MARDIE PROJECT

ENVIRONMENTAL REVIEW DOCUMENT
MARDIE MINERALS PTY LTD

22 JUNE 2020
ASSESSMENT NUMBER: 2167
DOCUMENT NUMBER: BCI-MAR-ERD-01_REV 0

PREPARED FOR MARDIE MINERALS PTY LTD
BY PRESTON CONSULTING PTY LTD

Document prepared for:

MARDIE MINERALS PTY LTD

Contact Person: Michael Klvac –General Manager Corporate Affairs
Email: michael.klvac@bciminerals.com.au
Phone: (08) 6311 3400
Street Address: Level 2, 1 Altona Street, West Perth WA 6005
Postal Address: GPO Box 2811, Perth WA 6872

Document developed by:

PRESTON CONSULTING PTY LTD

Contact Person Gavin Edwards – Director
Email: gedwards@prestonconsulting.com.au
Website: www.prestonconsulting.com.au
Phone: +61 8 9221 0011
Fax: +61 8 9221 4783
Street Address: Level 3, 201 Adelaide Terrace, East Perth WA 6004
Postal Address: PO Box 3093, East Perth WA 6892

DOCUMENT CONTROL

Document Title	Environmental Review Document - Mardie Project		
Document Number	BCI-MAR-ERD-01		
Revision Number	0		22/06/2020
Status	FINAL		
Author	Harry Jockel – Preston Consulting	Signature	22/06/2020
Checked	Gavin Edwards – Director, Preston Consulting	Signature	22/06/2020
Authorisation	Michael Klvac –General Manager Corporate Affairs, BCI Minerals Pty Ltd	Signature	22/06/2020

INVITATION TO MAKE SUBMISSION

The Environmental Protection Authority (EPA) invites people to make a submission on the environmental review for this Proposal. Mardie Minerals Pty Ltd (Mardie Minerals) is seeking to develop a Greenfields high-quality salt and Sulphate of Potash (SoP) project and associated export facility at Mardie, approximately 80 km south west of Karratha, in the Pilbara region of Western Australia (WA) (the Proposal). The Proposal will utilise seawater, solar energy and wind energy to produce a high purity salt product and SoP.

The Proposal includes the development of seawater intake, concentrator and crystalliser ponds, processing plant, bitterns disposal pipeline and outfall, trestle jetty export facility, dredge channel, causeway, administration buildings, drainage channels and sea walls, access / haul roads, desalination plant, borrow pits, freshwater supply bores and pipelines, and associated infrastructure (power supply, communications equipment, workshops, laydown areas, sewage treatment plant, landfill facility, etc.). Salt and potash product would be transported overseas from the onsite export facility.

Mardie Minerals has prepared this Environmental Review Document (ERD) in accordance with the EPA's Procedures Manual (Part IV Divisions 1 and 2). The Environmental Review Document (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 10 weeks from 29 June 2020, closing on 7 September 2020. Information on the Proposal from the public may assist the EPA to prepare an assessment report in which 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 the Proposal, 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 on similar 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, ensure that you:

- Clearly state your point of view and give reasons for your conclusions;
- Reference the source of your information, where applicable; and
- Suggest alternatives to improve the outcomes to 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; and
- Attach any reference material, if applicable. Make sure your information is accurate.

The closing date for public submissions is: 7 September 2020.

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: the Environmental Protection Authority, Prime House, The Atrium, 8 Davidson Terrace, Perth 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.

