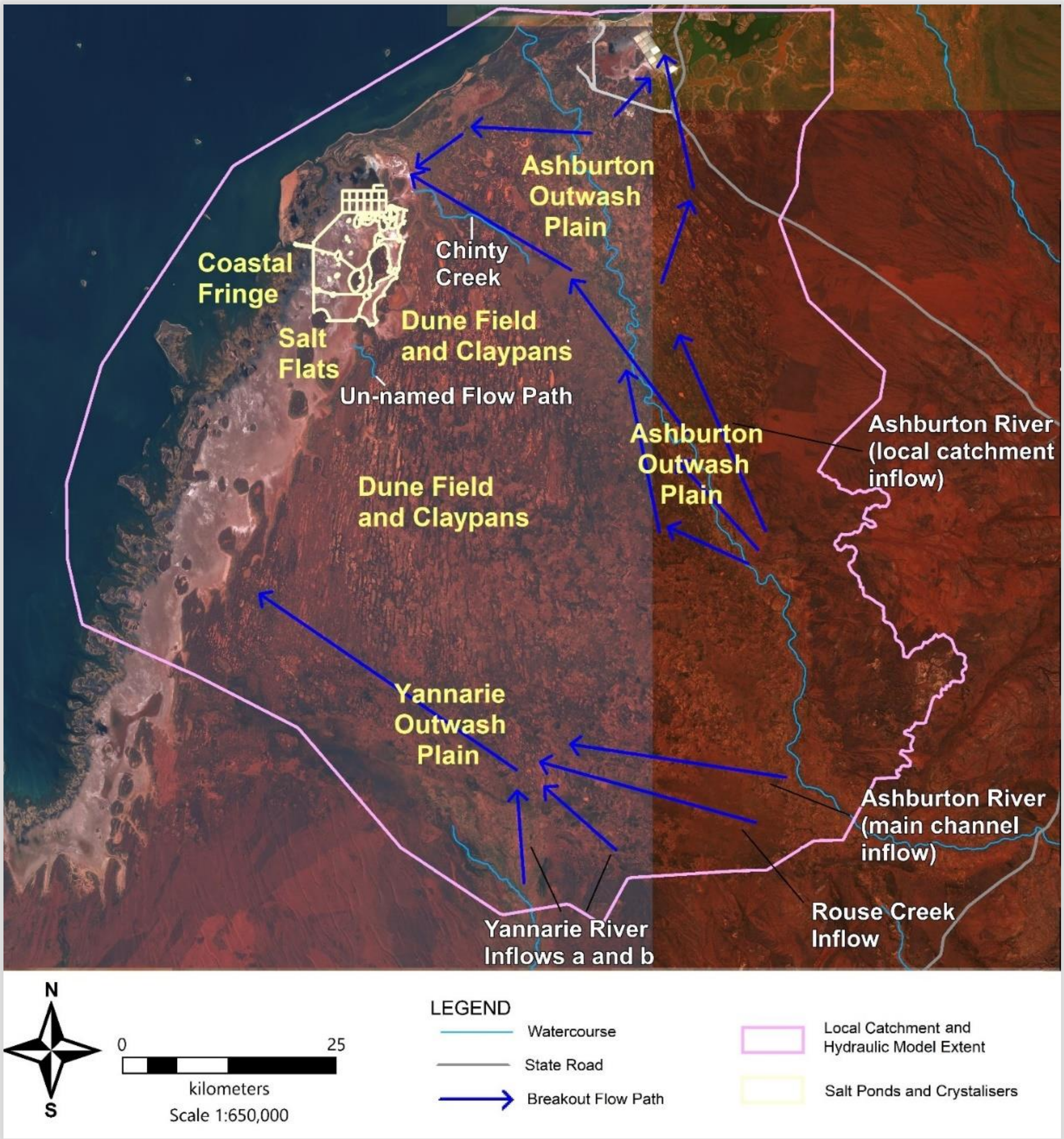

Figure 130: Local Catchment Geomorphic Features and Generalised Flow Paths
(Water Technology, 2021c)

13.4.4 LOCAL SURFACE WATER FEATURES

Surface water modelling by Water Technology (Water Technology, 2021c) has assisted with the identification of key surface water features in the Proposal area. These include (Figure 131):

- Chinty Creek a minor meandering overland flow path to the north and east of the Proposal area which conveys overland flow from the dunefields and basins to the east of the Proposal area. This flow path conveys both minor local flows (from minor rainfall events) and major flows including breakouts from the Ashburton River after major rainfall within the catchment.
- An un-named minor flow path to the immediate south of the Proposal which conveys sheetflow from the dunefield and basins to the east.
- A basin immediately adjacent to the proposed south-eastern pond embankments (South East Basin) which connects to the salt flats under flooded conditions and conveys sheet flow from the dune field and basins to the south east.

Figure 131 shows modelled pre-development flood levels for a minor rainfall event (50% AEP or approximately 1 in 2 year rainfall event) with the above local surface water features labelled.

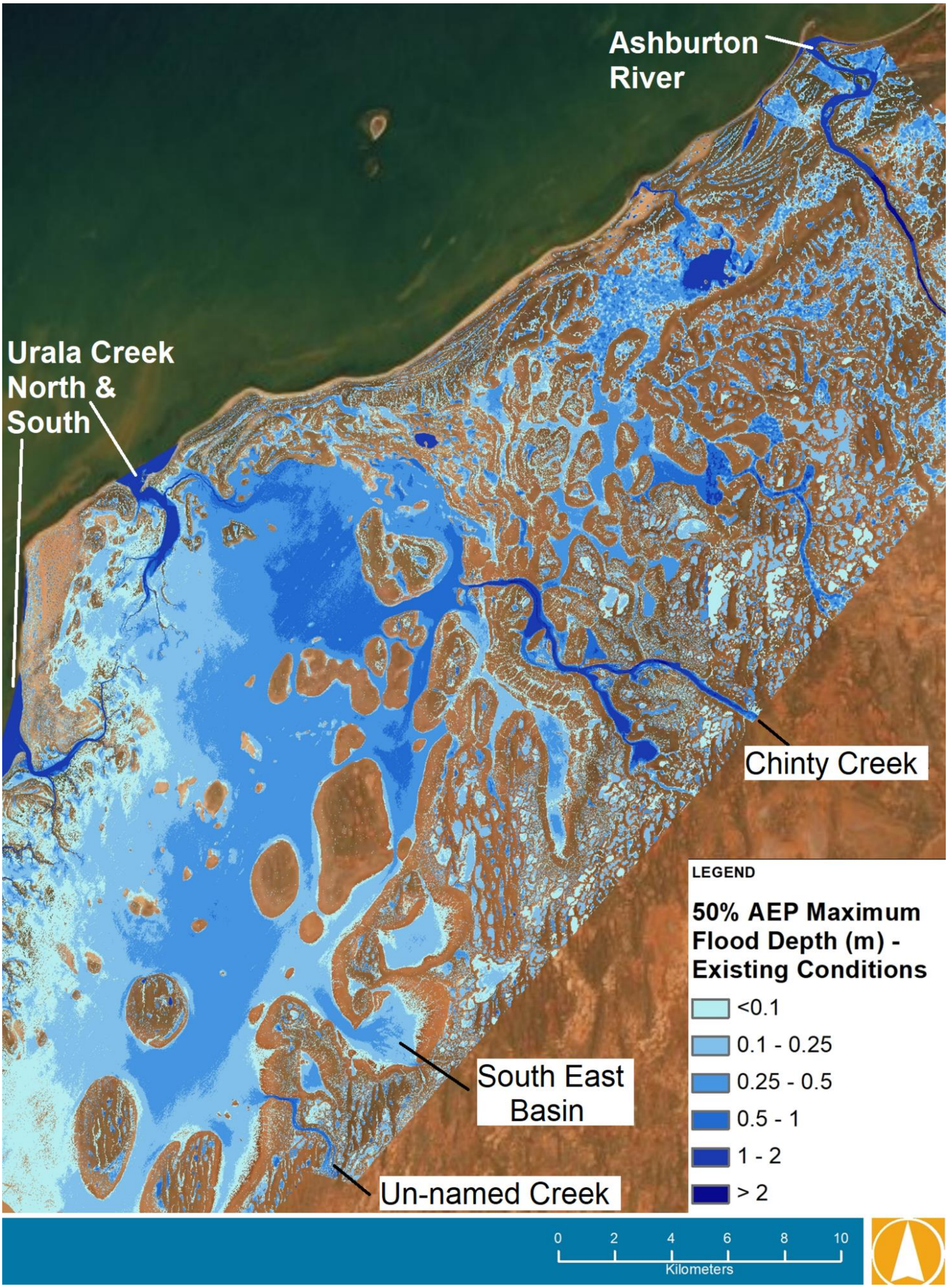

Figure 131: Modelled Pre-development 50% AEP Flood Levels and Local Surface Water Features
(Water Technology, 2021c)

13.4.5 REGIONAL HYDROGEOLOGY

The Proposal area is associated with the alluvial aquifer of the Ashburton River. The Lower Ashburton River flows over the Onslow plain, which is covered with Quaternary alluvium. The alluvium is underlain by Tertiary and Cretaceous-aged sediments. Underlying the Cretaceous sediments are Palaeozoic and Proterozoic basement rocks. Although significant flow volumes are recorded in the Ashburton River, drilling data indicates that not enough alluvial thickness is present to develop a significant groundwater source. There are large supplies of brackish to saline water available from palaeochannels in the south-west portion of the Lower Ashburton River (Haig, 2008).

13.4.6 LOCAL HYDROGEOLOGY

The hydrogeology for the main landform types present within or adjacent to the Proposal area are described in Table 97.

Table 97: Local Hydrogeology
(Blandford and Associates, 2005)

Landform	Description
Outwash Plains (associated with Ashburton River and other local rivers)	Freshwater flow in the river is the main recharge mechanism for this superficial aquifer. The water bearing calcrete unit is generally located close to the existing river channel suggesting the calcrete may be precipitated from recharge waters from the river channel. Groundwater electrical conductivity increases with distance from the river channel, indicating the main recharge mechanism is following River flow events. Groundwater quality in bores decreases significantly following periods of high abstraction due to up-coning of saline water, indicating that water recharged from the River is present as a lens overlying a more saline regional groundwater system.
Dune Fields and Claypans (associated with the hinterland inland of the salt flats and Proposal)	Groundwater is approximately 4 m and 8 m below the level of the claypans coincident with thin, discontinuous lenses of calcrete. Rainfall infiltrates into the dunes surrounding each claypan, discharging at the base of the dune as a wetting front. Infiltrated rain water then flows onto the claypan surface and collects in the topographic lows of the claypans where it is lost to evaporation. It would also be expected that during significant rain events, some fresh water would infiltrate into the underlying formations.
Salt Flats (Proposal proposed to be constructed on these salt flats)	The salt flats are underlain by a thin surficial aquifer (2.6 m to 5.0 m thick) of low permeability marine and terrestrial sediments (clayey silts and silty sands) containing saline to hypersaline water (34,000 mg/L to 306,000 mg/L). The small gradient of flow through the aquifer provides ample time for evaporation to occur and ensures the groundwater in this aquifer is hypersaline. This is supported by the extremely low hydraulic gradient of 0.00009. The surficial aquifer is underlain by a very low permeability sedimentary sequence, comprising plastic, red-brown clay and silty clay. This unit was found to be up to around 11 m thick. A deeper aquifer was found to underlie the clay. This consisted of sands and gravels and was found to be hydraulically separated from the upper surficial aquifer (based on an interpretation of differing chemistry and head values). Groundwater flow within the shallow aquifer is expected to approximately follow the topographic slope, with the flow expected to be from the higher ground to the east, discharging to the coastal region to the west.

13.4.7 GROUNDWATER LEVELS

Groundwater levels vary from a few centimetres below ground level in the salt flats to 4 to 8 metres in the dune fields. The drilling of boreholes was completed by GHD on 31st March 2020. Further fieldwork was undertaken between 30th August and 4th September 2020 to gather additional groundwater data for the hydrogeological modelling. The depth to groundwater records is included in Table 98 and Figure 132 below (GHD, 2021c).

Table 98: Bore Depth to Groundwater Summary

(GHD, 2021c)

ID	Type	Ground level (m AHD)	Depth to top of screen (m)	Depth to bottom of screen (m)	Depth to water (m)	Water level (mAHD)
BH01	Single bore: watertable (shallow)	7.08	2	8	Dry	0
BH02S	Pair: shallow bore	1.72	5	8	3.64	-1.92
BH02D	Pair: deep bore	1.72	12.2	18.2	3.66	-1.94
BH03S	Pair: shallow bore	2.51	2	5	1.42	1.09
BH03D	Pair: deep bore	2.51	11	14	1.56	0.95
BH04	Single bore: watertable (shallow)	3.45	3.4	8.4	2.96	0.49
BH05S	Pair: shallow bore	0.71	1	2	0.28	0.43
BH05D	Pair: deep bore	0.71	12	15	2.25	-1.54
BH07S	Pair: shallow bore	1.58	1.8	7.8	0.88	0.7
BH07D	Pair: deep bore	1.58	10.6	13.6	0.94	0.64
BH08	Single bore: watertable (shallow)	5.42	5.6	10.1	4.58	0.84
BH09S	Pair: shallow bore	3.37	0.5	3	2.27	1.1
BH09D	Pair: deep bore	3.37	6	9	2.32	1.05
BH10S	Pair: shallow bore	0.90	2	5	0.36	0.54
BH10D	Pair: deep bore	0.90	8.5	11.5	0.34	0.56
BH11S	Pair: shallow bore	1.21	1.5	4.5	0.41	0.8
BH11D	Pair: deep bore	1.21	6	9	0.42	0.79
BH12	Single bore: watertable (shallow)	9.94	4	10	7.43	2.51
BH13	Single bore: watertable (shallow)	6.88	3	6	2.31	4.57
BH14S	Pair: shallow bore	0.96	3	6	0.23	0.73
BH14D	Pair: deep bore	0.96	11	14	0.16	0.8
BH15S	Pair: shallow bore	1.49	2	5	0.66	0.83
BH15D	Pair: deep bore	1.49	9	12	0.76	0.73

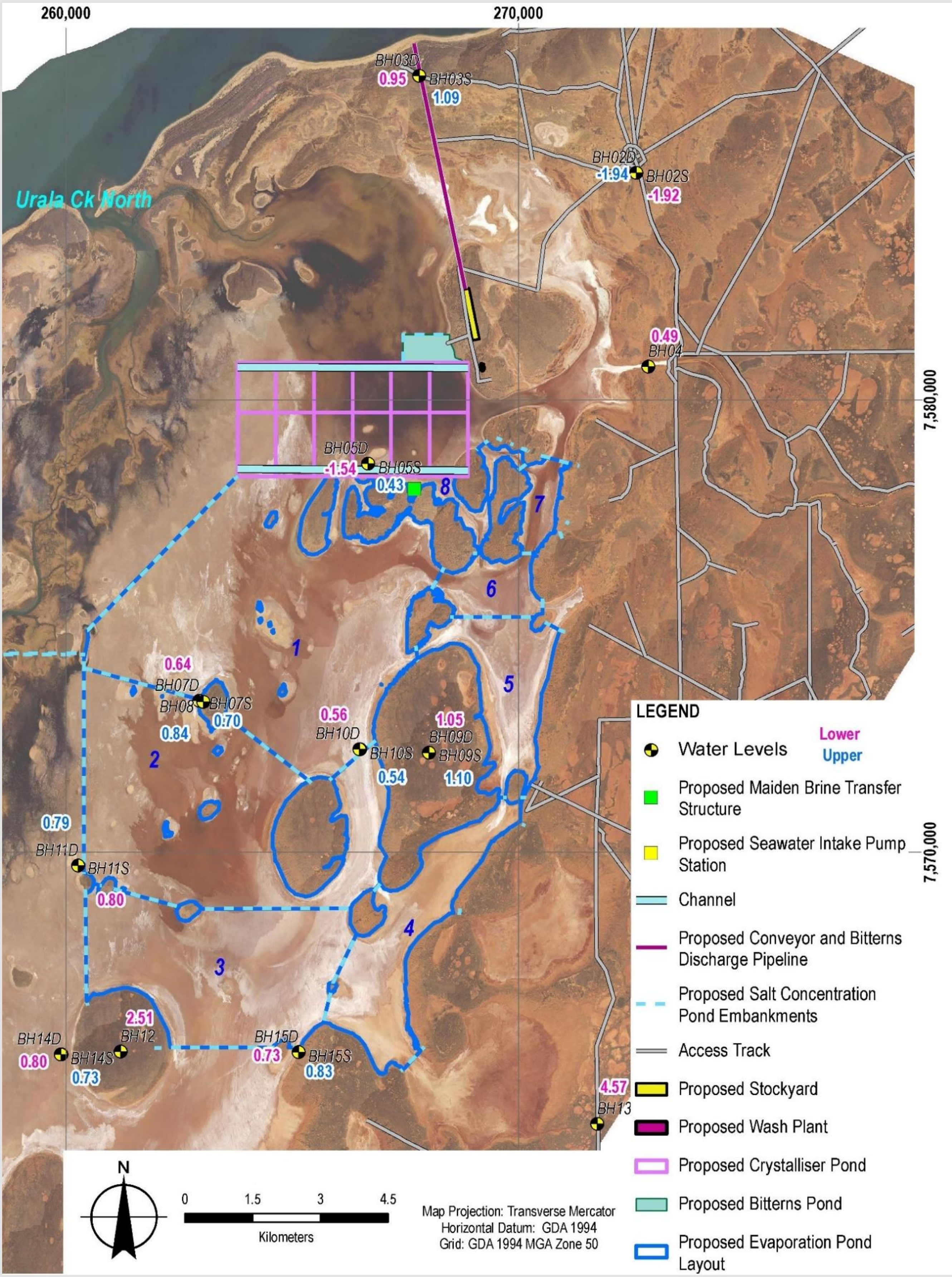

Figure 132: Measured Groundwater Levels
(GHD, 2021c)

13.4.8 GROUNDWATER FLOWS

Groundwater flow direction is generally from inland to the coast (east to west). The salt flats which act as a large evaporation basin intercept the groundwater flow from the upgradient dune field. Intercepted groundwater is lost to evaporation. Groundwater gradients in this area are flat, almost unmeasurable, resulting in almost stagnant groundwater kept in this state by evaporation effects (GHD, 2021c).

The groundwater flow gradients are extremely flat due to two main factors:

- Strong evaporation from the flats which forces discharge from the groundwater system. This results in substantial removal of groundwater from the inflowing groundwater throughflow from the east and a water table controlled by evaporation. Net recharge is insignificant since all recharge is effectively removed by evaporation; and
- The higher permeability of sand dunes also results in flatter flow gradients. Following rainfall events any mounding of groundwater in the dunes is quickly removed radially from the centre of the mound and the water table equilibrates to its pre-recharge level (GHD, 2021c).

It is possible that during some conditions, groundwater flows are reversed from the ocean to the centre of the flats (such as high tide events) (GHD, 2021c).

Due to the high salinity of groundwater underneath the salt flats, groundwater flows are also affected by density differences. The hypersaline character of groundwater in salt flats has led to development of a saltwater edge on both the seaward and inland sides of the tidal flat strip. This zone of hypersaline groundwater developed parallel to the coast forces upward flow of inflowing groundwater from the dune fields. As groundwater comes to the surface along the edges of the hypersaline groundwater body it is exposed to evaporation which results in on-going salinisation (GHD, 2021c).

13.4.9 HYDROGEOLOGICAL CONCEPTUALISATION

The site investigation results and review of existing information were used by GHD to develop a hydrogeological conceptual model (GHD, 2021c). The key features of the hydrogeological conceptualisation are as follows:

- The Proposal footprint covers a coastal area which has been emerging from previous seawater inundation for the last 5000 years. The mostly flat area with ground elevations around 1 to 2 m AHD contains mainland remnant 'islands', up to 16 m AHD. To the east of the Proposal area exists an elevated dune landscape (16 – 19 m AHD) with interspersed claypans. The water levels in the salt flats (when inundated) are shallow (less than a metre) subjecting groundwater to evaporation effects.
- Groundwater salinity is affected by tidal flushing within intertidal areas which exports salt from the shallow groundwater in intertidal areas.
- Inland water flows import fresher although brackish water which is concentrated beneath the salt flat into a hypersaline state via evaporation.
- The hydrogeology is characterised by the presence of hypersaline groundwater beneath the supratidal salt flats. It is thought to have formed over time from the combined actions of:
    - Seawater submersion,
    - Evaporitic concentration of salts supplied periodically by tidal inundation and storm surge; and
    - Contribution from the regional throughflow from east to west.
- This has created a dense hypersaline waterbody underneath the salt flats which affects incoming shallow groundwater flows from inland areas.

This hydrogeological conceptualisation is represented in Figure 133 below.

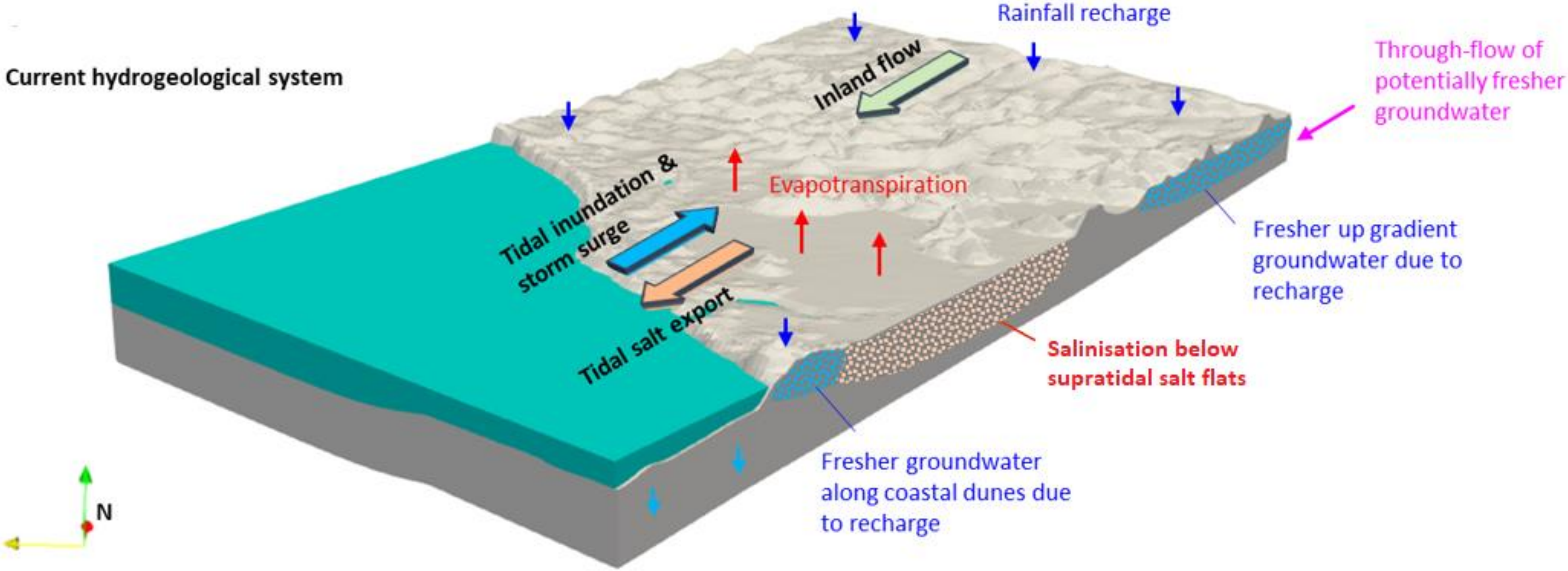

Figure 133: Hydrogeological Conceptualisation
(GHD, 2021c)

13.4.10 SURFACE WATER GROUNDWATER INTERACTION

The surface water and groundwater environment of the salt flats, including supratidal and intertidal flats has been formed by interaction of the on-going tidal action, flooding from occasional surface runoff, rainfall, evaporation, and groundwater discharge.

(Water Technology, 2021c) have identified two drainage pathways that can bring surface runoff to the Proposal area after large (10-year ARI and above) rainfall events including breakout inflow from Ashburton River (inflow branching off the main river course). However, given the low frequency of these rainfall events and high evaporation rates they are considered unlikely to have a major influence on local groundwater processes. Given the frequency of tidal inundation, it is considered to have a more frequent influence on the salt flats than surface runoff from rainfall events (GHD, 2021c).

The majority of surface water (either from tidal or runoff flooding) in the salt flats is lost to evaporation, increasing the salt contents in the surficial sediments and the underlying groundwater. These salts are remobilised and redistributed by subsequent flooding leading to spread of salts and development of hypersaline groundwater (GHD, 2021c).

In addition, the density-driven groundwater flow effects in combination with surface water sources result in the following:

- Gradual vertical downward movement of dense groundwater as it is displaced by less dense surface water sources.
- Occasional or temporary development of a thin layer of fresher groundwater in response to rainfall or tidal flooding of less saline water. In the mainland remnant sand islands embedded in the tidal flats this could lead to locally fresher lenses of groundwater floating on top of the hypersaline water body (similar to fresh groundwater lenses in ocean islands) prevented from high evaporative salinisation by greater topographic elevations of these features and subsequently localised greater depth to groundwater.
- More permanent presence (compared to salt flats) of less saline groundwater at the water table beneath tidal creeks due to more frequent tidal inundation (tidal flushing twice a day) resulting in a thin surface layer of less saline groundwater beneath tidal creeks (GHD, 2021c).

13.4.11 GROUNDWATER MANAGEMENT AREAS

The Proposal occurs within the Pilbara Groundwater Area managed under the *Rights in Water and Irrigation Act 1914*. In this area it is illegal to take groundwater without a licence to do so issued by DWER. No taking of groundwater is proposed by this Proposal.

13.4.12 GROUNDWATER ABSTRACTION BY OTHER USERS

There are no licensed groundwater abstractions within the Proposal area or in its immediate vicinity. This is likely the result of groundwater's little beneficial use due to its excessive salinity and the general lack of suitability for human or animal consumption or irrigation (GHD, 2021c).

Unlicensed groundwater withdrawals for stock watering purposes occur further east or north from the Proposal area where groundwater quality achieves brackish levels or where freshwater lenses sporadically occur (e.g., associated with infrequent stream recharge along Ashburton River, north of the site) (GHD, 2021c).

Public beneficial uses of surface water may include use of surface water flows in local rivers by pastoralists for cattle and domestic uses. The Proposal will not disrupt any such existing public uses.

13.4.13 GROUNDWATER DEPENDENT ECOSYSTEMS

The Proposal area is located within the Exmouth Gulf East Wetland (WA007) which is listed in the Directory of Important Wetlands in Australia (EnviroWorks 2016). The Directory describes the significance of the wetland as “An outstanding example of tidal wetland systems of low coast of northwest Australia, with well-developed tidal creeks, extensive mangrove swamps and broad saline coastal flats. This wetland is tidal in nature and not considered to be groundwater dependent.

No Groundwater Dependent Ecosystems exist in the vicinity of the Proposal area. Generally, the hypersaline groundwater of the Proposal area is not tolerable by the majority of vegetation communities (GHD, 2021c).

Mangroves receive tidal inundation by ocean water twice a day for their shallow root system. They are known to tolerate shallow groundwater that does not exceed salinity of approximately 90 g/L. The Onslow Salt Plain also host algae mats which are understood to be surface water (tide) dependent and do not rely on underlying groundwater. In the Proposal area these ecosystems are dependent on tidal flushing to retain hydration and remove salt from the system. These ecosystems are not groundwater dependent (GHD, 2021c).

Due to the hypersaline character of the salt flats the vegetation is sparse or non-existent. Mainland remnant sand islands in the salt flat landscape can potentially host vegetation communities that could make use of relatively thinner (temporary) groundwater lenses that may occur at the top of the saturated profile after rainfall (GHD, 2021c).

13.4.14 LOCAL ENVIRONMENTAL VALUES

Local environmental values related to hydrological processes have been identified as follows:

- The connectivity of the local catchment and local surface water flows to the coast.
- The ability of the salt flats to act as a compensating basin during flood events.
- The availability of local flooded areas (habitat) after heavy rainfall.
- The local groundwater regime including water levels, water flows and recharge.

These local values have been mapped overlayed by the Proposal in Figure 134 using GIS data from the Proposal surface water study (Water Technology, 2021c) and groundwater study (GHD, 2021c).

13.4.15 REGIONAL ENVIRONMENTAL VALUES

Regional environmental values related to hydrological processes have been identified as follows:

- The connectivity of the wider Ashburton, Yannarie and Rouse catchments and regional surface water flows to the coast.
- The availability of regional flooded areas (habitat) after heavy rainfall.
- The surface water and groundwater regime of the Exmouth Gulf East Wetland (WA007) which is listed in the Directory of Important Wetlands in Australia.

These regional values have been mapped overlayed by the Proposal in Figure 135 using GIS data from the Proposal surface water study (Water Technology, 2021c) and the Directory of Nationally Important Wetlands GIS boundary for Exmouth Gulf East Wetland (WA007).

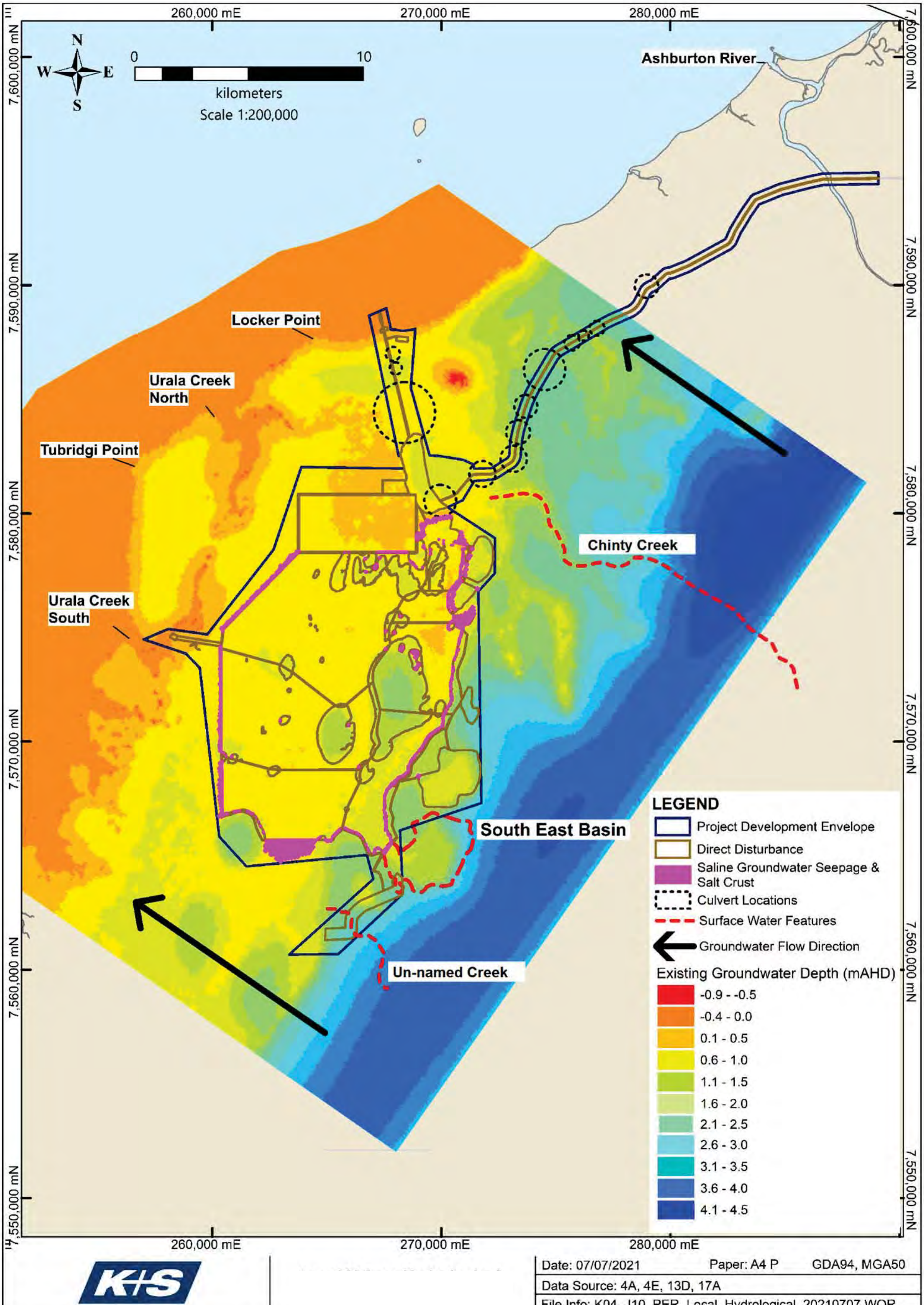

Figure 134: Local Values Hydrological Processes

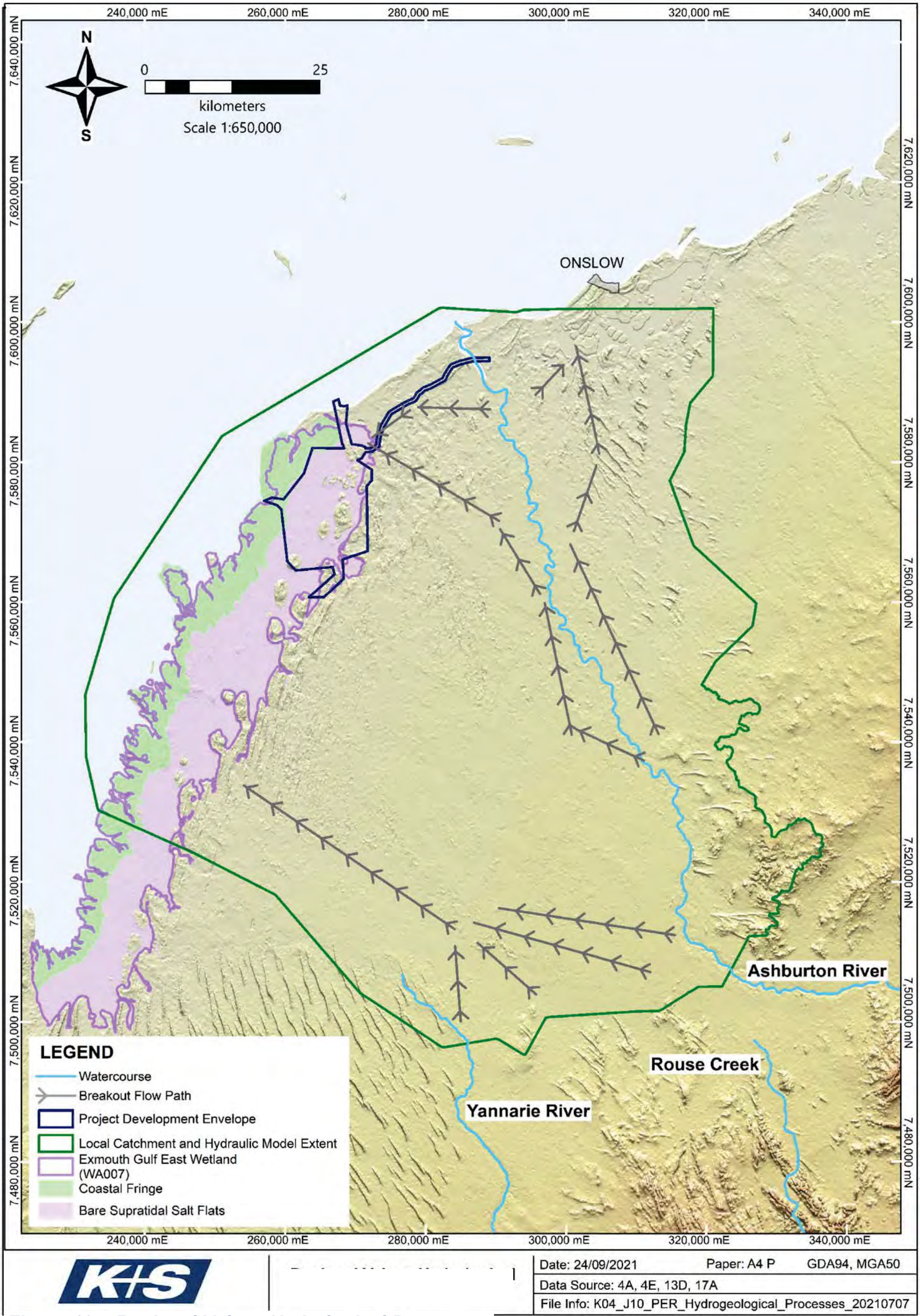

Figure 135: Regional Values Hydrological Processes

13.5 POTENTIAL IMPACTS

The following potential hydrological impacts have been identified for this Proposal as discussed in the sub-sections below:

- Direct Impacts:
  - Direct disturbance excising of a portion of the surface water catchment.
- Indirect impacts:
  - Altering surface water flows resulting in reduced connectivity of catchments to the coast and changes in the local surface flooding regime.
  - Changes to the local groundwater regime, in particular groundwater movement, waterlogging and seepage.

13.5.1 DIRECT DISTURBANCE

The Proposal will create direct disturbance of 11,990 ha (~120 km^2) of land predominantly on the supratidal salt flats which will excise a proportionally small area of the local and Ashburton River catchments as outlined in Table 99.

Table 99: Proportional Direct Disturbance of Catchment

Direct Disturbance km^2	Local Catchment km^2	Ashburton Catchment km^2	% Local Catchment	% Ashburton River Catchment
120	6,962	71,000	1.7%	0.2%

13.5.2 INDIRECT IMPACTS

13.5.2.1 ALTERING SURFACE WATER FLOWS

To understand the potential impacts of the Proposal on surface water flows, detailed hydrologic and hydraulic modelling of the surface water flow systems was undertaken. Hydrologic modelling involved developing estimates of design flood hydrographs for the Ashburton River and four local catchments for input to the hydraulic model for the 0.5%, 1%, 2%, 5%, and 10% AEP flood events. The design flows were then applied to the hydraulic model boundaries. The hydraulic modelling then also utilised a RoG approach for estimating runoff within the model domain. Two hydraulic modelling software packages were used to simulate the catchment to ensure accuracy of modelled surface water flows at the site and the areas immediately surrounding the site infrastructure. Regional catchments were modelled using MIKE21FM, a two dimensional (2D) flexible mesh hydraulic model, whereas local catchments at the site were modelled using a 2D HPC TUFLOW hydraulic model. Both are industry standing modelling packages (Water Technology, 2021c).

The larger regional model was developed to simulate surface water flows from the hinterland areas towards the Proposal area, while the local model was more detailed and focussed on the assessment changes to surface flows from the Proposal itself. The TUFLOW hydraulic model has adopted a combined approach for rainfall-runoff modelling at the site which involves two key inputs. These include; catchment-routed inflow hydrographs representing the runoff from the larger external catchments which are modelled as boundary inflows, and direct-rainfall inflow hyetographs which directly applies design rainfall depths to each active cell in the hydraulic model. This combination allows for the hydraulic model to incorporate regional flooding influences at the site as well as localised rainfall (Water Technology, 2021c).

This localised rainfall is applied to each active cell in the model; the accumulated water on each cell subsequently reaches a specified depth before propagating to adjacent cells; The nature of this propagation is mostly dominated by the topography and hydraulic roughness and is suitable for representing the movement of water across the landscape. This movement can be considered sheet flow.

As part of the flood impact assessment, the sheet flow in the model is affected by the construction of the ponds, through changes to the model's topography, and therefore any redistribution of water accumulation or redirection of flow across the model is suitably captured. This applies to water sourced both from the regional external boundary inflows as well as the localised direct-rainfall inflows. The outcomes of the flood impact assessment estimate the overall change in water levels and velocities caused by the construction of the ponds and any other infrastructure (Water Technology, 2021c).

The secondary influence on the propagation of water between each of the active modelling cells, the hydraulic roughness, is also relevant. The TUFLOW hydraulic model adopted a Manning's 'n' Roughness of 0.04. This roughness is suitable for environments which are naturally vegetated, have light shrubs and tree populations, and have irregular or rough landscapes. This is consistent with the landscape surrounding the site (Water Technology, 2021c).

Modelling the Proposal without mitigation measures in place identified water flow blockage and flooding impacts to (Figure 134):

- Chinty Creek at the northeast of the Proposal.
- An unnamed minor creek to the southeast.
- A basin of the supratidal salt flats termed "South East Basin".

Therefore, flood modelling was used to develop the following strategies to maintain connectivity of the local and regional surface water flow paths where they were potentially blocked by the access road, conveyor, and pond embankments. Mitigation strategies included:

- Locate key infrastructure areas outside the 2% AEP (~1 in 50 year ARI) flood zone where possible.
- Divert flows around key infrastructure areas that intersect flow paths.
- Divert flows back onto natural flow paths.
- Ensure full conveyance of 10% AEP surface water flows under the main access road into site.
- Ensure surface water flows into downstream receptors are not impeded by proposed infrastructure.
- Protect infrastructure that falls outside of direct flow paths, but which is within the 2% AEP flood zone.

Culvert locations and sizes were identified for the main access road and conveyor embankment to maintain flow connectivity along with a series of diversion channels. Levees were also proposed to protect pond embankments from floodwaters within the eastern basins. These recommended mitigation measures are being adopted by the Proposal as outlined in Section 2.3.12. Modelling with mitigation measures in place indicates that overall, the effects on flow depths (afflux) and velocities are localised to the immediate vicinity of the Proposal infrastructure (Water Technology, 2021c) as shown below in Figure 136 and further described in the sub-sections below.

No impact to samphire, terrestrial vegetation or terrestrial fauna habitats are predicted as a result of surface water flow changes as described in Section 8.6.1, 0 and 11.5.2.1.

Impacts on intertidal water flows associated with the seawater intake and embankments which are in intertidal areas are covered Section 6.5.2.3 and related impacts to BCH are described in Section 8.6.1.

13.5.2.1.1 CATCHMENT CONNECTIVITY TO THE COAST

As shown in Figure 130, surface water flow paths in and around the Proposal are towards the coast are a complex interaction between watercourses including the Ashburton River, Yannarie River and Rouse Creek and the wide outwash plain, salt flats and dune fields adjacent to the coast. To maintain the connectivity of catchment generated surface flows to the coast, the Proposal has been positioned to prevent interference with the major flow paths of Yannarie and Ashburton Rivers and thereby maintain the connectivity of the salt flats and the coast. As described above mitigation measures such as drainage diversions and culverts have been designed to maintain local flow paths underneath linear infrastructure and around the ponds, so that local water flows can still reach the salt flats. Overall, the effects on catchment flow paths are localised to the immediate vicinity of the Proposal infrastructure and will be mitigated by the adoption of the proposed drainage strategy. There are no credible regional impacts on catchment flows or flow connectivity (Water Technology, 2021c).