SCOPING CHECKLIST

Task No.	Required work	Relevant section
Benthic Communities and Habitats		
1	Develop appropriate Local Assessment Units (LAUs) in consideration of: • Intertidal and sub-tidal Benthic Communities and Habitats (BCH) mapping ; • Management boundaries (i.e. Regionally significant mangrove areas); • Bathymetry; and • Coastal geomorphology.	7.3.5
2	Undertake an intertidal habitat field survey within the LAUs to produce local and regional scale maps of algal mats, mangroves, samphire and bare areas, as well as a list of species found. The survey will include: a. Broadscale mapping of algal mats, mangroves, samphire and bare areas within LAUs b. Detailed mapping of the boundary of key habitat such as mangroves and algal mats within the predicted impact areas; c. Assessment of the functional ecological value and regional significance of key habitat such as mangroves and algal mats that may be impacted by the Proposal; d. Health assessment to determine the current status of the habitat; and e. Expert advice on the significance of the habitats impacted by the Proposal from a local and regional perspective.	7.3, Appendix 2
3	Undertake subtidal habitat field surveys within the LAUs to produce local and regional scale maps of BCH and bare areas, as well as a list of species found. The survey will include: a. Broadscale mapping of subtidal BCH within LAUs b. Detailed mapping of the boundary of key BCH such as corals and seagrass (if present) within predicted impact areas; c. Assessment of the functional ecological value and regional significance of key habitat such as coral and seagrass communities that may be impacted by the Proposal; d. Assessment of seasonal variation in presence / absence of seagrass; e. Health assessment to determine the current status of the BCH; and f. Expert advice on the significance of the BCH impacted by the Proposal from a local and regional perspective.	Appendix 2, Section 7.3
4	Assessment of contemporary scientific information on pressure response pathways, bio-indicators, thresholds, tolerance limits and resilience (resistance and recovery potential) of BCH that may be impacted by the dredging.	7.5
5	Assessment of spatial and temporal variability of BCH types within the potential impact area and associated influence on predicted impacts.	7.5
6	Collect adequate baseline water quality data to describe baseline light and turbidity values at sensitive receptors and to inform dredge plume impact modelling.	6.3, Appendix 5
7	Undertake dredge plume modelling to determine the location, extent and duration of a potential dredge plume. The modelling is to consider: a. Annual seasonal variability in nearshore current patterns as appropriate; b. Realistic sediment plume modelling outputs in units relevant to the scale of the dredging and potential impacts on biota, and based on likely dredge disposal locations, timing scenarios and equipment; and c. Potential worst-case impact scenarios to guide appropriate management	6.5.1, Appendix 6
8	Develop a Dredging and Spoil Disposal Management Plan (DSDMP). The DSDMP will be prepared in accordance with 'Instructions on how to prepare *Environmental Protection Act 1986* (WA) (EP Act) Part IV Environmental Management Plans' (Environmental Protection Authority (WA), 2018a) and Environmental Management Plan Guidelines (Cth DoE, 2014a, Department of the Environment and Energy (Commonwealth), 2018a). Consideration should also be given to the requirements of the *Environment Protection (Sea Dumping) Act 1981* (Sea Dumping Act) and associated guidance. The plan will consider the results of dredge plume modelling, sediment quality investigation baseline water quality and BCH surveys to inform monitoring and management. The plan will include:	6.6, 7.6, 8.6 Appendix 4.1

Task No.	Required work	Relevant section
	a. Presentation of model outputs and potential impacts in an impact zonation scheme including both Environmental Protection Outcomes (EPOs) and management targets; b. 'Most likely best case' and 'most likely worst case' impacts and losses of BCH for each of the dredge timing scenarios (e.g. accounting for seasonal variation in BCH or current patterns); c. Monitoring / management feedback loops and triggers to achieve the EPOs (focussing on the Zone of Moderate Impact / Zone of Influence Boundary) and management targets; d. Selection of indicators for management triggers to be used to assess achievement of EPOs and management triggers based on pressure response pathways and proposed adaptive management actions; e. Monitoring program including site locations and methods to provide data to allow assessment against the management triggers; f. Contingency management strategies to be employed if triggers are reached; and g. Performance criteria and method for demonstrating during and immediately following dredging that the impact predictions have been achieved, focusing on the Zone of Moderate Impact / Zone of Influence Boundary.	
9	Discuss the applicability of and need for a permit under the *Environment Protection (Sea Dumping) Act 1981* (Cth).	5.3.3
10	Undertake a water level assessment of the local intake creek.	5.5.3
11	Undertake a surface water flow and inundation study to produce a series of flood and storm surge maps for different event scenarios, with and without the Proposal (using confirmed Proposal general arrangement drawings and levels). It will incorporate weather data, accurate contour data and tidal information. The study will include the following: a. Modelling and assessment of inland surface water flows before and after the development of the Proposal, using several inflow scenarios (i.e. general creek flow events, large storm flows through to 1:5 year flow events including combined scenarios with tidal inundation). This will determine if, and the frequency of, any areas to be starved of this water and any areas that will flood due to the development; b. Assessment of the potential changes to the surface water regime with respect to the exposure of BCH to lower salinity waters and nutrient inputs associated with stormwater inflows; and c. Modelling and assessment of tidal flows before and after the development of the Proposal, using several scenarios (i.e. spring high tide through to storm surge events). This will determine which areas will remain inundated under a range of scenarios after these events and for how long (pre and post development).	5.3, Appendix 1
12	Undertake a literature review of current scientific knowledge regarding the potential changes in nutrient inputs and flow paths to coastal waters as a result of loss of algal mat BCH. Utilise this information to assess potential impacts to BCH (e.g. mangroves and seagrass meadows).	7.3, Appendix 2
13	Conduct permeability assessment of pond floors and walls to determine the likelihood of groundwater mounding interactions with underlying groundwater. If significant interactions are predicted then conduct hydrostatic modelling to determine if the potential for the movement of hypersaline groundwater towards mangrove habitat and assess potential impacts.	5.3, Appendix 11
14	Undertake a climate change intertidal habitat assessment, using the predicted sea level rise associated with climate change to undertake modelling.	5.5
15	Identify and assess any critical linkages between important marine fauna (including sea and coastal birds) and key BCH that are likely to be impacted.	7.5, 10.5.1
16	Characterise the biodiversity and functional ecological values and significance of BCH, particularly in relation to arid-tropical mangrove communities (Guidance Statement 1 – Protection of Tropical Arid Zone Mangroves along the Pilbara Coastline (EPA, 2001)).	7.3
17	Identify the proposed activities and the potential scale and significance of direct and indirect impacts to BCH.	7.4, 7.5