13.5.2.1.2 SURFACE WATER FLOODING REGIME

The surface water flooding regime refers to the distribution, depth, and movement of catchment generated flood flows. As detailed in the preceding sections, mitigation measures such as drainage diversions and culverts have been designed to maintain local flow paths underneath linear infrastructure and around the ponds, so that local water flows can still reach the salt flats. As shown in Figure 136, changes to the flooding regime as a result of the Proposal are localised to areas along the access road, east of the crystalliser ponds, and the South East Basin. Flooding along linear infrastructure is addressed through the positioning and sizing of culverts, whilst flooding in the South East Basin applies drainage diversions to alleviate flooding and move water from one basin to another towards the salt flats. While the proposed mitigation structures do not eliminate increased water levels, they do reduce them (Water Technology, 2021c). Further refinement of the proposed drainage strategy (diversion channels and culverts) will be undertaken during detailed design to further reduce flood impacts and ensure that all engineering requirements are met.

13.5.2.2 GROUNDWATER MOVEMENT, WATERLOGGING AND SEEPAGE

A numerical groundwater model was used by GHD (2021c) to simulate the key hydrogeological processes of the Proposal area. The key issue simulated by the modelling was the potential for seepage from the salt ponds to migrate and impact on the receiving environment. The nature of interaction between the salt ponds and groundwater is due to hydraulic, salinity (concentration) and density effects which vary over time.

Key findings from the GHD (2021c) modelling of groundwater changes are:

- The water table beneath the footprint of salt ponds is shallow, typically around 0.3 to 0.5 m below surface. When the salt ponds are filled, the water table will quickly equilibrate with the pond water level. The seepage of fresher pond water is predicted to displace existing groundwater radially away from the ponds
- This displacement effect is likely to lead to waterlogging adjacent to the ponds. As the rate of evapotranspiration is greater than the rate of seepage of pond water, the extent of potential waterlogging and surface seepage is largely constrained to a narrow area (~50 m wide) immediately adjacent to the ponds. In some areas this seepage is predicted to lead to surface salt crusting due to evaporation as described in Section 12.4.4.1.
- Seepage is not predicted to cause waterlogging a significant distance away from the ponds or within mangroves.
- The impacts of groundwater seepage and associated salt crusting to BCH, terrestrial vegetation and terrestrial fauna habitat have been assessed separately under Sections 8.6.1, 10.5.2.1 and 11.5.2.1. In summary these impacts are proportionally small and localised with the following areas predicted to be affected (AECOM, 2022a) (Biota, 2022a) (Biota, 2022b):
  - 3.92 ha of algal mat (0.14% of algal mat of East Exmouth Gulf).
  - 2.28 ha of samphire (0.6% of samphire in West Pilbara).
  - 119 ha of acacia shrubland/woodland (0.7% of similar vegetation in the study area).
  - 3.91 ha of claypan (0.017% of claypan of East Exmouth Gulf).

13.5.3 CUMULATIVE IMPACTS

No cumulative impacts are identified as there are no other projects in the local area proposing to impact the hydrological regimes of groundwater and surface water.

Cumulative impacts regarding BCH, terrestrial vegetation and terrestrial fauna habitat which may be impacted by groundwater seepage and salt crusting have been discussed under Sections 8.6.2, 10.5.3 and 11.5.2.1.

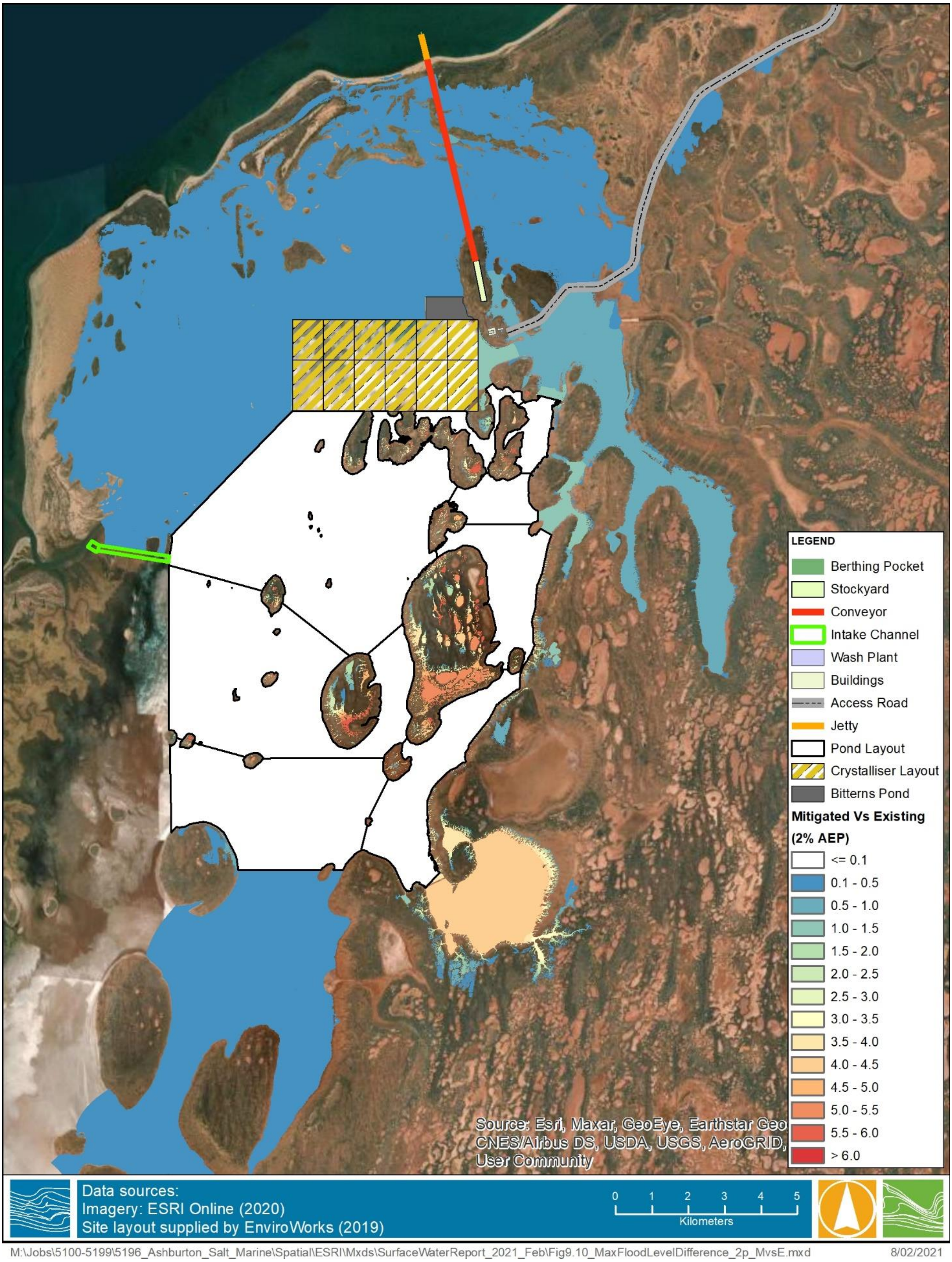

Figure 136: Modelled Water Level Change 2% AEP (existing versus developed with mitigation)
(Water Technology, 2021c)

13.6 ASSESSMENT OF IMPACTS

Detailed investigations including (Water Technology, 2021a), (Water Technology, 2021b), (Water Technology, 2021c) and (GHD, 2021c) have been completed to develop a comprehensive understanding of the existing hydrological processes at a local and regional scale and how they may be impacted by the Proposal. The focus of these assessments has been to inform the Proposal such that the surface water and groundwater systems are maintained, and environmental values are protected.

Indirect impacts to hydrological processes are associated with potentially altered surface flow pathways, connectivity, and flooding regime associated with changes in surface water flows due to the development layout. There may also be indirect impacts on groundwater resulting in radial groundwater movement, waterlogging and seepage.

These impacts can be summarised as:

- The proposed development will locally alter surface flow paths and resultant surface water flows; however, these impacts are mitigated by locating Proposal infrastructure outside the flow paths wherever possible, and implementing mitigation strategies, which include culverts, levees and drainage diversion channels.
- The effects of the Proposal on radial groundwater movement, water logging and seepage are localised to the immediate vicinity of the pond infrastructure. Impacts to the surrounding environment are predicted to be localised and proportionally small as discussed under Sections 8.6.2, 10.5.3 and 11.5.2.1 and summarised below:
  - No impact to mangroves.
  - 3.92 ha of algal mat (0.14% of algal mat of East Exmouth Gulf).
  - 2.28 ha of samphire (0.6% of samphire in West Pilbara).
  - 119 ha of acacia shrubland/woodland (0.7% of similar vegetation in the study area).
  - 3.91 ha of claypan (0.017% of claypan of East Exmouth Gulf).

Overall, the effects of groundwater movement, water logging and seepage are localised to the immediate vicinity of the pond infrastructure and the predicted extents have been conservatively estimated (GHD, 2021c). There are no regional impacts.

13.7 MITIGATION

13.7.1 AVOID

To avoid wherever possible any impacts on hydrological processes associated with groundwater and surface water systems both regionally and locally:

- The Proposal has been positioned to prevent interference with the major flow paths of Yannarie and Ashburton Rivers and thereby maintain the connectivity of the salt flats and the coast.
- Eight iterations of the pond design have been undertaken to minimise the footprint. Alignment of the western boundary of concentration ponds was moved further east to avoid seepage-related impacts to mangroves.

13.7.2 MINIMISE

The following strategies have been adopted to minimise hydrological impacts:

- Locate key infrastructure areas outside the 2% AEP (~1 in 50 year ARI) flood zone where possible.
- Divert flows around key infrastructure areas that intersect flow paths.
- Divert flows back onto natural flow paths.
- Ensure full conveyance of 10% AEP surface water flows under the main access road into site.
- Ensure surface water flows into downstream receptors are not impeded by proposed infrastructure.
- Protect infrastructure that falls outside of direct flow paths, but which is within the 2% AEP flood zone.

- Culvert locations and sizes were identified for the main access road and conveyor embankment to maintain flow connectivity
- Drainage diversions were also designed to remove floodwaters from the salt flats Eastern Basin, along a series of salt flat basins to maintain connectivity with the salt flats.

Two management plans are planned to be developed at the final design stage. Given the limited scale of impacts to surface water and groundwater K+S considers that these management plans are not critical to the initial assessment phase of the Proposal and were not required by the ESD. A description of these plans is provided below.

To ensure the surface water strategies are adequately implemented at the final design stage a detailed Surface Water Management Plan (SWMP) will be developed prior to construction. The SWMP will be completed following detailed design to ensure all measures to minimise impacts to surface water flow have been implemented.

A Groundwater Monitoring and Management Plan (GWMMP) will be implemented to ensure that groundwater seepage and mounding impacts are monitored and managed to ensure they do not exceed the extent predicted in this ERD. The final location of monitoring bores and other associated items will be determined at the detailed design stage of the Proposal. At a minimum the GWMMP will include:

- Detailed monitoring of groundwater levels and quality down-gradient of the concentrator and crystalliser ponds. Monitoring bores will be installed down-gradient of each bank of crystalliser ponds, and along the concentrator pond walls. The monitoring information will be used to determine whether any impacts to groundwater are occurring that do not align with modelled predictions. Suitable reference bores will also be monitored to allow an appropriate comparison.
- Details of cut-off bores, sumps and / or trenches that would be installed to pump the water to the appropriate salinity pond if the monitoring described above either:
    - Identifies sustained mounding that is outside of modelled predictions; or
    - Identifies seepage of high salinity brine that is above the natural groundwater range and likely to significantly impact on environmental values.

13.7.2.1 GROUNDWATER MONITORING AND MANAGEMENT PLAN

The GWMMP is currently being developed using baseline information collected during the study phase and modelling results. K+S intends to finalise the GWMMP as part of the response to submissions phase of the assessment to ensure that all concerns have been addressed if possible. K+S has provided the information below to present information about what the GWMMP is intended to address and proposed monitoring and mitigation.

Given the similarities between the two proposals, information has generally been sourced from the Mardie Project draft GWMMP (BCI Minerals, 2022).

13.7.2.1.1 BORE NETWORK

A monitoring bore network be installed which would consist of the following:

- Transects of bore sites, each consisting of sets of bores between the pond walls and the nearest mangroves;
- Further sites adjacent to the pond walls, where they intersect with mapped areas of algal mats;
- Each bore site will have discrete monitoring bores screened individually (one near the water table and one at depth), to quantify the magnitude of vertical hydraulic gradients and vertical variations of salinity; and
- Nested deep/shallow bores may be constructed to quantify hydraulic gradients and salinity variations.

Transects and single nested bore sites will be positioned to assist with characterisation of the groundwater regime beneath the supratidal flats and to detect changes in levels and gradients (vertical and horizontal). The monitoring network will be designed to characterise existing groundwater regimes beneath the intertidal zone (salt flats).

Given the size of the Proposal blanket detailed coverage is not feasible. Instead, the monitoring network will be located to be representative of the area. Baseline data will be collected from installation up until the time of filling of the nearest evaporation pond.

13.7.2.1.2 TRIGGER CRITERIA

The proposed criteria are based on the groundwater model and findings from groundwater investigations conducted to date. Table 100 provides the current justification and rational for the proposed criteria.

Table 100: Justification for trigger and threshold criteria assigned to each GWMMP outcome

Criteria	Justification
Outcome: No changes to the health, extent of diversity of intertidal benthic communities and habitat and terrestrial vegetation outside the predicted areas of impact presented in this ERD as a result of changes to groundwater regimes or groundwater quality associated with the Proposal.	
Trigger criterion 1 EC/TDS in monitoring bore(s) down-gradient from the ponds display sustained increase of 50% above the previous monitoring event for two or more quarterly sampling events.	This would conservatively indicate an interaction between the crystallizer ponds and the groundwater at the bore location. To avoid scientific error only a sustained increase across two sampling events would exceed the trigger.
Threshold criterion 1 Sustained doubling of EC/TDS from baseline values for two or more quarterly sampling events.	Doubling of EC/TDS above the previous monitoring event would strongly suggest an interaction between the groundwater and crystalliser ponds as such a change would be unlikely to result from natural variation. To avoid scientific error only a sustained increase across two sampling events would exceed the threshold.
Trigger criterion 2 Bromide concentration increased by more than 10 mg/L for two or more quarterly sampling events. Trigger to be adjusted as baseline data is acquired.	Bromide is a key element accurately detected within brine with minimal risk of variation due to with laboratory dilution error. An increase in Bromide concentration of 10 mg/L or more would be easily detected and demonstrate a strong indication of groundwater quality impacts.
Threshold criterion 2 Bromide concentration increased by more than 20 mg/L for more than two quarterly sampling events. Threshold to be adjusted as baseline data is acquired.	Bromide is a key element accurately detected within brine with minimal risk of variation due to with laboratory dilution error. An increase in Bromide concentration of 20 mg/L or more would provide an unacceptable level which could compromise the health of down-gradient ecosystems.
Trigger criterion 3 Groundwater levels down-gradient of the ponds increase by more than 0.5 m over two or more consecutive monitoring events.	Groundwater level rises could indicate mounding effects attributed to seepage from the ponds. An increase in water level rise of more than 0.5 m above baseline value would be a strong indicator that the groundwater regime is altered beyond that of natural variation.
Threshold criterion 3 Surface expression of groundwater down-gradient of the ponds.	Surface water expressions unrelated to a climatic event would suggest an unacceptable event and would lead to potential loss of habitat.

13.7.2.1.3 METHODS FOR ESTABLISHING BASELINE VALUES

Baseline values for groundwater levels and water quality will be established through ongoing monitoring as defined in the monitoring schedule (Table 102). Specific baseline values will be developed for each monitoring location using data acquired up until the time at which the adjacent ponds are filled. Table 101 describes the baseline parameters for each of the desired outcomes and the methods used to establish the baseline values.

Table 101: Methods for establishing baseline data

Criteria	Baseline	Method for Establishing Baseline	Period of Baseline data collection
Outcome: No changes to the health, extent of diversity of intertidal benthic communities and habitat and terrestrial vegetation outside the predicted areas of impact presented in this ERD as a result of changes to groundwater regimes or groundwater quality associated with the Proposal.			
1	Groundwater quality and EC/TDS, down-gradient from ponds.	Calculation of mean quality parameters for each monitoring bore from samples taken from upper portion of the water column. Maximum EC value measured in each bore from samples taken from upper portion of the water column.	From time of installation of the environmental monitoring bores up until the time of filling of the nearest pond. A minimum of 4 sampling events over a 12-month period.
2	Groundwater levels down-gradient from ponds.	Calculation of the mean seasonal standing water level for each monitoring bore.	From time of installation of the environmental monitoring bores up until the time of filling of the nearest evaporation pond. A minimum of 4 monitoring events over a 12-month period.

13.7.2.1.4 ADAPTIVE MANAGEMENT AND REVIEW OF THE GWMMP

K+S is committed to improving environmental results and management practices throughout the implementation of the Proposal and therefore will use an adaptive management approach for the GWMMP. Adaptive management practices will include:

- Annual review and comparison of monitoring data against established baseline data;
- Annual evaluation of monitoring and management outcomes against management targets and the objectives of the GWMMP; and
- Review of management actions throughout the implementation of the Proposal, and identification of potential new management measures and technologies that may be more effective.

13.7.2.1.5 OUTCOMES-BASED MANAGEMENT ACTIONS

Table 102: Preliminary trigger and threshold criteria, response actions, timing, reporting and monitoring requirements

Trigger Criteria Trigger Thresholds	Response actions	Monitoring	Timing/frequency of monitoring	Reporting
Trigger criterion 1 EC/TDS in monitoring bore(s) down-gradient from the ponds display sustained increase of 50% above the previous monitoring event for two or more quarterly sampling events. **Threshold criterion 1** Sustained doubling of EC/TDS from baseline values for two or more quarterly sampling events.	**Trigger level actions** • Monthly water quality monitoring at the affected bore and adjacent bores. Conduct investigation and determine appropriate response actions. **Threshold exceedance action** • Report to DWER. • Conduct investigation and report to DWER with appropriate remedial actions.	**Indicator** • Electrical conductivity (EC). **Method for data collection and analysis** • EC of water sample collected from upper portion of the water column in monitoring bores. **Location of monitoring sites** • To be defined.	Monthly monitoring of EC in bores to occur within 1 month of trigger criterion being identified.	**Reporting Exceedance** • Notify DWER within two weeks of the threshold criterion being identified. **Contingency Progress Report** • Develop remediation plan and notify regulator within one month of exceedance of threshold criterion. **Annual Reporting** • Annual groundwater level and quality assessment to be prepared and submitted each calendar year.
Trigger criterion 2 Bromide concentration increased by more than 10 mg/L for two or more quarterly sampling events. Trigger to be adjusted as baseline data is acquired. **Threshold criterion 2** Bromide concentration increased by more than 20 mg/L for more than two quarterly sampling events. Threshold to be adjusted as baseline data is acquired.	**Trigger level actions** • Monthly water quality monitoring at the affected bore and adjacent bores. Conduct investigation and determine appropriate response actions. **Threshold exceedance action** • Report to DWER. • Conduct investigation and report to DWER with appropriate remedial actions.	**Indicator** • Groundwater quality parameters such as bromide concentration as an indicator of brine derived from sea water. **Method for data collection and analysis** • Water sample collected from upper portion of the water column in monitoring bores. **Location of monitoring sites** • To be defined.	Quarterly groundwater quality sampling.	
Trigger criterion 3 Groundwater levels down-gradient of the ponds increase by more than 0.5 m over two or more consecutive monitoring events.	**Trigger level actions** • Monthly water quality monitoring at the affected bore and adjacent bores. Conduct investigation and	**Indicator** • Groundwater level. **Method for data collection and analysis**	Monthly monitoring of EC in bores to occur within 1 month of trigger criterion being identified.	

Trigger Criteria Trigger Thresholds	Response actions	Monitoring	Timing/frequency of monitoring	Reporting
Threshold criterion 3 Surface expression of groundwater down-gradient of the ponds.	determine appropriate response actions. **Threshold exceedance action** • Report to DWER. • Conduct investigation and report to DWER with appropriate remedial actions.	• Water level to be measured and compared with baseline and trend water levels. **Location of monitoring sites** • To be defined.		

13.7.2.1.5.1 EARLY RESPONSE INDICATORS, CRITERIA AND ACTIONS

If monitoring data indicate the potential presence of hypersaline brine seepage or mounding, active responses or remediation will take place if investigations indicate that the seepage may have an unacceptable effect on groundwater or the surrounding environment.

Appropriate installation locations for recovery bores or trenches would be guided by groundwater flow characteristics determined during seepage modelling. Modelling scenarios will be used to develop appropriate recovery infrastructure designs.

The following response measures, or combinations thereof, may be implemented at the Proposal:

- Monitoring frequency would be increased for affected bores to assist with rapid response to changes/trends in groundwater quality;
- Installation of seepage recovery bores or other interception method near the location of the potential seepage, with design based on the perceived nature of the leakage, the determined groundwater flow regime, and the feasibility of the recovery infrastructure;
- An additional line of monitoring/seepage recovery bores may be drilled at an appropriate distance down gradient between the affected bores and BCH areas;
- New monitoring bores would become part of the regular monitoring network with quarterly water quality sampling (or loggers) and possibly salinity profiling to determine baseline values. The new bores would serve as downgradient monitoring points to detect further propagation of the seepage plume, and to detect changes in groundwater gradients (and hence flow direction) which may be induced by pumping at the originally affected bore(s); and
- Extraction rates at seepage recovery bores would be altered as necessary, and new bores would be installed should this be required to minimise environmental impacts related to seepage.

13.7.3 REHABILITATE

At the completion of the Proposal the site will be rehabilitated to reinstate hydrological processes. At the completion of operations, all buildings and structures on land will be removed from the site and the pond areas may be selectively reconnected to the existing tidal flat system. K+S preferred post closure land use is to leave the evaporation ponds in situ so that they become fauna habitat for shore birds (including migratory birds which require “wetland areas” for migratory stop over).

If ponds are to be reconnected, the MCP will establish which bunds to breach that will enable inwards tidal movement bringing sediments and allowing tidal channels to expand naturally. Natural tidal flows will allow movement of mangrove plant and seed material which will passively revegetate the reconnected tidal areas. This will enhance the habitat values of the ponds post closure.

Consideration will be given to the removal of specific culverts, levees and diversion channels as required to reconnect the groundwater and surface water hydrological regime in areas modified by the Proposal.

An Interim MCP for the Proposal has been provided in Appendix BB and will continue to evolve during the life of the Proposal. If the Proposal receives Ministerial Approval under Part IV of the EP Act as well as under the EPBC Act, the MCP will be developed in more detail and submitted to DMIRS for approval as required by the *Statutory Guidelines for MCPs under the Mining Act 1978* – DMIRS (2020b).

13.8 PREDICTED OUTCOME

The EPA objective in relation to hydrological processes is *to maintain the hydrological regimes of groundwater and surface water so that environmental values are protected*. This objective is met by the proposed development because the Proposal has been located and designed to eliminate or minimise changes to surface flow regimes. In addition, the development and implementation of surface water mitigation strategies will occur to further minimise impacts.

Detailed technical assessments have developed a comprehensive understanding of the hydrological processes both regionally and locally including surface flow and groundwater systems and the potential impacts associated with the Proposal were found to be localised in the vicinity of the Proposal and proportionally small on a regional basis.

While impacts were deemed to not be extensive during modelling, monitoring and management plans will be developed at the detailed design phase to ensure impacts are within modelled predictions and to inform management measures.

Given the minor nature of the direct and indirect impacts from the development on hydrological processes the residual impacts to this factor are not considered to be significant.

14 INLAND WATERS ENVIRONMENTAL QUALITY

14.1 EPA OBJECTIVE

To maintain the quality of groundwater and surface water so that environmental values are protected.

14.2 POLICY AND GUIDANCE

- *Environmental Factor Guideline: Inland Waters Environmental Quality* (EPA, 2016p).
- *Environmental Factor Guideline: Hydrological Processes* (EPA, 2016q).
- *Acid Sulfate Soil Guideline Series: Identification and investigation of acid sulfate soils and acidic landscapes* (DER, 2015a)
- *Acid Sulfate Soil Guideline Series: Treatment and management of soils and water in acid sulfate soil landscapes* (DER, 2015b)
- *Australian and New Zealand Guidelines for Fresh and Marine Water Quality* (ANZG, 2018)
- *Australian groundwater modelling guidelines (Waterlines Report Series No. 82)* (Barnett et al., 2012).
- *Rights in Water and Irrigation Act 1914*.
- *State Water Quality Management Strategy No. 6: Implementation Framework for Western Australia for the Australian and New Zealand Guidelines for Fresh and Marine Water Quality and Water Quality Monitoring and Reporting (Guidelines Nos. 4 & 7: National Water Quality Management Strategy) (Report No. SWQ 6)* (Government of Western Australia, 2004).
- *Western Australia water in mining guideline (Water licensing delivery report series: Report No. 12)* (DoW, 2013).
- "Appendix B: Potentially contaminating industries, activities and land uses" in *Assessment and management of contaminated sites: Contaminated sites guidelines* (DER, 2014).

14.3 INLAND WATERS ENVIROMENTAL QUALITY STUDIES

Studies to assess inland waters environmental quality have been conducted as outlined in Table 103.

Table 103: Inland Waters Environmental Quality Studies

Report	Reference	Appendix
Marine and Coastal Assessment and Modelling	Water Technology, 2022b	A
Surface Water Assessment and Modelling	Water Technology, 2022a	B
Marine, Coastal and Surface Water Data Collection	Water Technology, 2021a	C
Marine, Coastal and Surface Water Existing Environment	Water Technology, 2021b	D
Surface Water Assessment and Modelling	Water Technology, 2021c	E
Marine, Surface Water and Nutrient Modelling Peer Review	DHI, 2021	F
Acid Sulfate Soils Study	GHD, 2021a	K
ASSSMP	GHD, 2021b	BB
Materials Characterisation Study	GHD, 2021d	U
Memorandum Ashburton groundwater modelling- updated results	GHD, 2022	V
Hydrogeological Investigation	GHD, 2021c	W
Hydrogeology Modelling Peer Review	Cymod, Systems, 2022	X
Hydrogeology Modelling Peer Review	Cymod, Systems, 2021	Y

14.3.1 MODELLING

A specific hydrodynamic modelling study for surface water (Water Technology, 2021c) and a hydrogeology modelling study (GHD, 2021c) have been conducted to assess potential hydrological impacts of the Proposal regarding surface water and groundwater.

14.3.2 MODELLING PEER REVIEWS

Peer reviews of the above modelling studies have been conducted. The peer review process was undertaken in a comprehensive, rigorous and iterative manner.

- It is the opinion of the surface water model peer reviewer that the surface water model (Water Technology, 2021c) can be considered suitable for the purpose of identifying potential surface water impacts of the Proposal (DHI, 2021).
- It is the opinion of the groundwater model peer reviewer that the groundwater model (GHD, 2021c) is fit for the purpose of assessing groundwater related environmental impacts of the Proposal (CyMod Systems, 2022).

14.4 EXISTING ENVIRONMENT

14.4.1 REGIONAL SURFACE WATER QUALITY

The Ashburton River is located approximately 25 km northeast of the proposed salt ponds. The Ashburton River is generally fresh, with TDS (a measure of salinity) being around 133 mg/L (Ruprecht and Ivanescu, 2000). This is similar to other rivers in the Pilbara region (TDS range 50 – 1,000 mg/L). Salinity in the Ashburton River, and all Pilbara region rivers, generally decreases with increasing flow and becomes more saline during times of low flow (URS, 2010b).

TSS and turbidity in the Ashburton River are generally low, and generally increase with increasing flow. The turbidity of the Ashburton River ranges from less than 10 NTU over a range of flows, from 30 m^3/sec to 250 m^3/sec, to 3,300 NTU at a flow rate of around 250 m^3/sec. The flow weighted turbidity for Ashburton River is 1,705 NTU, which is higher than other Pilbara river sites, which range from 10 – 587 NTU (Ruprecht and Ivanescu, 2000).

14.4.2 SITE SPECIFIC SURFACE WATER QUALITY

Due to the low frequency of significant rainfall events resulting in surface water flows or flooding, limited local surface water quality data is available. Two significant rainfall events have occurred in the Proposal area since 2019 which have allowed K+S to sample the flooded salt flat areas (one rainfall event of 44 mm in April 2019 and another of 79.5 mm in March 2021). Both rainfall events resulted in flooding of local claypans and salt flats as illustrated in (Figure 137). The data from this sampling are presented in (Water Technology, 2021a) and show:

- TDS measurements indicate that surface water is saline to hypersaline on the salt flats with TDS in salt flat samples ranging from 45,000 mg/L to 120,000 mg/L.
- pH across the salt flats and inland flow paths ranged from neutral to slightly alkaline (pH range 7.3 – 8.6).
- TSS varied significantly with lower levels on the salt flats (<5 – 87 mg/L) and higher levels inland of the salt flats (up to 19,000 mg/L). Levels within an inland flow path were extremely high (resembling a slurry) at 510,000 mg/L.
- Levels of chlorophyll-a were low in all samples (<0.001 to 0.006 mg/L) except that from the overland flow sample which resembled a slurry (0.32 mg/L).
- The mean total nitrogen concentration across nine sites (excluding the high sediment sample) was 1.1 mg/L. The high sediment sample was excluded as it was more a sediment slurry, as opposed to a representative surface water sample.

- Samples were comprised of predominantly dissolved organic nitrogen (ranging from <.0.2 mg/L to 1.7 mg/L).
- The overland flow sample which resembled a slurry and had high total nitrogen content (120 mg/L), representative of nitrogen within the sediments from overland flows.
- Phosphorus was highest at the most inland sites and largely particulate at these locations. The sites with the high phosphorus also corresponded to sites with the highest TSS. This is the result of phosphorus adsorption to sediment. This observation adds further confidence to the assertion that the environment is nitrogen limited, as there is phosphorus readily available in soils across the site.
- The results show that the nitrogen in the water ponding on the bare salt flats is low compared with the other samples, particularly those received as suspended solids in overland flows (such as the highly turbid water from overland flows entering the salt flats). The data shows that the bare salt flats do not generate comparatively large amounts of nitrogen in ponded water, even after inundation with rainfall, compared with turbid overland flows/ponding from the hinterland.
- High levels of TDS in the samples from the bare salt flats indicate that the surface salt crust was dissolving into the ponded water on the bare salt flats, but there are comparatively low levels of nitrogen in this dissolved salt crust compared with overland flows.


Aerial view of flooded claypans from helicopter


Large expanse of flooded salt flat


Flooded claypan (cracking clay)


Flooded algal mat fringe, salt flat in background

Flooded claypan (highly turbid)

Flooded algal mat fringe

Figure 137: Photographs of Surface Water Flooding after Rainfall on 13th of April 2019

14.4.3 REGIONAL GROUNDWATER QUALITY

In order to assess existing groundwater data, a search was made of the DWER Water Information Reporting (WIR) database. This database includes records of existing and historic bores, including data on bore lithology, water levels and water quality. Following receipt of bore records within 50 km of the centre of the site, the data was collated and assessed, and summarised to provide relevant data on bore depths, groundwater depths, and water quality. A total of 126 bores are identified within the 50 km search radius, however of these only 26 bore records are within 25 km radius of the centre of the site. Bore locations closest to the site tend to be aligned either along the coast north of the site, or south of the site. Of the 126 bores recorded in the WIR data, drilled depth information is available for 92, with the depth ranging between 1 m and 694 m. The median depth of 12 m likely reflects that the majority of bores are relatively shallow stock bores.

The data shows that of the 126 bores within 50 km of the site, salinity data (as TDS or EC) is available for 51 bores. TDS (measured and calculated) ranges between 355 mg/L and 147,000 mg/L. The median TDS is 5,800 mg/L and the average TDS is 14,000, highlighting that the TDS data is skewed by the two maximum values of 130,000 mg/L and 147,500 mg/L. The two bore sites recording these high salinities are both located within the tidal flats south of the Proposal area. The majority of the bores located on the coastal ridge north of the site have relatively low salinities. It appears these bores, mostly stock watering bores, are located within the sand (and possibly limestone/calcrete) ridge adjacent to the shoreline. Whilst these bores are relatively fresh (TDS <5,000 mg/L), the presence of much more saline bores inland of the bores indicates that the freshwater aquifer is localised and possibly restricted to the elevated areas along the coastal ridge. The freshwater aquifer is likely relatively thin and overlying the more saline, seawater affected groundwater (GHD, 2021c).

14.4.4 LOCAL GROUNDWATER QUALITY

Geomorphology of the coastal area and interaction of tidal flooding, surface runoff, groundwater flow and evaporation has resulted in the salinity pattern observed at the site. Due the high evaporitic action, sodium-chloride dominates in groundwater. The coastal zonation ensures a strip pattern of salinity developed along the coast as follows (GHD, 2021c):

- The salt flats host hypersaline groundwater in a strip parallel to the coast. The salinities in this zone vary between 150 to 300 g/L. Due to its high salinity, the groundwater forms a dense water body, potentially distorting incoming fresher groundwater flow from inland locations.
- The coastal dunes and mangrove swamps between the ocean and salt flats form a transition zone. This zone is influenced by seawater of lower salinity, fresh groundwater recharge from rainfall (unaffected by evaporation) in elevated dunes and the potential hypersaline wedge extending seaward from the salt flat zone. This area has a range of salinities between 20 and 100 g/L.

- The gradually emerging dune system rising landward from the salt flats is also a transition zone. It contains comparatively fresher, but potentially still saline or brackish groundwater originated from the upgradient dune fields. This transition zone is considered to have a range of salinities from the brackish end (of about as low as 5 to 6 g/L) to hypersaline near the contact with the salt flats.

14.4.5 SITE SPECIFIC GROUNDWATER DATA COLLECTED

The drilling of boreholes was completed on 31st March 2020. Further fieldwork was undertaken between 30th August and 4th September 2020 to gather additional groundwater data for the hydrogeological modelling. Of the 14 selected and accessible locations, nine were completed as paired sites with two monitoring bores constructed to represent the shallow and deep groundwater horizons or units. At three of these locations a third bore was constructed using 100 mm diameter casing to facilitate aquifer testing of the site. Groundwater samples were analysed for a general suite to provide baseline data on groundwater quality (GHD, 2021c).

14.4.5.1 TDS AND EC

EC and TDS results are summarised below:

- EC and TDS dry were found to be unreliable indicators of groundwater salinity, especially in hypersaline samples. In general, the correlation between EC and TDS for samples with salinity exceeding 150 g/L TDS (sum of dissolved ions as opposed to TDS dry) is unreliable beyond that salinity threshold. TDS as sum of dissolved ions is therefore adopted as the more reliable indicator of salinity.
- TDS is well correlated with chloride concentrations – chloride can be used as surrogate TDS indicator (Cl = 0.17 x TDS; R2 = 0.99).
- All the bores showed saline or hypersaline groundwater conditions. EC values ranged between 20 g/L (BH03S) to 306 g/L (BH14D, but only 234 g/L during September run). Largest salinities observed during the September sampling run were detected in BH10D and BH11D (251 and 269 g/L respectively).
- The least saline groundwater was measured in both the shallow and deep bores at BH03, where the shallow bore was slightly less saline than the deep bore (20 and 30 g/L the shallow and deep bore, respectively). The location of BH03 in an area of elevated dunes, and some distance from the supratidal flats, may suggest that there is the possibility of a fresher water lens at this location.
- The next lowest salinity was measured in BH13 (61 g/L). BH13 is the furthest inland located bore, indicating that background salinities are still high, suggesting only minor freshening from recharge. This is supported by the hypersaline groundwater also found at BH04 (105 g/L), located immediately adjacent to Chinty Creek. The hypersaline water here suggests (current) insufficient capacity and availability of fresh water from this creek line to refresh groundwater (it was dry at the time of sampling).
- All the bores located within the supratidal salt flats showed hypersaline conditions. The average of these bores (BH05, BH07, BH08, BH10, BH11, BH14 and BH15) is 215 g/L, compared to an average of 78 g/L for the bores located either within mainland remnant islands or located off the flats (BH02, BH03, BH04, BH09, BH12 and BH13).
- All paired sites show a slight stratification of groundwater quality between deep and shallow bores, with higher salinities found in the deeper screened bores (GHD, 2021c).

The TDS values for the bores (from September 2020 sampling run) are presented in Figure 138, with the paired sites (deep and shallow screens) highlighted.

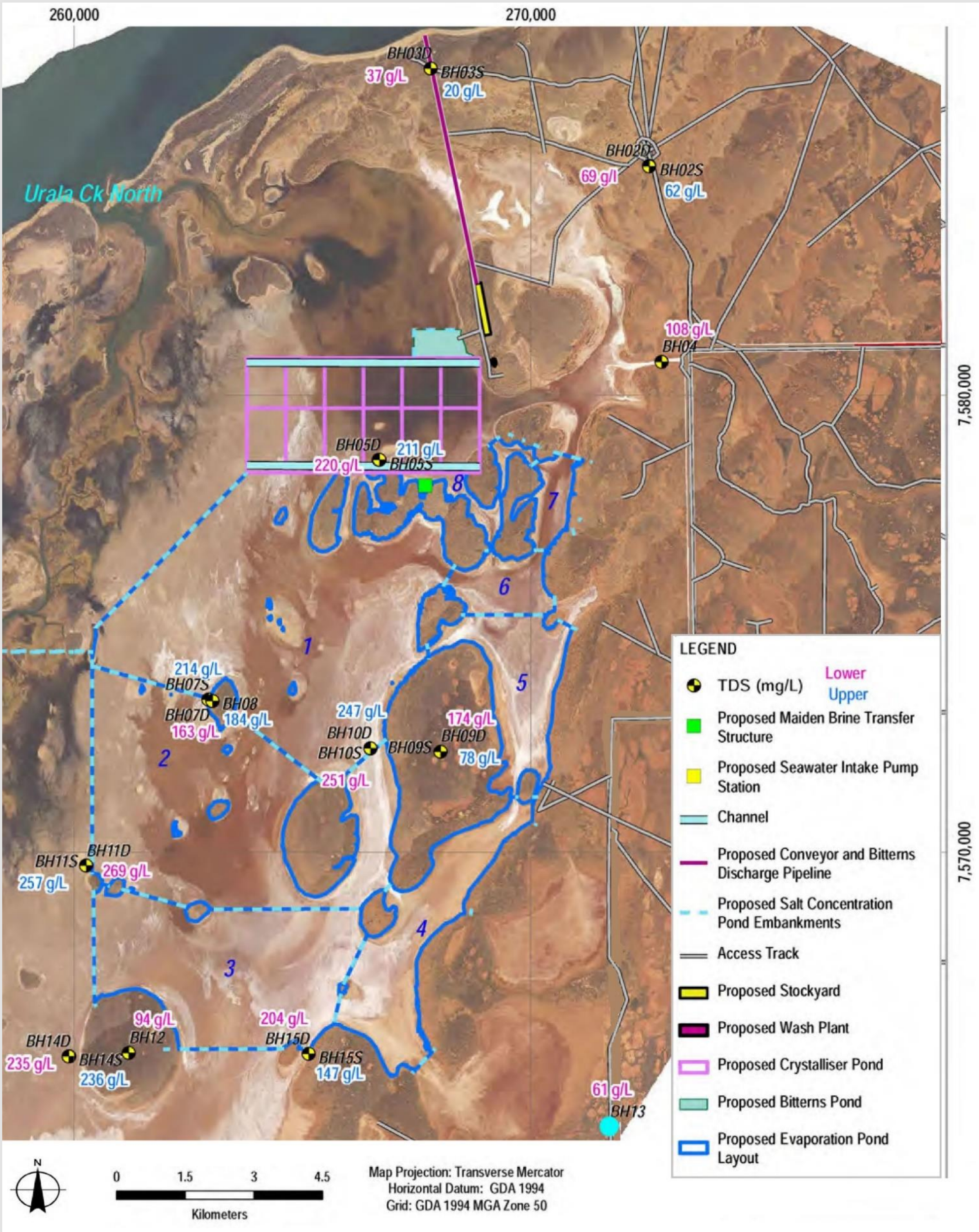

Figure 138: Measured Total Dissolved Solids in Groundwater

(GHD, 2021c)

14.4.5.2 INORGANIC CONSTITUENTS

Inorganic groundwater chemistry results are summarised below:

- pH results reported for groundwater indicate that groundwater across the site is relatively neutral. pH values ranged from 6.7 to 7.7 pH units, with the minimum pH reported at BH10S/D and maximum value reported at BH03S/D. pH values did not demonstrate significant variability between screen depths, with all shallow and deep paired wells displaying pH variance <0.2, with the exception of 0.5 difference between BH02S and BH02D. Spatially, pH values appeared to increase towards the peripheries of the site, with the lowest pH values returned for the central evaporation pond area.
- Alkalinity (total as $CaCO_3$) concentrations were generally consistent across the site with a minimum concentration of 77 mg/L, maximum of 690 mg/L and average of 162 mg/L. Two comparatively high results were returned at locations BH12 (690 mg/L) and BH09S (510 mg/L). Spatially, negligible variability is seen in alkalinity results, with the exception of the two high results being confined to mainland remnant islands within the evaporation pond area.
- Chloride concentrations are the dominant contributor to groundwater salinity. They vary from 11 g/L in BH03S to 190 g/L in BH14D. The highest values, consistent with TDS, are found in the salt flats.
- Sulfate concentrations demonstrated variability across the site with a minimum concentration of 1,700 mg/L (BH03S), maximum of 18,000 mg/L (BH07S – this value was only 8470 mg/L in September sampling run) and average of 7,978 mg/L. Comparatively high sulfate concentrations were reported for groundwater samples within the south- western evaporation pond area, while lower concentrations were reported further inland and in the northern portion of the site.
- Silica concentrations slight variability across the site with a minimum concentration of 9 mg/L (BH14S), maximum of 82 mg/L (BH15S) and average of 24 mg/L. Comparatively high silica concentrations were reported towards the southern portion of the site and generally confined to monitoring wells on or proximal to mainland remnant islands (GHD, 2021c).

14.4.5.3 NUTRIENTS

Nitrogen species are represented as ammonia N and nitrate N:

- Ammonia concentrations are generally consistent across the site with a minimum concentration of 0.02 mg/L (BH03D), maximum of 6 mg/L (BH12) and average of 0.89 mg/L. Four exceedances of the *ANZG Freshwater 95% Guideline* assessment criteria were reported with comparatively high results returned for BH05D (5.2 mg/L) and BH12 (6 mg/L).
- Nitrate concentrations are on average generally low, with 52% samples below the detection limit. Largest concentrations, detected during the September sampling run, were obtained from BH15S and BH15D (8.2 and 8.8 mg/L as N) and BH08 (5.7 mg/L as N) (GHD, 2021c).