Task No.	Required work	Relevant section
18	Discuss proposed management, monitoring and mitigation methods to be implemented demonstrating that the design of the Proposal has addressed the mitigation hierarchy in relation to impacts on BCH. If management plans are to be developed to address specific impacts they are to comply with the Instructions on how to prepare EP Act Part IV Environmental Management Plans (EPA, 2018a) and Environmental Management Plan Guidelines (Cth DoE, 2014a; DotEE, 2018a).	7.5
19	Evaluate the combined direct and indirect impacts to BCH, after demonstrating how the mitigation has been considered and applied. Predictions shall: a. Align with the approaches and standards outlined in Technical Guidance - Protection of BCH (EPA, 2016c); b. Involve application of contemporary scientific information on pressure response pathways, bio-indicators, thresholds, tolerance limits and resilience (resistance and recovery potential) of BCH types in relation to dredging pressures; c. Consider any spatial and temporal variability of BCH types within the study area and how this effects the predicted impacts; d. Consider annual seasonal variability in nearshore current patterns and how this affects the predicted sediment plume and loss of BCH; e. Consider historic cumulative impacts to BCH within the LAUs; f. 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; g. Include an estimate of the level of confidence underpinning predictions of residual impacts; and h. Give consideration to plausible events with the potential to significantly impacting BCH including the introduction of marine pests, breached levee walls, hydrocarbon and other spills, and extreme episodic events (e.g. tropical lows and cyclones).	7.5
20	Ensure that the assessment of impacts is consistent with the requirements of the generic guidelines for the content of a draft *Environment Protection and Biodiversity Conservation Act 1999* (Cth) (EPBC Act) Public Environment Report (PER)/Environmental Impact Statement (EIS) (including the objects and principles of the EPBC Act, 1999) (DotEE, 2016b).	7.2
21	Provide figures of the proposed disturbance and predicted indirect impact to BCH.	7.5
22	Discuss closure and rehabilitation management measures, outcomes / objectives to be implemented. If a Mine Closure Plan is to be developed to address specific impacts then it is to be developed in accordance with Guidelines for Preparing Mine Closure Plans (DMP and EPA, 2015).	7.6.3
23	Discuss management measures, outcomes / objectives sought to ensure residual impacts (direct and indirect) are not greater than predicted.	7.6
24	Determine and quantify any significant residual impacts by applying the Residual Impact Significance Model (page 11) and WA Offset Template (Appendix 1) in the WA Environmental Offsets Guidelines (2014), the EPBC Act Environmental Offsets Policy and include reference to the Commonwealth Offset Assessment Guide for any Matters of National Environmental Significance (MNES).	12, Appendix 10
25	Where significant residual impacts remain, propose an appropriate offsets package that is consistent with the WA Environmental Offsets Policy and Guidelines and the EPBC Act Environmental Offsets Policy. Any proposed offsets package will be assessed against the six offsets principles in the WA Environmental Offsets Policy. Spatial data defining the area of significant residual impacts will also be provided.	12
26	Demonstrate and document in the ERD how the EPA objective for this factor can be met.	7.7
27	Demonstrate and document in the ERD information sufficient to allow the Commonwealth Minister to make an informed decision on whether or not to approve, under Part 9 of the EPBC Act, the taking of the action for the purposes of each controlling provision.	7.4, 7.5, 7.7, 13
Marine Environmental Quality		
28	Develop a DSDMP (refer to item 8).	6.6, 7.6, Appendix 4.1

Task No.	Required work	Relevant section
29	Undertake a baseline water quality assessment at the bitterns outfall location including physical characteristics and chemical constituents.	6.3, Appendix 5
30	Undertake a baseline sediment quality assessment at the outfall location including physical (i.e. particle size) and chemical (metals, tributyltin, hydrocarbons).	6.3, Appendix 5
31	Undertake bitterns outfall dilution modelling, utilising local conditions (bathymetry and tides) to determine: a. Dilution contours around the outfall, using several outfall designs; b. Dilution that can be achieved by discharge velocity alone (no underlying currents); and c. Predicted mixing zones required to meet the level of ecological protection of the waters surrounding the mixing zone.	6.5, Appendix 6
32	Conduct whole effluent toxicity (WET) testing to determine and describe the toxic effects of the bitterns discharge and predict the number of dilutions required to meet the different levels of ecological protection surrounding the outfall as shown in the Environmental Quality Plan (EQP- refer below). Specifically utilise available information to undertake a marine biota ecotoxicology assessment of local marine indicator species for proposed marine discharges.	6.5, Appendix 6
33	Describe and map the key sensitive biological receptors likely to be affected by the discharges. Provide a figure showing the receptors as an overlay on the EQP.	6.5
34	Utilise the findings of the bitterns outfall modelling and the boundary of the vessel loading area to develop proposed boundaries of Low and Moderate Ecological Protection Zones respectively. An EQP will be developed that will identify the ecological values to be protected and spatially define the Ecological Protection Zones. The EQP will be based on the updated *Pilbara Coastal Water Quality Consultation Outcomes – Environmental Values and Environmental Quality Objectives.*	6.5
35	Collect adequate baseline water and sediment quality data to document background marine environmental quality (including spatial and temporal variation) within the receiving marine environment. Baseline data acquisition will be adequate for the derivation of environmental quality criteria for indicators relevant to the discharge(s) e.g. water, sediment and/or infauna quality indicators.	6.3, Appendix 5
36	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).	6.5, Appendix 6
37	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).	6.3, Appendix 11
38	Undertake a study to identify any acid sulphate soils or sediment that could potentially be disturbed by the Proposal.	6.3, Appendix 5, Appendix 11
39	Characterise the ecological values and significance of marine environmental quality in the area that may be directly or indirectly impacted by the Proposal.	6.4, 6.5
40	Identify the proposed activities and the potential scale and significance of direct and indirect impacts to marine environmental quality.	6.4, 6.5
41	Discuss proposed management, monitoring and mitigation methods to be implemented demonstrating that the design of the Proposal has addressed the mitigation hierarchy in relation to impacts on marine environmental quality. If management plans are to be developed they are to apply the environmental quality management framework, be consistent with the requirements of the Commonwealth's Environmental Management Plan Guidelines (DotE, 2014a, DotEE, 2018a) and be designed to ensure the levels of protection listed in the EQP are achieved.	6.6
42	Discuss closure and rehabilitation management measures, outcomes / objectives to be implemented. If a Mine Closure Plan is to be developed to address specific impacts then	6.6.3