14.4.5.4 METALS AND METALLOIDS

Metals groundwater chemistry results are summarised below:

- Aluminium (total) concentrations were reported above the ANZG Freshwater 95% Guideline (0.055 mg/L) at all locations, with the exception of BH10 and BH15D. Limited variability was seen in aluminium (total) across the site; however, a comparatively high result of 200 mg/L was reported at BH09S.
- The aluminium (filtered) results were below laboratory limits of reporting (LOR) for all locations except for five locations which showed *ANZG Freshwater 95% Guideline* exceedances.
- Iron (total) concentrations were above the *ANZG Freshwater 95% Guideline* (0.055 mg/L) at all locations, with the exception of BH10 and BH15D. Limited variability was seen in iron (total) across the site; however, a comparatively high result of 490 mg/L was reported at BH09S.
- The iron (filtered) results were generally below laboratory limits of reporting (LOR) and only one location (BH14D) showed a guideline exceedance (GHD, 2021c).

14.4.6 LOCAL ENVIRONMENTAL VALUES

Local environmental values related to inland water environmental quality have been identified as follows:

- The surface water and tidal nutrient levels and pathways to support ecosystem productivity.

- The tidal flushing regime to maintain appropriate salinity regimes for intertidal BCH.
- The lack of surface hypersaline groundwater seepage in key ecosystems (mangroves, algal mats, terrestrial vegetation).
- A lack of contamination of the local surface and groundwater by acid sulfate soil disturbance, metals, NORMs, salt/bitterns spillage, hydrocarbons and chemicals.

These local values have been mapped overlayed by the Proposal in Figure 139 using GIS data from the Proposal surface water study (Water Technology, 2021c) and groundwater study (GHD, 2021c).

14.4.7 REGIONAL ENVIRONMENTAL VALUES

Regional environmental values related to inland water environmental quality have been identified as follows:

- The surface water quality of the Ashburton River.
- The surface water and groundwater regime of the Exmouth Gulf East Wetland (WA007) which is listed in the Directory of Important Wetlands in Australia.

These regional values have been mapped overlayed by the Proposal in Figure 140 using GIS data from the Proposal surface water study (Water Technology, 2021c) and the Directory of Nationally Important Wetlands GIS boundary for Exmouth Gulf East Wetland (WA007).

14.5 POTENTIAL IMPACTS

The following potential impacts have been identified for this Proposal:

- Direct impacts:
  - Spills and contamination.
  - Acid sulfate soils and sediment.
  - Erosion and scour.
- Indirect impacts
  - Altered nutrient pathways.
  - Altered tidal flushing of shallow groundwater.
  - Groundwater salinity changes.
  - Saline groundwater seepage.
  - Extreme events.

14.5.1 DIRECT IMPACTS

14.5.1.1 SPILLS AND CONTAMINATION

During construction and operations there is the potential for accidental spills or inappropriate waste disposal to occur that may cause contamination of surface water or groundwater. Potential contaminants could include salt product, bitterns, hydrocarbons and general site wastes. With appropriate mitigation these impacts should not occur, therefore they are considered low risk. Spills and contamination will be prevented and mitigated through appropriate planning and management measures including the following management plans:

- CEMP (to be prepared prior to construction).
- OEMP (to be prepared prior to operations).
- MEQMMP (Appendix BB).
- WMP (Appendix BB).

ASSS is discussed in Section 14.5.1.2. Erosion and sedimentation due to dispersive soils is discussed in Section 14.5.1.3. No other naturally occurring soil properties are considered likely to create a risk of contamination of terrestrial environmental quality (GHD, 2021d) (Section 12.3.5 and 12.4.4.2).

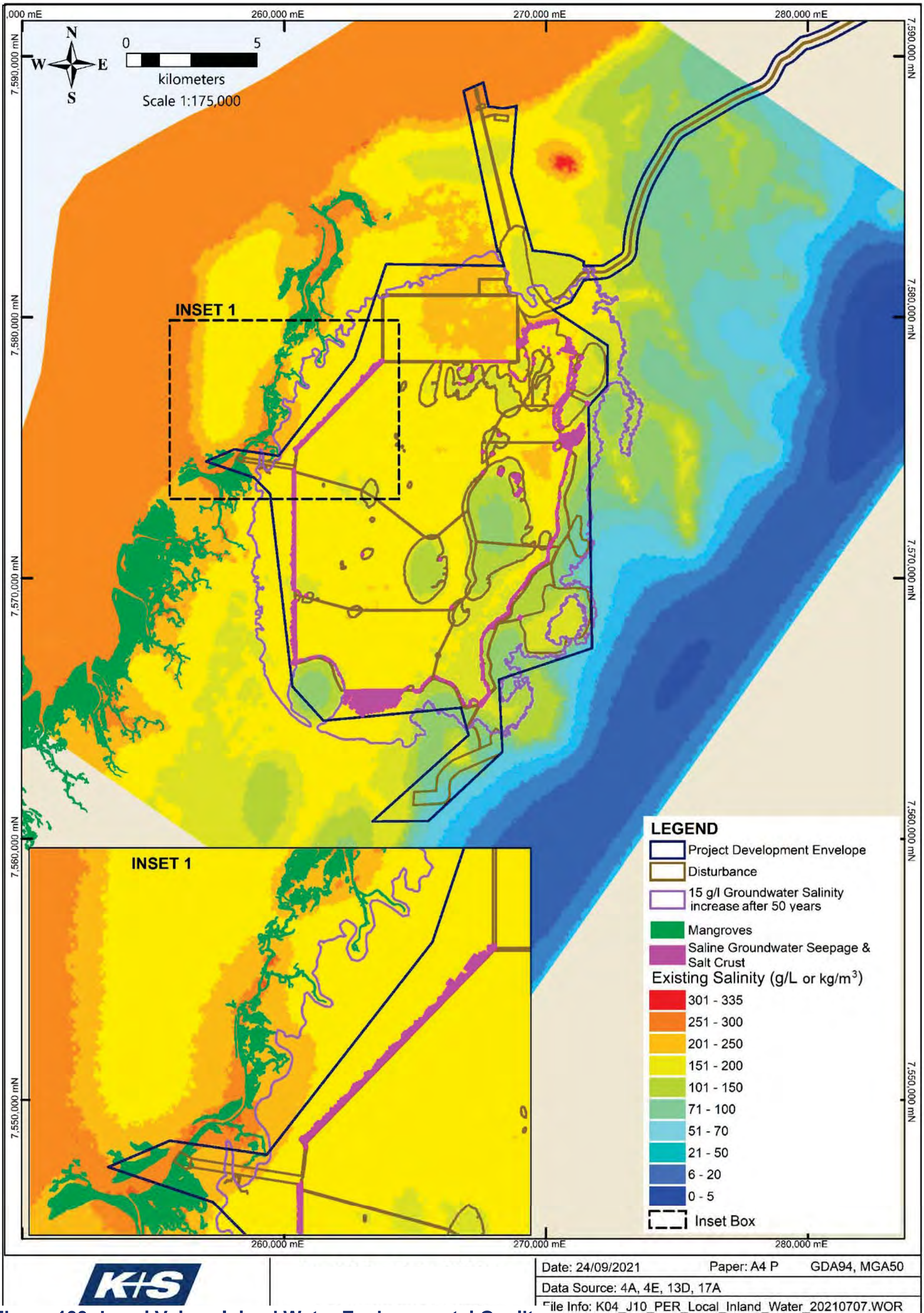

Figure 139: Local Values Inland Water Environmental Quality

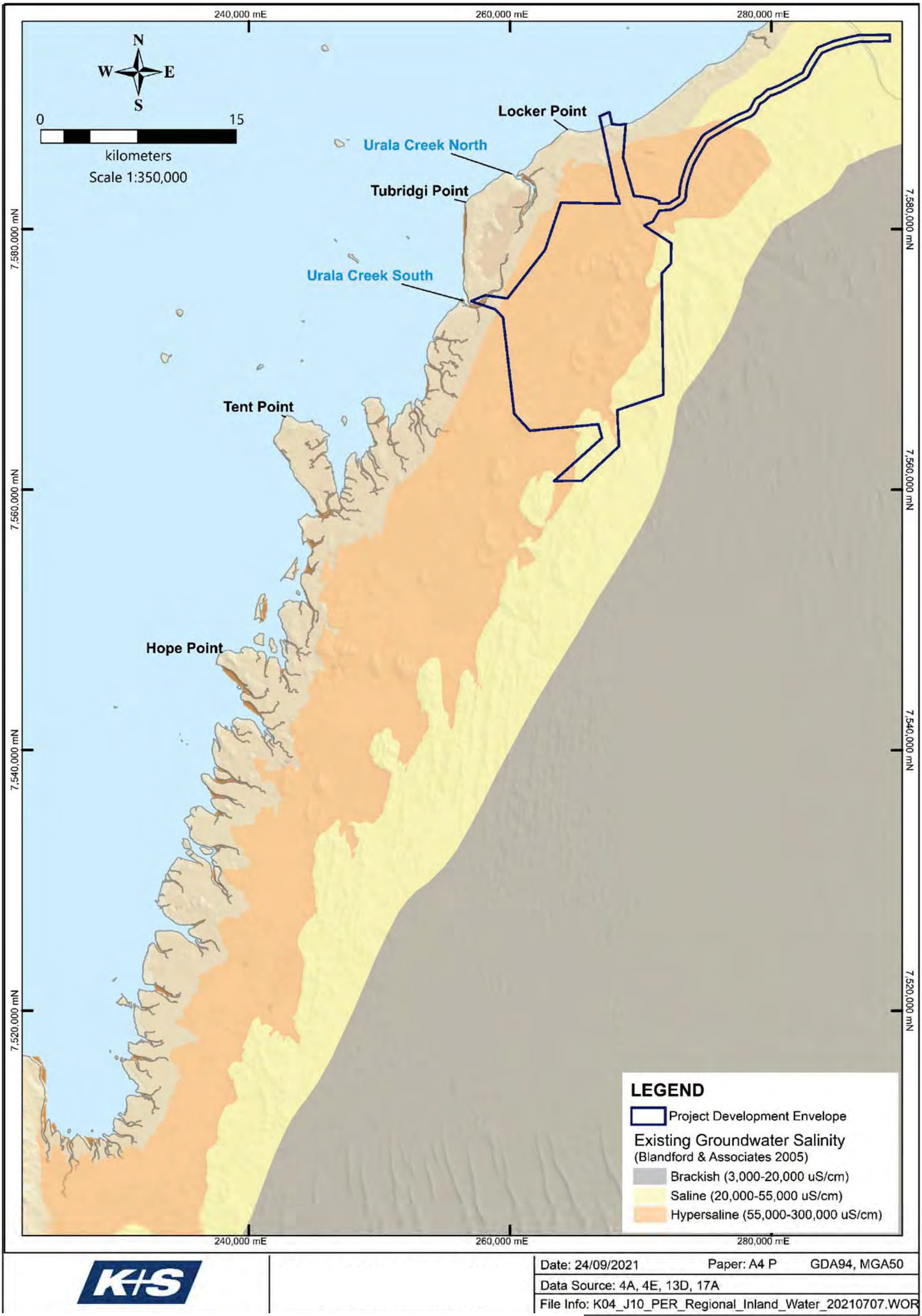

Figure 140: Regional Values Inland Water Environmental Quality

14.5.1.2 ACID SULFATE SOILS AND SEDIMENT

During the ASSS sampling program, sulfidic material was encountered on site within the supratidal flats, creek mudflats and lower lying regions of the Proposal area as well as the berthing pocket dredging location.

Infrastructure requiring excavation and disturbance in these areas and land disposal of dredged sediment may lead to sulfide oxidation and the generation of sulfuric acid (GHD, 2021a) which could contaminate surface water or groundwater. Table 94 in Section 12.4.3.2 summarises areas of potential ASS risk and treatment required across the Proposal. An ASSSMP has been developed for the Proposal and is included as Appendix BB (GHD, 2021b).

14.5.1.3 EROSION, SCOUR AND SEDIMENTATION

Erosion and scouring at drainage diversions and the dredge spoil disposal site could lead to surface water contamination with sediment. Appropriate engineering controls will be applied to prevent erosion and scour including geofabric, rock armouring and revegetation.

The disturbance of sodic and/or dispersive soils could exacerbate erosion and increase the potential for increased turbidity and sediment loading of surface waters. A Materials Characterisation Study (GHD, 2021d) identified naturally occurring geochemical and physical soil properties which may have environmental or employee health impacts and made recommendations for management. Potential naturally occurring soil properties considered including sodic and dispersive soils and recommended management are summarised in Table 95, Section 12.4.4.2.
Appropriate management of erosion and scour and management of sodic/dispersive soil properties during construction and operations will be documented and approval sought under other regulatory processes as follows:

- Mining Proposal and MCP to be submitted to DMIRS in accordance Statutory Guidelines for Mining Proposals (DMIRS, 2020a) and Statutory Guidelines for MCPs (DMIRS, 2020b). An Interim MCP for the Proposal has been provided in Appendix BB and will continue to evolve during the life of the Proposal.

14.5.2 INDIRECT IMPACTS

14.5.2.1 ALTERED NUTRIENT PATHWAYS

Section 7.5.3.1 details the impacts of the development on nutrient pathways. The detailed analysis showed that the predicted impacts are small in proportion to the total estimated nutrient flows into the local catchment. Highly conservative modelling predicted a local post-development proportional reduction in nitrogen flows into the Proposal catchment of 0.8% of land and ocean sources (Water Technology, 2021d).

Based on this conservative assessment, it can be concluded that the proposed development will not significantly alter nutrient exports or pathways due to the small scale of the predicted reductions and their infrequent nature. This will therefore also have only limited impact on the inland water quality of the local catchment in terms of nutrient volumes and concentrations available to local ecosystems.

14.5.2.2 ALTERED TIDAL FLUSHING OF SHALLOW GROUNDWATER

As described in Section 13.4.9 and Figure 133 groundwater salinity is affected by tidal flushing which exports salt from the shallow groundwater in intertidal areas (GHD, 2021c). The shallow groundwater salinity gradients maintained by tidal flushing are important to the survival of mangroves in intertidal areas as described in Section 8.5.4.2 (AECOM, 2022a).

The relationship between tidal elevation and frequency of tidal inundation plays a central role in controlling the distribution of mangrove species and assemblages by developing salinity gradients across the tidal zone. The dominant species adjacent to the Proposal (*A. marina*) has the greatest salinity tolerance of the Pilbara mangrove species and occurs in areas where groundwater salinity reaches up to 90 ppt (approximately 2.5 times seawater) (Gordon, 1987). With increasing tidal elevation through landward sections of the mangrove zone, the reduction in tidal inundation in combination with high evaporation rates results in shallow groundwater and soil water conditions (mainly salinity) that are beyond the threshold tolerated by mangroves. In these areas the mud flats become devoid of mangrove vegetation and grade into a zone of bioturbated mud flat or algal mat habitat. This zonation in response to salinity gradient is represented schematically in Figure 91 within Section 8.5.4.2 (AECOM, 2022a).

As described in Section 6.5.2.3 and 8.6.1, tidal inundation modelling outputs show that, due to the alignment of salt pond outer levees being located well landward (> 800 m) of the mangrove zone and above Mean High Water Spring (MHWS) elevations, there is not expected to be any significant modifications to tidal flows to/from mangrove and algal mat areas that are likely to cause impacts. There are no predicted changes to percentage submergence time (over one year) for all mangrove habitats surrounding Urala Creek North and South, due to the large setback between the seaward embankments and the mangrove zone (with the exception of a small area of mangroves near the intake channel which causes a barrier to tidal flows, as discussed in Section 8.6.1). The modelling indicates minimal impacts to water levels or duration of tidal inundation Section 6.5.2.3 (Water Technology, 2022b) (AECOM, 2022a).

Therefore, it is expected there will not be significant changes to the tidal removal of salt from the shallow groundwater in mangrove areas which is required to maintain salinity levels tolerable to mangroves. In other words, the tidally moderated salinity levels within shallow groundwater beneath the mangroves is expected to be unaffected by the Proposal.

14.5.2.3 GROUNDWATER SALINITY CHANGES

As described above in Section 14.5.2.2, shallow groundwater salinity is moderated by tidal flushing in intertidal areas, such as beneath the mangroves and tidal channels. However significant increases in groundwater salinity beneath these areas combined with increases in groundwater levels, could reduce the effectiveness of tidal flushing and therefore increase salinity in these areas, possibly beyond salinity ranges tolerable to mangroves.

The nature of interaction between the salt ponds and groundwater is due to hydraulic, salinity (concentration) and density effects which vary over time. GHD (2021c) modelling of groundwater level and salinity changes indicates that the hypersaline water table beneath the footprint of salt ponds is shallow, typically around 0.3 to 0.5 m below surface. When the salt ponds are filled, the water table will quickly equilibrate with the pond water level. The seepage of fresher pond water is predicted to displace existing hypersaline groundwater radially away from the ponds causing a “halo” of increased salinity in groundwater around the perimeter of the ponds, which will propagate laterally further away from the ponds over time (GHD, 2021c). As described in Section 8.6.1, given the shallow root structure of mangroves, further analysis was undertaken to account for the salinity stratification where tidal flushing results in less saline groundwater at the surface of the water table which is tapped by mangrove roots (AECOM, 2022a) (GHD, 2021c) (Figure 141).

Salinity increases were estimated for the top 0.2 m of the water table to correlate with the zone of the water table (approximately 0.3-0.5 m BGL) into which mangrove roots would tap. The result of this analysis is a contour of maximum salinity increase of 15 kg/m^2 in the top 0.2 m of the water table after 50 years (Figure 142). The analysis suggests that there will not be any impacts to mangroves from Project-related salinity increases given they are likely to be less than the salinity increase trigger levels (10-15 kg/m^2) used in mangrove monitoring programs in the Pilbara that are designed to correlate changes in mangrove health with changes in shallow groundwater conditions (URS, 2010a), (Chevron, 2015) (AECOM, 2022a). In other words, the halo of increased salinity groundwater propagating radially from the ponds, is unlikely to reach most of the mangrove zone which is >800 m from the salt ponds. Any increase in salinity that does occur below the minor tidal sub-creeks which are closest to the salt ponds, will be likely effectively moderated by tidal flushing resulting in fresher layer of tidal water occurring in the shallow groundwater tapped by the mangrove roots as described in Section 14.5.2.2 above. Increases in groundwater salinity are not likely to result in impacts to algal mats as the mat structures occur as a 2-3 cm veneer on the ground surface and salinity conditions in that layer are regulated by surface water flows from either tidal inundation or rainfall events, rather than by connectivity to groundwater approximately 1.5 m below the ground surface. The model results and subsequent interpretation are considered conservative due to assumptions and limitations in the modelling, as detailed in (AECOM, 2022a) (GHD, 2021c)

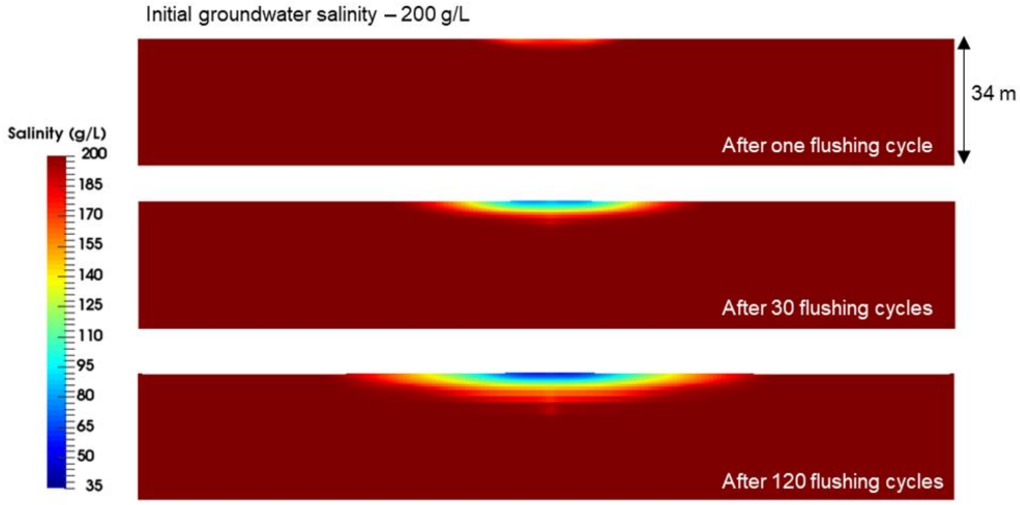

Figure 141: Simulated Changes in Groundwater Salinity due to Tidal Flushing
(GHD, 2021c)

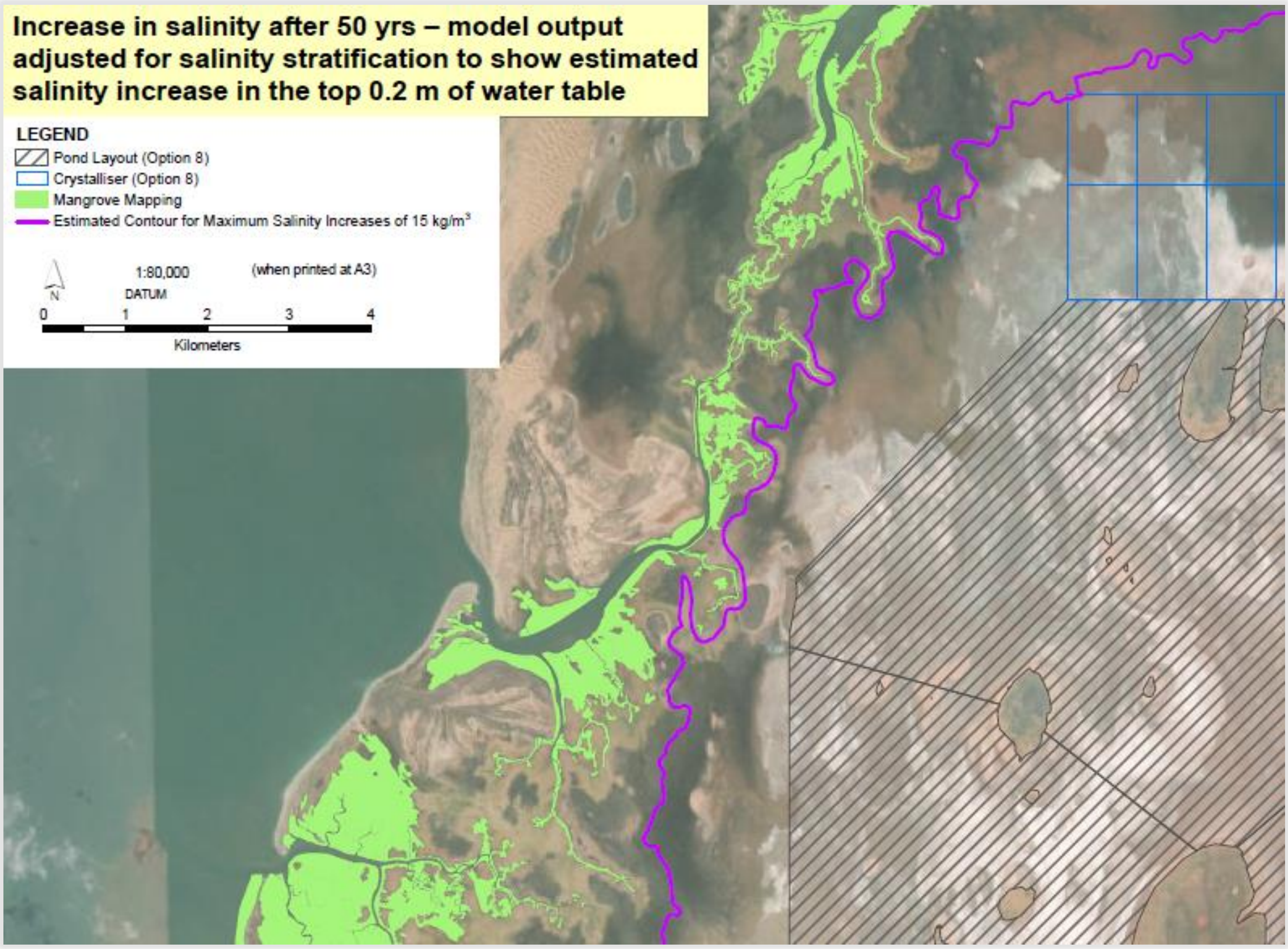

Figure 142: Predicted Increase in Groundwater Salinity after 50 Years
(AECOM, 2022a)

14.5.2.4 SALINE GROUNDWATER SEEPAGE

A numerical groundwater model was used by GHD (2021c) to simulate the key hydrogeological processes of the Proposal area. The key issue simulated by the modelling was the potential for seepage from the salt ponds to migrate and impact on the receiving environment. Key findings from the GHD (2021c) modelling of groundwater level and salinity changes are:

- The hypersaline water table beneath the footprint of salt ponds is shallow, typically around 0.3 to 0.5 m below surface. When the salt ponds are filled, the water table will quickly equilibrate with the pond water level. The seepage of fresher pond water is predicted to displace existing hypersaline groundwater radially away from the ponds causing a "halo" of increased salinity in groundwater around the perimeter of the ponds. This displacement effect is likely to lead to waterlogging adjacent to the ponds and cause formation of a surface salt crust in some areas due to evaporation and salt crystallisation.
- As the rate of evapotranspiration is greater than the rate of seepage of pond water, the extent of potential waterlogging is largely constrained to a narrow area (~50 m wide) immediately adjacent to the ponds (Figure 139).

Overall, the effects of groundwater seepage (surface expression) are localised to the immediate vicinity of the pond infrastructure and the predicted extents have been conservatively estimated. The changes to surface water salinity as a result of this seepage and salt crust formation and therefore also localised.

Saline seepage and salt crust will have no credible impact to salt flat areas which already have a thick salt crust due to naturally occurring saline seepage and evaporation as outlined in Section 8.5.3.3.

The impacts of groundwater seepage and associated salt crusting to BCH, terrestrial vegetation and terrestrial fauna habitat have been assessed separately under Sections 8.6.1, 10.5.2.1 and 11.5.2.1. In summary these impacts are proportionally small and localised with the following areas predicted to be affected (AECOM, 2022a) (Biota, 2022a) (Biota, 2022b):

- 3.92 ha of algal mat (0.14% of algal mat of East Exmouth Gulf).
- 2.28 ha of samphire (0.6% of samphire in West Pilbara).
- 119 ha of acacia shrubland/woodland (0.7% of similar vegetation in the study area).
- 3.91 ha of claypan (0.017% of claypan of East Exmouth Gulf).

14.5.2.5 EXTREME EVENTS

There is the potential for discharges of contaminants associated with extreme events such as cyclones or tsunamis. Such an event could cause overtopping or breaching of the bitterns, salt, or crystalliser pond embankments and/or flooding of the salt stockpiles.

However, the current engineering design requirements for these structures require that the embankment crest to be designed to such a level as to accommodate a 1 in 50-year flood event (~ 2% AEP). This includes inclusion of freeboard above the predicted design water level. Stockpiles will also be elevated above this level. The embankments are also designed with rock armouring to limit the potential for breaching due to wind and wave erosion.

Exceedance of these flood levels have a low (~2%) annual probability of occurring (i.e., ~ 2% AEP). If a major cyclone or tsunami occurred which exceeded these 1 in 50-year flood levels, the volume of water that would be deposited onto the site due to storm surge, rainfall or tsunami would be proportionally overwhelming of any contaminants and cause dilution of the bitterns/pond water/salt that was released, to such an extent it would be insignificant and undetectable.

14.5.3 CUMULATIVE IMPACTS

No cumulative impacts are identified as there are no other projects in the local area proposing to impact the inland water quality of groundwater and surface water.

Cumulative impacts regarding BCH, terrestrial vegetation and terrestrial fauna habitat which may be impacted by groundwater seepage and salt crusting have been discussed under Sections 8.6.2, 10.5.3 and 11.5.2.1.

14.6 ASSESSMENT OF IMPACTS

Detailed investigations including (Water Technology, 2021a), (Water Technology, 2021b), (Water Technology, 2021c) and (GHD, 2021c) have been completed to develop a comprehensive understanding of the existing inland water quality at a local and regional scale and how they may be impacted by the Proposal. The focus of these assessments has been to inform the Proposal such that the inland water quality of surface water and groundwater is maintained, and environmental values are protected.

Potential direct impacts to inland water environmental quality are associated with:

- Accidental spills or inappropriate waste disposal which may cause direct contamination. A range of management plans will be developed to prevent these occurrences, and if they accidentally occur ensure they are appropriately remediated.
- Disturbance of sulfidic material within the supratidal salt flats, creek mudflats and lower lying regions of the Proposal area or inappropriate management of dredge spoil leading to the generation of sulfuric acid. To prevent this an ASSSMP has been developed for the Proposal – Appendix BB (GHD, 2021b).
- Erosion, scouring or disturbance of sodic and/or dispersive soils could cause increased turbidity and sediment loading of surface waters. Appropriate engineering controls will be applied to prevent erosion and scour including geofabric, rock armouring and revegetation. Appropriate management of sodic/dispersive soils will occur during construction and operations and approval sought under other regulatory processes requiring materials characterisation and management (DMIRS, 2020a) (DMIRS, 2020b).

Indirect impacts to inland water environmental quality are associated with:

- Altered nutrient pathways resulting in reduction of nutrients to receiving ecosystems. Highly conservative modelling predicted a local post-development proportional reduction in nitrogen flows into the Proposal catchment of 0.8% of land and ocean sources and unlikely to impact surrounding ecosystems (Water Technology, 2021d).
- Changes to tidal flushing could disrupt shallow groundwater salinity gradients maintained by tidal flushing are important to the survival of mangroves in intertidal areas as described in Section 8.5.4.2. Tidal inundation modelling outputs show that, due to the alignment of salt pond outer levees being located well landward (> 800 m) of the mangrove zone there is not expected to be any significant modifications to tidal flows, therefore the tidally moderated salinity levels within shallow groundwater beneath the mangroves is expected to be unaffected by the Proposal (Water Technology, 2022b) (AECOM, 2022a).
- Significant increases in groundwater salinity beneath mangrove zone could reduce the effectiveness of tidal flushing and therefore increase shallow groundwater salinity in these areas, possibly beyond salinity ranges tolerable to mangroves. Modelling indicates that the halo of increased salinity groundwater propagating radially from the ponds, is unlikely to reach most of the mangrove zone which is >800 m from the Salt Ponds. Any increase in salinity that does occur below the minor tidal sub-creeks which are closest to the salt ponds, will be likely effectively moderated by tidal flushing resulting in fresher layer of tidal water occurring in the shallow groundwater tapped by the mangrove roots as described in Section 14.5.2.2 above (AECOM, 2022a) (GHD, 2021c)
- The effects of groundwater seepage (surface expression) are localised to the immediate vicinity of the pond. Saline seepage and salt crust will have no credible impact to salt flat areas which already have a thick salt crust as outlined in Section 8.5.3.3. The impacts of groundwater seepage and associated salt crusting to other habitats are proportionally small and localised with the following areas predicted to be affected (AECOM, 2022a) (Biota, 2022a) (Biota, 2022b):
    - 3.92 ha of algal mat (0.14% of algal mat of East Exmouth Gulf).
    - 2.28 ha of samphire (0.6% of samphire in West Pilbara).
    - 119 ha of acacia shrubland/woodland (0.7% of similar vegetation in the study area).

- 3.91 ha of claypan (0.017% of claypan of East Exmouth Gulf).

Overall, the proposed development shows the potential for minor and manageable impacts on inland water environmental quality. Several Management Plans will be developed to address specific impacts.

14.7 MITIGATION

14.7.1 AVOID

The Proposal has undertaken significant design optimisation to avoid impacts to inland water environmental quality including:

- Eight iterations of the pond design have been undertaken to minimise the footprint. Alignment of the western boundary of concentration ponds was moved further east to avoid seepage and salinity related impacts to mangroves.
- The Proposal is located largely in the supratidal zone, resulting in minimal interference of tidal inundation which plays an important role in moderating shallow groundwater salinity important for mangroves.
- A range of measures to avoid impacts related to acid sulphate soils and sediment as outlined in Section 12.6.1.

14.7.2 MINIMISE

The following measures are proposed to minimise impacts to inland waters environmental quality:

- Surface water engineering mitigation measures (culverts and drainage diversions) have been designed to maintain connectivity of the local and regional surface water flow paths, thereby minimising impacts to overland nutrient pathways.
- Appropriate engineering controls will be applied to prevent erosion and scour including geofabric, rock armouring and revegetation.
- The area and volume of sediment to be dredged was minimised to 0.7 ha and 17,000 m^3 minimising ASS risks associated with the onshore disposal of dredge spoil.
- Implement the DMP (Appendix BB) for the disposal of dredged material.
- The excavation of the seawater intake inlet well, will be managed in accordance with the ASSSMP (GHD, 2021b; Appendix BB) so that spoil is contained and treated with no discharge of decant water:
  - Spoil will be delivered onshore into the proposed seawater intake channel and contained within its embankments;
  - Designated area(s) will be prepared to contain the spoil and tailwater to allow the spoil to become 'spadable' and enable it to be blended and neutralised prior to re-use;
  - Tailwater will be collected and contained within an impermeable lined sump and treated with neutralising material such as lime. The treated tailwater will be retained within the treatment area and allowed to evaporate; and
  - Tailwater will be monitored to meet required water quality criteria as listed in the ASSSMP prior to discharge to the marine environment.
- Further testing for ASS will be undertaken in the following proposed excavation areas to confirm acid generation potential and if acid generating potential exists, spoil will be managed in accordance with the ASSSMP:
  - Borrow pits 3 and 4;
  - All drainage diversions; and
  - Any proposed areas of salt flat disturbance (including in where any pond or other embankments may be "keyed into" the salt flats.
- Appropriate erosion protection will be implemented in the location of coastal dune disturbance (geological unit Qs) at the site of the conveyor and jetty, such as rock armouring and dune revegetation.
- Further testing of materials (soils/borrow) will be undertaken prior to disturbance of the geological units outlined in Table 95 and appropriate management plans developed for any potential impacts (to be approved by DMIRS under other regulatory processes).

- Detailed management strategies will be developed to prevent, mitigate and remediate accidental spills or inappropriate waste disposal, such as:
  - Pipelines will be fitted with leak detection;
  - Water flows will be shut off if leaks are detected;
  - Pipelines will be inspected regularly, especially during extreme heat or fire events;
  - Pipelines will be located off access road surfaces;
  - If pipelines have to cross access roads, then they will be buried;
  - Investigations will be conducted into the cause of any spills, and remedial actions will be taken to minimise the chance of reoccurrence; and
  - Spills response training to mitigate damage for site-based personnel.
- To manage any disturbance of sulfidic material within the supratidal salt flats, mudflats, lower lying ground and dredging area and ensure appropriate management of spoil from these areas, an ASSSMP has been developed – Appendix BB (GHD, 2021b).
- Implement the DSMP (Appendix BB).
- Implement MEQMMP (Appendix BB) which encompasses both marine and intertidal areas.
- Implement the WMP (Appendix BB).
- Management plans and measures to manage naturally occurring properties of materials which may affect the environment, workforce health or rehabilitation as required under:
  - Mining Proposal and MCP to be submitted to DMIRS in accordance Statutory Guidelines for Mining Proposals (DMIRS, 2020a) and Statutory Guidelines for MCPs (DMIRS, 2020b). An Interim MCP for the Proposal has been provided in Appendix BB and will continue to evolve during the life of the Proposal; and
  - Works Approval to be submitted to DWER.

14.7.3 REHABILITATE

At the completion of the Proposal the site will be rehabilitated to reinstate the inland waters environmental quality. At the completion of operations, all buildings and structures on land will be removed from the site and the pond areas may be selectively reconnected to the existing tidal flat system. K+S preferred post closure land use is to leave the evaporation ponds in situ so that they become fauna habitat for shore birds (including migratory birds which require “wetland areas” for migratory stop over).

If ponds are to be reconnected, the MCP will establish which bunds to breach that will enable inwards tidal movement bringing sediments and allowing tidal channels to expand naturally. Natural tidal flows will allow movement of mangrove plant and seed material which will passively revegetate the reconnected tidal areas. This will enhance the habitat values of the ponds post closure.

Consideration will be given to the removal of specific culverts, levees and diversion channels as required to reconnect the groundwater and surface water in areas modified by the Proposal. All potential sources of ongoing contamination (bitterns, bitterns pond, crystallisers, salt stockpiles) will be removed and rehabilitated.

An Interim MCP for the Proposal has been provided in Appendix BB and will continue to evolve during the life of the Proposal. If the Proposal receives Ministerial Approval under Part IV of the EP Act as well as under the EPBC Act, the MCP will be developed in more detail and submitted to DMIRS for approval as required by the *Statutory Guidelines for MCPs under the Mining Act 1978* – DMIRS (2020b).

14.8 PREDICTED OUTCOME

The EPA objective in relation to inland waters environmental quality is *to maintain the quality of groundwater and surface water so that environmental values are protected*.

The Proposal does not include any direct / intentional impacts to inland waters environmental quality, however without appropriate mitigation the Proposal may result in the disturbance of ASS and spillages of product, brine, waste or hydrocarbons that could impact this factor.

K+S has incorporated avoidance and minimisation measures into five key management plans that are relevant to this factor:

1. The ASSSMP, which details how ASS will be managed during the construction phase to minimise impacts to the surrounding environment;
2. The DSMP, which details how dredged material will be managed to minimise impacts if disposed of onshore;
3. The MEQMMP, which details how product, brine and hydrocarbons will be managed to minimise impacts to the inland waters intertidal environment;
4. The WMP, which details how waste will be managed on site to minimise impacts to inland waters environmental quality; and
5. The MCP, which details how the Proposal will be closed and rehabilitated to minimise short and long-term impacts to inland waters environmental quality.

With the implementation of mitigation, K+S considers that the Proposal is able to be implemented without any significant residual impacts to this factor.

15 SOCIAL SURROUNDINGS

15.1 EPA OBJECTIVE

To protect social surroundings from significant harm.

15.2 POLICY AND GUIDANCE

- *Environmental Factor Guideline: Social Surroundings* (EPA, 2016r).
- *Guidance Statement 41 – Assessment of Aboriginal Heritage* (EPA, 2004).
- *Aboriginal Heritage – Due Diligence Guidelines (Version 3.0)* (DAA and DPC, 2013).
- *Aboriginal Heritage Act 1972* and *Aboriginal Cultural Heritage Act 2021.*

15.3 SOCIAL SURROUNDINGS STUDIES

Studies to assess impact to social surroundings have been conducted as outlined in Table 104.

Table 104: Social Surroundings Studies

Report	Reference	Appendix
Cultural Heritage Study	Archae-aus, 2020	Z
Cultural Associations Consultation	BTAC, 2021b	A
Marine Fauna Impact Assessment	AECOM, 2022b	N
Light Spill Modelling	Pendoley Environment, 2020	N
Underwater Sound Modelling	Talis, 2021	N
Ecotoxicology Assessment	AECOM, 2022	L
Prawn Assessments	Water Technology, 2022c	P
Prawn Sampling Study	Murdoch University, 2020	N
Assessment of Benthic Communities and Habitats	AECOM, 2022a	M
Nutrient Pathways Assessment and Modelling	Water Technology, 2021d	F
Marine and Coastal Assessment and Modelling	Water Technology, 2022b	A
Marine, Surface Water and Nutrient Modelling Peer Review	DHI, 2021	F
Seawater Intake Assessment	Water Technology, 2018	I
Materials Characterisation Study	GHD, 2021d	U

15.3.1 MODELLING

A predictive model or "heat map" of the likelihood of cultural heritage site occurrence within the Proposal Area was developed by Archae-aus (2020).

Specific modelling studies (Pendoley Environmental, 2020), (Pendoley Environmental, 2023), (Water Technology, 2021d), (AECOM, 2022b) have been conducted to assess potential impacts to commercial fisheries of the Proposal regarding:

- Anthropogenic light spill.
- Dredging sediment release.
- Bitterns discharge.
- Nutrient pathways.
- Seawater intake.

K+S commissioned Water Technology to undertake an ABM study to assess the potential impacts of the intake and outfall on prawn populations in Exmouth Gulf. This study has been a collaborative effort with extensive stakeholder engagement with participants from DPIRD, MG Kallis and Murdoch University. The results of this prawn modelling exercise are intended to be provided to DPIRD as the managers of the fisheries.

15.3.2 MODELLING PEER REVIEW

A peer review of the above water related modelling studies have been conducted. The peer review process was undertaken in a comprehensive, rigorous and iterative manner. It is the opinion of the peer reviewer that the models constructed by Water Technology (2021 c and d) can be considered suitable for the purpose of identifying potential environmental impacts (DHI, 2021).

15.4 EXISTING ENVIRONMENT

15.4.1 ABORIGINAL HERITAGE

15.4.1.1 OVERVIEW

K+S recognises the importance of Aboriginal culture and heritage in the communities in which we intend to operate.

Aboriginal sites are places of importance and significance to Aboriginal people and to the cultural heritage of WA. Aboriginal sites include:

- Archaeological – places where material remains associated with past Aboriginal land use.
- Anthropological – places of spiritual importance and significance to Aboriginal people.

The AH Act protects places and objects that may be of importance and significance to Aboriginal people in WA. The Department of Planning, Lands, and Heritage (DPLH) maintains a register of Aboriginal sites that are protected under the AH Act. The AH Act provides it is an offence to excavate, destroy, damage, conceal, or in any way alter any Aboriginal site, without prior authorisation of the Registrar of Aboriginal sites or consent of the Minister. The AH Act is set to be repealed and replaced by the ACH Act in the near future.

15.4.1.2 TRADITIONAL OWNERS

The recognised Aboriginal traditional owners of the local area are the Thalanyji people. The BTAC is the Registered Native Title Body Corporate for the Thalanyji People (BTAC, 2021a).

K+S has been actively, openly and regularly consulting with the Thalanyji People and BTAC about the Proposal since 2016. The BTAC and K+S negotiation teams reached an in principle agreement in late 2021 in relation to the proposed key terms for a Proposal Agreement and Indigenous Land Use Agreement, including in respect of cultural heritage management. BTAC and K+S are currently continuing consultation about these agreements, with K+S' aim being to have them concluded and finalised as soon as possible.

Thalanyji Country spreads out across the Ashburton River coastal plain south to Tubridji Point, then across to Yannarie River and upstream to Emu Creek, across the range hills of southwest Pilbara to Henry River and Cane River in the north. Thalanyji People have lived on Country from the Creation – from time immemorial. In Thalanyji culture, everything is interconnected – people, animals, plants, ancestors, creation beings, waterways, the sea, the sky, the earth, the wind and the rain (BTAC, 2021a).

"Everything, even our names, is connected to our culture. We all have Thalanyji names, given to us by our Elders, that are connected with weather patterns and water." – Glenys Hayes, traditional owner (BTAC, 2021a).