Task No.	Required work	Relevant section
	it is to be developed in accordance with *Guidelines for Preparing Mine Closure Plans* (DMP and EPA, 2015).	
43	Discuss management measures, outcomes / objectives sought to ensure residual impacts (direct and indirect) are not greater than predicted.	6.6
44	Determine and quantify any significant residual impacts by applying the Residual Impact Significance Model (page 11) and WA Offset Template (Appendix 1) in the WA Environmental Offsets Guidelines (2014), the EPBC Act Environmental Offsets Policy and include reference to the Commonwealth Offset Assessment Guide for any MNES.	6.7
45	Where significant residual impacts remain, propose an appropriate offsets package that is consistent with the WA Environmental Offsets Policy and Guidelines and the EPBC Act Environmental Offsets Policy. Any proposed offsets package will be assessed against the six offsets principles in the WA Environmental Offsets Policy. Spatial data defining the area of significant residual impacts will also be provided.	12, Appendix 10
46	Where significant residual impacts remain, propose an appropriate offsets package that is consistent with the WA Environmental Offsets Policy and Guidelines and the EPBC Act Environmental Offsets Policy. Spatial data defining the area of significant residual impacts should also be provided.	12, Appendix 10
47	Demonstrate and document in the ERD how the EPA objective for this factor can be met.	6.7
48	Demonstrate and document in the ERD information sufficient to allow the Commonwealth Minister to make an informed decision on whether or not to approve, under Part 9 of the EPBC Act, the taking of the action for the purposes of each controlling provision.	6.4, 6.5, 6.6, 6.7, 13
Marine Fauna		
49	Survey for relevant EPBC species listed in Appendix A in accordance with Commonwealth survey guidelines. Any deviations from these guidelines should be discussed and justified.	8.3, Appendix 7
50	Discuss the likely presence of these listed threatened species or their habitat within/near the proposed project area, in addition to any other EPBC Act listed species identified during the proposed faunal surveys.	8.3
51	Undertake benthic habitat field surveys as described in 'Benthic Communities and Habitat' section.	6.3, Appendix 2
52	Undertake a desktop review to identify what marine fauna species would be expected to utilise marine waters surrounding the Proposal, including those protected under the *EPBC Act and* those that may inhabit the Montebello Marine Park.	8.3, Appendix 7
53	Undertake a marine turtle field survey to identify the species present, population, key nesting beaches, foraging areas and their significance.	8.3, Appendix 7
54	Undertake a marine mammal field survey to identify the potential species present and populations.	8.3.1
55	Undertake a baseline light survey to identify the current light environment and undertake a light spill study to consider the direction and intensity of the expected light sources to determine whether the Proposal will attract turtle hatchlings or otherwise alter their behaviour. The light spill study will consider cumulative lighting impacts on the turtle population of the North West Shelf.	8.3, Appendix 7
56	Assess the impacts of jetty and other structures located adjacent to important marine turtle nesting habitat.	8.5
57	Undertake underwater noise risk assessment that includes a sensitivity assessment of the marine fauna likely to occur in the area during construction activities such as piling and dredging. The risk assessment is to include (but not limited to) disturbance to resting or nursing Humpback Whale mothers and calves.	8.5, Appendix 7
58	Undertake a desktop Introduced Marine Pests (IMPs) investigation, including: a. Review to define baseline IMPs; and	7.5, 8.5 Appendix 2

Task No.	Required work	Relevant section
	b. Risk assessment for the introduction of IMPs during construction (dredging and other construction vessels) and operations	
59	Develop a DSDMP as previously described in Item 8. The DSDMP will include management actions to prevent injury and death to marine fauna.	8.5, Appendix 4.1
60	Identify any significant marine fauna (as well as ecological 'keystone' species, species important to commercial and recreational fishers) likely to be found in the area of influence of the Proposal, including commercially important species, species protected under the EPBC Act and migratory species.	8.3
61	Identify any critical periods for key environmental/life cycle events for marine fauna (e.g. turtle nesting).	8.3.12
62	Identify likelihood of significant marine fauna species occurring near the development envelopes, including: a. Information on the abundance, distribution, ecology and habitat preferences of any significant species; b. Information on the conservation value of each habitat type from a local and regional perspective; c. If a population of a significant species is present and may be impacted by the Proposal, its size and the importance of that population from a local and regional perspective; d. Baseline mapping of local occurrences; e. An assessment of the risk of impact to any listed threatened species as a result of project activities ; f. For any impact identified, appropriate mitigation/management measures to reduce the level of impact; and g. An assessment of residual impact to each species after all avoidance and mitigation measures are undertaken.	8.3
63	Characterise the ecological values and significance of marine fauna and habitat in the area that may be directly or indirectly impacted by the Proposal.	8.4, 8.5
64	Identify the proposed activities and the potential scale and significance of direct and indirect impacts to marine fauna, giving regard to any relevant EPBC Act Threat Abatement Plan, Recovery Plan or Approved Conservation advice.	8.4, 8.5
65	Discuss proposed management, monitoring and mitigation methods to be implemented demonstrating that the design of the Proposal has addressed the mitigation hierarchy in relation to impacts on marine fauna. If management plans are to be developed to address specific impacts they are to comply with the Instructions on how to prepare EP Act Part IV Environmental Management Plans (EPA, 2018a) and Environmental Management Plan Guidelines (Cth DotE, 2014a; DotEE, 2018a).	8.6
66	Quantify and assess the impacts of all shipping and proposal-related boat traffic and identify mitigation measures to avoid and minimise marine fauna collisions and noise / light related impacts.	8.6
67	Discuss closure and rehabilitation management measures, outcomes / objectives to be implemented. If a Mine Closure Plan is to be developed to address specific impacts then it is to be developed in accordance with Guidelines for Preparing Mine Closure Plans (DMP and EPA, 2015).	8.6.3
68	Discuss management measures, outcomes / objectives sought to ensure residual impacts (direct and indirect) are not greater than predicted.	8.6
69	Determine and quantify any significant residual impacts by applying the Residual Impact Significance Model (page 11) and WA Offset Template (Appendix 1) in the WA Environmental Offsets Guidelines (2014), the EPBC Act Environmental Offsets Policy and include reference to the Commonwealth Offset Assessment Guide for any MNES.	12, Appendix 10
70	Where significant residual impacts remain, propose an appropriate offsets package that is consistent with the WA Environmental Offsets Policy and Guidelines and the EPBC Act Environmental Offsets Policy. Any proposed offsets package will be assessed against the six offsets principles in the WA Environmental Offsets Policy. Spatial data defining the area of significant residual impacts will also be provided.	12, Appendix 10