15.4.1.3 ETHNOGRAPHIC BACKGROUND

The Thalanyji people are the traditional custodians and occupants of the Onslow region in the West Pilbara, WA. The Thalanyji people's society and culture were first described in the late 1800s. Their traditional country is focussed along the lower reaches of the Ashburton River (Mindurru) and extends from the vicinity of Mt Stuart and Uaroo Station in the south-east to the current town of Onslow and the Old Onslow townsite in the north-west, including the pastoral stations of Minderoo, Uaroo, Nanutarra, Yanrey, Emu Creek (Nyang), Urala, and Koordarrie (Archae-aus, 2020).

Mindurru (The Ashburton River) is central to Thalanyji culture. Detailed dreaming stories about the creation of the river by *Warnamankura* (water snake) are well understood by Thalanyji people and these stories imbue the River with a sacred significance. This significance has important practical applications for Thalanyji people because it enshrines a responsibility to protect and care for the river into law and custom, and all Thalanyji people understand that they inherit this responsibility from their ancestors and bequeath it to their children. In addition to sacred values, Mindurru was and continues to be an important resource for Thalanyji people for activities such as camping and hunting (Archae-aus, 2020).

Today, most Thalanyji people reside in Onslow, Carnarvon or elsewhere in the Pilbara or Perth. They still maintain deep connections to their traditional land and culture, maintaining distinct laws and customs that distinguish them as Thalanyji people (Archae-aus, 2020).

15.4.1.4 ARCHAEOLOGICAL BACKGROUND

Previous heritage surveys of the Onslow coastal region, stretching from Giarlia Bay in the west to Cane River in the east, have recorded over 100 middens. Research has focused on the timing of economic shellfish exploitation and the extent to which changes in species reflect either cultural preference or coastal productivity. The Onslow coast is unusual within the context of the larger Pilbara region in that it is located within a sedimentary/limestone belt. It contains both terminal Pleistocene and emergent Holocene sand dunes and therefore can preserve both older and more recent coastal occupations (Archae-aus, 2020).

Results from archaeological research and previous cultural heritage work along Australia's northwest coast and its hinterland provide a data set on which to build an understanding of the *Thalanyji* people's ancestors past use of the landscape. This is an essential component in understanding and interpreting the results of the current archaeological survey (Archae-aus, 2020).

Archae-aus (2020) has compiled the results of over 20 Aboriginal heritage surveys with details of almost 700 Aboriginal sites from the northwest coastal area, primarily comprising work from around Onslow and Cape Preston. Summaries from this dataset are provided in Appendix Z. The results of previous archaeological works in the region show a predominance of open stone artefact scatters; with numerous middens / shell scatters, reduction areas, quarries and sites with grinding material; occasional rock shelters and rock art sites and small numbers of structures, burials, water sources, scarred trees, historical / maritime sites and ceremonial places. The majority (81%) of the sites in the sample include a stone artefact scatter component, with lesser numbers comprising middens / shell scatters (22%) and grindstones (13%) (Archae-aus, 2020).

15.4.1.5 CULTURAL HERITAGE SITES

For this study, after a detailed desktop review of relevant environmental information and previous surveys of the area, fourteen Heritage Investigation Areas (HIAs) (Figure 143) were selected to sample a range of environment types and previously recorded sites. They were accessed by Archae-aus using a helicopter to fly the survey team to each area between the 2nd and 6th of November 2019.

During the survey of the 14 HIAs, 32 previously recorded sites recorded by Hammond et. Al. (2005) were revisited and 19 newly identified sites that require further recording were identified (
Table 105) (Figure 143) (Archae-aus, 2020).

Detailed descriptions and mapping of these cultural heritage sites are provided in Appendix Z (Archae-aus, 2020).

15.4.1.6 PREDICTIVE MODEL

A predictive model or "heat map" of the likelihood of cultural heritage site occurrence within the Proposal Area was developed by Archae-aus (2020) (Figure 144). The modelling to create this heat map, was completed by comparing the results of past work and the recently identified places. A single point was created for each site. This was then plotted in GIS with an underlay of the surface geology. Within the model area the total area of each geological unit and its percentage of the area was calculated. The site locations were then compared against the surface geology area percentages to predict the likelihood of occurrence of Aboriginal archaeological sites within specific surface geology types (Archae-aus, 2020).

There are inherent assumptions within this type of modelling, however, the results are transparent and replicable. The major limitation is that this type of process fails to identify sites that don't fit the pattern. Therefore, field checking and sampling in all areas of proposed disturbance, including areas with a low prediction, is still recommended prior to commencing ground disturbing activities (Archae-aus, 2020).

Table 105. Heritage Investigation Areas – Summary of Results
(Archae-aus, 2020)

Heritage Investigation Area	Environmental Context	Archaeological Materials Observed During 2019 Fieldwork	Previously Recorded Sites	New Sites
HIA 001	Claypans and dunes	-	-	-
HIA 002	Claypans and eroding dunes	Stone artefacts (dolerite river pebbles, chert – flakes and cores)	-	TBR10
HIA 003	Claypans, vegetated dunes and limestone outcrops	Stone artefacts (including a tula adze) and shell Melo spp., *Tegillarca granosa* and *Terebralia spp*.	SS05-08, SS05-09, SS05-13, SS05-14, SS05-15	-
HIA 004	Vegetated dunes and claypans	Stone artefacts	SS05-11	-
HIA 005	Claypan	Stone artefacts (basalt, dolerite river pebbles – flakes, fragments, cores manuports)	-	TBR09
HIA 006	Claypan and Sand dunes	Stone artefacts (basalt, chert, quartz, silcrete -flakes, single platform cores, all small in size)	-	TBR08, TBR19
HIA 007	Claypan, red sand dunes	Chert reduction area (river rounded chert cores and flakes), possible weathered basal sandstone grindstone, mullers, baler shell	-	TBR05, TBR06
HIA 008	Claypan	Stone artefacts (Quartz, basalt, chert, silcrete, dolerite, banded iron formation, quartzite – flakes and single platform cores)	-	TBR13, TBR12, TBR11
HIA 009	Vegetated dunes	-	-	-
HIA 010	Claypan and eroding dunes	Stone Artefacts (silcrete, basalt, quartz, dolerite – flakes, cores), oyster shell	-	TBR18, TBR17
HIA 011	Red sand dunes and claypan	Baler shell and stone artefacts (dolerite, quartz, basalt and chert – manuports, flakes, cores)	DPLH-809, DPLH-15309, DPLH-15310	TBR03, TBR04
HIA 012	6-8 small claypans, sand dunes	Stone Artefacts (quartz, basalt, dolerite, silcrete, quartzite, chert – flakes, cores and manuports)	-	TBR16, TBR15, TBR14
HIA 013	Claypans and vegetated dunes. Cattle causing heavy ground disturbance	Stone artefacts (including large millstone and muller, quartz flakes, chert flakes, dolerite manuports, quartzite grinding fragment, dolerite muller fragment, basalt flakes, quartzite and chert single platform	DPLH-814, DPLH-808	-

Heritage Investigation Area	Environmental Context	Archaeological Materials Observed During 2019 Fieldwork	Previously Recorded Sites	New Sites
		cores). Shell material (lots of broken *Terebralia spp*.		
HIA 014	Claypans (some vegetated), vegetated and eroding sand dunes	Shell material (including *Cerithiopsis, Tegillarca*, baler, *tellin*) and stone artefacts (including quartz, - flakes, a tula adze, cores and manuports)	SS05-27, SS05-28, SS05-30, SS05-32, SS05-44, SS05-45, SS05-46, SS05-47	TBR07

15.4.1.7 CULTURAL ASSOCIATIONS WITH THE ENVIRONMENT

K+S consultation with the Thalanyji people through their representative BTAC has been extensive and is ongoing (as described in Section 3 and Table 18). Through this consultation Thalanyji cultural associations with the environment have been discussed as described in Appendix AA. In summary the following cultural associations are important to the Thalanyji people (BTAC, 2021b):

- Traditional taking and resources
  - The mangrove trees are important habitat supporting shellfish, crabs, water birds and fish resources. All were traditionally taken by Thalanyji people as food resources.
  - The tidal flat areas were also flagged as important habitat supporting a variety of marine resources. Here fish were caught using spears as the tide rose and fell.
  - It was also discussed that sawfish are known from this coast and tributaries and have been caught rarely, from time to time.
- Coastal access and camping
  - It was discussed that families would access the Proposal Area in the past with a focus on pastoral infrastructure and now ruined buildings in the vicinity of Whittaker's Well (noted on plans as within or near the Proposal Area).
  - It was discussed that K + S have made commitments to allow access to the Proposal Area for a variety of activities. It was however noted that access during construction may be limited, subject to safety.

K+S is committed to working with the Thalanyji people and their representative BTAC on maintaining existing cultural associations with the environment during Proposal construction and operations.

15.4.2 EUROPEAN HERITAGE

The nearest European Heritage sites are described in Table 106 below. There are no European heritage sites within the Proposal Development Envelope.

Table 106: European Heritage Sites
(InHerit, 2021), (DPLH, 2021a)

Site	Heritage Place No.	Distance from Salt Production	Distance from Main Access Road
Minderoo Homestead	15369	28 km East	30 km Southeast
Ashburton River Road Bridge (Bridge No 841, Minderoo Bridge)	3395	25 km East	27 km Southeast
Old Onslow Police Station	3949	23 km Northeast	2.8 km North
Old Onslow Town Site	3444	20 km Northeast	1 km North

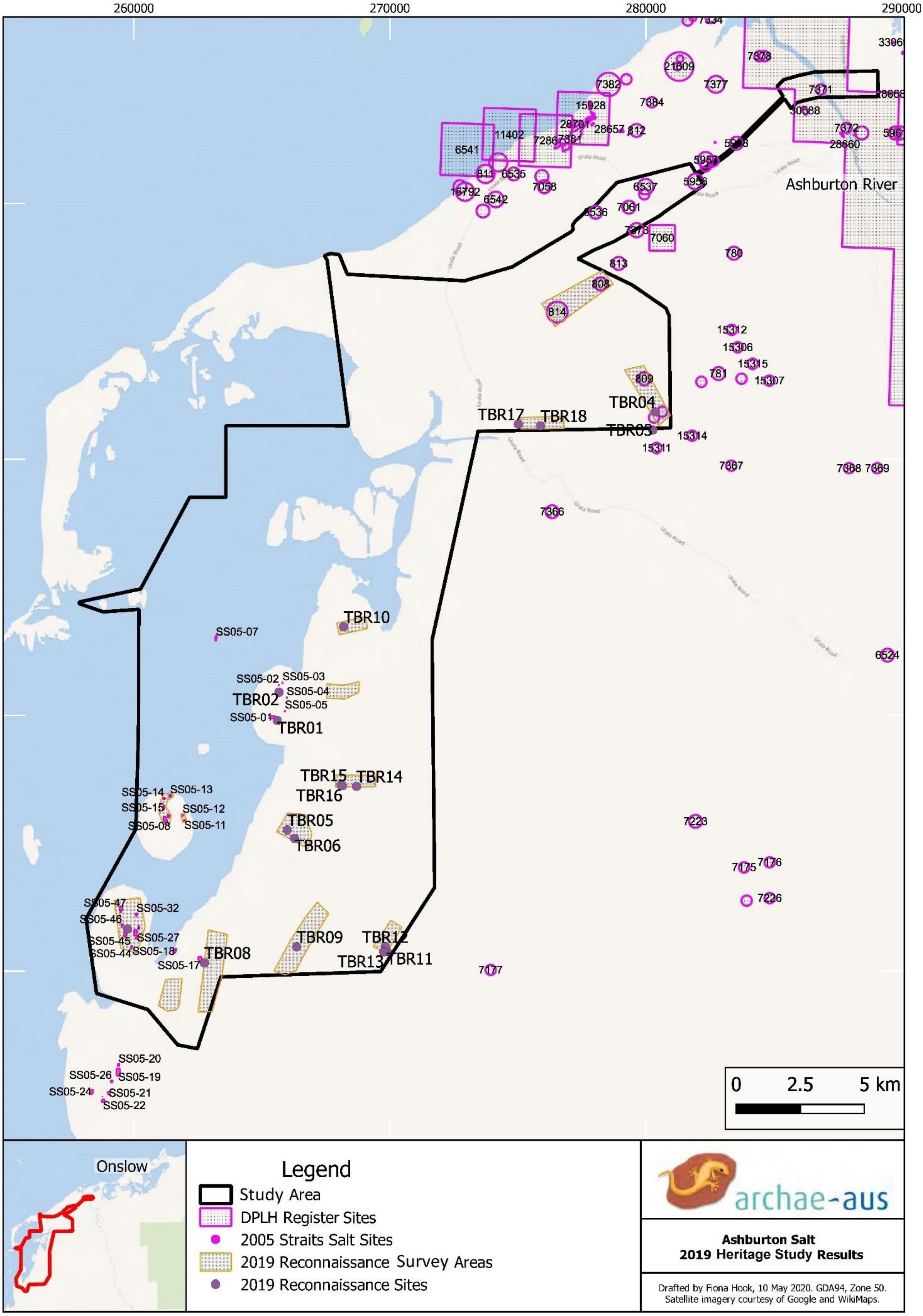

Figure 143: Aboriginal Heritage Sites

(Archae-aus, 2020)

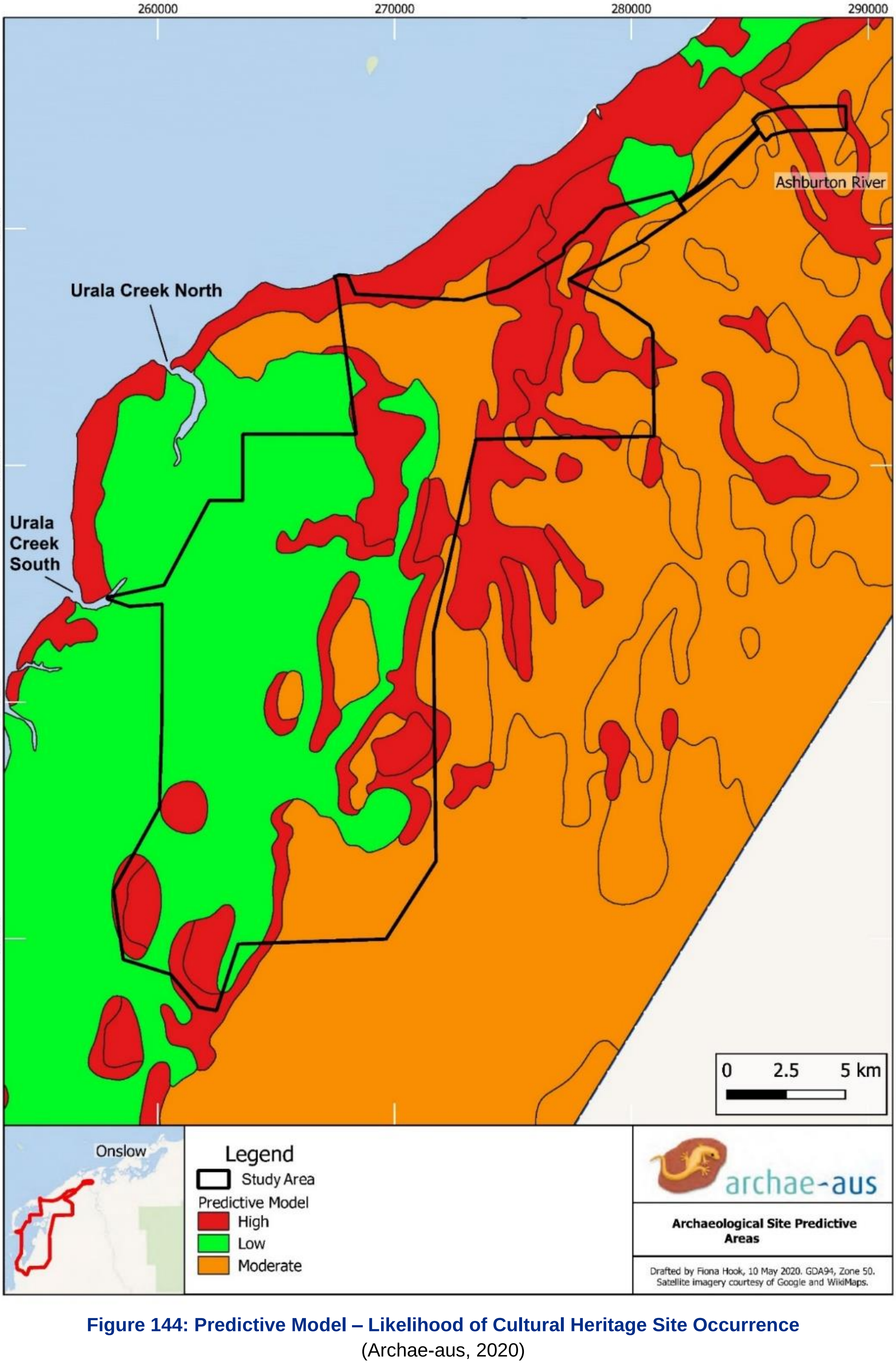

Figure 144: Predictive Model – Likelihood of Cultural Heritage Site Occurrence
(Archae-aus, 2020)

15.4.3 COMMERCIAL FISHERIES (ECONOMIC)

The Proposal footprint intersects with a number of commercial fisheries boundaries. An overview of these and their potential relevance to the Proposal are detailed in Table 107.

Table 107: Commercial Fisheries Relevant to the Proposal
(AECOM, 2022b)

Fishery	Overview	Relevance to the Proposal
Exmouth Gulf Prawn Fishery	The EGPMF uses low opening, otter prawn trawl systems within the sheltered waters of Exmouth Gulf to target western king prawns (*Penaeus latisulcatus*), brown tiger prawns (*Penaeus esculentus*), endeavour prawns (*Metapenaeus endeavouri*) and banana prawns (*Penaeus merguiensis*) (DoF, 2015a) (DoF, 2015b).	The Proposal area is adjacent to the northern section of the EGPMF, with Urala Creek South (the proposed intake location) located within the dedicated nursery area for the EGPMF. Potential impacts to this fishery are discussed in Section 15.5.2.1.
North Coast Prawn Fishery including Onslow Prawn Managed Fishery (OPMF)	The north coast prawn fishery operates as four separate fisheries; Kimberley, Broome, Nickol Bay and Onslow. The OPMF encompasses the WA coastal waters between the EGPMF and the Nickol Bay prawn fishery out to the 200 m depth isopleth (DoF 2013). The fishery is divided into three parts with associated 'size management fish grounds' (SMFGs).	The jetty and bitterns discharge point are located just outside the southern boundary of the OPMF The offshore transhipment locations are located within Area 1. Potential impacts to this fishery are discussed in Section 15.5.2.2.
West Coast Deep Sea Crustacean Fishery	The West Coast Deep Sea Crustacean Managed Fishery targets crystal (snow) crabs (*Chaceon albus*), giant (king) crabs (*Pseudocarcinus gigas*) and champagne (spiny) crabs (*Hypothalassia acerba*) using baited pots operated in a longline formation in the shelf edge waters (>150 m deep) of the West Coast and Gascoyne Bioregions. The boundaries of this fishery include all the waters lying north of latitude 34° 24' S (Cape Leeuwin) and west of the Northern Territory border on the seaward side of the 150m isobath, out to the extent of the Australian Fishing Zone (DoF, 2015a) (DoF, 2015b).	The Proposal is located within waters that are permanently closed to this fishery; however, the ocean-going product export vessels would transit through the fishery zone. Due to the extent of this fishery, it is unlikely that vessel movements associated with the Proposal would impact this fishery.
WA Pearl Oyster Managed Fishery	The Western Australian pearl oyster fishery is the only remaining significant wild-stock fishery for pearl oysters in the world. It is a quota based, dive fishery, operating in shallow coastal waters along the North West Shelf. The fishery is separated into four zones, Zone 1 extends from North West Cape (including Exmouth Gulf) to longitude 119˚ 30'E (DoF, 2013).	The Proposal area falls within Zone 1 of this fishery. Due to the extent of this fishery, it is unlikely that the Proposal would impact this fishery.
WA Sea Cucumber Fishery (Beche-de-mer Fishery)	The WA sea cucumber fishery is a hand-harvest fishery, with animals caught principally by diving and a smaller amount (<5%) by wading. The fishery is permitted to operate throughout WA coastal waters, with the exception of several permanently closed areas. Fishing to date has only occurred in the NCB (DoF, 2013).	Proposal area is within the fishery boundary. Due to the extent of this fishery, it is unlikely that the Proposal would impact this fishery.
North Coast Crab Fishery	Blue swimmer crabs are targeted by the Pilbara Developing Crab Fishery within inshore waters around Nickol Bay using hourglass traps. Mud crabs are also targeted in the area between Broome and Cambridge Gulf (DPIRD, 2020).	The Proposal area falls outside of the area targeted for fishing (Nickol Bay) and therefore is unlikely to impact this fishery.
Mackerel Fishery	The fishery extends from the West Coast Bioregion to the WA/Northern Territory border, with most effort and catches recorded north of Geraldton, especially from the Kimberley and Pilbara coasts of the NCB (DoF, 2013).	The Proposal area falls within Area 2 (Pilbara) for this fishery. Due to the extent of this fishery, it is unlikely that the Proposal would impact this fishery.

15.4.4 COMMUNITY RECREATIONAL ACTIVITIES

Local nearshore marine waters, local creeks (Urala Creek North and South) and beaches are utilised by small numbers of community visitors, accessing the area by boat for low density recreational activities such as fishing. Wider marine waters of Exmouth Gulf and beyond, beaches and offshore islands are used by the local Exmouth and Onslow community and the wider regional community for a range of recreational pursuits including fishing, diving and eco-tourism.

The areas west of the Proposal, including Tubridgi Point, are almost completely inaccessible from land, given the extensive mudflats and tidal creeks through that area. Access to the north of the Proposal is however available from land.

15.4.5 LOCAL ENVIRONMENTAL VALUES

Local environmental values related to social surroundings have been identified as follows:

- Aboriginal heritage sites and areas likely to contain such sites.
- Aboriginal cultural associations with the environment.
- Recreational opportunities for local community.
- Commercial fishing opportunities for EGPMF and OPMF.

These local values have been mapped overlayed by the Proposal in Figure 145 using GIS data from the cultural heritage study (Archae-aus, 2020) and other publicly available information.

15.4.6 REGIONAL ENVIRONMENTAL VALUES

Regional environmental values related to social surroundings have been identified as follows:

- Commercial fishing opportunities for EGPMF and OPMF.
- Community recreational uses of the wider Exmouth Gulf, its islands and its beaches.
- Ashburton River – considered a regionally important Aboriginal Heritage site.

These local values have been mapped overlayed by the Proposal in Figure 146 using publicly available information.

15.5 POTENTIAL IMPACTS

The following potential impacts have been identified for this Proposal:

- Direct impacts:
  - Disturbance to Aboriginal heritage sites.
  - Disturbance to Aboriginal cultural associations within the area.
  - Disturbance to European heritage sites.
- Indirect impacts
  - Disturbance to community recreational activities.
  - Disturbance to fishing opportunity for commercial fisheries.
  - Access and visual amenity of visitors to the area or local pastoral homesteads.
  - Light spill.
  - Dust.
  - Noise.

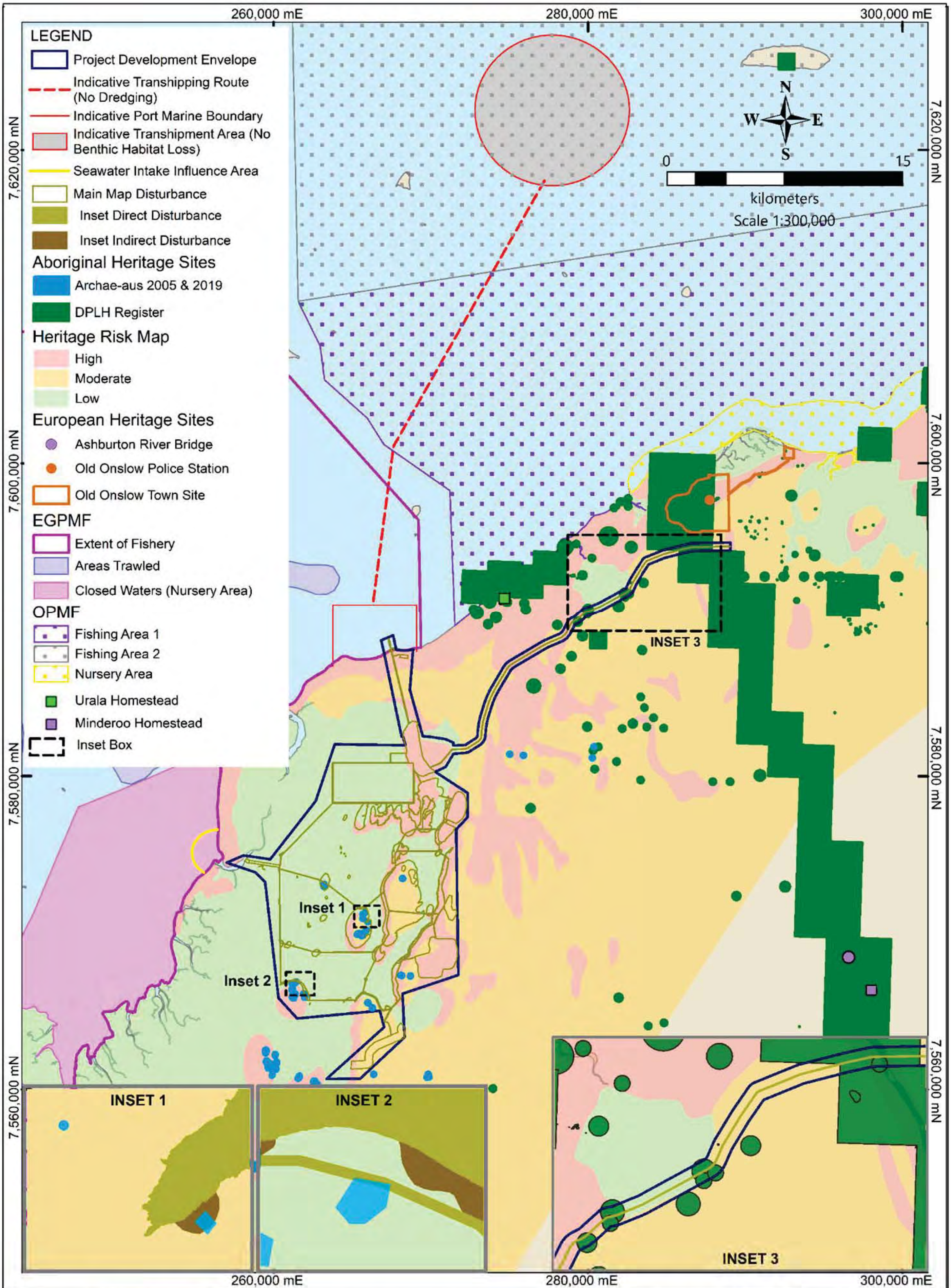

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Figure 145: Local Values Social Surroundings

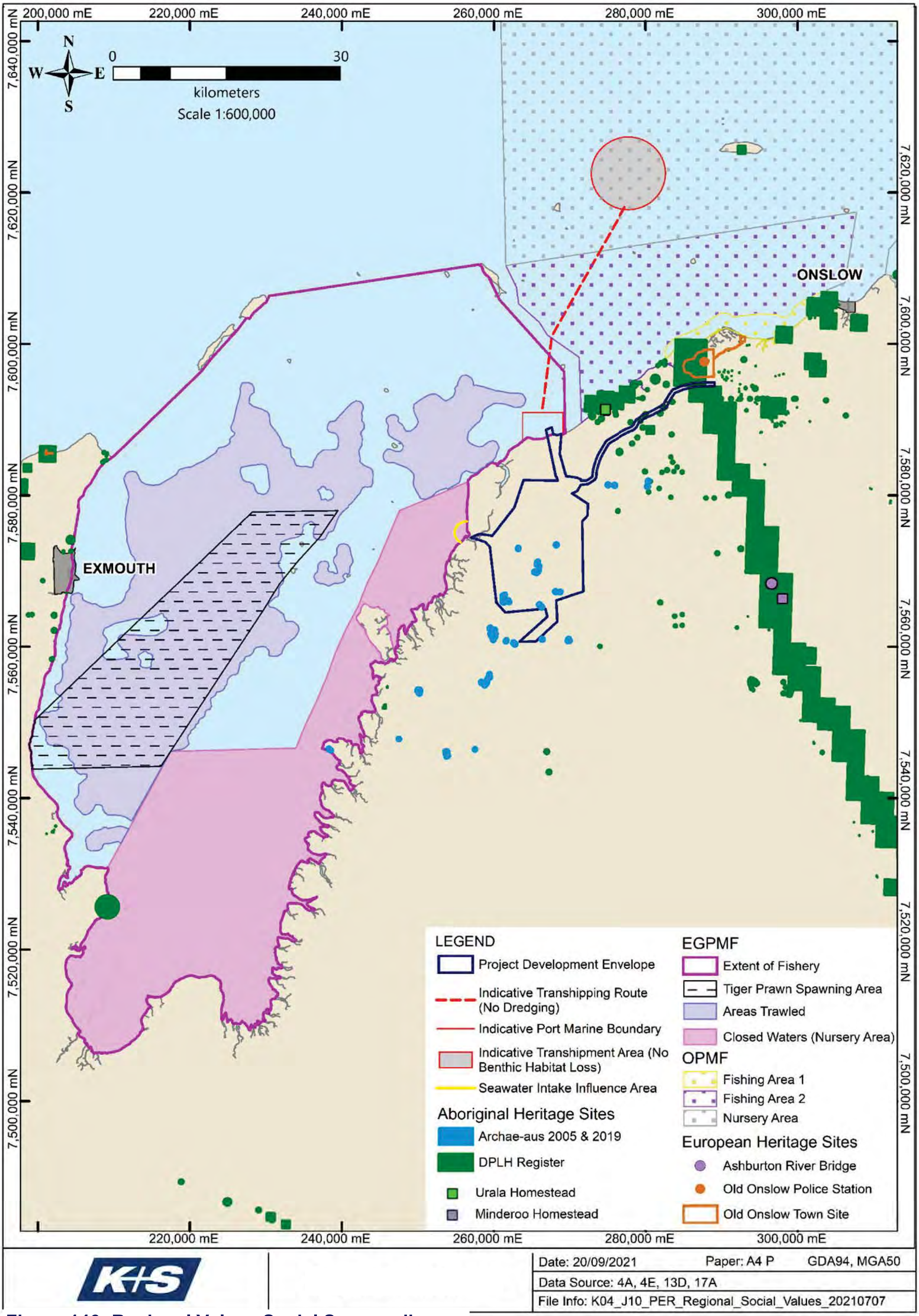

Figure 146: Regional Values Social Surroundings

15.5.1 DIRECT IMPACTS

15.5.1.1 DISTURBANCE TO ABORIGINAL HERTIAGE SITES

It is likely that construction works will require the disturbance of cultural heritage sites. Table 108 below outlines the proportional disturbance of areas which have been mapped as having a high, medium and low risk of containing aboriginal heritage sites. In total the Proposal will disturb 5.57% of areas mapped as having a high or medium likelihood of containing Aboriginal heritage sites (Archae-aus, 2020).

Table 108: Proportional Disturbance of Aboriginal Heritage Risk Areas
(Archae-aus, 2020)

Risk of Aboriginal Heritage Site Occurrence	Disturbance (ha)	Total in Study Area (ha)	% of Total in Study Area
High	2023.86	38,640	5.24%
Medium	481.86	142,985	0.34%
Low	9633.93	82,522	11.67%

Table 109 below and Figure 145 details the Archae-aus (2020) and DPLH Register of Aboriginal heritage sites (DPLH, 2021b) which occur within the Proposal Disturbance Footprint. Additional sites may be discovered once all disturbance areas are surveyed, prior to disturbance occurring. Consultation will occur with the Thalanyji people and their representative BTAC on minimising disturbance and mitigating the impacts of disturbance as far as practicable. Appropriate approvals to undertake disturbance of Aboriginal heritage sites will be sought under the AH Act or the ACH Act.

Table 109: Aboriginal Heritage Sites (or stored data) within Proposal Disturbance Footprint
(Archae-aus, 2020), (DPLH, 2021b)

Place_ID	Name	Status	Type
SS05-04	Straits Salt 04	Not Lodged	Artefacts / Scatter
SS05-13	Straits Salt 13	Not Lodged	Artefacts / Scatter, Midden / Scatter
5957	GRIFFIN GAS 07	Stored Data / Not a Site	Midden / Scatter
6537	URALA SAND RIDGE	Registered Site	Artefacts / Scatter, Midden / Scatter
7061	URALA MIDDEN 4	Stored Data / Not a Site	Artefacts / Scatter, Midden / Scatter
7371	URALA STATION CROSSING 1	Registered Site	Artefacts / Scatter, Midden / Scatter
7374	URALA STATION 02.	Registered Site	Artefacts / Scatter, Midden / Scatter, Camp
7375	URALA STATION 03	Stored Data / Not a Site	Artefacts / Scatter, Midden / Scatter
7376	URALA STATION 04	Stored Data / Not a Site	Artefacts / Scatter, Midden / Scatter
37522	Mindurru (Ashburton River)	Registered Site	Mythological

15.5.1.2 DISTURBANCE TO ABORIGINAL CULTURAL ASSOCIATIONS

The following cultural associations are important to the Thalanyji people (BTAC, 2021b):

- Mangroves for taking of fauna as food resources.
- Tidal flat areas for taking of fauna as food resources, with sawfish as a unique species historically caught occasionally (tidal flats have been interpreted to contain transitional mudflats, tidal creeks, beaches and subtidal habitats, given all of these areas contain food resources historically taken by Aboriginal people).
- Access to the coast and beaches for camping and taking of food resources.

Table 110 below summarises the Proposal proportional disturbance of habitats mapped by AECOM (2022a) which have cultural associations for the Thalanyji people (BTAC, 2021b). Proportional disturbance of these habitats compared with surrounding similar habitat is very low.

The Proposal impacts on marine fauna (including sawfish) are assessed under Section 9 and are considered low with mitigation measures in place (AECOM, 2022a).

The agreements being finalised with BTAC include for continued access to the Proposal area by the Thalanyji People subject to safety requirements.

Table 110: Proportional Disturbance of Habitats with Thalanyji Cultural Associations
(AECOM, 2022a)

Habitat	Disturbance (ha)	% of LAU	% of Tubridgi to Tent Point	% Exmouth Gulf Region
Mangroves	4.57	0.85	0.12	0.04
Transitional Mudflats	17.78	0.9	0.22	0.09
Beaches	0.99	0.78	0.33	0.1
Tidal Creeks	0.56	0.19	0.06	0.02
Subtidal Habitat	8.68	0.17	0.09	0.008

15.5.1.3 DISTURBANCE OF EUROPEAN HERITAGE SITES

It is not expected that the Proposal will disturb any European heritage sites given none occur within or near the Proposal disturbance footprint.

15.5.2 INDIRECT IMPACTS

15.5.2.1 DISTURBANCE TO COMMERCIAL FISHING OPPORTUNITIES

15.5.2.1.1 COMMERCIAL FISHERIES POTENTIALLY IMPACTED

As outlined above in Table 107, most of the commercial fisheries identified are considered unlikely to be impacted by Proposal because the Proposal does not occur within fishing target areas or due to the large extent of the fisheries in comparison to the limited marine interface of the Proposal.

Of the commercial fisheries identified in Table 107 , only two are considered potentially impacted by the Proposal (Figure 146):

- EGPMF which occurs within Exmouth Gulf. The Proposal seawater intake in Urala Creek South is located adjacent to the untrawled fishery nursery area and is southeast of the occasionally trawled area adjacent to Tubridgi Point.
- OPMF which occurs to the immediate north of the Proposal area, along the coast to Dampier and offshore approximately 150 km.

15.5.2.1.2 PRAWN ENTRAINMENT IN SEAWATER INTAKE

Both EGPMF and OPMF fish for prawns which utilise nearshore nursery habitats in the early part of their life cycle as larvae, post-larvae and juvenile prawns, before moving offshore into deeper waters later in their life cycle. The EGPMF is considered reliant on the nursery habitat along the nearshore waters of the Eastern Exmouth Gulf (Figure 146). OPMF is also likely to harvest a small proportion of prawns originating from the EGPMF nursery area, known as “overspill”, in other words prawns which have moved as adult prawn northwards out of Gulf (Pers. Comm. Kangas, 2020). On this basis, it considered that key impact the Proposal may have on prawn populations available for harvest by the EGPMF and OPMF is entrainment of larval / juvenile prawns within the seawater intake in Urala Creek South, thereby removing these prawns from the adult populations available for harvest within the commercial fisheries.

Modelling of the area of influence from which the seawater intake could credibly entrain prawns was undertaken (Water Technology, 2018) as summarised in Appendix I. It was identified that the area of potential prawn entrainment is relatively small and localised surrounding the creek mouth (Figure 147).

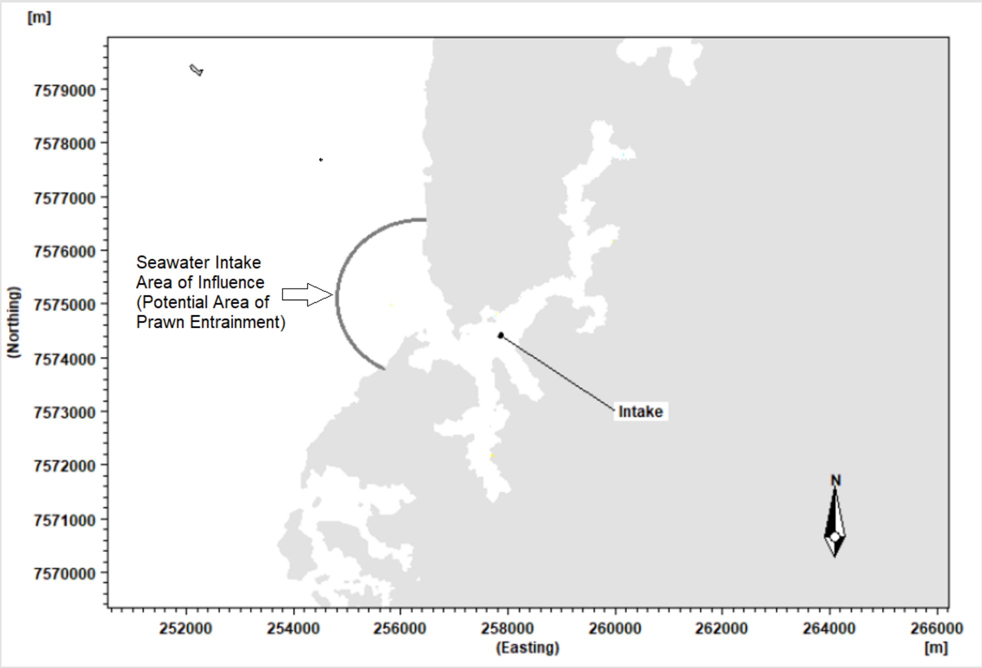

Figure 147: Modelled Seawater Intake Area of Influence with Potential for Prawn Entrainment
(Water Technology, 2018)

The prawn habitat within the above area of influence (including both the nearshore habitat and creek habitat) has been mapped and compared proportionally to the entire nursery habitat of the EGPMF (Figure 146). As outlined in Table 111 below, the potential prawn entrainment area of influence of the seawater intake is proportionally very small in comparison to the size of the nursery habitat of the EGPMF. On this basis it is considered unlikely that a significant proportion of the prawn population available for commercial harvest will be removed by the Proposal seawater intake.

Table 111: Modelled Seawater Intake Area of Influence as a Proportion of EGPMF Nursery Area
(Water Technology, 2018)

Seawater Intake Area of Influence (ha)	Total Size of EGPMF Nursery Area (ha)	% of EGPMF Nursery Area
437	113,481	0.39

15.5.2.1.3 IMPACT OF OTHER PROPOSAL ASPECTS

Aspects of the Proposal such as jetty construction, bitterns discharge, dredging, underwater sound, artificial lighting and alteration of nutrient pathways are considered unlikely to significantly impact the prawn fisheries given their limited disturbance footprint, limited interface with the marine environment and low proportional impacts (AECOM, 2022b) in comparison to the large extent of the prawn fisheries.

It is considered that the frequency of transhipper movements and ocean-going vessel loading, will be insufficiently great to impact commercial fishing opportunities in the area.

15.5.2.1.4 AGENT BASED PRAWN MODEL

K+S commissioned Water Technology to undertake an ABM study to assess the potential impacts of the intake and outfall on prawn populations in Exmouth Gulf. This study has been a collaborative effort with extensive stakeholder engagement with participants from DPIRD, MG Kallis and Murdoch University. Rather than simply determining habitat loss on a proportional basis (Table 111), this is an “agent-based” modelling exercise.

Agent-based models are computer models that attempt to capture the behaviour of individuals within an environment, in this case the behaviour of prawns in the Exmouth Gulf over their life cycle. The aim is to determine how may prawns (as a proportion) may be removed from the commercial fishing environment due to the Proposal. The results of this prawn modelling exercise can be found in Section 9.4.6 and are intended to be provided to DPIRD as the managers of the fisheries, as well as other interested parties as required.

15.5.2.2 DISTURBANCE TO COMMUNITY RECREATIONAL ACTIVITIES

Observations during field studies indicate that local nearshore marine waters, local creeks (Urala Creek North and South) and beaches are utilised for recreation by very small numbers of occasional community visitors, accessing the area by boat. Wider marine waters beaches and offshore islands of Exmouth Gulf are used by the community for fishing, diving and eco-tourism.

The Proposal will not prevent access by the community to local waters by boat, except for the Port Marine Boundary which will be an exclusion zone for recreational vessels. However, the Port Marine Boundary is localised, proportionally small compared to surrounding available marine waters and site observations revealed it is seldom used by recreational vessels given the shallow waters and fringing reef platform making it a dangerous place to take a recreational vessel.

The Proposal will include defined access points across (under) the product conveyor to allow free land access to areas north of the Proposal.

The Proposal is not expected to impact recreation in the wider area, given its limited interface with the Exmouth Gulf and transhipment within offshore waters to the northeast. It is considered that the frequency of transhipper movements and ocean-going vessel loading, will be insufficiently great to impact recreational opportunities in the area.

15.5.2.3 SOCIAL AMENITY

15.5.2.3.1 ACCESS AND VISUAL AMENITY

Due to the remote location of the proposal, and adjacent mud flats, access to the Proposal area rarely occurs. There is no usage of the site by the public for camping or fishing given there is no public access through Urala pastoral lease, which is held by AGIG and utilised for the Tubridgi Gas Storage Operation which does not allow public access to the area.

Urala homestead is located approximately 8 km along the coast to the northeast of the proposed jetty. Due to distance from the Proposal and topography of landforms in between the Proposal and Urala Homestead, Proposal infrastructure will not be visible from the homestead.