Task No.	Required work	Relevant section
71	Demonstrate and document in the ERD how the EPA objective for this factor can be met.	8.7
72	Demonstrate and document in the ERD information sufficient to allow the Commonwealth Minister to make an informed decision on whether or not to approve, under Part 9 of the EPBC Act, the taking of the action for the purposes of each controlling provision.	8.4, 8.5, 8.6, 8.7, 13
Flora and Vegetation		
73	Undertake detailed and targeted flora and vegetation surveys in accordance with Technical Guidance – Flora and Vegetation Surveys for Environmental Impact Assessment (EPA, 2016) and other specific guidance identified in Appendix A in areas that are likely to be directly or indirectly impacted by the proposal, and more broadly if required to inform local and regional context. Weed information collected by the Pilbara Mesquite Management Committee is to be incorporated in the survey information.	9.3, Appendix 8
74	Provide figures of the proposed direct and predicted indirect impact to significant vegetation and flora species	9.3.3, 9.3.4
75	Provide an analysis of the vegetation and significant flora species present and likely to be present within the proposed disturbance footprint and the Development Envelope, including any potential indirect impact areas outside of the Development Envelope. Include an assessment of the significance of flora and vegetation in a local and regional context (refer to Environmental Factor Guideline – Flora and Vegetation and relevant EPBC Act guidance (Appendix A) for definition of significance). Include a quantitative assessment of levels of impact on significant flora, priority ecological communities and all vegetation units. a. For significant flora, this includes: i. Number of individuals and population records in a local and regional context, ii. Numbers and proportions of individuals and populations directly or potentially indirectly impacted, and iii. Numbers/proportions/populations currently protected within the conservation estate (where known). b. For significant ecological communities and all vegetation units this includes i. The area (in hectares) and proportions directly or potentially indirectly impacted, and ii. Proportions / hectares of the species, community or vegetation unit currently protected within conservation estate.	9.3.3, 9.3.4, 9.4, 9.5
76	Demonstrate that all practicable measures have been taken to reduce both the area of the proposed disturbance footprint and the Development Envelope based on progress in the Proposal design and understanding of the environmental impacts.	2.2.2
77	Undertake a groundwater abstraction study if GDEs are identified in areas targeted for water supply. This will assess the abstraction requirements from each bore location and determine whether the drawdown would be significant within the boundary of any GDEs.	2.3.5
78	Characterise the ecological values and significance of flora and vegetation in the Development Envelopes and any areas that may be indirectly impacted by the Proposal.	9.4, 9.5
79	Identify the proposed activities and the potential scale and significance of direct and indirect impacts to flora and vegetation.	9.4, 9.5
80	Discuss proposed management, monitoring and mitigation methods to be implemented demonstrating that the design of the Proposal has addressed the mitigation hierarchy in relation to impacts on flora and vegetation. If management plans are to be developed to address specific impacts they are to comply with the 'Instructions on how to prepare *EP Act* Part IV Environmental Management Plans (EPA, 2018a) and Environmental Management Plan Guidelines (Cth DotE, 2014a, DotEE, 2018a).	9.6
81	Discuss closure and rehabilitation management measures, outcomes / objectives to be implemented. If a Mine Closure Plan is to be developed to address specific impacts then it is to be developed in accordance with Guidelines for Preparing Mine Closure Plans (DMP and EPA, 2015).	9.6.3
82	Discuss management measures, outcomes / objectives sought to ensure residual impacts (direct and indirect) are not greater than predicted.	9.6

Task No.	Required work	Relevant section
83	Determine and quantify any significant residual impacts by applying the Residual Impact Significance Model (page 11) and WA Offset Template (Appendix 1) in the WA Environmental Offsets Guidelines (2014), the EPBC Act Environmental Offsets Policy and include reference to the Commonwealth Offset Assessment Guide for any MNES.	9.7
84	Where significant residual impacts remain, propose an appropriate offsets package that is consistent with the WA Environmental Offsets Policy and Guidelines and the EPBC Act Environmental Offsets Policy. Any proposed offsets package will be assessed against the six offsets principles in the WA Environmental Offsets Policy. Spatial data defining the area of significant residual impacts will also be provided.	12, Appendix 10
85	Demonstrate and document in the ERD how the EPA objective for this factor can be met.	9.7
86	Demonstrate and document in the ERD information sufficient to allow the Commonwealth Minister to make an informed decision on whether or not to approve, under Part 9 of the EPBC Act, the taking of the action for the purposes of each controlling provision.	9.4, 9.5, 9.6, 9.7, 13
Terrestrial Fauna		
87	Survey for relevant EPBC species listed in Appendix A in accordance with Commonwealth survey guidelines. Any deviations from these guidelines should be discussed and justified.	10.3, Appendix 9
88	Discuss the likely presence of these listed threatened species or their habitat within/near the proposed project area, in addition to any other EPBC Act listed species identified during the proposed faunal surveys.	10.3.4
89	Undertake a desktop fauna study in accordance with the EPA technical guidance for Terrestrial Fauna to determine the fauna that may be present within the Proposal Area or indirectly impacted by the Proposal. The study will consider significant fauna species including relevant EPBC species listed in Appendix A in accordance with Commonwealth survey guidelines and will focus on identifying species that may have significant habitat that could be impacted. Any deviations from survey guidelines should be discussed and justified.	10.3, Appendix 9
90	Undertake Targeted Level 2 migratory coastal bird field survey to determine what coastal bird species would be expected to utilise the shorelines surrounding the Proposal. Assessments should not be limited to surveys over a single season and considerations should be given to irregular visitation over a medium to long term cycle. Survey should also focus on numbers to determine the significance of the area on a national and international scale. Surveys should be conducted in accordance with EPBC Act Policy Statement 3.21 (Industry guidelines for avoiding, assessing and mitigating impacts on EPBC Act listed migratory coastal bird species) (DotEE, 2017a).	10.3, Appendix 9
91	Undertake a targeted Night Parrot survey in accordance with Interim guideline for preliminary surveys of night parrot in Western Australia (DPaW, 2017) and EPBC Act Survey Guidelines for threatened birds (DEWHA, 2010) to predict presence / absence of this species. Specialist opinion should be sought to confirm recordings of Night Parrot from persons with experience in this species. If it is recorded then Department of Biodiversity, Conservation and Attractions (DBCA) will be approached to determine the most appropriate course of action regarding range and population estimates.	10.3, Appendix 9
92	Undertake terrestrial fauna surveys in accordance with EPA Guidance and EPBC Act survey guidelines as identified in Appendix A to provide/identify: a. Fauna habitat mapping, identifying special or constrained habitat; b. Presence of significant fauna species; c. Likelihood of other significant fauna being present; d. Population and habitat description for any listed fauna that were found; and e. Presence of feral fauna species	10.3, Appendix 9
93	Undertake a Level 2 SRE fauna survey in accordance with EPA Guidance to identify the presence of SRE species and undertake habitat mapping.	10.3, Appendix 9
94	Data analyses, specimen processing and species identifications for specimens collected during the field surveys.	10.3, Appendix 9