An access agreement to enable construction of the Proposal on Urala Pastoral Lease will be in negotiated with AGIG prior to implementation of the Proposal.

15.5.2.3.2 ANTHROPOGENIC LIGHT SPILL

Modelling of anthropogenic light spill from the Proposal was conducted by Pendoley Environmental (2023) as described in Section 9.5.2, with the full report in Appendix DD concluding that:

- Under a ‘worst’ case scenario with all jetty lighting switched on, light emissions from the project could increase the existing WOS and horizon brightness by up to 216% and 514% respectively at the monitoring site situated closest to the project jetty (Mainland West). At this site, while the localised topography provides some natural shielding in the direction of the project, the jetty extends beyond this shielding allowing both direct light and sky glow to be visible.
- Under a ‘best’ case scenario with all jetty lighting switched off, the change in WOS and horizon brightness at Mainland West is predicted to be an increase of 11%.

- At Mainland East, the localised dune and beach headland/topography shielded the visibility of modelled light resulting in a substantially smaller increase of 11% WOS brightness and 9% horizon brightness compared to the Mainland West site.
- At monitoring sites on the offshore islands, there was no detected difference in WOS and horizon brightness between the two modelled scenarios, indicating that while effective at monitoring sites situated in proximity to the source on the mainland, the switching off of jetty lighting would have no influence on reducing the visitbility of light at monitored offshore islands.
- There were detected increases in brightness from benchmark light levels with the inclusion of the modelled outputs, ranging from 8 to 14% for the WOS area and 6 to 15% for the horizon area for offshore sites.
- The predicted light emissions from TSV and OGV vessels at the transhipment area were notably visible in the modelled outputs at the monitoring sites on Thevenard and Bessieres islands only and shielded or barely visible at all other sites. When the vessels are operating in this area, it is likely that they will be a new source of offshore light on the horizon and will appear at different bearings depending on the perspective at these two nearby islands (Pendoley Environmental, 2023).

15.5.2.3.3 NOISE

Construction of the Proposal will result in relatively low levels of noise as most of the works will be conducted in narrow strips on soft mudflats (for the pond walls). Minimal night works are expected during pond construction given the difficult terrain.

The operation of the Proposal will result in low noise overall as it relies on solar evaporation for the majority of the process. Noise from the ponds is therefore unlikely to be significant enough to affect the behaviour of terrestrial fauna species.

The Proposal will ensure it complies with the EP Act Noise Regulations and noise will be assessed by DWER during the works approval and licencing process under Part IV of the EP Act.

15.5.2.3.4 DUST

The Proposal will result in minimal dust emissions during construction as most of the works will be conducted in narrow strips on soft mudflats (for the pond walls).

Standard dust suppression measures will be used during construction as necessary, such as a water cart and sprinklers. Water or dust suppressant will be applied to disturbed areas and product transfer / storage areas as required to minimise dust generation

The Proposal is located within a remote location, with the nearest sensitive receptor (Urala Homestead) approximately 8 km away. Therefore, dust impacts to community are unlikely to be significant.

Dust management measures will be assessed and regulated by DWER during the works approval and licencing process under Part IV of the EP Act.

15.5.3 CUMULATIVE IMPACTS

There are no other projects in the local area which create significant impacts to social surroundings. Hence, it is considered that local cumulative impacts do not need to be considered when assessing the impacts of the Proposal on social surroundings.

The only current developments for which it can feasibly be considered that the Proposal could represent a source of potential regional cumulative impacts are the Wheatstone LNG plant and accommodation village, and the Macedon gas treatment plant, all of which are some 20-25 km to the north-east of the Proposal. As discussed in Section 9.5.2, light spill from the Proposal will be additive to the light generated at the other three sources. However, given the relatively low magnitude of light spill from the Proposal, in comparison to the light from the other three sources, it is considered that the Proposal will not contribute significantly to the overall light climate in the region, and therefore will not raise the risk of significant impacts to sensitive receptors to a substantially greater degree than presently exists in the region.

Current activities in the vicinity of the jetty, the ocean-going vessel loading anchorages, and the transhipper route between them, primarily comprise existing recreational or commercial vessel movements. It is considered that the frequency of transhipper movements and ocean-going vessel loading, in conjunction with existing vessel movements, will be insufficiently great to impact recreational use or commercial fishing opportunities in the area.

15.6 ASSESSMENT OF IMPACTS

The location and design of the Proposal results in a very small scale of impacts to social surroundings as outlined in Sections 15.5.1 to 15.5.3 above:

- The disturbance of areas which may contain Aboriginal heritage sites (Archae-aus, 2020) is proportionally small as follows:
    - 5.24% of high likelihood areas locally.
    - 0.34% of medium likelihood areas locally.
- Whilst Aboriginal heritage sites will be disturbed as outlined in Section 15.5.1.1, consultation will occur with the Thalanyji people and their representative BTAC on minimising and mitigating the impacts of disturbance as far as practicable. Appropriate approvals to undertake disturbance will be sought under the AH Act or ACH Act.
- Disturbance of habitats with cultural associations for Thalanyji people (BTAC, 2021b) is proportionally small in relation to surrounding similar habitats as follows:
    - Mangroves: 4.57 ha (0.85% locally and 0.04% regionally)
    - Transitional Mudflats 17.78 ha (0.9% locally and 0.09% regionally)
    - Beaches: 0.99 ha (0.78% locally and 0.1% regionally)
    - Tidal Creeks: 0.56 ha (0.19% locally and 0.02% regionally)
    - Subtidal Habitat: 8.68 ha (0.17% locally and 0.008% regionally).
- No disturbance of European heritage sites will occur.
- The area of habitat within the seawater intake area of influence (including both the nearshore habitat and creek habitat) (Water Technology, 2018) is proportionally low compared to the entire nursery habitat of the EGPMF (approximately 0.39% of the nursery area). On this basis it is unlikely that a significant proportion of the prawn population available for commercial harvest will be removed by the seawater intake.
- Jetty construction, bitterns discharge, dredging, underwater sound, artificial lighting and alteration of nutrient pathways are considered unlikely to significantly impact the prawn fisheries given their limited interface with the marine environment in comparison to the large extent of the prawn fisheries.
- K+S commissioned Water Technology to undertake an ABM study to assess the potential impacts of the intake and outfall on prawn populations in Exmouth Gulf. This study has been a collaborative effort with extensive stakeholder engagement with participants from DPIRD, MG Kallis and Murdoch University
- It is considered that the frequency of transhipper and ocean-going vessel movements will be low and unlikely to impact recreational or commercial vessel movements in the area.
- The Proposal will not prevent access by the community to local waters by boat, except for the Port Marine Boundary which is localised and proportionally small compared to surrounding available marine waters.
- The Proposal is not expected to impact recreation in the wider area, given its limited interface with the Exmouth Gulf and relatively low number of vessel movements.
- Given the relatively low magnitude of light spill from the Proposal, in comparison to the light from other sources, it is considered that the Proposal will not contribute significantly to the overall light climate in the region, and therefore will not raise impacts from light spill to a substantially greater degree than presently exists.

15.7 MITIGATION

15.7.1 AVOID

The following design and mitigation measures have been undertaken or will be implemented to avoid impacts on social surroundings:

- K+S will meet its obligations under the AH Act and ACH Act.
- K+S will engage with BTAC for an agreed programme for the undertaking of archaeological and ethnographic surveys, which will occur prior to any ground disturbing works, to be undertaken with BTAC.
- Wherever possible works will avoid disturbance of Aboriginal Heritage Sites.
- Eight iterations of the pond design have been undertaken to minimise the footprint.
- Proposal design measures have been implemented to avoid impacts to benthic habitats with cultural associations for Thalanyji people as outlined in Section 8.8.1.
- Disturbance of European Heritage Sites will not occur.

15.7.2 MINIMISE

The following design and mitigation measures have been undertaken or will be implemented to minimise impacts on social surroundings:

- BTAC and K+S are finalising a Project Agreement and Indigenous Land Use Agreement (ILUA).
- Where it is not possible to avoid disturbance of Aboriginal sites, consultation will occur with the Thalanyji people on minimising disturbance and mitigating the impacts of disturbance as far as practicable and appropriate approvals to undertake disturbance will be sought under the AH Act or the ACH Act.
- K+S will work with the Thalanyji people and their representative BTAC on maintaining existing cultural associations with the environment during Proposal construction and operations (subject to safety requirements).
- The Proposal will include defined access points across (under) the product conveyor to allow free land access to areas north of the Proposal.
- The location and design of the Proposal minimises its interface with the Exmouth Gulf thereby minimising impacts to commercial fisheries and recreational users. Nevertheless, K+S will continue to liaise with commercial and recreational fishing groups to ensure impacts are minimised over the life of the Proposal.
- The location and design of the Proposal minimises the social impacts of access restrictions, visual amenity, anthropogenic light pollution, noise and dust. K+S will record any complaints or incidences associated with these potential impacts and implement measures as required to minimise the likelihood or re-occurrence.

15.7.3 REHABILITATE

At the completion of the Proposal the site will be rehabilitated to reinstate the natural environment and pre-development social surroundings. At the completion of operations, all buildings and structures on land will be removed from the site and the pond areas may be selectively reconnected to the existing tidal flat system. K+S preferred post closure land use is to leave the evaporation ponds in situ so that they become fauna habitat for shore birds (including migratory birds which require “wetland areas” for migratory stop over).

If ponds are to be reconnected, the MCP will establish which bunds to breach that will enable inwards tidal movement bringing sediments and allowing tidal channels to expand naturally. Natural tidal flows will allow movement of mangrove plant and seed material which will passively revegetate the reconnected tidal areas. This will enhance the habitat values of the ponds post closure.

Consultation has occurred with the Shire of Ashburton and the Thalanyji people on end land use as outlined in Section 3.3 and such consultation will continue for the life of the Proposal.

An Interim MCP for the Proposal has been provided in Appendix BB and will continue to evolve during the life of the Proposal. If the Proposal receives Ministerial Approval under Part IV of the EP Act as well as under the EPBC Act, the MCP will be developed in more detail and submitted to DMIRS for approval as required by the *Statutory Guidelines for MCPs under the Mining Act 1978* – DMIRS (2020b).

15.8 PREDICTED OUTCOME

The EPA objective in relation to social surroundings is *to protect social surroundings from significant harm*. This objective is met by the proposed development because:

- Disturbance to Aboriginal Heritage Sites and culturally significant habitats will be minimised as far as practicable in consultation with the Thalanyji people.
- No disturbance of European Heritage Sites will occur.
- The Proposal is unlikely to significantly impact commercial fishing opportunities or recreational use of the environment.
- The Proposal will not restrict access to any coastal areas other than the small narrow area associated with the conveyor and jetty, with crossing points to be installed to allow access under the conveyor.
- Social amenity will not be significantly impacted by the Proposal due to access restrictions, visibility, lighting, noise or dust.

The development and proposed implementation of a range of mitigation strategies will occur to further minimise impacts.

Detailed technical assessments have developed a comprehensive understanding of social surroundings both regionally and locally. The potential impacts associated with the Proposal were found to be localised and proportionally small on both a local and regional basis.

Given the minor nature of the direct and indirect impacts from the development on social surroundings it is considered that there are no significant residual impacts for this factor.

16 OTHER ENVIRONMENTAL MATTERS OR FACTORS

16.1 DUST

The Proposal will result in minimal dust emissions during construction as most of the works will be conducted in narrow strips on soft mudflats (for the pond walls). Standard dust suppression measures will be used during construction as necessary, such as a water cart and sprinklers. Water or dust suppressant will be applied to disturbed areas and product transfer / storage areas as required to minimise dust generation The proposed Proposal is located within a remote location, with the nearest sensitive receptor (Urala Homestead) approximately 8 km away. Therefore, dust impacts to community are unlikely to be significant.

Dust management measures will be documented and implemented through the CEMP and OEMP and will be further assessed by DWER during the works approval and licencing process under Part IV of the EP Act.

The following dust related potential workforce health and safety issues (GHD, 2021d) will be further assessed and managed via the Proposal CEMP and OEMP:

- A generic silicates assay has been conducted on select geological units proposed to be disturbed. Analysis identified significant quarts content in all samples presented values up to 71%, with minerals susceptible to fibrous crystal habit confined to clays/micas (GHD, 2021d). Further assessment of potential dust and workforce inhalation airborne particles will be undertaken prior to ground disturbance works. Dust suppression measures will be implemented in accordance with an appropriate CEMP during construction phase to minimise the risk of workers inhaling and ingestion of air borne particles. Appropriate dust management and monitoring will be established in the CEMP and OEMP.
- Although considered unlikely, sediments in the area may contain naturally occurring heavy minerals (resistates) concentrated in channel systems, which may be elevated in minerals exhibiting radioactivity above generalised background concentrations. Whilst these channel systems are not proposed to be excavated or disturbed as part of the Proposal, borrow pits for clay located within claypans could potentially contain such resistates due to receiving material from channel systems (GHD, 2021d). Borrow pits within claypans and drainage diversions will be further assessed prior to disturbance. Testing of material from any borrow pits within claypans (geological unit Qp) and drainage diversions for NORMs will be conducted and if present management of this material considered (including dust management and monitoring) in the CEMP and OEMP.

16.2 NOISE

The Proposal will result in low noise emissions during construction as most of the works will be conducted in narrow strips on soft mudflats (for the pond walls) and minimal night work will be undertaken sure to site terrain.

During operation as solar evaporation is the main process noise emissions will be low.

K+S will ensure that the Proposal complies with the EP Act Noise Regulations, through the implementation of CEMP and OEMP, and will be further assessed by DWER during the works approval and licencing process under Part IV of the EP Act.

16.3 AIR EMISSIONS

No air emissions are expected from the Proposal other than dust (described above) and vehicle exhaust emissions.

The Proposal is located in a remote location where such emissions are not expected to be a significant impact for the local community.

16.4 CLIMATE CHANGE AND GREENHOUSE GASES

The effects of climate change will occur with or without the Proposal in place. As climate change is a global issue, mitigation of this global issue by an individual Proposal is not possible. However, the Proposal is proposing to minimise its generation of greenhouse emissions so as not to contribute significantly to climate change. Given the Proposal relies on solar and wind energy for the salt evaporation process, energy requirements are considered to be minimal.

Electrical power will be provided by an offsite nearby natural gas fired power station. Electrical power lines will be constructed by the provider to bring reticulated electricity to the Ashburton Salt site.

Site-specific greenhouse gas emission estimates are currently being developed, however a reasonable approach at this early planning stage is to use a similar emission intensity as the Mardie Project (12,112 t CO_2-e per million tonnes of salt). This is considered to be a conservative position as the Proposal utilises a smaller pond footprint due to the elevated salinity in its intake water (i.e., less evapoconcentration is required). Based on this position the Proposal would be estimated to produce a total of 57,000 t CO_2-e per annum during operations, 19,000 t CO_2-e per annum of Scope 1 emissions (predominantly diesel usage) and 38,000 t CO_2-e per annum of Scope 2 emissions (electrical power sourced from a third party).

The effect of climate induced SLR will be considered during the closure planning process, and it may be possible to create a “niche” environment for mangroves and/or algal mats which may enable them to continue to exist beyond the currently anticipated timeframe of SLR induced mangrove/algal mat loss, by providing physical protection from the effects of SLR behind rock armoured embankments.

17 OFFSETS

17.1 OVERVIEW

Environmental offsets are actions that provide environmental benefits which counterbalance the significant residual impacts of a proposal. The EPA may apply environmental offsets where it determines that the residual impacts of a proposal are significant, after avoidance, minimisation and rehabilitation have been pursued. Consistent with the WA Environmental Offsets Guidelines (Government of Western Australia, 2014), the EPA will consider whether offsets can counterbalance and are appropriate for the proposal's residual impacts.

Offsets are the last of the four steps in the mitigation hierarchy (Avoid, Minimise, Rehabilitate and Offset). They are only applied to counterbalance residual significant impacts when the other steps have already been applied to a Proposal.

K+S has commissioned numerous environmental surveys and studies for the Proposal. Assessment of these surveys and research has enabled K+S to determine key environmental values requiring protection at the Proposal, including significant BCH, marine and terrestrial fauna habitat, flora and vegetation, and areas of Aboriginal cultural value. Changes to the Proposal design have been made to avoid and minimise significant impacts to the key environmental factors during Proposal construction and operations.

An Interim Offsets Strategy has been provided in Appendix CC. This section summarises the content of that document.

17.2 SUMMARY OF SIGNIFICANT RESIDUAL IMPACTS

The WA Environmental Offsets Guidelines (EPA, 2014) states:

> "In general, significant residual impacts include those that affect rare and endangered plants and animals (such as declared rare flora and threatened species that are protected by statute), areas within the formal conservation reserve system, important environmental systems and species that are protected under international agreements (such as Ramsar listed wetlands) and areas that are already defined as being critically impacted in a cumulative context. Impacts may also be significant if, for example, they could cause plants or animals to become rare or endangered, or they affect vegetation which provides important ecological functions".

The assessments conducted in Sections 0 – 16 have utilised the findings of the numerous surveys and studies completed for the Proposal. K+S has assessed the residual impacts of the Proposal against the residual impact significance model provided in the WA Environmental Offsets Guidelines (EPA, 2014). As described in the preceding sections of this ERD, the Proposal's predicted significant residual impacts on the environmental values are summarised in Table 112 and the MNES listed in Table 113.

K+S has assessed the residual impacts of the Proposal against the residual impact significance model provided in the WA Environmental Offsets Guidelines (EPA, 2014). The findings of this assessment are provided in Table 114.

Table 112: Summary of significant residual impacts – Part IV EP Act Environmental Values

Environmental value	Other associated values (as defined in relevant Recovery Plans or species guidance)	Residual Impacts
Nearshore BCH	Turtles (Threatened), dugong (specially protected), green sawfish (Threatened) and other elasmobranchs	Loss of up to 226.2 ha
Migratory Shorebirds (Threatened and Migratory)	Green turtle juveniles and Northern Coastal Free-tailed Bat (Priority 1) (Mangrove BCH), turtles (Sandy Beach BCH), Exmouth Gulf East Wetland (WA007) which is listed in the Directory of Important Wetlands in Australia	Loss of: • 0.99 ha of Sandy Beaches BCH; • 4.28 ha of Mangroves BCH, which may also be utilised by green turtle juveniles; • 17.81 ha of Transitional Mudflat BCH; • 16.68 ha of Algal Mats BCH.
Tidal Creek BCH	Green sawfish and green turtle juveniles	Loss of 0.54 ha
'Good' to 'Excellent' condition native vegetation	Pilbara Olive Python and Northern Quoll	Clearing of up to **1,053** ha of good to excellent condition native vegetation, including 67 ha of foraging and dispersal habitat for Pilbara Olive Python and Northern Quoll (discussed below)
River bank / creekline / drainage habitat	Pilbara Olive Python and Northern Quoll (critical habitat)	Disturbance of 0.53 ha

Table 113: Summary of significant residual impacts – MNES

Relevant MNES	Residual Impacts
Listed threatened species and communities (Sections 18 & 18A)	
Migratory Shorebirds (Threatened and Migratory)	Clearing of: • Up to 0.99 ha of Sandy Beaches habitat; • Up to 4.57 ha of Mangroves habitat; • Up to 17.78 ha of Transitional Mudflat habitat; • Up to 16.69 ha of Algal Mats habitat; • Up to 69.21 ha of Freshwater Claypan habitat
Pilbara Olive Python (*Liasus olivaceaus barroni*) – (Vulnerable) critical habitat	Clearing of up to 0.53 ha of River bank / creekline / drainage habitat on the Ashburton River (critical habitat)
Northern Quoll (*Dasyurus hallucatus*) - Endangered	Clearing of up to 0.53 ha of River bank / creekline / drainage habitat on the Ashburton River (critical habitat) Clearing of up to 67 ha of surrounding foraging habitat
Marine Fauna, including elasmobranchs, Marine Turtles and marine mammals	Loss of up to 226.2 ha of nearshore BCH, 4.28 ha of Mangrove BCH and 0.54 ha of Tidal Creeks BCH Indirect impacts associated with marine noise, vessel strike, water quality (from dredging and bitterns disposal) and unplanned pollution (i.e., spills)
Listed migratory species (Sections 20 & 20A)	
Migratory Shorebirds (Threatened and Migratory)	Clearing of: • Up to 0.99 ha of Sandy Beaches habitat; • Up to 4.57 ha of Mangroves habitat; • Up to 17.78 ha of Transitional Mudflat habitat; • Up to 16.69 ha of Algal Mats habitat; • Up to 69.21 ha of Freshwater Claypan habitat

Table 114: Assessment again residual impact significant model

Part IV Environmental Factors	Vegetation and Flora						
					Marine Fauna		
		Benthic Habitat and Communities			Benthic Habitat and Communities		
				Terrestrial Fauna			
Part V Clearing Principles	**c –** Rare flora	**d –** TECs	**e –** Remnant vegetation	**f –** Wetlands and waterways	**h –** Conservation areas	**a –** High biological diversity	**b –** Habitat for fauna
Residual impact that is environmentally unacceptable and cannot be offset	No residual impacts are considered to meet this criterion: • No Threatened Flora records are located within the disturbance footprint • No significant Priority Flora impacts	No residual impacts are considered to meet this criterion – no TECs were recorded within the Study Area	Residual impacts to vegetation in 'good' to 'excellent' condition are unlikely to meet this criterion. Up to 1,053 ha of good to excellent condition native vegetation is proposed to be cleared, however the Proposal is located in an area that remains mostly remnant vegetation.	Direct and indirect impacts to the Exmouth Gulf East Wetland (WA007) which is listed in the Directory of Important Wetlands in Australia (EnviroWorks 2016) are considered significant however the Proposal is unlikely to impact the overall value and function of this wetland area at such a scale that it would meet this criterion.	Direct and indirect impacts to the Exmouth Gulf East Wetland (WA007) and Area 2 – Exmouth East Shore' MMA are considered significant however the Proposal is unlikely to impact the overall value and function of these conservation areas at such a scale that it would meet this criterion.	Mangroves and tidal creeks would be considered areas of high biological diversity – however almost all of these areas have been avoided.	Direct and indirect impacts to several fauna species (discussed below) are considered significant however the Proposal is unlikely to impact these species at such a scale that it would meet this criterion.
Significant residual impacts that will require an offset – *all significant residual impacts to species and ecosystems are protected by statute or where the cumulative impact is already at a critical level*	No residual impacts are considered to meet this criterion: • No Threatened Flora records are located within the disturbance footprint • No significant Priority Flora impacts	No residual impacts are considered to meet this criterion – no TECs were recorded within the Study Area	Some significant residual impacts to vegetation in 'good' to 'excellent' condition are likely to meet this criterion: Up to 1,053 ha of good to excellent condition native vegetation, including potential habitat for significant flora and fauna	Some residual impacts are considered to meet this criterion: • Direct and indirect impacts to the Exmouth Gulf East Wetland (WA007) which is listed in the Directory of Important Wetlands in Australia (EnviroWorks 2016). These impacts are considered residual impacts in the context of Terrestrial Fauna (primarily Migratory Shorebirds)	Some residual impacts are considered to meet this criterion: • Direct and indirect impacts to the Exmouth Gulf East Wetland (WA007). • Direct and indirect impacts to the Area 2 – Exmouth East Shore' MMA These impacts are considered residual impacts in the context of BCH and Terrestrial Fauna (primarily Migratory Shorebirds)	Some residual impacts are considered to meet this criterion: • Mangroves and tidal creeks would be considered areas of high biological diversity – almost all of these areas have been avoided.	• Direct and indirect impacts to subtidal BCH that provides habitat for marine fauna • Direct and indirect impacts to potential habitat for Migratory Shorebirds (including several Threatened species) Some significant residual impacts to habitat in 'good' to 'excellent' condition are likely to meet this criterion: Up to 1,053 ha of good to excellent condition fauna habitat, including potential habitat for significant flora and fauna listed below: • 0.53 ha of River bank / creekline / drainage habitat on the Ashburton River that provides potential habitat for the Pilbara Olive Python and Northern Quoll • 67.00 ha of surrounding Northern Quoll foraging habitat
Significant residual impacts that may require an offset – *any significant residual impacts to potentially threatened species and ecosystems, areas of high environmental value or where the cumulative impact may reach critical levels if not managed*	Potential residual impacts to *Minuria tridens* habitat may meet this criterion. Potential residual impacts to *Triumfetta echinata, Stackhousia clementii, Eremophila forrestii* subsp. *viridis,* and *Abuliton sp. pritzelianum* may meet this criterion if conservation status or scale of impact was to increase.	No residual impacts are considered to meet this criterion – no TECs were recorded within the Study Area.	No other residual impacts are considered to meet this criterion – refer above	No additional residual impacts are considered to meet this criterion	No additional residual impacts are considered to meet this criterion	No additional residual impacts are considered to meet this criterion	No additional residual impacts are considered to meet this criterion
Residual impacts that are not significant	No known Threatened Flora listed under the EPBC Act or BC Act will be disturbed. Priority flora species were recorded within the development envelopes. Based on the assessments of these species in Section 10 the Proposal is unlikely to significantly impact the local or regional extent of these species.	No other residual impacts are considered to meet this criteria – refer above	Clearing of vegetation that is in poor or degraded condition will occur as a result of the Proposal however this is not considered to be a significant residual impact.	No other residual impacts are considered to meet this criteria – refer above	No other residual impacts are considered to meet this criteria – refer above	With the exception of the above, the Proposal avoids areas of high biological diversity.	Clearing of fauna habitat that is in poor or degraded condition will occur as a result of the Proposal however this is not considered to be a significant residual impact.

17.3 DETAILS OF PROPOSED OFFSETS

Table 115 describes the measures proposed to offset the additional residual impacts associated with the Proposal. These measures are subject to refinement as the Proposal assessment progresses, and pending discussions with influencing parties such as DBCA. A meeting with DBCA was held in early 2023, which assisted in the refinement of the proposed offsets, and identified that there is uncertainty around land management and research offsets in regards to timing and scope (DBCA land management programs, research etc.). K+S will continue discussions with DBCA to refine the preferred offsets methodology.

Table 115: Proposed offsets

Offset	Type	Details	Relevant values / MNES
Terrestrial land management – contribution to land management for direct and indirect impacts to Pilbara Olive Python habitat and Northern Quoll supporting habitat. A minimum of 200 ha of degraded Pilbara Olive Python habitat and Northern Quoll supporting habitat in the local area is proposed to be managed to improve habitat quality.	Direct – management of existing habitat	Large areas of the study area and the Northern Quoll supporting habitat have been heavily impacted by invasive weeds and grazing. The funds will be collated with other terrestrial fund commitments discussed below to focus on improving the quality of the broader landscape, with these specific funds focused on areas of Northern Quoll and Pilbara Olive Python habitat within the local area. DBCA have identified that there may be some suitable land management programs may be established at the time of approval (if approved) that could be suitable to align with. DBCA is currently conducting research and planning for these programs. The aim is to deliver a land management project that achieves overall biodiversity conservation outcomes.	Pilbara Olive Python, Northern Quoll
Terrestrial land management – contribution to land management for direct and indirect impacts to 'Good' to 'Excellent' condition native vegetation not already offset by the measure above. A minimum of 3,200 ha of degraded vegetation in the local area is proposed to be managed to improve vegetation / habitat quality.	Direct – management of existing flora, vegetation and fauna habitat	Large areas of the study area and surrounds have been heavily impacted by invasive weeds and grazing. The funds will be collated with the terrestrial fund commitments discussed above to focus on improving the quality of the broader landscape. DBCA have identified that there may be some suitable land management programs may be established at the time of approval (if approved) that could be suitable to align with. DBCA is currently conducting research and planning for these programs. The aim is to deliver a land management project that achieves overall biodiversity conservation outcomes.	Native vegetation, fauna habitat, *Minuria tridens*
Contribution of $230,000 to a relevant scientific initiative regarding intertidal BCH on the eastern Exmouth Gulf shoreline. DBCA have noted that there are clear knowledge gaps regarding intertidal BCH on	Indirect (research) – contribution prior to or within 12 months of the commencement of construction for the purpose of research	DBCA have noted that there are clear knowledge gaps regarding intertidal BCH on the eastern Exmouth Gulf coastline. DBCA are currently identifying research programs required for management of the marine park, there is potential for funds to	• Migratory shorebirds • Marine fauna • Mangroves • Samphire

Offset	Type	Details	Relevant values / MNES
the eastern Exmouth Gulf coastline. DBCA are currently identifying research programs required for management of the marine park, there is potential for funds to be used to improve one of these research programs. Funding will be maintained through indexation to the Perth CPI.		be used to improve one of these research programs. The proponent shall ensure that the real funding will be maintained through indexation to the Perth CPI, commencing in 2023.	• Algal Mats • Transitional Mudflats
Marine (offshore) management - $1 million contribution to management of regional threats to the Eastern Exmouth Gulf area. Funding will be maintained through indexation to the Perth CPI.	Direct – management of marine waters, fauna and/or subtidal BCH	K+S is aware of plans to designate a marine park for Exmouth Gulf. It is expected that several management measures will be put in place to conserve the values of the Exmouth Gulf marine park, and K+S proposes to provide funds to either: • Extend the managed areas outside of the marine park, in areas advised by DBCA; and/or • Provide management within the marine park that is in addition to what is being undertaken by DBCA (to achieve better outcomes)	• Migratory shorebirds • Marine fauna

17.4 ASSESSMENT OF OFFSETS – WA

K+S has implemented the WA Offsets Template as shown in Table 116, following the requirements of the WA Environmental Offsets Guideline (Government of WA, 2014).

Table 116: WA offsets policy template

Existing environment / Impact	Mitigation			Significant residual impact	Offset calculation methodology				
	Avoid and minimise	Rehabilitation type	Likely rehab success		Type	Risk	Likely offset success	Time lag	Offset quantification
Good to Excellent Condition native vegetation – clearing of up to 1,053 ha of good to excellent condition native vegetation, including potential habitat for significant flora and fauna species **Pilbara Olive Python and Northern Quoll potential habitat** – up to 0.53 ha of river bank / creekline / drainage of the Ashburton River, and 67 ha of surrounding Northern Quoll foraging habitat	**Avoid**: Impact to vegetation and flora have been avoided by placing most of the Proposal disturbance (salt ponds) on the bare salt flats which are devoid of vegetation **Minimise**: • Minimise clearing within good to excellent vegetation • Industry standard clearing controls • Compliance with Part IV EP Act approval, Part V EP Act Works Approval and Licence, and *Mining Act 1978* approvals.	• Site will be rehabilitated to reinstate the flora and vegetation. • Vegetation to be respread with topsoil and reseeded.	<u>Can the environmental values be rehabilitated / Evidence?</u> Yes, Pilbara rehabilitation methods are well established and while success has been varied, additional scientific information is likely to be available at closure given the long life of the Proposal. <u>Operator experience in undertaking rehabilitation?</u> K+S will source experienced rehabilitation operators at closure. <u>What is the type of vegetation being rehabilitated?</u> Various <u>Time lag?</u> Up to several decades for vegetation to fully re-establish. <u>Credibility of the rehabilitation proposed (evidence of demonstrated success)</u> Credible, Pilbara rehabilitation methods are well established and while success has been varied, additional scientific information is likely to be available at closure given the long life of the Proposal.	<u>Extent</u> 1,053 ha <u>Quality</u> Good to Excellent <u>Conservation Significance</u> No formal listing on good to excellent vegetation Pilbara Olive Python – Vulnerable (BC Act) Northern Quoll – Endangered (BC Act) <u>Land Tenure</u> Pastoral Leases, Mining Act leases <u>Time Scale</u> Long-term, areas will remain cleared for up to 100 years	Terrestrial land management – refer to Section 17.3	Low – clear management requirements (weed and grazing management) and DBCA may have established programs at the time of offset.	<u>Can the values be defined and measured?</u> Yes – value to ecosystem can be measured <u>Operator experience/Evidence?</u> Experienced land managers will manage the offset (DBCA or contractor) <u>What is the type of vegetation being revegetated?</u> N/A <u>Is there evidence the environmental values can be re-created (evidence of demonstrated success)?</u> Evidence of successful weed control measures is available	Minimal – manages habitat type and affected species soon after payment and management strategies are developed.	Offset would protect / improve / maintain the quality of significant areas of these environmental values.
Migratory shorebird habitat – Loss of: • 0.99 ha of Sandy Beaches habitat; • 4.28 of Mangroves habitat (which also provides habitat for marine fauna and the Northern Coastal Free-tailed Bat (Priority 1); • 17.81 ha of Transitional Mudflat habitat; • 16.69 ha of Algal Mats habitat; Some potential indirect impacts.	**Avoid**: Impacts to fauna habitat have been avoided by placing most of the Proposal disturbance (salt ponds) on the bare salt flats which are devoid of vegetation and other valuable habitat features. **Minimise**: • Minimise clearing within these habitat type • Mangrove disturbance limits • Ensure low noise and light emissions • Industry standard clearing controls. • Compliance with Part IV EP Act approval, Part V EP Act Works Approval and Licence, and *Mining Act 1978* approvals.	• All buildings and structures on land will be removed from the site and the pond areas may be selectively reconnected to the existing tidal flat system, with consideration of the ponds becoming fauna habitat for shore birds • Brine and salts to be removed from ponds • Pond walls to be breached to allow flows to re-enter the pond footprint, with consideration of BCH that has become established on the pond walls	<u>Can the environmental values be rehabilitated / Evidence?</u> Yes, the majority of the disturbance is bare mudflat and will remain at closure. Natural processes are expected to gradually reinstate the remaining BCH, although some boundaries may be altered due to SLR. BCH are relatively dynamic due to cyclone events. <u>Operator experience in undertaking rehabilitation?</u> None required, rehabilitation will occur via natural processes. <u>What is the type of vegetation being rehabilitated?</u> Algal mat, transitional mudflat, samphire and some mangrove BCH <u>Time lag?</u> Up to two years to remove salts depending on rainfall events, then several decades for BCH to re-establish <u>Credibility of the rehabilitation proposed (evidence of demonstrated success)</u> Credible, intertidal processes are dynamic and will flush the area and allow BCH to spread across the area over time. There is evidence in the	<u>Extent</u> • 0.99 ha of Sandy Beaches habitat • 4.28 of Mangroves habitat • 17.81 ha of Transitional Mudflat habitat; • 16.68 ha of Algal Mats habitat <u>Quality</u> Good to Excellent <u>Conservation Significance</u> Various – threatened and migratory species. <u>Land Tenure</u> Unallocated Crown Land, Mining Act leases <u>Time Scale</u> Long-term, areas will remain	Research – refer to Section 17.3	Low – DBCA has identified suitable research benefits	<u>Can the values be defined and measured?</u> <u>Yes – value to ecosystem can be measured due to increased knowledge base</u> <u>Operator experience/Evidence?</u> <u>DBCA is likely to manage the offset if integrated into an existing program. Otherwise, experienced organisation will be engaged.</u> <u>What is the type of vegetation being revegetated?</u> N/A <u>Is there evidence the environmental values can be re-created (evidence of demonstrated success)?</u> There is evidence in the Pilbara of mangroves growing on man-made structures.	Minimal – funding is intended to be provided to an established research program	Offset would provide important information to better assess and manage this environmental value.

Existing environment / Impact	Mitigation			Significant residual impact	Offset calculation methodology				
	Avoid and minimise	Rehabilitation type	Likely rehab success		Type	Risk	Likely offset success	Time lag	Offset quantification
			Pilbara of mangroves growing on man-made structures.	cleared for up to 100 years					
Marine Fauna: • Loss of up to 226.2 ha of nearshore BCH, 4.28 ha of Mangrove BCH and 0.54 ha of Tidal Creeks BCH • Indirect impacts associated with marine noise, vessel strike, water quality (from dredging and bitterns disposal) and unplanned pollution (i.e., spills)	**Avoid**: Impacts to marine fauna habitat have been avoided by placing most of the Proposal disturbance (salt ponds) away from the coastline. **Minimise**: • Minimise disturbance within subtidal BCH • Dilute bitterns prior to discharge • Mangrove disturbance limits • Ensure low marine noise and light emissions • Implement management plans. • Compliance with Part IV EP Act approval, Part V EP Act Works Approval and Licence, and *Mining Act 1978* approvals.	Jetty and seawater intake will be removed, and the dredge pocket will be allowed to re-fill with sediment over time.	Can the environmental values be rehabilitated / Evidence? Yes, there is minimal infrastructure in the marine environment Operator experience in undertaking rehabilitation? No specific experience required; rehabilitation will occur via natural processes. What is the type of vegetation being rehabilitated? Subtidal BCH Time lag? Up to two years to remove infrastructure, then several decades for natural seabed profile to establish Credibility of the rehabilitation proposed (evidence of demonstrated success) Credible given simple nature proposed.	Extent Loss of up to 226.2 ha of nearshore BCH, 4.28 ha of Mangrove BCH and 0.54 ha of Tidal Creeks BCH, indirect impacts Quality High quality Conservation Significance Provides habitat for several Threatened and Migratory species Land Tenure xx Time Scale Direct impacts likely to remain in the long-term, and some indirect impacts (bitterns disposal) to continue over a long time period (up to 100 years)	Marine (offshore) management - $1 million contribution to management of regional threats to the Eastern Exmouth Gulf area. Funding will be maintained through indexation to the Perth CPI.	Low – similar measures are predicted to be implemented for the Exmouth Gulf marine park when implemented	Can the values be defined and measured? Yes – value to ecosystem can be measured Operator experience/Evidence? Marine park managers may manage the offset (DBCA), or experienced contractor will be engaged What is the type of vegetation being revegetated? N/A Is there evidence the environmental values can be re-created (evidence of demonstrated success)? Exmouth Gulf is susceptible to numerous environmental threats which can be reduced by the proposed offset.	Minimal – manages habitat type and affected species soon after payment and management strategies are developed.	Offset would protect / improve / maintain the quality of significant areas of these environmental values.

17.4.1 OFFSET PRINCIPLES

Six principles support the assessment and decision-making process undertaken by the WA Government in relation to the use of environmental offsets. These principles are set out in the Environmental Offsets Policy (EPA, 2011). The Proposal and proposed offsets have been assessed against each of these principles, as provided in Table 117.

Table 117: Assessment of the proposed offsets against the six principles

Number	Principle	Consideration
1	Environmental offsets will only be considered after avoidance and mitigation options have been pursued.	K+S has applied the mitigation hierarchy by identifying measures to avoid, minimise and rehabilitate potential impacts. The primary action taken to meet this policy's requirements was site selection and design, which avoided and minimised impacts to key environmental features, and reduced the development envelope and required disturbance to the smallest size possible.
2	Environmental offsets are not appropriate for all projects.	It is acknowledged that offsets are not appropriate for all projects. The Proposal is not predicted to result in impacts that cannot be suitably offset as they are not at a scale that would lead to significant long-term impacts to local populations of listed flora or fauna (refer to Section 10.8 and 11.8).
3	Environmental offsets will be cost-effective, as well as relevant and proportionate to the significance of the environmental value being impacted.	K+S proposes to contribute funding into land management for residual impacts to terrestrial habitats. There is a clear requirement for land management in the area (due to weed infestation) and therefore the funding will be cost-effective and is relevant and proportionate to the Proposal's potential significant residual impacts. K+S also intends to contribute funding for research and management of marine fauna and intertidal areas near the Exmouth Gulf. These offsets are cost-effective as they are designed to align with existing or planned programs (rather than be stand-alone). These offsets are relevant and proportionate to the Proposal's potential significant residual impacts based on a review of offsets for the Mardie Project, with additional consideration of the significance of the Exmouth Gulf area for marine fauna.
4	Environmental offsets will be based on sound environmental information and knowledge.	The proposed offsets are based on knowledge gained during studies for the Proposal, and regional knowledge collated by WAMSI for the Exmouth Gulf.
5	Environmental offsets will be applied within a framework of adaptive management.	The management programs can be adaptively managed to adjust their delivery over time as more information and opportunities become available. The proposed research program will be developed to include a review and revision component to ensure it utilises the most up-to-date information and research measures.
6	Environmental offsets will be focused on longer term strategic outcomes.	The management and research programs will be developed to focus on longer-term strategic outcomes.

17.4.2 WA OFFSET CALCULATOR

The WA offsets calculator is only relevant to the offsets proposed for the disturbance of terrestrial impacts as the other proposed offsets are not land management offsets. A copy of the WA offsets calculator is provided for Good to Excellent quality vegetation and Northern Quoll and Pilbara Olive Python (combined) as appendices in the Interim Offset Strategy (Appendix CC).

The following values were used in the calculators:

- Disturbance to 67.53 ha of Northern Quoll and Pilbara Olive Python habitat (including 0.53 ha of denning / shelter habitat);
- Disturbance to 986 ha of Good to Excellent quality vegetation (total area disturbed minus the Northern Quoll and Pilbara Olive Python habitat already included in that calculator);
- Rehabilitation credit – zero. Given the long life of the Proposal a conservative position has been taken regarding rehabilitation;

- Quality of disturbed habitat = 7. Biota (2022) shows that the Ashburton River and surrounds varied from Poor to Very Good Quality, with no Excellent quality vegetation identified in that area, and limited extent in the surrounds. A score of 7 was deemed to be a reasonable average.
- Minimum area targeted for land management = 200 ha for Northern Quoll and Pilbara Olive Python habitat offsets, and 3,200 ha for Good to Excellent quality vegetation offets;
- Quality of area proposed to be targeted for land management = 4, based on targeting areas mapped as being in 'Poor' condition;
- Future quality of offset management areas without the offset = 3, based on expected gradual decline in quality over time;
- Future quality of offset management areas with the offset = 6, reasonable improvements based on clear options available through weed and grazing control;
- Risk of loss with and without offset = 10% (for both scenarios). The site is not being acquired for conservation therefore there is no difference between the risk of loss; and
- Confidence in result = 80%. Relatively conservative values have been used above, leading to a high confidence in the result.

17.5 ASSESSMENT OF PROPOSED OFFSETS – EPBC ACT

17.5.1 COMMONWEALTH ENVIRONMENTAL OFFSETS GUIDELINES

Offsets are defined as measures that compensate for the residual adverse impacts of an action on the environment. Where appropriate, offsets are considered during the assessment phase of an EIA under the EPBC Act.

The EPBC Act Environmental Offsets Policy (Commonwealth of Australia, 2012) states:

> "The term 'environmental offsets' refers to measures that compensate for the residual adverse impacts of an action on the environment. Offsets provide environmental benefits to counterbalance the impacts that remain after avoidance and mitigation measures. These remaining, unavoidable impacts are termed 'residual impacts'. For assessments under the EPBC Act, offsets are only required if residual impacts are significant.
> Offsets can help to achieve long-term environmental outcomes for matters protected under the EPBC Act, while providing flexibility for proponents seeking to undertake an action that will have residual impacts on those protected matters."

17.5.2 OFFSET PRINCIPLES

Table 118 provides the overarching principles that are applied in determining the suitability of offsets. In assessing the suitability of an offset, government decision-making will be informed by scientifically robust information and incorporate the precautionary principle in the absence of scientific certainty and conducted in a consistent and transparent manner.

Table 118: EPBC Act overarching principles applied in determining the suitability of offsets

No.	Principle	Offset suitability
1	Offsets must deliver an overall conservation outcome that improves or maintains the viability of the environmental aspect that is protected by national environment law and affected by the proposed action	K+S proposes to contribute funding into land management for residual impacts to terrestrial habitats. There is a clear requirement for land management in the area (due to weed infestation) and therefore the funding will deliver an overall conservation outcome that improves or maintains the viability of the environmental aspect that is protected by national environment law and affected by the proposed action. K+S also intends to contribute funding for research and management of marine fauna and intertidal areas near the Exmouth Gulf. These offsets are cost-effective as they are designed to align with existing or planned programs (rather than be stand-alone). These offsets are delivering an overall conservation outcome that improves or maintains the viability of the environmental aspect that is protected by national environment law and affected by the proposed action.
2	Offsets must be built around direct offsets but may include other compensatory measures	K+S has proposed direct offsets as well as research (indirect offset). The WA EPA identified a lack of scientific knowledge about the ecological roles, values and functions of intertidal BCH on the west Pilbara coast. Research offsets were therefore deemed appropriate to offset intertidal residual impacts as the research will result in positive conservation outcomes, address priority knowledge gaps and provide critical information to improve environmental assessment of future projects.
3	Offsets must be in proportion to the level of statutory protection that applies to the protected matter	K+S acknowledged the various levels of statutory protection that apply to the protected matters. This was considered when assessing the significance of the residual impacts. The scale of the proposed offsets takes into account these considerations.
4	Offsets must be of a size and scale proportionate to the residual impacts on the protected matter	The proposed offsets are significant in size and scale, proportionate to the predicted residual impacts. The information gathered during the research offsets will inform management on a regional scale, providing valuable scientific knowledge to inform regional and strategic protection of these values.
5	Offsets must effectively account for and manage the risks of the offset not succeeding	An Offsets Strategy will be developed that includes detailed information about each research program, including its management, governance and outcomes. These will be developed in consultation with relevant stakeholders to ensure that there is minimal risk of the offset not succeeding.
6	Offsets must be additional to what is already required, determined by law or planning regulations, or agreed to under other schemes or programs	The proposed offsets are In addition to 'that which is already required, determined by law or planning regulations, or agreed to under other schemes or programs.
7	Offsets must be efficient, effective, timely, transparent, scientifically robust and reasonable	An Offsets Strategy will be developed that will include detailed information about timeframes and transparency of information. The research program will be implemented by WAMSI in consultation with relevant stakeholders to ensure that it is effective, scientifically robust and reasonable.
8	Offsets must have transparent governance arrangements including being able to be readily measured, monitored, audited and enforced	An Offsets Strategy will be developed to provide information about the transparent governance proposed to be implemented during the development and implementation of the research programs. The research programs will be able to be readily measured, monitored, audited and enforced.

17.5.3 EPBC OFFSET CALCULATOR

The EPBC offsets calculator is only relevant to the offsets proposed for the disturbance of potential Northern Quoll and Pilbara Olive Python as the other EPBC offsets are not land acquisition / management offsets. A copy of the EPBC calculator is provided for Northern Quoll and Pilbara Olive Python in Appendix CC.

The following values were used in the calculator:

- Disturbance to 67.53 ha of Northern Quoll and Pilbara Olive Python habitat (including 0.53 ha of denning / shelter habitat);

- Quality of disturbed habitat = 7. Biota (2022a) shows that the Ashburton River and surrounds varied from Poor to Very Good Quality, with no Excellent quality vegetation identified in that area.
- Minimum area targeted for land management = 200 ha;
- Quality of area proposed to be targeted for land management = 4, based on targeting areas mapped as being in 'Poor' condition;
- Future quality of offset management areas without the offset = 3, based on expected gradual decline in quality over time;
- Future quality of offset management areas with the offset = 6, based on clear improvements available through weed control;
- Risk of loss with and without offset = 10% (for both scenarios). The site is not being acquired for conservation therefore there is no difference between the risk of loss; and
- Confidence in result = 80%. Relatively conservative values have been used above, leading to a high confidence in the result.

18 MATTERS OF NATIONAL ENVIRONMENTAL SIGNIFICANCE

18.1 CONTROLLED ACTION PROVISIONS

On 7 October 2016, K+S submitted a Referral to the Federal Department of the Environment and Energy (DoEE) under section 75 of EPBC Act (Reference: EPBC 2016/7793). The DoEE (now DCCEEW) decided that the Proposal will be assessed by the WA EPA as an EPBC Act accredited assessment under Part IV of the EP Act (WA) due to the following potentially significant factors:

- Listed threatened species and communities (sections 18 & 18A)
- Listed migratory species (sections 20 & 20A)
- Commonwealth marine areas (sections 23 & 24A).

Table 119: Matters of National Environmental Significance that may be impacted by the Proposal

Common Name	Species Name	Conservation Status	Recorded within Proposal Surveys
Flora			
Minnie Daisy	*Minuria tridens*	Vulnerable	Yes
Mammals			
Antarctic minke whale	*Balaenoptera bonaerensis*	Migratory	Unlikely to occur
Australian humpback dolphin	*Sousa sahulensis*	Migratory	May occur
Blue whale	*Balaenoptera musculus*	Endangered/ Migratory	Unlikely to occur
Bryde's whale	*Balaenoptera edeni*	Migratory	Unlikely to occur
Dugong	*Dugong dugon*	Migratory	Likely to occur
Fin whale	*Balaenoptera physalus*	Vulnerable/ Migratory	Unlikely to occur
Humpback whale	*Megaptera novaeangliae*	Vulnerable/ Migratory	Likely to occur
Killer whale	*Orcinus orca*	Migratory	Unlikely to occur
Northern Quoll	*Dasyurus hallucatus*	Endangered	Likely to occur
Sei whale	*Balaenoptera borealis*	Vulnerable/ Migratory	Unlikely to occur
Shark Bay Bandicoot or Little Marl	*Perameles bougainville*	Endangered	Would not occur
Southern right whale	*Eubalaena australis*	Endangered/ Migratory	Unlikely to occur
Sperm whale	*Physeter macrocephalus*	Migratory	Unlikely to occur
Spotted bottlenose dolphin	*Tursiops aduncus*	Migratory	Likely to occur
Reptiles			
Flatback turtle	*Natator depressus*	Vulnerable/ Migratory	Likely to occur
Green turtle	*Chelonia mydas*	Vulnerable/ Migratory	Likely to occur
Hawksbill turtle	*Eretmochelys imbricata*	Vulnerable/ Migratory	Likely to occur
Leatherback turtle	*Dermochelys coriacea*	Endangered/ Migratory	Unlikely to occur
Loggerhead turtle	*Caretta*	Endangered/ Migratory	Likely to occur
Pilbara Olive Python	*Liasis olivaceus barroni*	Vulnerable	Likely to occur
Short-nosed sea-snake	*Aipysurus apraefrontalis*	Critically Endangered	May occur
Elasmobranch			
Dwarf sawfish	*Pristis clavata*	Vulnerable	May occur
Giant manta ray	*Manta birostris*	Migratory	May occur
Green sawfish	*Pristis zijsron*	Vulnerable/ Migratory	Likely to occur

Common Name	Species Name	Conservation Status	Recorded within Proposal Surveys
Grey nurse shark (west coast)	*Carcharias taurus*	Vulnerable	May occur
Longfin mako	*Isurus paucus*	Migratory	Unlikely to occur
Narrow sawfish	*Anoxypristis cuspidata*	Migratory	May occur
Reef manta ray	*Manta alfredi*	Migratory	May occur
Shortfin mako	*Isurus oxyrinchus*	Migratory	Unlikely to occur
Whale shark	*Rhincodon typus*	Vulnerable/ Migratory	Unlikely to occur
White shark	*Carcharodon carcharias*	Vulnerable/ Migratory	Unlikely to occur
Birds			
Asian Dowitcher	*Limnodromus semipalmatas*	Marine/ Migratory	Unlikely to occur
Australian painted snipe	*Rostratula australis*	Endangered/ Marine	Unlikely to occur
Barn Swallow	*Hirundo rustica*	Migratory	May potentially occur
Bar-tailed Godwit (baueri)	*Limosa lapponica baueri*	Vulnerable/ Migratory	May occur
Bar-tailed Godwit (menzbieri)	*Limosa lapponica menzbieri*	Critically Endangered/ Migratory	Yes
Bridled Tern	*Onychoprion anaethetus*	Migratory	Unlikely to occur
Bridled Tern	*Sterna anaethetus*	Migratory	May occur
Broad-billed Sandpiper	*Limicola falcinellus*	Migratory	Yes
Campbell Albatross	*Thalassarche impavida*	Vulnerable/ Migratory	Unlikely to occur
Caspian Tern	*Hydroprogne caspia*	Migratory	Yes
Caspian Tern	*Sterna caspia*	Migratory	Likely to occur
Common Greenshank	*Tringa nebularia*	Migratory	Yes
Common Noddy	*Anous stolidus*	Migratory	Unlikely to occur
Common Sandpiper	*Actitis hypoleucos*	Migratory	Yes
Common Tern	*Sterna hirundo*	Migratory	Yes
Crested Tern	*Thalasseus bergii*	Migratory	Yes
Curlew Sandpiper	*Calidris ferruginea*	Critically Endangered/ Migratory	Yes
Eastern Curlew	*Numenius madagascariensis*	Critically Endangered/ Migratory	Yes
Eastern Osprey	*Pandion cristatus*	Migratory	Yes
Eastern Yellow Wagtail	*Motacilla tschutschenis*	Migratory	Would not occur
Fairy Tern	*Sternula nereis*	Migratory	Likely to occur
Flesh-footed shearwater	*Puffinus carneipes*	Migratory/ Marine	Unlikely to occur
Fork-tailed Swift	*Apus pacificus*	Migratory	Yes
Great Knot	*Calidris tenuirostris*	Critically Endangered/ Migratory	Yes
Greater Sand Plover	*Charadrius leschenaultia*	Vulnerable/ Marine/ Migratory	Yes
Grey Plover	*Pluvialis squatarola*	Migratory	Yes
Grey-tailed Tattler	*Tringa brevipes*	Migratory	Yes
Grey Wagtail	*Motacilla cinerea*	Migratory	Would not occur
Gull-billed Tern	*Gelochelidon nilotica*	Migratory	Yes
Indian Yellow-nosed Albatross	*Thalassarche carteri*	Vulnerable/ Marine Migratory	Unlikely to occur
Lesser Frigatebird	*Fregata ariel*	Migratory	Unlikely to occur
Lesser Sand Plover	*Charadrius mongolus*	Endangered/ Marine/ Migratory	Yes
Little Tern	*Sternula albifrons*	Migratory	Yes

Common Name	Species Name	Conservation Status	Recorded within Proposal Surveys
Night Parrot	*Pezoporus occidentalis*	Critically Endangered	May occur
Oriental Plover	*Charadrius veredus*	Migratory	Likely to occur
Oriental Pratincole	*Glareola maldivarum*	Migratory	Unlikely to occur
Osprey	*Pandion haliaetus*	Migratory	Unlikely to occur
Pacific Golden Plover	*Pluvialis fulva*	Migratory	Yes
Pectoral Sandpiper	*Calidris melanotos*	Migratory	May occur
Pomarine Jaeger	*Stercorarius pomarinus*	Migratory	May potentially occur
Red Knot	*Calidris canutus*	Endangered/ Migratory	Yes
Red-necked Stint	*Calidris ruficollis*	Migratory	Yes
Roseate Tern	*Sterna dougallii*	Migratory	Likely to occur
Ruddy Turnstone	*Arenaria interpres*	Migratory	Yes
Sanderling	*Calidris alba*	Migratory	Yes
Sharp-tailed Sandpiper	*Calidris acuminata*	Migratory	Yes
Southern Giant-Petrel	*Macronectes giganteus*	Endangered/ Migratory	Unlikely to occur
Streaked Shearwater	*Calonectris leucomelas*	Migratory	Unlikely to occur
Terek Sandpiper	*Xenus cinereus*	Migratory	Yes
Wedge-tailed Shearwater	*Ardenna pacifica*	Migratory	Unlikely to occur
Wedge-tailed Shearwater	*Puffinus pacificus*	Migratory	Unlikely to occur
Whimbrel	*Numenius phaeopus*	Migratory	Yes
White-tailed Tropic Bird	*Phaethon lepturus*	Marine Migratory	Unlikely to occur
White-winged Black Tern	*Chlidonias leucopterus*	Migratory	Yes
Wilson's Storm-Petrel	*Oceanites oceanicus*	Marine; Migratory	Unlikely to occur

18.2 COMMONWEALTH POLICY AND GUIDANCE

- A Directory of Important Wetlands in Australia (ANCA, 1993).
- *National Recovery Plan for Olearia macdonnellensis, Minuria tridens (Minnie Daisy) and Actinotus schwarzii (Desert Flannel Flower)* (DNREAS, 2008)
- *Approved Conservation Advice for Megaptera novaeangliae (humpback whale)* (TSSC, 2015b)
- *Approved Commonwealth Conservation Advice on Pristis 458eschen (Dwarf sawfish)* (TSSC, 2009a)
- *Approved Conservation Advice for Pristis zijsron (Green Sawfish*) (TSSC, 2008).
- *Marine Bioregional Plan for the North-West Marine Region* (DSEWPaC, 2012).
- *Sawfish and River Sharks Multispecies Recovery Plan* (DotE, 2015a)
- *Threat Abatement Plan for the Impacts of Marine Debris on Vertebrate Marine Life* (DEWHA, 2009b)
- *Significant impact guidelines for 36 migratory shorebird species (EPBC Act Policy Statement 3.21)* (DEWHA, 2009a).
- *Recovery Plan for Marine Turtles in Australia* (Commonwealth of Australia, 2017b).
- *Australian Ballast Water Management Requirements* (DAWR, 2017).
- *Significant impact guidelines for 36 migratory shorebird species (EPBC Act Policy Statement 3.21)* (DEWHA, 2009a).
- *Survey Guidelines for Australia's Threatened Bats* (DEWHA, 2010).
- *Survey Guidelines for Australia's Threatened Birds* (DSEWPaC, 2011b).
- *Survey Guidelines for Australia's Threatened Mammals* (DSEWPaC, 2011c).
- *Survey Guidelines for Australia's Threatened Reptiles* (DSEWPaC, 2011d).
- *Industry guidelines for avoiding, assessing and mitigating impacts on EPBC Act listed migratory shorebird species* (DotEE, 2017a).
- *National Recovery Plan for the Northern Quoll Dasyurus hallucatus* (Hill & Ward, 2010).

- *Approved Conservation Advice for Calidris ferruginea (Curlew Sandpiper)* (TSSC, 2016a).
- *Approved Conservation Advice for Limosa lapponica baueri (Bar-tailed godwit (western Alaskan))* (TSSC, 2016e).
- *Approved Conservation Advice* for *Limosa lapponica menzbieri (Bar-tailed godwit (northern Siberian))* (TSSC, 2016f).
- *Approved Conservation Advice for Numenius madagascariensis (Eastern Curlew)* (TSSC, 2015c).
- *Commonwealth Conservation Advice on Sternula nereis (Fairy Tern)* (TSSC, 2011a).
- *Approved Conservation Advice for Calidris tenuirostris (Great knot)* (TSSC, 2016b).
- *Approved Conservation Advice for Calidris canutus (Red knot)* (TSSC, 2016a).
- *Approved Conservation Advice for Charadrius leschenaultia (Greater sand plover)* (TSSC, 2016c).
- *Approved Conservation Advice for Charadrius mongolus (Lesser sand plover)*. (TSSC, 2016d).
- *Threat Abatement Plan for Predation by the European Red Fox* (DEWHA, 2008c).
- *Threat abatement plan for predation by feral cats* (DotE, 2015b).
- *Wildlife Conservation Plan for Migratory Shorebirds* (DotE, 2015c).
- *Threat abatement plan for the biological effects, including lethal toxic ingestion, caused by cane toads* (DSEWPaC, 2011e).

18.3 MNES IMPACT ASSESSMENT

The potential Proposal impact on MNES is outlined in Table 120. A summary of surveys undertaken and a detailed description of survey findings relevant to each of the MNES species and their respective habitats is provided in Section 9 (Marine Fauna MNES), Section 10 (Flora MNES – *Minuria tridens*) and Section 11 (Terrestrial Fauna MNES). A summary of the findings is provided below in Table 120.
Table 120.

Table 120: Potential Impact on Matters of National Environmental Significance

MNES	Proposal
World Heritage Properties	The closest World Heritage Area to the proposal is the Ningaloo Coast. The Proposal is separated from the Muiron Islands Marine Management Area component of the World Heritage Area by approximately 40 km across the Exmouth Gulf marine waters. The Proposal is separated from the Ningaloo Marine Park (Commonwealth waters) component of the World Heritage Area by approximately 90 km across the Exmouth Gulf marine waters and the Exmouth land peninsular. It is considered unlikely the Proposal will have any impact on the Ningaloo Coast World Heritage Area given: • The significant distance between the Proposal and the various components of the World Heritage Area. • Localised impacts on marine environmental quality and benthic habitat as described in Sections 7.5 and 8.6. • Mitigation measures proposed for protection of the marine environment as outlined in Sections 7.7 and 8.8.
National Heritage Places	The closest National Heritage Place to the variation proposal is the Ningaloo Coast, approximately 40 km northwest. As outlined above under World Heritage Properties, it is unlikely the variation proposal will have any impact on the Ningaloo Coast.
Ramsar Wetlands	The nearest Wetland of International Importance is the Ramsar Wetland Eighty Mile Beach, approximately 546 km northeast of the Proposal. Given the large distance between the Proposal and Eighty Mile Beach, the variation proposal will have no impact on any Wetland of International Importance.
Listed Threatened Species and Ecological Communities	• Flora and Vegetation surveys conducted for the proposal indicate (Biota, 2022a; 2022b) (Section 10.3): ○ No Threatened Ecological Communities are present ○ The Threatened Flora Species *Minuria tridens* (Vulnerable) was potentially present, however it has not been identified to species level. The location of the single record of

<table>
<tr><th>MNES</th><th>Proposal</th></tr>
<tr><td></td><td>Minuria tridens was re-visited and the surrounding area searched during the recent targeted survey, however no individuals were located (Biota, 2022e).
• Terrestrial Fauna surveys conducted for the Proposal (Biota, 2022b) (Biota, 2022c) (Section 11.3) recorded the following threatened vertebrate fauna species in the vicinity of the Proposal:
1. Liasis olivaceus barroni, Pilbara Olive Python (Vulnerable)
2. Dasyurus hallucatus, Northern Quoll (Endangered)
3. Sternula nereis, Fairy Tern (Vulnerable)
4. Charadrius mongolus, Lesser Sand Plover (Endangered/Migratory)
5. Charadrius leschenaultia, Greater Sand Plover (Vulnerable/Migratory)
6. Limosa lapponica menzbieri, Bar-tailed Godwit (Critically Endangered/Migratory)
7. Numenius madagascariensis, Eastern Curlew (Critically Endangered/Migratory)
8. Calidris tenuirostris, Great Knot (Critically Endangered/Migratory)
9. Calidris canutus, Red Knot (Endangered/Migratory)
10. Calidris ferruginea, Curlew Sandpiper (Critically Endangered/Migratory)
• Marine Fauna surveys conducted for the Proposal (AECOM, 2022b) (Morgan et. Al. 2020) (Section 9.4) indicate the following threatened marine fauna species are likely to occur or have been recorded in the vicinity of the Proposal:
1. Pristis zijsron, Green sawfish (Vulnerable, Marine Migratory)
2. Megaptera novaeangliae, Humpback whale (Vulnerable, Marine Migratory)
3. Sousa sahulensis, Australian humpback dolphin (Marine Migratory)
4. Dugong dugon, Dugong (Marine Migratory)
5. Eretmochelys imbricata, Hawksbill turtle (Vulnerable, Marine Migratory)
6. Natator depressus, Flatback turtle (Vulnerable, Marine Migratory)
7. Chelonia mydas, Green turtle (Vulnerable, Marine Migratory)
8. Caretta, Loggerhead turtle (Endangered, Marine Migratory)

Impacts to the threatened species above are discussed in the following ERD Sections:
• Minuria tridens – Section 10.5.
• Terrestrial fauna (including birds) – Section 11.5.
• Marine fauna – Section 9.

Impacts are considered localised and proportionally small as outlined in Table 122 below for many species, and significant for others. Table 107provides an assessment against the EPBC Act MNES Significant Impact Criteria (Australian Government, 2013). With successful implementation of management measures and offsets discussed in Sections 9.7, 10.7 and 11.7, the residual impacts to Listed Threatened Species from the proposal should be minor.</td></tr>
<tr><td>Listed Migratory Species</td><td>• Terrestrial Fauna and shorebird surveys conducted for the Proposal indicate (Biota, 2022b) (Biota, 2022c) (Section 11.3) the following migratory shorebirds species are likely to occur or have been recorded in the vicinity of the Proposal:
1. Charadrius mongolus, Lesser Sand Plover (Endangered/Migratory)
2. Charadrius leschenaultia, Greater Sand Plover (Vulnerable/Migratory)
3. Limosa lapponica menzbieri, Bar-tailed Godwit (Critically Endangered/Migratory)
4. Numenius madagascariensis, Eastern Curlew (Critically Endangered/Migratory)
5. Calidris tenuirostris, Great Knot (Critically Endangered/Migratory)
6. Calidris canutus, Red Knot (Endangered/Migratory)
7. Calidris ferruginea, Curlew Sandpiper (Critically Endangered/Migratory)
8. Apus pacificus, Fork-tailed Swift (Migratory)
9. Pandion cristatus, Eastern Osprey (Migratory)
10. Pluvialis fulva, Pacific Golden Plover (Migratory)
11. Pluvialis squatarola, Grey Plover (Migratory)
12. Numenius phaeopus, Whimbrel (Migratory)
13. Xenus cinereus, Terek Sandpiper (Migratory)
14. Actitis hypoleucos, Common Sandpiper (Migratory)</td></tr>
</table>

MNES	Proposal
	15. *Tringa brevipes*, Grey-tailed Tattler (Migratory) 16. *Tringa nebularia*, Common Greenshank (Migratory) 17. *Arenaria interpres*, Ruddy Turnstone (Migratory) 18. *Calidris alba*, Sanderling (Migratory) 19. *Calidris ruficollis*, Red-necked Stint (Migratory) 20. *Calidris acuminata*, Sharp-tailed Sandpiper (Migratory) 21. *Limicola falcinellus*, Broad-billed Sandpiper (Migratory) 22. *Stercorarius pomarinus*, Pomarine Jaeger (Migratory) 23. *Sternula albifrons*, Little Tern (Migratory) 24. *Gelochelidon nilotica*, Gull-billed Tern (Migratory) 25. *Hydroprogne caspia*, Caspian Tern (Migratory) 26. *Chlidonias leucopterus*, White-winged Black Tern (Migratory) 27. *Sterna dougallii*, Roseate Tern (Migratory) 28. *Sterna hirundo*, Common Tern (Migratory) 29. *Thalasseus bergii*, Crested Tern (Migratory) 30. *Hirundo rustica*, Barn Swallow (Migratory) • Marine Fauna surveys conducted for the Proposal indicate (AECOM, 2022b) (Morgan et. Al. 2020) (Section 9.4) indicate the following migratory marine fauna species are likely to occur or have been recorded in the vicinity of the Proposal: 1. *Pristis zijsron,* Green sawfish (Vulnerable, Marine Migratory) 2. *Megaptera novaeangliae*, Humpback whale (Vulnerable, Marine Migratory) 3. *Sousa sahulensis*, Australian humpback dolphin (Marine Migratory) 4. *Dugong dugon*, Dugong (Marine Migratory) 5. *Eretmochelys imbricata*, Hawksbill turtle (Vulnerable, Marine Migratory) 6. *Natator depressus*, Flatback turtle (Vulnerable, Marine Migratory) 7. *Chelonia mydas*, Green turtle (Vulnerable, Marine Migratory) 8. *Caretta*, Loggerhead turtle (Endangered, Marine Migratory) Impacts to the migratory species above are discussed in the following ERD Sections: • Migratory birds – Section 11.5. • Marine fauna – Section 9. Impacts are considered localised and proportionally small as outlined in Table 122 below for many species, and significant for others. Table 107provides an assessment against the EPBC Act MNES Significant Impact Criteria (Australian Government, 2013). With successful implementation of management measures and offsets discussed in Sections 9.7, 10.7 and 11.7, the residual impacts to Listed Threatened Species from the proposal should be minor.
Commonwealth Marine Areas	The closest Commonwealth marine area is the Ningaloo Commonwealth Marine Reserve, approximately 90 km west-northwest of the Proposal on the other side of the Exmouth Gulf and Peninsular. Given the significant distance between the proposal and the Ningaloo Commonwealth Marine Reserve, and the large Ocean Gulf and Peninsula land mass separating the Ningaloo Commonwealth Marine Reserve from the proposal, it is unlikely the proposal will have any impact on the Ningaloo Commonwealth Marine Reserve.
Great Barrier Reef Marine Pk.	The Proposal is located in WA and does not include any impacts to Great Barrier Reef Marine Park in Queensland.
Nuclear Actions	The Proposal does not include any nuclear actions.
Coal Seam Gas & Large Coal Mining Dvt. (Water)	The Proposal does not include any Coal Seam Gas Development or Large Coal Mining Development.

18.4 HABITAT SUITABILITY FOR MNES

Eight terrestrial habitat types were recorded in the Biota (Biota 2022a; Appendix Q and Biota 2022e; Appendix R) Study Area:

- Creekline Woodland/Shrubland
- Sand Dune Woodland/Shrubland
- Sand Plain Acacia Shrubland/Grassland
- Saline Shrubland
- Dune Blowout/Mobile Dune
- Cleared Areas
- Freshwater Claypan
- *Tecticomia* Community (Samphire)

These are described in detail in Section 10 and shown on Figure 111.

Four broad supratidal BCH habitat types were recorded across the Study Area surveyed by Biota (Biota, 2022a; Appendix Q) and AECOM (AECOM, 2022a; Appendix M):

- Bare Salt flat
- Dune
- Cleared Areas
- *Tecticomia* Community (Samphire)

Five broad intertidal BCH habitat types were recorded across the Study Area surveyed by AECOM (AECOM, 2022a; Appendix M):

- Algal Mat
- Mangroves
- Transitional Mudflat
- Sandy Beaches
- Tidal Creeks

Three broad sub-tidal BCH habitat types were recorded across the Study Area surveyed by AECOM (AECOM, 2022a; Appendix M):

- Soft Sediment (Potential Seagrass)
- Macroalgae
- Macroalgae and Sparse Coral Reef

Of the habitat types listed above, the following are considered to have elevated conservation significance:

- Mangroves, due to their importance in supporting roosting, loafing and foraging of Migratory and Threatened bird species. Mangroves are additionally known to support marine fauna including juvenile turtles. 2185 ha of this habitat type were mapped within the Study Area.
- Transitional Mudflats, due to their importance in supporting foraging of Migratory and Threatened bird species. 4020 ha of this habitat type were mapped within the Study Area.
- Sandy Beaches, due to their importance in supporting roosting of Migratory and Threatened bird species. Sandy Beaches also provide nesting habitat for marine turtles. 132.8 ha of this habitat type were mapped within the Study Area.
- Ashburton River Habitat, due to Northern Quoll and Pilbara Olive Python being considered locally dependent on permanent pools and shelter within the riparian zone.
- Sand/Clay Plains, due to their importance in supporting foraging of northern quoll. 7,952.9 ha of this habitat type were mapped within the Study Area.
- Soft Sediments (Potential Seagrass), due to their importance as secondary nurseries for sawfish. 4,674 ha of this habitat type were mapped within the Study Area. Seagrasses are additionally known to support marine fauna including turtles and dugong.
- Macroalgae and Sparse Coral, due to their role in contributing to primary production, nutrient recycling, and providing habitat and a food source for a myriad of marine species. 244 ha of this habitat type were mapped within the Study Area.

18.5 RELEVANT IMPACTS

Sections 6 to 16 of this ERD have assessed the potential impacts on MNES in detail. To avoid repetition, Table 121 summarises the findings of those assessments as applicable to MNES.

Table 121: Potential Impact on Matters of National Environmental Significance (MNES)

Potential Impacts	Assessment of Impacts	Relevant MNES
Direct Disturbance/ loss of habitat		
Disturbance of 0.53 ha of Ashburton River habitat and 67 ha of sand/clay plains habitat	**Nature and extent of impact:** 0.53 ha of Ashburton River habitat for bridge installation and 67 ha of sand/clay plains adjoining the Ashburton River for the main access road. **Unknown, unpredictable or irreversible impacts**: 0.53 ha of Ashburton River habitat is predicted to occur as a result of the Proposal. 67 ha of sand/clay plains adjoining the Ashburton River is predicted to occur as a result of the Proposal. No unknown impacts are predicted from this direct disturbance of habitat. **Significance of impacts**: A long-term decrease in the size of the local populations at the Ashburton River (or the regional Pilbara population) is unlikely given the proportion of suitable habitat to be disturbed is very low. The location of the proposed Proposal bridge is ~3 km north of the thick riparian vegetation, does not contain a large or dense riparian zone (only a few trees) and does not have permanent water pools. The bridge crossing will be prefabricated concrete modular design, allowing it to be craned into place, which will minimise onsite disturbance during installation. Vehicle movements along the main access road will be minimal and measures will be in place to prevent road kills particularly on the main access road and in the vicinity of Ashburton River. Ashburton River will provide a corridor for movement along riparian habitat with the bridge designed to allow fauna to pass underneath. **Additional technical data:** • Section 2.3.9.7 provides further detail regarding the main access road within the Study Area • Section 2.3.12.3 provides further detail regarding the Ashburton River crossing within the Study Area • Section 11.4.1.4 provides further detail regarding important habitat used by these species • Section 11 provides further detail regarding the calculation of impacts to Terrestrial Fauna Habitat	Northern Quoll Pilbara Olive Python
Disturbance of 17.81 ha of transitional mudflats habitat	**Nature and extent of impact:** 17.78 ha of transitional mudflats for clearing and impoundment. **Unknown, unpredictable or irreversible impacts**: 17.78 ha of transitional mudflats habitat is predicted to occur as a result of the Proposal. No unknown impacts are predicted from this direct disturbance of habitat. **Significance of impacts**: Due to the limited physical footprint of Proposal infrastructure and locating the Proposal predominantly on the supratidal salt flats, direct disturbance of transitional mudflat habitat is localised and proportionally small on a local and regional basis. A long-term decrease in the size of the local or the regional Pilbara shorebird population is unlikely given the proportion of habitat to be disturbed is very low. **Additional technical data:** • Section 8.5.4.3 provides detail regarding the transitional mudflat BCH identified within the Study Area	Lesser Sand Plover Greater Sand Plover Bar-tailed Godwit Eastern Curlew Great Knot Red Knot Curlew Sandpiper Other migratory birds Fairy Tern

Potential Impacts	Assessment of Impacts	Relevant MNES
	• Section 8.7 provides further detail regarding the assessment of significance of the potential impacts • Section 11.4.1.3.2 provides further detail regarding the importance of transitional mudflats to migratory shorebird species • Section 8 and Appendix M) provides further technical information regarding the transitional mudflat BCH within the Study Area • Section 8 and Appendix M provides further detail regarding the calculation of impacts to transitional mudflat BCH	
Disturbance of 0.99 ha of sandy beaches habitat	**Nature and extent of impact:** 0.99 ha of sandy beaches cleared for conveyor. **Unknown, unpredictable or irreversible impacts**: Temporary disturbance of areas due to construction are limited, however construction of the conveyor embankment connecting to the jetty could expose areas of the coastal dune barrier to wind erosion. Appropriate protection measures including dune revegetation will be used to rehabilitate and protect these areas from wind erosion. **Significance of impacts**: Due to the limited physical footprint of Proposal infrastructure and locating the Proposal predominantly on the supratidal salt flats, direct disturbance of sandy beach habitat is localised and proportionally small on a local and regional basis. Sediment transfer along the coast and increased breaching risk of the coastal barrier due to SLR is expected to remain largely unaltered due to the Proposal, given these processes will be occurring along the coastline some distance from the Proposal. The beach from Urala Creek North to Ashburton River is low quality nesting habitat. Turtles nest at low density in sandy beaches locally, with higher density nesting on local islands. **Additional technical data:** • Section 8.5.4.5 provides detail regarding the sandy beaches identified within the Study Area • Section 8.7 provides further detail regarding the assessment of significance of the potential impacts • Section 9.4 provides further detail regarding the importance of sandy beaches to marine fauna • Section 11.4.1.3.2 provides further detail regarding the importance of sandy beaches to migratory shorebird species • Biota (2022c; Appendix O) provides further technical information regarding sandy beaches within the Study Area • Section 8 provides further detail regarding the calculation of impacts to sandy beaches • AECOM (2022a; Appendix M) provides a detailed assessment of habitat loss for highly mobile migratory marine fauna	Lesser Sand Plover Greater Sand Plover Bar-tailed Godwit Eastern Curlew Great Knot Red Knot Curlew Sandpiper Other migratory birds Fairy Tern Threatened Turtle Species
Disturbance of 219.3 ha of soft sediment/potential seagrass habitat	**Nature and extent of impact:** 219.3 ha of soft sediment/potential seagrass for dredging, jetty installation and bitterns discharge outfall. **Unknown, unpredictable or irreversible impacts**: Sedimentation may occur during tropical storms when the bottom shear stress will be enhanced by storm waves. This will likely drive resuspension/transportation/deposition of seabed materials and periodic morphology variations. The shoreline morphological impacts from the proposed jetty and berth facilities are expected to be minimal because the jetty is open to incoming waves and the piles do not obstruct the wave propagation towards the shore. **Significance of impacts**: All efforts have been made during the Proposal design and engineering stages to avoid soft sediment/potential seagrass disturbance with modifications made including:	Green sawfish Threatened Turtle Species

Potential Impacts	Assessment of Impacts	Relevant MNES
	• Extending the jetty length to reach sufficient water depth to minimise the depth and volume of dredging required to allow safe under keel clearance for transhipment barges. • Construction of a purpose-built, shallow draft transhipper specifically for the Proposal to further minimise the area, volume and depth of dredging required. • Placing all dredged material onshore, to be used as construction material for the onshore infrastructure, thus avoiding direct impacts to BCH from disposal of dredge material at sea or from land reclamation. Impact to soft sediment nearshore areas which are important habitat for marine fauna is proportionally low. **Additional technical data:** • Section 8.5.5.3.1 provides detail regarding the soft sediment (potential seagrass) habitat identified within the Study Area • Section 8.7 provides further detail regarding the assessment of significance of the potential impacts • Section 9.4 provides further detail regarding the importance of soft sediment (potential seagrass) habitat to marine fauna • AECOM (2022a; Appendix M) provides further technical information regarding soft sediment (potential seagrass) habitat within the Study Area • Biota (2022a; Appendix Q) provides further detail regarding the calculation of impacts to soft sediment (potential seagrass) habitat • AECOM (2022b; Appendix N) provides a detailed assessment of habitat loss for highly mobile migratory marine fauna	
Disturbance of 4.28 ha of mangrove BCH	**Nature and extent of impact:** 4.28 ha to allow for the development of the seawater intake channel, pump station, concentration ponds, jetty installation and bitterns discharge outfall. **Unknown, unpredictable or irreversible impacts**: Irreversible loss of 4.28 ha of mangroves. No unknown impacts are predicted from this direct disturbance of habitat. The growth of new mangrove communities on built structures (i.e., pond walls or underneath the jetty structure) is difficult to predict. **Significance of impacts**: AECOM (2022a; Appendix M) determined that the mangroves identified during the field surveys to be cleared were comprised of structural variants of monospecific Avicennia marina which are widely represented in Exmouth Gulf and the Onslow coastline. All efforts have been made during the Proposal design and engineering stages to avoid mangrove disturbance with alignment of the western boundary of concentration ponds moved further east to provide greater areas of setback or buffer areas to accommodate potential indirect impacts to mangroves from edge effects such as localised seepage, and appropriate culverts / drainage diversions designed to maintain existing tidal and surface waterflows. The MCP will be to breach selected embankments that will enable inwards tidal movement bringing sediments and allowing tidal channels to expand naturally. Natural tidal flows will allow movement of mangrove plant and seed material which will passively revegetate the reconnected tidal areas. This will enhance the habitat values of the ponds post closure (section 6.7). **Additional technical data:** • Section 8.5.4.2 provides detail regarding the mangrove community identified within the Study Area • Section 8.7 provides further detail regarding the assessment of significance of the potential impacts	Threatened Turtle Species

Potential Impacts	Assessment of Impacts	Relevant MNES
	• Section 9.4 provides further detail regarding the importance of soft mangrove communities to marine fauna • AECOM (2022a; Appendix M) provides further technical information regarding mangrove communities within the Study Area • Biota (2022a; Appendix Q) provides further detail regarding the calculation of impacts to mangrove communities • AECOM (2022b; Appendix N) provides a detailed assessment of habitat loss for highly mobile migratory marine fauna	
Disturbance of 4.76 ha of macroalgae and 2.3 ha of macroalgae/ sparse coral habitat	**Nature and extent of impact:** 4.76 ha of macroalgae and 2.3 ha of macroalgae/ sparse coral habitat for dredging, jetty installation and bitterns discharge outfall. **Unknown, unpredictable or irreversible impacts**: Irreversible loss of 4.76 ha of macroalgal habitat and 2.3 ha of macroalgae/ sparse coral habitat. **Significance of impacts**: All efforts have been made during the Proposal design and engineering stages to avoid macroalgae/ sparse coral disturbance with modifications made including: • Extending the jetty length to reach sufficient water depth to minimise the depth and volume of dredging required to allow safe under keel clearance for transhipment barges. • Construction of a purpose-built, shallow draft transhipper specifically for the Proposal to further minimise the area, volume and depth of dredging required. • Placing all dredged material onshore, to be used as construction material for the onshore infrastructure, thus avoiding direct impacts to BCH from disposal of dredge material at sea or from land reclamation. Given the very low proportion of macroalgal and coral habitat within the Nearshore LAU that is predicted to be affected, it is considered that there is no credible risk of impacts from dredging and tailwater discharge leading to significant regional impacts to these communities. **Additional technical data:** • Section 8.5.5 provides detail regarding the macroalgae and sparse coral community identified within the Study Area • Section 8.6 and 8.7 provides further detail regarding the assessment of significance of the potential impacts • AECOM (2022a; Appendix M) provides further technical information regarding macroalgae/sparse coral communities within the Study Area • AECOM (2022a; Appendix M) and Water Technology (2022a; Appendix B) provides further detail regarding the calculation of impacts to macroalgae/ sparse coral • AECOM (2022a; Appendix M) provides a detailed assessment of habitat loss for highly mobile migratory marine fauna	Threatened Turtle Species Lesser Sand Plover Greater Sand Plover Eastern Curlew Great Knot Red Knot Curlew Sandpiper Other migratory birds
Indirect Impacts		
Light spill	**Nature and extent of impact:** Light spill modelling was undertaken to predict Proposal related light change at seven locations: 1) Locker Island (2019 and 2022); 2) LM3 located 1 km north of Locker Point (2019 and 2022); 3) Mainland East (2022); 4) Ashburton Island (2022); 5) Bessieres Island (2022); 6) Serrurier Island (2022); and 7) Thevenard Island (2022). Modelling considered two scenarios: 1) Worst case - the jetty and conveyor lights always switched on; and 2) Best case - the jetty and conveyor lights switched off when not in use. The potential light spill impacts on marine fauna are summarised below (Pendoley Environmental, 2020), (Pendoley Environmental, 2023), (AECOM, 2022b):	Green sawfish Threatened Turtle Species

Potential Impacts	Assessment of Impacts	Relevant MNES
	• The brightest source of light on the horizon was the Wheatstone LNG Facility which appears as bright skyglow at all sites as well as a direct source from nearby Ashburton Island. Similarly, light from the Macedon LNG Facility is also visible from all monitoring sites, although it is substantially darker than the Wheatstone LNG Facility and, at some sites, both sources have an overlapping bearing. • The visibility of other sources of light at each site was dependent on the bearing of the light source and whether the source was shielded from nearby dunes or other localised topographic features. For example, artificial light from Exmouth was only visible from Locker Island and shielded elsewhere, and the Tubridgi Gas Facility was visible from all sites except Locker Island, Mainland West, and Thevenard Island. • At Ashburton Island, light emissions from the TSV and OGV at the transhipment area are visible in the model output but would be naturally shielded by the island topography meaning it is unlikely to be visible from the nesting habitat on the south and southwest sides of the island. The project jetty and infrastructure are barely visible within the modelled output and are not discernible as separate light sources in the benchmark + modelled output. • At Bessieres, light emissions from the TSV and OGV at the transhipment area are visible in the model output and are clearly visible offshore as a separate source of light in a NNE direction from the island in the benchmark + modelled output. The project jetty and infrastructure are barely visible within the modelled output and are not discernible as a separate light source in the benchmark + modelled output. • At Locker, light emissions from the TSV and OGV at the transhipment area are visible in the model output but would be naturally shielded by the island topography meaning it is unlikely to be visible from the nesting habitat on the south side of the island. The project jetty and infrastructure are visible within the modelled output and are visible as a separate source of light on the mainland in a southerly direction from the island in the benchmark + modelled output. • At Serrurier, light emissions from the TSV and OGV at the transhipment area are visible in the model output but would be naturally shielded by the island topography meaning it is unlikely to be visible from the nesting habitat on the south side of the island. The project jetty and infrastructure are barely visible in a southerly direction from the island within the modelled and the benchmark + modelled output. • At Thevenard, only light emissions from the TSV and OGV at the transhipment area are visible in the model output, with the project jetty and infrastructure not discernible as a separate source of light. The light emissions from the TSV and OGV are visible offshore in a southwest direction from the island within the benchmark + modelled output. • At the Mainland East site situated to the east of the project jetty, light emissions from the TSV and OGV at the transhipment area are barely visible in a northerly direction from the site within the modelled and the benchmark + modelled outputs. The project jetty and infrastructure are visible within the modelled output and are not discernible as a separate light source in the benchmark + modelled output due to shielding from a dune and localised topography. • At the Mainland West site situated to the west of the project jetty, light emissions from the TSV and OGV at the transhipment area appear similar to the Mainland East site and are barely visible in a northerly direction from the site within the modelled and the benchmark + modelled outputs. The project jetty is clearly visible within the modelled output and appears as a separate light source in northeast direction from the site in the benchmark + modelled output. The project infrastructure is also visible within the modelled output but is not discernible as a separate light source in the	

Potential Impacts	Assessment of Impacts	Relevant MNES
	benchmark + modelled output due to shielding from a dune and localised topography. • With the inclusion of the modelled project lighting, the largest increase to benchmark light levels for both WOS and horizon areas are predicted to occur at the Mainland West site which is situated close to the jetty (+216 % WOS and +514 % horizon), and the smallest increase at Ashburton Island (+8 % WOS and +6 % horizon). The second largest change is predicted for Bessieres Island with a +14 % increase in WOS brightness and +15 % increase in horizon brightness. The other monitored sites, including the Mainland East site, all experienced an +11 % increase in WOS brightness, and varying increases in horizon brightness (+9 to +11 %) due to shielding from nearby dunes and localised topographic features, and existing visible light sources on an overlapping bearing with the project location. • Under Scenario 2 when lights from the jetty are switched off, the predicted change in light emissions visible from the Mainland West site shows a +11 % increase for both WOS and horizon areas on benchmark levels which was a substantially lower increase than under Scenario 1 (+216 % WOS and +514 % horizon increase). All other sites showed no change in brightness between scenarios on benchmark levels. No irreversible impacts are predicted from this indirect impact. **Significance of impacts**: • Turtles – (from Pendoley, 2023) The updated modelling demonstrated that under a 'worst' case scenario with all jetty lighting switched on, light emissions from the Proposal could increase the existing WOS and horizon brightness by up to 216% and 514% respectively at the monitoring site situated closest to the project jetty (Mainland West). At this site, while the localised topography provides some natural shielding in the direction of the Proposal, the jetty extends beyond this shielding allowing both direct light and sky glow to be visible. However, under a 'best' case scenario with all jetty lighting switched off, the change in WOS and horizon brightness at the same site is predicted to be an increase of 11% indicating the importance of this lighting control. Note that the marine turtle surveys undertaken by AECOM in 2018 and 2019 recorded only one adult female turtle track to the west of the jetty indicating that this area is not likely to be significant for marine turtle nesting (AECOM 2021). At the other mainland monitoring site (Mainland East), despite being relatively close to the jetty (~4 km), the localised dune and beach headland/topography shielded the visibility of the modelled light resulting in a substantially smaller increase of 11% WOS brightness and 9% horizon brightness compared to the Mainland West site. At the monitoring sites on the offshore islands, there were detected increases in brightness from benchmark light levels with the inclusion of the modelled outputs, ranging from 8 - 14% for the WOS area and 6 - 15 % for the horizon area. The range in percentage change between the sites is likely due to a combination of factors, including the proximity of the monitoring site to the modelled light source itself, the occurrence of shielding of the modelled light from existing dunes or localised topography, or the overlapping of the modelled light source with an existing source. The predicted light emissions from the TSV and OGV vessels at the transhipment area were notably visible in the modelled outputs at the monitoring sites on Thevenard and Bessieres islands only and shielded or barely visible at all other sites. When the vessels are operating in this area, it is likely that they will be a new source of offshore light on the horizon and will appear at different bearings depending on the perspective at these two nearby islands. This means that the risk of impact from the light source on a marine turtle will change spatially across the habitat depending on where an adult turtle nests or a hatchling emerges. The risk of impact may also be counteracted by the visibility and bearing of other sources of existing	

Potential Impacts	Assessment of Impacts	Relevant MNES
	light, notably the Wheatstone LNG Facility which appears notably brighter at Thevenard Island compared to the modelled vessels. • Elasmobranchs – The distance of the jetty from Urala Creek North (8 km) and Urala Creek South (19 km) will likely preclude significant light impacts from this source within the creeks. Light spill may occur in Urala Creek South if lighting is associated with the seawater intake pumpstation. Additional light spill will be introduced along the shoreline between Urala Creek North and the Ashburton River mouth from jetty operations. The effects of light pollution on sawfish are unknown, with no previous work investigating effects of changes in lighting regimes on the movement and behaviour of wild sawfish. However, considering that sawfish are largely crepuscular or nocturnal, artificial light during night-time hours has the potential to alter both the movements of sawfish around lighted areas and the timing of movements and activity, as has been suggested for other elasmobranch species. Impacts to Elasmobranchs will be considered and minimised within the LMP. • Marine Mammals – Marine mammals are highly mobile and are not expected to occur in high densities in close proximity to the Proposal. Given the small increase in whole of sky and horizon brightness modelled at a relatively short distance from the Proposal compared with surrounding habitat for marine mammals (i.e. modelled results for Locker Island 8 km away) it is unlikely that marine mammals will be adversely affected by Proposal light spill. • Migratory Shorebirds – The migratory shorebirds near the Proposal are likely to occur within their prime foraging grounds around the intertidal mudflats and creeks during the day. However, there is the potential for attraction for shorebirds to utilise the Proposal concentration ponds. This may therefore increase the presence of shorebirds in the area and attraction to artificial light at night for foraging purposes. Impacts to shorebirds will be considered and minimised within the LMP **Additional technical data**: • Section 2.3.10 provides detail regarding lighting within the study area • Section 9.4.3 provides detail regarding marine turtles and their habitat identified within the Study Area • Section 9.5 provides further detail regarding the assessment of significance of the potential impacts. • AECOM (2022a and 2022b; Appendix M and Appendix N), Pendoley Environment (2023; Appendix DD) and Talis (2021; Appendix N) provide further technical information regarding light spill modelling and impacts to marine fauna • A LMP will be developed to reduce the volume of light spill that is emitted from the Proposal.	
Vessel / propeller strike	**Nature and extent of impact:** The Proposal includes the movement of vessels, including a dredge, support vessels and, potentially, a piling barge. The risk of vessel strike is predicted to be greater during the construction phase when greater numbers of vessels (particularly smaller vessels) will be in the area. **Unknown, unpredictable or irreversible impacts**: The number and severity of vessel strikes is unpredictable, however other port operations in the Pilbara provide some context (refer below). **Significance of impacts**: The consequence of vessel strike on marine mammals may result in injury or mortality; however, the likelihood of a vessel strike during dredging and construction from proposed vessel movements is considered low as the dredge, support vessels and, potentially, a piling barge will be stationary during most of the works, as well as generating noise and vibration which is likely to discourage any species that may be present from approaching. When moving these vessels will transit at low	Humpback Whale Threatened Turtle Species

Potential Impacts	Assessment of Impacts	Relevant MNES
	speeds and only over small distances during each move (typically tens of metres) minimising the risk to marine fauna. During operations, a transhipment vessel will traverse approximately 9 nm at a limited speed of 9 knots, between the jetty and the transhipment location on a daily basis. It is estimated (depending on salt product demand) there could be in the order of 30 to 70 ocean-going vessels proceeding to offshore anchor points per year and 400 to 600 transhipper movements per year between the jetty and transhipment anchor points. Elasmobranch (sharks, fish and rays) are not known to be naturally inquisitive and are therefore not expected to approach vessels whilst in operation. They are also sufficiently mobile that there would be negligible potential for physical impacts upon them during vessel movements. Vessel strike is unlikely to pose a major impact upon marine mammals (dugongs, whales and dolphins) due to most vessels moving at speeds less than 10 knots, at least 4 knots slower than the high-risk speed identified by Laist et. Al. (2001) of 14 knots at which marine mammals may not outswim the vessel. **Additional technical data**: • Section 9.4.3 provides detail regarding marine turtles and mammals and their habitat identified within the Study Area • Section 9.5 provides further detail regarding the assessment of significance of the potential impacts. • AECOM (2022a and 2022b; Appendix M and Appendix N), Pendoley Environment (2020; Appendix N) and Talis (2021; Appendix N) provide further technical information regarding vessel use within the study area and impacts to marine fauna • The risk of Vessel Strike will be mitigated through a MFMP (Appendix BB).	
Marine Noise	**Nature and extent of impact:** The Proposal will produce marine noise, predominantly during the construction phase during dredging and pile driving activities. The Proposal will result in low noise emissions during construction as most of the works will be conducted in narrow strips on soft mudflats (for the pond walls) and minimal night work will be undertaken sure to site terrain. The operation of the Proposal will result in low noise overall as it relies on solar evaporation for the majority of the process. Soft start procedures will be implemented for dredging and pile driving to move away from the noise source before hearing sensitivity loss thresholds are reached. **Unknown, unpredictable or irreversible impacts**: Underwater noise generating activities have the potential to result in behavioural responses and injury in the form of temporary or permanent threshold shift of some marine fauna species. Marine noise impacts are known and were able to be predicted. No irreversible impacts are predicted from this indirect impact. **Significance of impacts**: Underwater sound modelling was undertaken to determine the distance from activities that marine fauna may experience a temporary reduction in hearing sensitivity (TTS) or permanent reduction in hearing sensitivity (PTS). Modelling and impact assessment predicts the following for MNES marine fauna (Talis, 2021) (AECOM, 2022b). Elasmobranchs: • Dredging: Low tide TTS = 150 m, PTS = 90 m. High tide TTS = 360 m, PTS = 170 m. It is highly unlikely that elasmobranchs will be exposed to these thresholds within their creek and nearshore habitats given the dredging will occur approximately 700 m offshore. Dredging soft start procedures will allow elasmobranchs to move away from the noise source before such thresholds are reached. • Pile driving: Low tide TTS = 450 m, PTS = 250 m. High tide TTS = 1,200 m, PTS = 550 m. It is possible that elasmobranchs will be	Green sawfish Humpback Whale Threatened Turtle Species

Potential Impacts	Assessment of Impacts	Relevant MNES
	exposed to a reduction in hearing sensitivity within their nearshore habitats during piling which will occur from the shoreline and along the 700 m length of the jetty. Elasmobranchs within creek habitats are unlikely to be impacted. Piling soft start procedures will allow elasmobranchs to move away from the noise source before such thresholds are reached. Whales: • Dredging: Low tide TTS = 180 m, PTS <5 m. High tide TTS = 260 m, PTS <5 m. Given whales are unlikely to occur in the immediate vicinity of dredging activities (due to shallow water depths) it is highly unlikely they will be exposed to these thresholds. Behavioural responses may occur to lower noise levels that may be heard by whales such as increased alertness, modification of vocalisations, interruption or cessation of feeding or social interactions and alteration of movement or diving behaviour, however these will be transient. • Pile driving: Low tide TTS = 2.7 km, PTS = 500 m. High tide TTS = 5 km, PTS = 900 m. Exposure ranges to noise levels exceeding the TTS thresholds are predicted to extend over several kilometres and likely to cause behavioural reactions (avoidance) with some acoustic masking of vocalisations. The underwater noise mitigation measures proposed will each contribute to reducing the underwater noise levels; however, reduction cannot be precisely quantified. Therefore, to minimise impacts to whales piling operations will be undertaken outside key ecological windows for humpback whales (in particular the southern migration September to November). Turtles: • Dredging: Low tide TTS = 150 m, PTS = 90 m. High tide TTS = 360 m, PTS = 170 m. Due to the short duration of dredging activities and the implementation of appropriate mitigation measures, it is unlikely that dredging activities will have significant impact on marine turtles. There may be some observable behavioural responses (such as avoiding the area). Dredging will be undertaken outside of the mating and nesting season (October to January) and soft start procedures will allow turtles to move away from the noise source before such thresholds are reached. • Pile driving: Low tide TTS = 450 m, PTS = 250 m. High tide TTS = 1,200 m, PTS = 550 m. Behavioural responses (avoidance) may be caused to turtles within the local area. Pile driving will be undertaken outside of the mating and nesting season (October to January) and soft start procedures will allow turtles to move away from the noise source before such thresholds are reached. With appropriate mitigation measures in place, significant impacts to marine fauna (such as permanent hearing damage and alteration of key behaviour during ecological windows) are considered unlikely. **Additional technical data**: • Section 9.4.3 provides detail regarding marine turtles and mammals and their habitat identified within the Study Area • Section 9.5 provides further detail regarding the assessment of significance of the potential impacts. • AECOM (2022a and 2022b; Appendix M and Appendix N), Pendoley Environment (2020; Appendix N) and Talis (2021; Appendix N) provide further technical information regarding noise modelling and impacts to marine fauna • A MFMP (Appendix BB) will be implemented to provide mitigation measures for all underwater noise sources (piling and dredging).	
Entrapment in seawater intakes	**Nature and extent of impact:** The seawater intake is located within Urala Creek South. It will operate throughout the year with the peak flows to occur in summer months when evaporation is highest. It will include a screened rock armoured inlet well excavated into the creek bank. The downward facing intake pipes within the intake well will also be screened.	Green sawfish Threatened Turtle Species

Potential Impacts	Assessment of Impacts	Relevant MNES
	Entrainment occurs when fauna (including zooplankton, gametes, larval, post-larval, sub-adult and adult stages of certain species) are small enough to pass through intake screens. Depending upon the resilience of the fauna, varying degrees of mortality will occur. The intake pumps mean water velocity has been calculated to operate at 0.11 m/s (Vortex Australia, 2020), potentially reducing biota passing through the intakes. All solar salt operations have marine biota in the salt ponds from the adjacent marine environment (AECOM, 2022b). Entrapment refers to the trapping of fauna against intake screens due to water velocity. USEPA (2014) recommendations screen water velocity of less than 0.15 m/s, for protection of 96% of motile species (concluded from fish swim speeds). The intake pumps mean water velocity has been calculated to operate at 0.11 m/s indicating screen velocity less than 0.15 m/s should be readily achievable (Vortex Australia, 2020). **Unknown, unpredictable or irreversible impacts**: Entrapment impacts were able to be predicted given the proposed flow rate and known swim speed of marine turtle hatchlings No irreversible impacts are predicted from this indirect impact. **Significance of impacts**: Dugongs, dolphins, turtles and sawfish are the key marine fauna of concern in relation to entrapment. Based on available literature, the maximum swimming speed of dugongs (5.6 m/s) and suggests that dugongs (and dolphins which swim faster than dugongs) would be quite capable of swimming away. To avoid sawfish and juvenile turtles becoming entrapped the inlet well screen will act as an exclusion device with screen velocity such that they will be capable of swimming away. The screen size will have a sufficiently small grid size to prevent sawfish rostra becoming entangled or suck in grid openings (AECOM, 2022b). The seawater Intake will minimise velocity below recommended fish swim speeds (USEPA, 2014) to avoid entrapment (Section 9.7) On this basis considered unlikely the proposal will affect habitat critical to survival. **Additional technical data**: • Section 9.4.3 provides detail regarding marine turtles and mammals and their habitat identified within the Study Area • Section 9.5 provides further detail regarding the assessment of significance of the potential impacts. • AECOM (2022b; Appendix N), provides further technical information regarding entrapment in seawater intakes and impacts to marine fauna • A MFMP will be implemented (Appendix BB).	
Dredging and tailwater release	**Nature and extent of impact:** Impact to 4.39 ha of macroalgal habitat due to tailwater discharge (if in winter), with recovery potentially >5 years. Dredging and tailwater discharge will additionally generate plumes of turbid water containing elevated levels of suspended sediments which can impact marine fauna through light reduction, clogging of feeding and respiratory structures and the mobilisation of nutrients and/or contaminants. **Unknown, unpredictable or irreversible impacts**: If tailwater discharge occurs in winter, it is predicted that the ZoHI will impact macroalgae habitat around the base of the jetty. Any impact within the ZoMI is considered to be recoverable and does not represent an area of BCH 'loss'. While the predicted ZoI from dredging and tailwater discharge (if these were to occur in winter) does impinge upon the fringing macroalgal and coral communities and habitat around the base of the jetty, the suspended sediment levels within the ZoI are predicted to be below those which may lead to adverse effects (Water Technology, 2022b) (AECOM, 2022a). Analysis of sediment indicated no toxicants exceeded screening levels (AECOM, 2022b).	Green sawfish Threatened Turtle Species

Potential Impacts	Assessment of Impacts	Relevant MNES
	The dredging campaign is planned to be of short duration (less than one month), and turbid plumes are predicted to be no longer detectable within a week after activities are completed. **Significance of impacts**: As recovery could reasonably be expected to occur within five years of completion of dredging and tailwater discharge, it is considered that there is no credible risk of 'loss' of seagrass habitat (outside of the berthing pocket) due to these activities (Water Technology, 2022b) (AECOM, 2022a). Additionally, marine fauna identified often inhabit turbid environments and therefore unlikely to be significantly impacted. Any loss in foraging habitat (if present) will be limited to the dredging footprint (considered under Habitat Loss in Section 9.5.1.1) and large amounts of similar soft sediment (potential seagrass) habitat exist locally. **Additional technical data**: • Section 9.4.3 provides detail regarding marine turtles and mammals and their habitat identified within the Study Area • Sections 7.5 and 9.5 provides further detail regarding the assessment of significance of the potential impacts. • AECOM (2022a and 2022b; Appendix M and Appendix N), Water Technology (2022a; Appendix B) provides further technical information regarding dredging and tailwater release and impacts to marine fauna • All dredge spoil will be disposed of on land in accordance with the DSMP (Appendix BB) and tailwater will be monitored to meet required water quality criteria as listed in the ASSSMP prior to discharge to the marine environment (GHD, 2021b; Appendix BB).	
Bitterns Discharge	**Nature and extent of impact:** Impact to 217ha of soft sediment habitat (with the potential to support seagrass) within the worst case LEPA zone. **Unknown, unpredictable or irreversible impacts**: Modelling has been conducted to predict LEPA and MEPA mixing zones around the bitterns diffuser. The outer boundary of the MEPA indicates the area which will remain a High Ecological Protection Area (HEPA). Mixing zone contours were generated to determine the predicted size of the LEPA and MEPA zones for the yearly average, best case (June) and worst case (November) bitterns discharges. For the worst-case scenario, the predicted size of the LEPA zone was 3,000 m in width. The MEPA was predicted to be approximately 4,300 m in width to approximately 2,000 m from the end of the jetty. (Water Technology, 2022b). The LEPA, MEPA and mixing zone are not predicted to significantly impact the macroalgal and sparse coral communities at the base of the jetty, or offshore from Locker Point. Rather, they overlie soft sediment habitat which may or may not, at certain times of the year in some years, support ephemeral seagrass communities (Water Technology, 2022b). No known seagrass BCH will intersect with the LEPA. It is likely that soft sediment habitat with the LEPA worst case zone will be permanently impacted, and this area is unlikely to be conducive to the establishment of ephemeral seagrass communities. **Significance of impacts**: Whilst the soft sediment in the worst case MEPA may experience reduced water quality (relative to baseline/existing) this area is likely to be able to still support future seagrass habitat which might establish there in some years, given the worst case reduced water quality will only occur for a few months of the year (summer) and the worst case increase above background of between 2.2 and 1.6 PSU in salinity falls within the natural salinity variation of the area (Water Technology, 2022b). Therefore, the MEPA is not considered to be a credible area of BCH loss (AECOM, 2022a). AECOM (2022c) undertook a Marine Ecotoxicology Assessment which found once the metals within the bitterns plume are diluted such that they	Green sawfish Threatened Turtle Species

<table>
<tr><th>Potential Impacts</th><th>Assessment of Impacts</th><th>Relevant MNES</th></tr>
<tr><td></td><td>meet the nominated 99% or 95% species protection level at the boundary of the modelled MEPA (as predicted by Water Technology, 2022b), they present very low risk of ecotoxicity or bioaccumulation in the marine environment.
Additional technical data:
Section 2.3 provides detail regarding bitterns discharge within the study area
Section 7.5 and 7.6 provides detail regarding potential water quality impacts of bitterns discharge
Section 8.5 and 8.6 provides detail regarding potential impacts of bitterns discharge on BCH
Section 9.4.3 provides detail regarding marine turtles and mammals and their habitat identified within the Study Area
Section 9.5 and 9.6 provides detail regarding potential impacts of bitterns discharge on marine fauna
AECOM (2022a; Appendix M) and Water Technology (2021d and 2022a; Appendix J and Appendix B) provides further technical information regarding bitterns discharge and impacts to marine fauna
A MEQMMP will be implemented (Appendix BB)</td><td></td></tr>
<tr><td>Vehicle Strike</td><td>Nature and extent of impact:
The Proposal includes the movement of vehicles which may lead to direct mortality of fauna.
Only a small proportion of potential habitat will be disturbed.
Unknown, unpredictable or irreversible impacts:
The number and severity of vehicle strikes is unpredictable, however likely to be rare (refer below).
Significance of impacts:
Vehicle speed limits will be set and enforced
There will be minimal vehicle traffic between ponds, jetty and coastal corridors, therefore risk of vehicle strike on fauna will be relatively low.
Direct disturbance of significant fauna habitats such as mangroves, bare intertidal / transitional mudflats, sandy beaches and isolated mainland remnant “islands” have been minimised, with the majority of the disturbance (88.6%) occurring on unvegetated Supratidal salt flats, which provide minimal fauna habitat value.
The Ashburton River crossing will be designed to allow fauna to pass underneath, minimising the likelihood of fauna crossing the road.
Additional technical data:
Section 2.3.9.7 provides further detail regarding the main access road within the Study Area
Section 2.3.12.3 provides further detail regarding the Ashburton River crossing within the Study Area
Section 11.4 provides further detail regarding important habitat used by these species
Section 11.5 provides further detail regarding vessel and equipment strike on terrestrial fauna
Section 11 provides further detail regarding the calculation of impacts to Terrestrial Fauna Habitat</td><td>Northern Quoll
Pilbara Olive Python</td></tr>
<tr><td>Pests</td><td>Nature and extent of impact:
The Proposal will utilise vessels during construction and operation that will be brought to Ashburton marine waters from other ports within Australia and overseas. These vessels have the potential to transport IMPs which can potentially impact intertidal BCH through (AECOM, 2022xx):
Out-competition with native species for resources;
Predation on native species; and
Alteration of trophic interactions and food-webs.</td><td>Green sawfish
Threatened Turtle Species
Humpback Whale</td></tr>
</table>

Potential Impacts	Assessment of Impacts	Relevant MNES
	Unknown, unpredictable or irreversible impacts: *Didemnum perlucidum* is widespread in the Pilbara and is expected to colonise artificial structures constructed by the Proposal (AECOM, 2022b). **Significance of impacts**: The introduction of IMP's resulting from the Ashburton Salt Proposal is considered highly unlikely due to the relatively small number of vessels involved. The various vessels required as part of the construction and operation of the Proposal have two potential introduction nodes for IMPs (ballast water and biofouling). There are clear Australian and WA government protocols for managing the risk of both ballast water and biofouling. An appropriate Monitoring and Management Plan to avoid and minimise pest and/or disease introduction is provided in Appendix BB. The resulting pest management strategy includes vessel ballast water/hull and construction equipment and materials risk assessment and mitigation prior to entry of vessels into State waters in addition to IMP monitoring and reporting, with the aim of: • preventing the establishment and proliferation of IMPs; • control (and eradication) any IMP that has established and proliferated. • minimising transfer of any established IMPs further within WA. **Additional technical data**: • Sections 8.5.6 and 9.4.5 provides further detail regarding IMP. • An IMPMMP has been developed to reduce the risk of pest and/or disease introduction and proliferation (Appendix BB).	
Feral Fauna	**Nature and extent of impact:** Changes to feral animal populations due to Proposal habitat modification can cause an increase in competition for resources and/or an increase in predation. A number of species of introduced animals are present at the site including the following (Biota, 2022b): • *Canis lupus* (Dog). • *Vulpes vulpes* (Red Fox). • *Felis catus* (Cat). • *Equus caballus* (Horse). • *Bos taurus* (European Cattle). • *Rattus rattus* (Black Rat). • *Rattus tunneyi* (Pale Field-rat). • *Mus musculus* (House Mouse). • *Oryctolagus cuniculus* (Rabbit). **Unknown, unpredictable or irreversible impacts**: No impacts would be considered unknown. The presence of introduced species is known as a result of fauna surveys. No irreversible impacts are predicted. **Significance of impacts**: The Proposal does not provide any significant vectors for increases in introduced fauna species; the accommodation camp will be relatively small, and there are no other Proposal activities that would either attract introduced fauna species or aid their survival in the area. With the implementation of mitigation measures the Proposal is not expected to result in additional feral species being introduced and may result in a reduction in the local feral animal population as a result of eradication programs **Additional technical data:** • Sections 11.4 and 11.5 provide further detail regarding feral fauna within the Study Area • Section 2.3.12.3 provides further detail regarding the Ashburton River crossing within the Study Area	Northern Quoll Pilbara Olive Python Threatened Bird Species Migratory Birds

Potential Impacts	Assessment of Impacts	Relevant MNES
	• The CEMP and OEMP will be developed and implemented prior to each phase to include feral/invasive species.	
Alteration of surface water regimes affecting downstream and upstream habitats	**Nature and extent of impact:** The alteration of surface water regimes (overland and intertidal) has the potential to indirectly impact the health of habitats utilised by these species. The proposed development will locally alter minor tidal and surface water flows; however, these impacts are mitigated by locating Proposal infrastructure outside major flow paths and implementing mitigation strategies, which include culverts, levees and drainage diversion channels (Water Technology, 2021c). The extraction of seawater has the potential to modify the existing tidal prism and reduce the tidal inundation regime upstream from the pump station, including in adjacent mangrove and algal mat areas. **Unknown, unpredictable or irreversible impacts**: No impacts would be considered unknown as all have been assessed and modelled if required. The changes to flow volumes and rates of overland and intertidal flows have been modelled based on adequate available information, however there will remain some unpredictable elements until monitoring is conducted and the model can be verified. No irreversible impacts are predicted from indirect impacts if mitigation measures are implemented. **Significance of impacts**: Due to the limited physical footprint of Proposal infrastructure and locating the Proposal predominantly on the supratidal salt flats, direct disturbance of tidal creeks is localised and proportionally small on a local and regional basis. Modelling undertaken to understand whether the increase in flood flows and reduced ebb flows due to the intake operation could potentially impact the current morphological condition in the creek predict minor localised changes that are unlikely to impact coastal processes. **Additional technical data**: • Sections 13.4 and 13.5 provide further detail regarding surface water flows and potential impacts on hydrological processes within the Study Area • Sections 14.4 and 14.5 provide further detail regarding surface water flows and potential impacts on inland waters environmental quality within the Study Area • DHI (2021; Appendix F) and Water Technology (2021a, 2021b, 2021c and 2021d; Appendix C, D, E and J) provides further technical information regarding surface water regimes within the Study Area • A SWMP will be implemented to further assess potential changes to surface water and nutrient flows and concentrations	Green sawfish Lesser Sand Plover Greater Sand Plover Eastern Curlew Great Knot Red Knot Curlew Sandpiper Other migratory birds Pilbara Olive Python
Pond seepage modifying the shallow groundwater and increased groundwater salinity	**Nature and extent of impact:** Impact to 3.92 ha of algal mat due to pond seepage modifying the shallow groundwater. No impacts to mangroves or algal mat due to increased groundwater salinity. Modelling indicates that groundwater seepage and subsequent evaporation has the potential to form a crystallised salt layer (salt crust) on the ground surface on localised areas of tidal flats immediately next to the pond levees. The predicted distribution of seepage water and salt crusts is immediately adjacent (within 50 m) of the pond embankments and is not predicted to impact mangroves which are > than 800 m away. However, the predicted seepage zones do coincide with some small areas of algal mats adjacent to the western pond embankments and	Green sawfish Lesser Sand Plover Greater Sand Plover Eastern Curlew Great Knot Red Knot Curlew Sandpiper Other migratory birds Pilbara Olive Python

Potential Impacts	Assessment of Impacts	Relevant MNES
	given these algal mats may become permanently submerged, it is assumed on conservative basis that these algal mats may be impacted (AECOM, 2022a) (GHD, 2021c). Additionally, the downward seepage of fresher pond water is predicted to displace existing hypersaline groundwater beneath the ponds. Over time, salts from existing hypersaline groundwater and seepage water are predicted to accumulate in the groundwater outside the salt ponds, resulting in the formation of more saline and denser groundwater. Predictive simulations indicate that over time a halo of increased groundwater salinity will propagate laterally around the perimeter of the pond complex (GHD, 2021c). **Unknown, unpredictable or irreversible impacts**: No impacts would be considered unknown. The rate of seepage from the concentrator and crystalliser ponds has been modelled based on adequate available information, however there will remain some unpredictable elements until monitoring is conducted and the model can be verified. No irreversible impacts are predicted from indirect impacts. **Significance of impacts**: Given the shallow root structure of mangroves, further analysis was undertaken to account for the salinity stratification where tidal flushing results in less saline groundwater at the surface of the water table which is tapped by mangrove roots. Salinity increases were estimated for the top 0.2 m of the water table to correlate with the zone of the water table (approximately 0.3-0.5 m BGL) into which mangrove roots would tap. The result of this analysis is a contour of maximum salinity increase of 15 kg/m^2 in the top 0.2 m of the water table after 50 years. The analysis suggests that there will not be any impacts to mangroves from Project-related salinity increases given they are likely to be less than the salinity increase trigger levels (10-15 kg/m^2) used in mangrove monitoring programs in the Pilbara that are designed to correlate changes in mangrove health with changes in shallow groundwater conditions (URS, 2010a), (Chevron, 2015)(AECOM, 2022a). Increases in groundwater salinity are not likely to result in impacts to algal mats as the mat structures occur as a 2-3 cm veneer on the ground surface and salinity conditions in that layer are regulated by surface water flows from either tidal inundation or rainfall events, rather than by connectivity to groundwater approximately 1.5 m below the ground surface. The model results and subsequent interpretation are considered conservative due to assumptions and limitations in the modelling, as detailed in (AECOM, 2022a) (GHD, 2021c). **Additional technical data**: • Section 8.6 provides further detail regarding impacts of pond seepage modifying the shallow groundwater • Sections 13.4 and 13.5 provide further detail regarding groundwater and potential impacts on hydrological processes within the Study Area • Sections 14.4 and 14.5 provide further detail regarding groundwater and potential impacts on inland waters environmental quality within the Study Area • GHD (2021C; Appendix W) provides further technical information regarding Groundwater Hydrogeology within the Study Area • A GWMMP will be implemented which includes groundwater monitoring to ensure any Proposal related changes to groundwater and related changes to intertidal BCH are understood and potential impacts can be mitigated.	

18.6 ASSESSMENT AGAINST SIGNIFICANT IMPACT CRITERIA

The EPBC Act MNES Significant Impact Guidelines (Australian Government, 2013) outline an assessment process, including detailed criteria, to assist in determining whether a proposed action will have a significant impact on a MNES. Under these guidelines an action is likely to have a significant impact on a species if there is a real chance or possibility that it will:

- For critically endangered or endangered species:
  - lead to a long-term decrease in the size of a population
  - reduce the area of occupancy of the species
  - fragment an existing population into two or more populations
  - adversely affect habitat critical to the survival of a species
  - disrupt the breeding cycle of a population
  - modify, destroy, remove, isolate or decrease the availability or quality of habitat to the extent that the species is likely to decline
  - result in invasive species that are harmful to a critically endangered or endangered species becoming established in the endangered or critically endangered species' habitat
  - introduce disease that may cause the species to decline, or
  - interfere with the recovery of the species.
- For vulnerable species:
  - lead to a long-term decrease in the size of an important population of a species
  - reduce the area of occupancy of an important population
  - fragment an existing important population into two or more populations
  - adversely affect habitat critical to the survival of a species
  - disrupt the breeding cycle of an important population
  - modify, destroy, remove or isolate or decrease the availability or quality of habitat to the extent that the species is likely to decline
  - result in invasive species that are harmful to a vulnerable species becoming established in the vulnerable species' habitat
  - introduce disease that may cause the species to decline, or
  - interfere substantially with the recovery of the species.
- For migratory species:
  - substantially modify (including by fragmenting, altering fire regimes, altering nutrient cycles or altering hydrological cycles), destroy or isolate an area of important habitat for a migratory species
  - result in an invasive species that is harmful to the migratory species becoming established in an area of important habitat for the migratory species, or
  - seriously disrupt the lifecycle (breeding, feeding, migration or resting behaviour) of an ecologically significant proportion of the population of a migratory species.

Impacts to threatened and migratory species are discussed in the following ERD Sections:

- *Minuria tridens* - Section 10.5.
- Terrestrial fauna (including threatened and migratory birds) - Section 11.5.
- Marine fauna (including threatened and migratory marine species) - Section 9.

Table 122 provides an assessment against the EPBC Act MNES Significant Impact Criteria (Australian Government, 2013). With successful implementation of management measures and offsets discussed in Sections 9.7, 10.7 and 11.7, any residual impacts to EPBC Listed Threatened and Migratory Species from the proposal should not be significant.

Table 122: MNES Significant Impact Criteria Assessment

Criteria	Assessment
Threatened Species	
Long-term decrease in the size of a population (or important population for V species)	• ***Minuria tridens* (V):** A single plant was found at the Proposal site thought to be *Minuria tridens* although some uncertainty exists regarding the species identification given the specimen was in poor condition and sterile (no fruit or flowers) (Biota, 2022a). A subsequent targeted survey failed to locate this specimen or any other records of this species. Two other recorded locations occur in WA. Five new populations of 75 individuals were found at the Mardie Project (EPA, 2021) Also ~20 populations in Northern Territory (DNREAS, 2008) although it is not confirmed they are the same species (Section 10.4.3.1). The Proposal is unlikely to have a significant impact on this species due to the following reasons: ○ The location of the single plant found is not proposed to be cleared. ○ It was found near the border of vegetation communities P1 and P2 which are extensive throughout the study area with 12,061 ha of these occurring. The impact to P1 and P2 communities from the Proposal is estimated to be 1,159 ha (9.61% P1 and P2 in the study area and <5% of those communities along the Eastern Exmouth Gulf, given the large contiguous similar habitat). Therefore, the Proposal disturbance is unlikely to lead to the long-term decrease of any local populations (if it is confirmed the species identification was correct and this is *M. tridens*). ○ Given the relatively large size of populations found elsewhere in WA the Proposal is unlikely to lead to a long term decrease in the WA population. • **Northern Quoll (E):** Is considered locally dependent on permanent pools and shelter within the riparian zone of the Ashburton River (possibly also foraging in nearby plains) within no other shelter / rocky / hilly habitat in the vicinity of the Proposal (Section 11.4.1.4). A long-term decrease in the size of the local population at the Ashburton River (or the regional Pilbara population) is unlikely given the proportion of suitable habitat to be disturbed is very low as follows (Section 11.5.3): ○ 0.53 ha of Ashburton River habitat for bridge installation (0.2% and 0.09% of local and regional Ashburton River habitat). ○ 67 ha of sand/clay plains adjoining the Ashburton River for the main access road (0.34% and 0.04% of local and regional sand/clay plains). • **Pilbara Olive Python (V):** Is considered locally dependent on permanent pools and shelter within the riparian zone of the Ashburton River, within no other shelter / rocky habitat in the vicinity of the proposal (Section 11.4.1.4). A long-term decrease in the size of the local population at the Ashburton River (or the regional Pilbara population) is unlikely given the proportion of suitable habitat to be disturbed is very low consisting of 0.53 ha of Ashburton River habitat for bridge installation (0.2% and 0.09% of local and regional Ashburton River habitat (Section 11.5.3). • **Threatened Bird Species (V, E and CE):** The Lesser Sand Plover, Greater Sand Plover, Bar-tailed Godwit, Eastern Curlew, Great Knot, Red Knot and Curlew Sandpiper are all threatened migratory shorebird species which prefer foraging on intertidal flats and roosting on sandy beaches (Biota, 2022c). The Fairy Tern also a shorebird (although not migratory) is found on coastal beaches, inshore and offshore islands and sheltered inlets. It feeds by diving in marine waters and breeds in colonies (BirdLife Australia, 2021). It's preferred habitat locally would be sandy beaches. No breeding colonies have been identified locally (Biota, 2022c). A long-term decrease in the size of the local or the regional Pilbara shorebird population is unlikely given the proportion of habitat to be disturbed is low as detailed in Section 11.5.3**Green sawfish (V):** Was recorded in Urala Creek North during targeted sawfish surveys conducted in 2018 (6 individuals). Urala Creek North and South are likely important secondary nurseries for sawfish (Morgan et. al, 2020) (Section 9.4.3.1.1). Impact to soft sediment nearshore areas which are important habitat for green sawfish is proportionally low (226.2 ha, 4.7% and 0.2% of this BCH locally and regionally). Given the large amount of similar habitat available for this mobile species, the relatively low and localised potential indirect impacts such as underwater noise, artificial light spill, dredging, bitterns discharge (Section 9.5.2) and mitigation measures in place (Section 9.7) it is considered unlikely the Proposal will lead to a long-term decrease in the size of an important population (Section 9.8). • **Threatened Turtle Species (V, E**): Are widespread in the region, along the eastern Exmouth Gulf and in the vicinity of transhipment operations (Irvine and Salgado Kent, 2018) (Jenner et. al., 2010). Turtle nesting surveys conducted in 2018 and 2019 indicate that the beach between Urala Creek North and Ashburton River supports low density nesting, with higher density nesting on Locker Island consistent with other local islands (AECOM, 2022b) (Section 9.4.3.3). Impact to important habitat for turtles is proportionally low (219.3 ha or 0.2% of regional of soft sediment/potential seagrass, 0.99 ha or 0.1% of regional of sandy beaches and 4.28 ha or 0.04% of regional mangal) (Section 9.5.1.1). Given the large amount of similar habitat available for this mobile species and relatively low proportion of habitat loss, the localised indirect impacts such as underwater noise, artificial light spill, dredging, bitterns discharge (Section 9.5.2) and mitigation measures in place (Section 9.7) it is considered unlikely the proposal will lead to a long-term decrease in the size of an important population
Reduction in area of occupancy of	• ***Minuria tridens* (V):** A single plant was found with uncertainty re: the identification as *M. tridens*. This plant is not proposed to be cleared; therefore, the Proposal is unlikely to reduce the area of occupancy of the species or an important habitat.

Criteria	Assessment
the species (or important population for V species)	• **Northern Quoll (E):** During the non-breeding season, home ranges are about 35 ha, but this can increase to about 100 ha for males during the breeding season (ADW, 2021). There is a proportion of Northern Quoll local habitat that will be affected by the Proposal. Therefore, the area of occupancy in the local area will be reduced. • **Pilbara Olive Python (V):** Occur throughout the region however are restricted to specific habitats. There is a proportion of Pilbara Olive Python local habitat that will be affected by the Proposal. Therefore, the area of occupancy in the local area will be reduced. • **Threatened Bird Species (V, E and CE):** Shorebirds are highly mobile and likely to utilise similar habitat associated with Exmouth Gulf totalling 20,747 ha of transitional mudflats and 1,040 ha of sandy beaches. The proportion of Exmouth Gulf habitat to be affected by the Proposal is very low (0.09% of transitional mudflats and 0.1% of beaches). There is a proportion of local habitat that will be affected by the Proposal. Therefore, the area of occupancy in the local area will be reduced. Solar salt ponds are well known to be a haven for shorebirds, with several salt projects listed as Nationally Important Shorebird areas in The National Directory of Important Shorebird Habitat (BirdLife Australia, 2020) (Section 11.5.2.8). Therefore, the Proposal will likely expand local habitat available, providing additional habitat within salt ponds. • **Green sawfish (V):** Impact to tidal creeks and soft sediment nearshore areas which are important habitat for green sawfish is proportionally low (less than 4.7% and 0.2% of this habitat locally and regionally). Nevertheless, there is a proportion of local habitat that will be affected by the Proposal. Therefore, the area of occupancy in the local area will be reduced. Given the relatively low and localised indirect impacts such as underwater noise, artificial light spill, dredging, bitterns discharge (Section 9.5.2) and mitigation measures in place (Section 9.7) it is considered unlikely the indirect impacts of the proposal will lead a reduction in area of occupancy of an important population. • **Threatened Turtle Species (V, E**): Impact to important habitat for turtles is proportionally low (less than 4.7% and 0.2% of this habitat locally and regionally). Nevertheless, there is a proportion of local habitat that will be affected by the Proposal. Therefore, the area of occupancy in the local area will be reduced. Given the relatively low and localised indirect impacts such as underwater noise, artificial light spill, dredging, bitterns discharge (Section 9.5.2) and mitigation measures in place (Section 9.7) it is considered unlikely the indirect impacts of the proposal will lead to a reduction in area of occupancy of an important population.

Fragment an existing population (or 2+ populations for V species)	• ***Minuria tridens* (V):** A single plant was found with uncertainty re: the identification as *M. tridens*. This plant (representing the only local population) will not be cleared.
	• **Northern Quoll (E) and Pilbara Olive Python (V):** Fragmentation of the local population is unlikely given:
	  ○ Only a small proportion of potential habitat will be disturbed.
	  ○ Vehicle movements along the main access road will be minimal and measures will be in place to prevent road kills particularly on the main access road and in the vicinity of Ashburton River.
	  ○ Ashburton River will provide a corridor for movement along riparian habitat with the bridge designed to allow fauna to pass underneath.
	• **Threatened Bird Species (V, E and CE):** Shorebirds are highly mobile species. Proposal infrastructure will not fragment their habitat given only narrow corridors will intersect with their habitat. Solar salt projects are well known to be a haven for shorebirds, with several listed as Nationally Important Shorebird areas (Section 11.5.2.8) – the Proposal will expand local habitat available.
	• **Green sawfish (V):** Impact to soft sediment nearshore areas which are important habitat for green sawfish is proportionally low (less than 4.7% and 0.2% of this habitat locally and regionally) and access around the impacted area will be available. On this basis considered unlikely the proposal will lead to population fragmentation.
	• **Threatened Turtle Species (V, E**): Impact to important habitat for turtles is proportionally low (less than 4.7% and 0.2% of this habitat locally and regionally) and access around the impacted area will be available. On this basis considered unlikely the proposal will lead to population fragmentation.

Adversely affect habitat critical to survival of species	• ***Minuria tridens* (V):** A single plant was found at the Proposal site thought to be *Minuria tridens* although some uncertainty exists regarding the species identification given the specimen was in poor condition and sterile (no fruit or flowers) (Biota, 2022a). A subsequent targeted survey failed to locate this specimen or any other records of this species. Two other recorded locations occur in WA. Five new populations of 75 individuals were found at the Mardie Project (EPA, 2021) Also ~20 populations in Northern Territory (DNREAS, 2008) although it is not confirmed they are the same species (Section 10.4.3.1). The Proposal is unlikely to have a significant adverse impact on the habitat of this species due to the following reasons:
	  ○ The location of the single plant found is not proposed to be cleared.
	  ○ It was found near the border of vegetation communities P1 and P2 which are extensive throughout the study area with 12,061 ha of these occurring. The impact to P1 and P2 communities from the project is estimated to be 1,159 ha (9.61% P1 and P2 in the study area and <5% of those communities along the

Criteria	Assessment
	Eastern Exmouth Gulf, given the large contiguous similar habitat). Therefore, the proposed Proposal disturbance is unlikely to lead to the long-term decrease of any local populations (if it is confirmed the species identification was correct and this is *M. tridens*). • **Northern Quoll (E):** The drainage line habitat along the Ashburton River would be considered 'habitat critical to the survival' of this species, based on the definition provided in EPBC Act referral guideline for the endangered northern quoll *Dasyurus hallucatus* (DotE, 2016). The proportion of habitat to be affected by the Proposal is very low however would be considered to "adversely affect habitat critical to the survival of this species". • **Pilbara Olive Python (V):** There is no definition for 'habitat critical to the survival' for this species however K+S notes that it prefers escarpments, gorges and water holes in the ranges of the Pilbara region (Pearson 1993; Wilson & Swan 2003). The drainage line habitat along the Ashburton River would be considered preferred habitat for this species, based on this definition. The proportion of this habitat to be affected by the Proposal is however very low. • **Threatened Bird Species (V, E and CE):** The shorebird habitat to be affected by the Proposal is not deemed to be critical habitat for these species, with 'important habitat' generally used when assessing Migratory birds (discussed later in this table). • **Green sawfish (V):** The Sawfish and River Sharks Multispecies Recovery Plan (DotE, 2015a) states that "all areas where aggregations of individuals have been recorded displaying biologically important behaviour such as breeding, foraging, resting or migrating, are considered critical to the survival of the species unless population survey data suggests otherwise". Impact to Tidal Creek areas which are important habitat for green sawfish will therefore "adversely affect habitat critical to the survival of this species". • **Threatened Turtle Species (V, E**): The Recovery Plan for Marine Turtles in Australia 2017-2027 (Commonwealth of Australia, 2017b) identifies habitat critical to the survival of various sea turtle species. The nearshore disturbance for the Proposal will occur within the areas noted as critical habitat for Flatback, Green, Hawksbill and Loggerhead Turtles. The Proposal will therefore "adversely affect habitat critical to the survival of these species.

Disrupt breeding cycle of species (or important population for V species)	• *Minuria tridens* (V): The Proposal is unlikely to have a significant impact on the breeding cycle of this species due to the following reasons:
	  ○ The location of the single plant found is not proposed to be cleared.
	  ○ It was found near the border of vegetation communities P1 and P2 which are extensive throughout the study area with 12,061 ha of these occurring. The impact to P1 and P2 communities from the Proposal is estimated to be 1,159 ha (9.61% P1 and P2 in the study area and <5% of those communities along the Eastern Exmouth Gulf, given the large contiguous similar habitat). Therefore, the Proposal disturbance is unlikely to lead to the long-term decrease of any local populations (if it is confirmed the species identification was correct and this is M. tridens).
	• **Northern Quoll (E):** Typically have an annual life cycle, with almost all males living for only one year and females for 3 years. Mating occurs late May-early June, most males then subsequently die. Young are typically born during the "dry" (June - Sept) and attain independence by the early wet (November) (ADW, 2021). The Proposal will not impact the breeding cycle of the species given the proportion of suitable breeding habitat to be affected is very low.
	• **Pilbara Olive Python (V):** Locally breeding habitat may be within dense riparian areas which provide shelter. The location of the proposed bridge does not have dense riparian vegetation (Section 11.4.1.4) and therefore is not considered likely breeding habitat. Pythons are slow moving reptiles. Vehicle movements along the main access road will be minimal and measures will be in place to prevent road kills particularly on the main access road and in the vicinity of Ashburton River. Ashburton River will provide a corridor for movement along riparian habitat with the bridge designed to allow fauna to pass underneath.
	Threatened Bird Species (V, E and CE): The Lesser Sand Plover, Greater Sand Plover, Bar-tailed Godwit, Eastern Curlew, Great Knot, Red Knot and Curlew Sandpiper are all threatened migratory shorebird species which prefer foraging on intertidal flats and roosting on sandy beaches (Biota, 2022c). The Fairy Tern also a shorebird (although not migratory) is found on coastal beaches, inshore and offshore islands and sheltered inlets. It feeds by diving in marine waters and breeds in colonies (BirdLife Australia, 2021). It's preferred habitat locally would be sandy beaches. No breeding colonies have been identified locally (Biota, 2022c). Therefore, it is considered unlikely the Proposal will disrupt the breeding cycle for these species.
	• **Green sawfish (V):** Recorded in Urala Creek North during targeted sawfish surveys conducted in 2018 (6 individuals). Urala Creek North and South are likely important secondary nurseries for sawfish (Morgan et. al, 2020) (Section 9.4.3.1.1). Impact to soft sediment nearshore areas which are important habitat for green sawfish is proportionally low. Given the large amount of similar habitat available for this mobile species and relatively low and localised indirect impacts such as underwater noise, artificial light spill, dredging, bitterns discharge (Section 9.5.2) and mitigation measures in place (Section 9.7) it is considered unlikely the Proposal will disrupt the breeding cycle for this species.
	• **Threatened Turtle Species (V, E**): Turtles are widespread in the region, along the eastern Exmouth Gulf and in the vicinity of transhipment operations (Irvine and Salgado Kent, 2018) (Jenner et. al., 2010). Turtle nesting surveys conducted in 2018 and 2019 indicate that the beach between Urala Creek North and Ashburton River supports low density nesting, with higher density nesting on Locker Island consistent with other local islands (AECOM, 2022b) (Section 9.4.3.3). Impact to important habitat for turtles is proportionally low. Given the large amount of similar habitat available for this mobile species and relatively low and localised indirect

Criteria	Assessment
	impacts such as underwater noise, artificial light spill, dredging, bitterns discharge (Section 9.5.2) and mitigation measures in place (Section 9.7) it is considered unlikely the Proposal will disrupt the breeding cycle for this species. The MFMP (Appendix BB) provides mitigation measures for all underwater noise sources (piling and dredging) and will include timing of work outside of key ecological windows such as turtle mating and nesting seasons. A LMP will be developed to reduce the volume of light spill that is emitted from the Proposal.
Modify, destroy, remove, isolate or decrease availability or quality of habitat to the extent that species is likely to decline	• ***Minuria tridens* (V):** The Proposal is unlikely to significantly impact the habitat of this species such that it is likely to decline due to the following reasons: ○ The location of the single plant found is not proposed to be cleared. ○ It was found near the border of vegetation communities P1 and P2 which are extensive throughout the study area with 12,061 ha of these occurring. The impact to P1 and P2 communities from the Proposal is estimated to be 1,159 ha (9.61% P1 and P2 in the study area and <5% of those communities along the Eastern Exmouth Gulf, given the large contiguous similar habitat). Therefore, the Proposal disturbance is unlikely to lead to the long-term decrease of any local populations (if it is confirmed the species identification was correct and this is *M. tridens*). • **Northern Quoll (E) and Pilbara Olive Python (V):** The proportion of suitable habitat in the local area affected by the Proposal is low and this impact is unlikely to cause a decline in the species. • **Threatened Bird Species (V, E and CE):** The proportion of suitable habitat in the local area affected by the Proposal is low and this impact is unlikely to cause a decline in the species. • **Green sawfish (V) and Threatened Turtle Species (V, E**): The proportion of suitable habitat in the local area affected by the Proposal is low and this impact is unlikely to cause a decline in the species.
Result in invasive species that are harmful to a species becoming established	• ***Minuria tridens* (V), Northern Quoll (E), Pilbara Olive Python (V) and Threatened Bird Species (V, E and CE):** With management, activity is unlikely to result in the introduction and establishment of invasive species. The Mining Proposal and associated CEMP and OEMP will be developed and implemented prior to each phase to include invasive weed species (Section 11.7.2). • **Green sawfish (V), Humpback Whale (V) and Threatened Turtle Species (V, E**): With management, activity is unlikely to result in the introduction and establishment of invasive pest species. An IMPMMP has been developed to reduce the risk of pest and/or disease introduction and proliferation (Appendix BB).
Introduce disease that may cause species to decline	The Proposal does not provide any vectors for disease.
Interfere with recovery of the species	• ***Minuria tridens* (V):** Will not affect recovery of species. The proportion of suitable habitat in the local area affected by the Proposal is low. Relatively large populations exist elsewhere. Targeted surveys and appropriate management measures will be implemented. • **Northern Quoll (E) and Pilbara Olive Python (V):** Will not affect recovery of species. Both species occur in relatively high densities in areas of suitable habitat in the Pilbara Region. The proportion of suitable habitat in the local area affected by the Proposal is low. • **Threatened Bird Species (V, E and CE):** Will not affect recovery of species. Species occur in relatively high densities in areas of suitable habitat in the Pilbara Region. The proportion of suitable habitat in the local area affected by the Proposal is low. • **Green sawfish (V), Humpback Whale (V), Threatened Turtle Species (V, E**): Will not affect recovery of species. Species occur in relatively high densities in areas of suitable habitat locally. The proportion of suitable habitat in the local area affected by the Proposal is relatively low.
Migratory Species	
Substantially modify [Note 1] destroy or isolate an area of important habitat for a migratory species.	• **Migratory Birds:** Migratory shorebird species identified locally are highly mobile and prefer foraging on intertidal flats and roosting on sandy beaches (Biota, 2022c). The proportion of habitat to be disturbed is very low as follows (Section 11.5.3): ○ 17.81 ha of transitional mudflats (0.22% and 0.09% of local and regional habitat). ○ 0.99 ha of beaches (0.33% and 0.1% of local and regional habitat). On this basis it is considered unlikely the Proposal will Substantially modify, destroy or isolate an area of important habitat for a migratory species. • **Migratory Marine Fauna**: A detailed assessment of habitat loss for highly mobile migratory marine fauna, has been included in the BCH assessment report (AECOM, 2022a) and summarised in Section 8. Migratory marine fauna habitat loss is proportionally (Section 9.5.1.1): ○ 4.28 ha of mangal (habitat for juvenile turtles – representing 0.12% locally and 0.04% regionally)

Criteria	Assessment
	○ 219.3 ha of soft sediment/potential seagrass (habitat for sawfish, turtles and dugong – representing 4.7% locally and 0.2% regionally). ○ 0.99 ha of sandy beach (nesting habitat for turtles – representing 0.33% locally and 0.1% regionally).
Result in an invasive species that is harmful to the migratory species	• **Migratory Birds:** With management, activity is unlikely to result in the introduction and establishment of invasive species. The Mining Proposal and associated CEMP and OEMP will be developed and implemented prior to each phase to include invasive weed species (Section 11.7.2). • **Migratory Marine Fauna:** With management, activity is unlikely to result in the introduction and establishment of invasive pest species. An IMPMMP has been developed to reduce the risk of pest and/or disease introduction and proliferation (Appendix BB).
Seriously disrupt the lifecycle [Note 2] of an ecologically significant proportion of the population of a migratory species.	• **Migratory Birds: P**refer foraging on intertidal flats and roosting on sandy beaches (Biota, 2022c). No breeding colonies or habitat have been identified locally (Biota, 2022c). The proportion of habitat to be disturbed is very low as follows (Section 11.5.3): ○ 17.81 ha of transitional mudflats (0.22% and 0.09% of local and regional habitat). ○ 0.99 ha of beaches (0.33% and 0.1% of local and regional habitat). Therefore, it is considered unlikely the Proposal will seriously disrupt the lifecycle of an ecologically significant proportion of the population. • **Migratory Marine Fauna:** Urala Creek North and South are likely important secondary nurseries for green sawfish (Morgan et. al, 2020). Humpback whales and newborn calves occur within offshore waters of Exmouth Gulf (5 – 10 km offshore from the Proposed Proposal Jetty) and within the proposed transhipment route and ocean-going vessel loading area (Irvine and Salgado Kent, 2018) (Jenner et. al. 2010) (Section 9.4.3.2.1). Turtle nesting surveys conducted in 2018 and 2019 indicate that the beach between Urala Creek North and Ashburton River supports low density nesting, with higher density nesting on Locker Island consistent with other local islands (AECOM, 2022b) (Section 9.4.3.3). Given the large amount of similar habitat available for these mobile species, the relatively low and localised indirect impacts such as underwater noise, artificial light spill, dredging, bitterns discharge (Section 9.5.2) and mitigation measures in place (Section 9.7) it is considered unlikely the Proposal will disrupt the breeding cycle for this species. A MFMP has been developed to provide mitigation measures for all underwater noise sources (piling and dredging) and will include timing of work outside of key ecological windows such as turtle mating and nesting seasons and whale migration. A LMP will be developed to reduce the volume of light spill that is emitted from the Proposal. Therefore, it is considered unlikely the Proposal will seriously disrupt the lifecycle of an ecologically significant proportion of the population.

Table Note 1: including by fragmenting, altering fire regimes, altering nutrient cycles or altering hydrological cycles.

Table Note 2: Including breeding, feeding, migration or resting behaviour.

18.7 OFFSETS

The *EPBC Act Environmental Offsets Policy* (Commonwealth of Australia, 2012) outlines the Australian Government's approach to the use of environmental offsets under the EPBC Ac). The *Offsets assessment guide*, which accompanies this policy, has been developed in order to give effect to the requirements of this policy, utilising a balance sheet approach to measure impacts and offsets. It applies where the impacted protected matter is a threatened species or ecological community. The *Offsets assessment guide* is a tool that has been developed for expert users in the department to assess the suitability of offset proposals.

As outlined in Section 17 several residual impacts of the Proposal are considered to be significant, and offsets have been proposed to counterbalance these impacts.

19 HOLISTIC IMPACT ASSESSMENT

This ERD has assessed the impacts of the Proposal against the objectives of the key environmental factors in Figure 148.

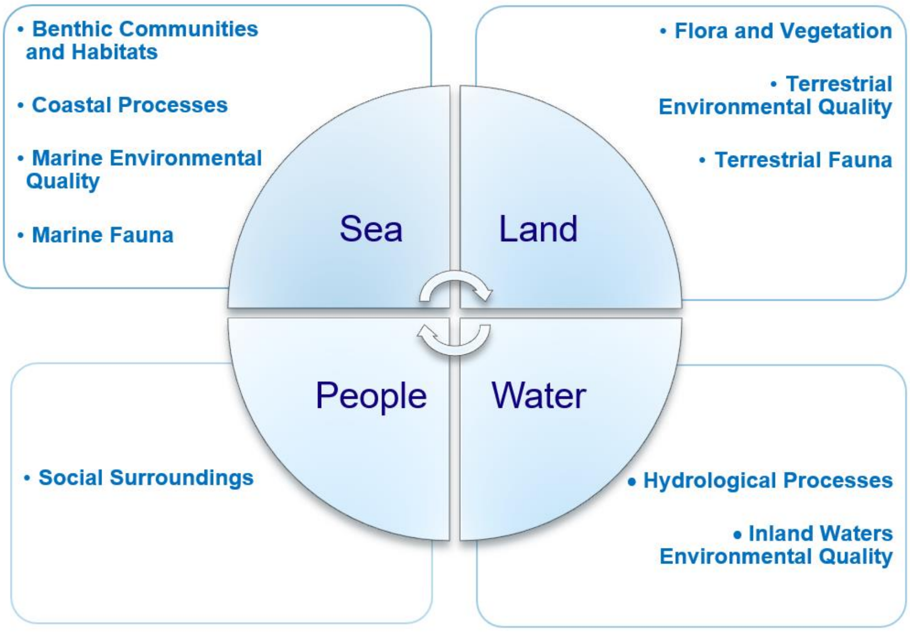

Figure 148: Key Environmental Factors

Many of these environmental factors are intrinsically linked (Table 123) and therefore the ERD has also considered the connections and interactions between parts of the environment to inform a holistic view of impacts to the whole environment, which is critical to assessing the significance of potential impacts.

Table 123: Intrinsic Links between Key Environmental Factors

Factor	Coastal Processes	Marine Environmental Quality	Benthic Communities & Habitats	Marine Fauna	Flora & Vegetation	Terrestrial Fauna	Terrestrial Environmental Quality	Hydrological Processes	Inland Waters Environmental Quality	Social Surroundings
Coastal Processes			■	■				■	■	■
Marine Environmental Quality	■		■	■						■
Benthic Communities & Habitats	■	■				■		■	■	■
Marine Fauna	■	■	■							■
Flora & Vegetation						■	■	■	■	■
Terrestrial Fauna					■		■	■	■	■
Terrestrial Environmental Quality		■						■	■	■
Hydrological Processes	■		■		■	■	■		■	■
Inland Waters Environmental Quality	■		■		■	■	■			■
Social Surroundings	■	■	■	■	■	■	■	■	■	

Table Key: ■ **= Intrinsic Link**

Proposal disturbance is predicted to occur over terrestrial, supratidal, intertidal and sub-tidal environments (Figure 149). Disturbance to important ecological habitats such as mangroves, algal mats and subtidal habitat has been minimised by placing most of the Proposal on the supratidal salt flats which are devoid of vegetation and have limited habitat value. The proposed disturbance is focused on the supratidal salt flat areas, with disturbance of other habitat types localised and proportionally small.

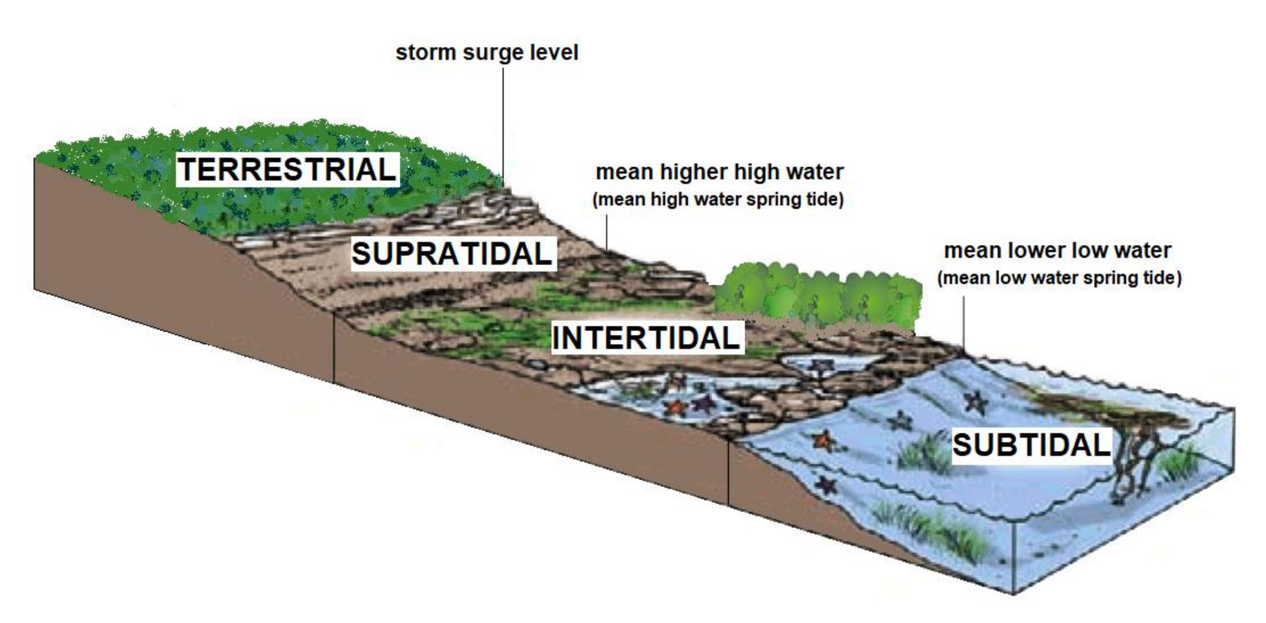

Figure 149: Local Environment Types

The receiving environment has been carefully considered and investigated in detail through 26 scientific technical studies which are appended to this ERD, to develop a comprehensive understanding of the existing environment at a local and regional scale and how it may be impacted by the Proposal. The focus of these assessments has been to inform the Proposal such that important environmental processes are maintained and therefore ensure that local and regional environmental values are protected.

Based on the preliminary findings of these technical studies, the Proposal has been iteratively re-designed to minimise impacts to the environment. Proposed disturbance is localised and proportionally small for all vegetation and habitat types. Important processes have been maintained so that local and regional environmental values are protected.

Direct impacts to important coastal features such as tidal creeks, intertidal mudflats and barrier dunes is proportionally small on a local and regional basis (less than 4.7M%). Potential indirect impacts to coastal processes associated with the seawater intake in Urala Creek South, the jetty near Locker Point and the salt ponds located on the supratidal tidal flats are predicted to be minor and unlikely to significantly impact coastal processes. The presence of the pile-supported jetty is predicted to have negligible influence on the hydrodynamic regime or coastal morphology due to its transmissive nature. Only minor and localised changes to fluvial morphology and tidal submergence time are predicted due to the seawater intake. Due to its position largely on the supratidal salt flats, the Proposal is predicted to have minimal impact on tidal inundation given it is beyond the reach of most tides. The Proposal will not impact the seashore or coastal barrier dune response to SLR due to distance from the Proposal.

Marine environmental quality impacts are associated with bitterns discharge and dredging of the small berthing pocket adjacent to the jetty. Detailed hydrodynamic modelling (Water Technology, 2022b) has predicted average, best case and worst case LEPA and MEPA sizes which exceed the EPA (2016a) guideline sizes, however are in line with other solar salt projects in WA, and predominantly located in areas of bare sediment. Detailed modelling of the small scale two week dredging program to remove 17,000 m^3 of sediment with onshore disposal of dredge spoil predicted a localised ZoHI confined around the immediate dredging area and tailwater discharge which will only cause elevated turbidity impacts for 1 week after the cessation of dredging (Water Technology, 2022b).

The Proposal will not significantly alter nutrient pathways due to the small and infrequent nature of the predicted terrestrial reductions and no impact to marine nitrogen sources on which the Exmouth Gulf is reliant. Conservative modelling predicted the Proposal will reduce nitrogen sources transported into the Exmouth Gulf by only 0.24% (Water Technology, 2021d). All potentially acid generating sediment removed through dredging will be treated on land with appropriate monitoring of decant water prior to marine disposal, in accordance with the ASSSMP (GHD, 2021b). An ecotoxicology assessment (AECOM, 2022c) concluded that the dredged material and appropriately diluted/discharged bitterns is likely to present a very low risk of marine ecotoxicity. Appropriate management plans are proposed to prevent and manage accidental spills of pollutants during construction and operations as outlined.

The location and design of the Proposal results in a very localised small scale of impacts to BCH as outlined in Section 8.7. The Proposal is unlikely to negatively impact the functioning and ecological productivity of the 'Exmouth Gulf East wetland (WA007)' and 'Area 2 – Exmouth East Shore' MMA given the majority of the Proposal is located outside of the mangrove and algal mat zones. Tidal flows that are predominantly responsible for mangrove ecosystem maintenance are not impacted locally or within the broader eastern Exmouth Gulf area. Sedimentation patterns are also likely to be maintained, so erosion and deposition within mangrove and tidal flats habitats is predicted to be within natural variation. Significant impacts to nutrient pathways, sources or sinks in the context of the local catchment or Exmouth Gulf are not predicted to occur. Key geomorphic features within the Eastern Exmouth Gulf, such as the Yanrey River Delta and the barrier islands of Tent Point and Tubridgi Point, will not be impacted. Overland flows from the Yanrey River Delta to the tidal flats and estuarine wetland system of eastern Exmouth Gulf will not be modified by the Proposal (AECOM, 2022a).

The functioning and ecological productivity of 'Exmouth Gulf East wetland (WA007)' and 'Area 2 – Exmouth East Shore' is reliant on expansive areas of mangroves and algal mats, which are at risk in the long term due to SLR. The natural loss of mangroves and algal mats from these areas is predicted to occur progressively after approximately 50 years due to SLR without the Proposal in place (Seashore Engineering, 2021). However, the Proposal is uniquely positioned to consider the creation of ongoing habitat for algal mat, mangroves and associated fauna as a part of Proposal closure. K+S preferred post closure land use is to leave the evaporation ponds in situ so that they become "wetland" habitat for mangroves, algal mats and associated fauna. Converting the ponds into a functioning wetland system at Proposal closure, could provide a niche for BCH survival longer than otherwise anticipated, by providing physical protection from the effects of sea level rise behind rock armoured embankments (AECOM, 2022a).

The area of marine fauna habitat that is likely to be impacted due to the Proposal is proportionally very small when compared to the availability of similar habitat in the surrounding areas, which will be easily accessible to highly mobile marine fauna species. There is a low risk of vessel collisions due to vessel speeds being limited to 9 knots. With the implementation of seawater intake inlet well and pipe screens, and intake velocity to remain below the USEPA (2014) recommended 0.15 m/s, it is considered that the risk of entrapment of marine fauna is low. Bitterns, dredging and nutrient pathway impacts are localised and therefore unlikely to significantly affect regional marine fauna populations. Underwater noise generating activities have the potential to result in behavioural responses of some marine fauna species. However, timing activities outside of key ecological windows (collectively September to January) will minimise impacts (Pendoley Environmental, 2020). Given the relatively low magnitude of light spill from the Proposal (Talis, 2021), it is considered that the Proposal will not contribute significantly to the overall light climate in the region, and therefore will not raise the risk of significant impacts upon marine fauna (from light spill) to a substantially greater degree than presently exists. A range of management plans have been developed or are proposed to minimise impacts to Marine Fauna. Therefore, is it unlikely that habitat loss resulting from construction and operation of the Proposal will significantly impact the biological diversity and ecological integrity of marine fauna populations and their habitats (AECOM, 2022b). However, given the presence of BIAs and critical habitat for some marine fauna species the losses of habitat and other potential direct and indirect impacts is considered to be a significant residual impact. Offsets are proposed to counterbalance those impacts.

The area of terrestrial vegetation that is predicted to be impacted due to the Proposal is proportionally small when compared to the amount of similar vegetation in the surrounding areas consisting of approximately 5.68% of vegetation in the study area (Biota, 2022a) and 1% of pre-European vegetation of Eastern Exmouth Gulf. The vegetation communities to be disturbed are not considered threatened with over 90% of their original extent remaining (Beard et. al. 2013). Therefore, is it unlikely that vegetation loss resulting from the Proposal will impact the biological diversity and ecological integrity of vegetation locally or regionally. The EPA considers that the clearing of native vegetation and impacts on other associated environmental values in the Pilbara IBRA bioregion is significant where the cumulative impact may reach critical levels if not managed. While the Proposal lies just outside the Pilbara IBRA bioregion, K+S has assessed vegetation loss in a similar manner, with the loss of Good to Excellent vegetation being considered to be a significant residual impact. Offsets are proposed to counterbalance those impacts. One plant of which may be *Mirunia tridens* will be avoided, therefore the Proposal is unlikely to cause a significant impact to this species or regional populations given *M. tridens* (75 plants) has also been recently recorded during surveys for the Mardie Project to the Northeast of this Project (EPA, 2021).

The area of significant terrestrial fauna habitat that is likely to be impacted due to the Proposal is proportionally small when compared to the amount of similar fauna habitat in the surrounding areas consisting of 4.27% of local habitat and 0.66% of Eastern Exmouth Gulf habitat. Predicted regional proportional disturbance to significant habitat for specific terrestrial fauna species is:

- Less than 0.5% of important habitat for northern coastal free-tailed bat, migratory birds, Pilbara olive python and northern quoll.
- 6.76% of potentially important habitat for mygalomorph spiders.

Salt ponds are well known to provide important habitat for migratory shorebirds including the salt evaporation ponds that already exist near Onslow, Port Hedland and Dampier, with such ponds being listed as important habitats in The National Directory of Important Shorebird Habitat (BirdLife Australia, 2020). It is likely that the Proposal if constructed will provide important new habitat for migratory shorebirds. Small portions of the proposed disturbance will occur within critical and important habitat for Northern Quoll, Pilbara Olive Python and Migratory Shorebird species. The loss of this habitat is considered to be a significant residual impact. Offsets are proposed to counterbalance those impacts.

A range of management plans are proposed to prevent contamination and spills. To prevent generation of sulfuric acid due to disturbance of sulfidic material an ASSSMP has been developed for the Proposal. Naturally occurring geochemical and physical soil properties which may have environmental or employee health impacts and will be managed and assessed under other regulatory processes administered by DMIRS under the Mining Act, 1972.

The Proposal will locally alter minor surface flow paths however these impacts are mitigated by locating Proposal infrastructure outside major flow paths, and implementing mitigation strategies, which include culverts, levees and drainage diversion channels (Water Technology, 2021c). The effects of the Proposal on radial groundwater movement, water logging and seepage are localised to the immediate vicinity of the pond infrastructure. No impacts to mangroves and no regional impacts are predicted from these processes (GHD, 2021c).

Predicted saline groundwater seepage and salt crust is localised to the immediate vicinity of the ponds (GHD, 2021c) and will not impact proportionally large areas of BCH or vegetation. Modelling indicates that the halo of increased salinity groundwater propagating radially from the ponds, is unlikely to reach most of the mangrove zone which is >800 m from the salt ponds. Any increase in salinity that does occur below the minor tidal sub-creeks which are closest to the salt ponds, will be likely effectively moderated by tidal flushing resulting in fresher layer of tidal water occurring in the shallow groundwater tapped by the mangrove roots (AECOM, 2022a) (GHD, 2021c). Overall, the Proposal shows the potential for minor and manageable impacts on inland water environmental quality. Several Management Plans will be developed to address specific impacts.

Disturbance of local areas predicted to contain Aboriginal heritage sites (Archae-aus, 2020) is proportionally small including 5.24% of high likelihood areas and 0.34% of medium likelihood areas. Whilst it is likely some Aboriginal heritage sites will be disturbed, consultation will occur with the Thalanyji people and their representative BTAC on minimising and mitigating the impacts of disturbance as far as practicable. Appropriate approvals to undertake disturbance will be sought under AH Act or ACH Act. Disturbance of intertidal and subtidal habitats with cultural associations for Thalanyji people (BTAC, 2021b) is proportionally small in relation to surrounding similar habitats (less than 1% locally and 0.1% or less regionally).

It is unlikely that a significant proportion of the prawn population available for commercial harvest will be removed by the seawater intake, which is predicted by modelling (Water Technology, 2018) to affect 0.39% of the EGPMF nursery area. Impacts due to jetty construction, bitterns discharge, dredging, underwater sound, artificial lighting and alteration of nutrient pathways are considered unlikely to significantly impact the prawn fisheries given their limited interface with the marine environment in comparison to the large extent of the prawn fisheries. Additional modelling work is underway to assess the impacts to commercial prawn fisheries.

It is considered that the frequency of transhipper movements and ocean-going vessel loading, will be insufficiently great to impact recreational or commercial vessel movements in the area. The Proposal will not prevent access by the community to local waters by boat, except for the Port Marine Boundary which is localised and proportionally small compared to surrounding available marine waters. The Proposal is not expected to impact recreation in the wider area, given its limited interface with the Exmouth Gulf and relatively low number of vessel movements. Given the relatively low magnitude of light spill from the Proposal, in comparison to the light from other sources, it is considered that the Proposal will not contribute significantly to the overall light climate in the region, and therefore will not raise impacts from light spill to a substantially greater degree than presently exists. The Proposal will result in minimal dust and noise during construction as most of the works will be conducted in narrow strips on soft mudflats (for the pond walls). Management measures will be in place for noise and dust, and these will be further assessed during the works approval and licencing process under Part IV of the EP Act. The Proposal is located within a remote location, with the nearest sensitive receptor (Urala Homestead) approximately 8 km away. Therefore, dust, noise and visual amenity impacts to community are unlikely to be significant.

In conclusion, the receiving environment has been carefully considered and investigated in detail. The Proposal has been iteratively re-designed to minimise impacts to the environment. Proposed disturbance is localised and proportionally small. Important processes have been maintained so that local and regional environmental values are protected. With mitigation measures it is predicted that some significant residual impacts will remain. Offsets are proposed to counterbalance these significant residual impacts and are deemed to be suitable given the limited scale of these impacts. With the implementation of these offsets, it is considered that the EPA objectives for each relevant Environmental Factor can be met.

20 CUMULATIVE IMPACT ASSESSMENT

In August 2020, the then WA Minister for Environment requested that the EPA provide strategic advice under Section (16e) of the EP Act on the potential cumulative impacts on the environmental, social and cultural values of Exmouth Gulf. The request for strategic advice originated from several potentially significant development proposals in the Exmouth Gulf region being referred to the EPA under Part IV of the EP Act. One of these proposals was the Proposal. A cumulative impact study was prepared by WAMSI in partnership with the EPA to assist in delivering this advice (WAMSI, 2021).

The report provided a review on the potential cumulative impacts of these projects on the environmental, social and cultural values of Exmouth Gulf. The report identified Exmouth Gulf to be a multi-use area, with various drivers and pressures across a multitude of sectors. Key values were considered across five themes (sea, land, water, air and people) within the context of the definitions under the EP Act and the EPA's framework of environmental factors and objectives (EPA, 2020b). No key values were identified to be in a state of very poor condition with most categorised in a state of good or very good condition. The EPA did, however, acknowledge that the condition of key values of the gulf are likely to continue to degrade overtime without improved coordination and management.

K+S has considered the cumulative pressures on the Exmouth Gulf in this assessment. When taking this into account K+S have determined that the combined Proposal impacts to marine fauna from habitat loss, marine noise, shipping, dredging and bitterns disposal are considered to be significant. Management offsets are proposed to counterbalance these impacts.

K+S also noted comments provided by the EPA (EPA Report 1704) regarding cumulative impacts in their assessment of the Mardie Project. The EPA advised that:

> "All future salt proposals on the West Pilbara Coast (defined as the area from the bottom of the Exmouth gulf to Karratha) which have the potential to impact tidal samphire mudflats habitat, algal mat and mangrove habitat will need to assess potential regional and cumulative impacts to these habitats. This consideration must include assessment of the cumulative impacts with existing, approved and proposed proposals, in the context of the known extent of habitats in the Pilbara. Assessment must include both direct impacts, and consideration of changes to the ecological process such as surface water, groundwater, and tidal inundation which support intertidal habitats".

K+S has considered the EPA's advice regarding cumulative impacts and designed the Proposal to avoid and minimise impacts to the key BCH values that were noted to be at threat of cumulative impacts from salt proposals ("tidal samphire mudflats habitat, algal mat and mangrove habitat"). As a result, the Proposal has been re-designed to reduce direct and indirect impacts to algal mats, mangroves and intertidal samphires. Impacts to these BCH types are now minor in the context of the Mardie Project, with only 76.7 ha of disturbance compared to the 1,267 ha proposed for the Optimised Mardie Project (Preston Consulting, 2022a). Nevertheless, given the cumulative pressures on these BCH types, the impacts were assessed as being significant, and research offsets were proposed to counterbalance these impacts.

The Proposal has specifically targeted areas of unvegetated supratidal flats, which has limited the extent of vegetation that will need to be cleared to implement the Proposal. There are limited cumulative clearing pressures on vegetation in the surrounding area, with more than 90% of their pre-European extent remaining. Nevertheless, K+S notes that the EPA considers that the clearing of native vegetation and impacts on other associated environmental values in the Pilbara IBRA bioregion is significant where the cumulative impact may reach critical levels if not managed. While the Proposal lies just outside the Pilbara IBRA bioregion, K+S has assessed vegetation loss in a similar manner, with the loss of Good to Excellent vegetation being considered to be a significant residual impact. Offsets are proposed to counterbalance those impacts, targeting the management of weed infestations in the region.

21 GLOSSARY

Term	Meaning
ABM	Agent-based modelling
ACH Act	*Aboriginal Cultural Heritage Act 2021* (WA)
ADCP	Acoustic Doppler Current Profiler
AEP	Annual Exceedance Probability
AGIG	Australian Gas and Infrastructure Group
AH Act	*Aboriginal Heritage Act 1972* (WA)
AHD	Australian Height Datum
ANC	Acid Neutralising Capacity
ANSIA	Ashburton North Strategic Industrial Area
ARI	Average recurrence interval
ARL	Analytical Reference Laboratory
ASS	Acid Sulphate Soil
ASSS	Acid Sulphate Soils and Sediment
ASSSMP	Acid Sulphate Soil and Sediment Management Plan
BC Act	*Biodiversity Conservation Act 2016* (WA)
BCH	Benthic Communities and Habitats
BGL	Below Ground Level
BIA	Biologically Important Areas
BOM	Bureau of Meteorology
BTAC	Buurabalayji Thalanyji Aboriginal Corporation
CCG	Cape Conservation Group
CEMP	Construction Environmental Management Plan
CP	Concentration Pond/ Internal Walls
CRS	Chromium Reducible Sulfur
Cth	Commonwealth
DAWE	Department of Agriculture, Water and the Environment (Commonwealth)
DAWR	Department of Agriculture and Water Resources
DBCA	Department of Biodiversity, Conservation and Attractions
DCCEEW	Department of Climate Change, Energy, the Environment and Water
DEM	Digital Elevation Model
DEWHA	Department of Environment, Water, Heritage and the Arts (now DotEE)
DGV	Default guideline values
DIN	Dissolved Inorganic Nitrogen
DJTSI	Department of Jobs, Tourism, Science and Innovation (WA)
DMAs	Decision Making Authorities
DMIRS	Department of Mines, Industry Regulation and Safety (WA)
DMP	Department of Mines and Petroleum (now DMIRS)
DoT	Department of Transport
DotEE	Department of the Environment and Energy (Cth)
DoW	Department of Water (WA), now DWER
DPIRD	Department of Primary Industries and Regional Development (WA)
DPLH	Department of Planning, Lands and Heritage (WA)
DSEWPaC	Department of Sustainability, Environment, Water, Population and Communities (Commonwealth), now DotEE
DSMP	Dredging and Sediment Management Plan
DWER	Department of Water and Environmental Regulation (WA)
EC	Electrical Conductivity
ECS	Economic Consulting Services
EGPMF	Exmouth Gulf Prawn Managed Fishery
EIA	Environmental Impact Assessment
EIL	Ecological Investigation Levels
EP Act	*Environmental Protection Act 1986* (WA)
EPA	Environmental Protection Authority (WA)
EPBC Act	*Environment Protection and Biodiversity Conservation Act 1999* (Cth)
EQC	Environmental Quality Criteria

Term	Meaning
EQP	Environmental Quality Plan
ERD	Environmental Review Document
ESD	Environmental Scoping Document
ESP	Exchangeable Sodium Percentage
FRP	Fibre Reinforced Plastic
GHRSST	Group for High Resolution Sea Surface Temperature
GIS	Geographic Information System
GL	Gigalitre
GWMMP	Groundwater Monitoring and Management Plan
ha	hectares
HAT	Highest Astronomical Tide
HDPE	High-density polyethylene
HEPA	High Ecological Protection Area
HIA	Heritage Investigation Areas
HLEP	High Level of Environmental Protection
IBRA	Interim Biogeographic Regionalisation for Australia
ICSM	Inter-governmental Committee on Surveying and Mapping
ILUA	Indigenous Land Use Agreement
IMP	Introduced Marine Pests
IMPMMP	Introduced Marine Pest Monitoring and Management Plan
IMS	Introduced Marine Species
IOD	Indian Ocean Dipole
IPCC	Intergovernmental Panel on Climate Change
ISQG	Interim Sediment Quality Guidelines
IUCN	International Union for Conservation of Nature
K+S	K plus S Salt Australia Pty Ltd
Kg/ha/y	Kilogram per hectare per year
Kg/m^3	Kilogram per cubic metre
kl	Kilolitre
kl/day	Kilolitre per Day
km	kilometres
km^2	Square kilometres
LAT	Low Astronomical Tide
LAU	Local Assessment Unit
LEP	Level of ecological protection
LEPA	Low Ecological Protection Area
LMP	Lighting Management Plan
LND	External Land Walls
LNG	Liquefied Natural Gas
LOS	Line-of-sight
m	Metres
m/s	Metres per second
m^3/s	Cubic Metre Per Second
MCMPR	Ministerial Council on Mineral and Petroleum Resources
MCP	Mine Closure Plan
MEPA	Moderate Ecological Protection Area
MEQMMP	Marine Environmental Quality Monitoring and Management Plan
MFMP	Marine Fauna Management Plan
MFO	Marine Fauna Observer
mg/L	Milligrams per litre
MgCl	Magnesium Chloride
MHWN	Mean High Water Neap
MHWS	Mean High Water Spring
MLEP	Maximum Level of Environmental Protection
MLWN	Mean Low Water Neap
MLWS	Mean Low Water Spring
mm	millimetres
MMA	Mangrove Management Area

Term	Meaning
MNES	Matters of National Environmental Significance
MOST	Method Of Splitting Tsunamis
MSAMMP	Mangrove, Samphire and Algal Mat Management Plan
MSL	Mean sea level
Mtpa	Million tonnes per annum
NAF	Non-Acid Forming
NAGD	National Assessment Guidelines for Dredging
NATA	National Association of Testing Authorities
NCB	Sec 15
NDVI	Normalised Difference Vegetation Index
NIDEM	National Intertidal Digital Elevation Model
NIMPCG	National Introduced Marine Pests Coordination Group
nm	Nautical miles
NORM	Naturally Occurring Radioactive Material
NPI	Non-process infrastructure
NTU	Nephelometric Turbidity Units
OEMP	Operations Environmental Management Plan
OGV	Ocean going vessel
OPMF	Onslow Prawn Managed Fishery
PAF	Potentially Acid Forming
PASS	Potential acid sulphate soil
PC	Physical Chemical
PEC	Priority Ecological Communities – plant communities listed as being potentially threatened under the *Biodiversity Conservation Act 2016*
PEOF	Pilbara Environmental Offsets Fund
PER	Public Environment Review
pH_{FOX}	Field pH peroxide test
pH_{LAB}	pH measured at the laboratory
PMST	Protected Matters Search Tool
PPA	Pilbara Ports Authority
ppt	Parts per thousand
PQL	Practical Quantitation Level
Proposal	Ashburton Salt Project
PS	Pump Station
PSU	Practical Salinity Units
PTS	Permanent Threshold Shift
SLR	Sea Level Rise
SPOCAS	Suspension Peroxide Oxidation Combined Acidity and Sulphur
SPP2.6	State Planning Policy No. 2.6: State Coastal Planning Policy
SRE	Short-range Endemic
SSD	species sensitivity distributions
SST	Sea Surface Temperature
SW	Seawalls
SWMP	Surface Water Management Plan
t	tonne
TC	Tropical Cyclone
TDS	Total dissolved solids
TEC	Threatened Ecological Communities – plant communities listed as being threatened and legally protected under the *Biodiversity Conservation Act 2016* and / or the *Environment Protection and Biodiversity Conservation Act 1999*
TIC	Total inorganic carbon
TN	Total Nitrogen
TP	Total Phosphorus
Transhipper	Self-propelled transhipment vessel
TSS	Total Suspended Solids
TSSC	Threatened Species Scientific Committee
TTS	Temporary Threshold Shift
UCL	Upper confidence limits

Term	Meaning
URS	URS Australia Pty Ltd
WA	Western Australia
WAMSI	Western Australia Marine Science Institute
WAPC	Western Australian Planning Commission
WET	Whole Effluent Toxicity
WIR	Water Information Reporting
WMP	Waste Management Plan
yr	Year
ZoHI	Zone of High Impact
ZoI	Zone of Influence
ZoMI	Zone of Moderate Impact

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