Task No.	Required work	Relevant section
95	Produce maps showing the locations of significant species records in relation to the areas of impact and habitats in the development envelopes.	10.3
96	Provide flexibility in development envelopes to allow the avoidance of any significant fauna habitat if identified during surveys.	2.2.2
97	For each relevant significant species identified within the development envelopes, provide: a. Baseline information on their known occurrences, distribution, ecology, and habitat preferences at both the site and regional levels; b. Information on the conservation value of each fauna habitat type from a local and regional perspective, including the percentage representation of each habitat type on site in relation to its local extent; and c. Maps illustrating the known recorded locations of conservation significant species and SRE invertebrates in relation to the proposed disturbance and areas to be impacted.	10.3.7
98	Consider habitat types that provide important ecological function within the development envelopes (e.g. refugia, important habitat corridors, areas of conservation significance or geological features which may support unique ecosystems).	10.3.2
99	Characterise the ecological values and significance of terrestrial fauna in the Development Envelopes and any areas of habitat that may be indirectly impacted by the Proposal.	10.4
100	Quantify the extent of direct and indirect impacts, including percentages of habitat types to be disturbed or otherwise impacted, to assist in determination of significance of impacts. Information, including maps, will also differentiate habitat on the basis of use if required e.g. breeding habitat, foraging / feeding / dispersal habitat. Consider whether the remaining habitat has adequate carrying capacity.	10.4, 10.5
101	Discuss known existing threats to any significant species, whether or not attributable to the proposal, with reference to relevant impacts from the Proposal.	10.5
102	Provide a detailed description of the potential direct, indirect and cumulative impacts to significant and SRE fauna species within the development envelopes and on a regional scale.	10.3.7
103	Provide figures clearly showing the predicted impacts (both direct and indirect) on conservation significant fauna and other fauna species, including amount of habitat.	10.3, 10.5
104	Discuss proposed management, monitoring and mitigation methods to be implemented including an assessment of the effectiveness of the methods, any statutory or policy basis for the methods and demonstrate that the design of the proposal has addressed the mitigation hierarchy in relation to impacts on terrestrial fauna. If management plans are to be developed to address specific impacts they are to comply with the Instructions on how to prepare *EP Act* Part IV Environmental Management Plans (EPA, 2018a) and Environmental Management Plan Guidelines (Cth DotE, 2014a, DotEE, 2018a).	10.6
105	Discuss closure and rehabilitation management measures, outcomes / objectives to be implemented. If a Mine Closure Plan is to be developed to address specific impacts then it is to be developed in accordance with Guidelines for Preparing Mine Closure Plans (DMP and EPA, 2015).	10.6.3
106	Identify management and mitigation measures to ensure residual impacts are not greater than predicted.	10.6
107	Determine and quantify any significant residual impacts by applying the Residual Impact Significance Model (page 11) and WA Offset Template (Appendix 1) in the WA Environmental Offsets Guidelines (2014), the EPBC Act Environmental Offsets Policy and include reference to the Commonwealth Offset Assessment Guide for any MNES.	12, Appendix 10
108	Where significant residual impacts remain, propose an appropriate offsets package that is consistent with the WA Environmental Offsets Policy and Guidelines and the EPBC Act Environmental Offsets Policy. Any proposed offsets package will be assessed against the six offsets principles in the WA Environmental Offsets Policy. Spatial data defining the area of significant residual impacts will also be provided.	12, Appendix 10

Task No.	Required work	Relevant section
109	Demonstrate how the EPA's objective for this factor will be met.	10.7
110	Demonstrate and document in the ERD information sufficient to allow the Commonwealth Minister to make an informed decision on whether or not to approve, under Part 9 of the EPBC Act, the taking of the action for the purposes of each controlling provision.	10.4, 10.5, 10.6, 10.7, 13
Inland Waters		
111	Undertake a surface water flow and inundation study to produce a series of flood and storm surge maps for different event scenarios, with and without the Proposal (using confirmed Proposal general arrangement drawings and levels). It will incorporate weather data, accurate contour data and tidal information. The study will include the following: a. Modelling and assessment of inland surface water flows before and after the development of the Proposal, using several inflow scenarios (i.e. large storm flows through to 1:5 year flow events). This will determine which areas will be starved of this water and any areas that will flood due to the Proposal; b. Modelling and assessment of tidal flows before and after the development of the Proposal, using several scenarios (i.e. spring high tide through to storm surge and cyclonic events). This will determine which areas will remain inundated under a range of scenarios after these events and for how long (pre- and post-development).	5.5.2
112	Undertake a desktop ASS risk assessment to determine the risk of presence of ASS. Undertake an ASS survey if results from the desktop risk assessment identify this to be necessary.	5.3, Appendix 5, Appendix 11
113	If the Proposal is predicted to result in seepage to groundwater or mounding then undertake a hydrogeological study to determine the quantity and quality changes to the surrounding groundwater systems as a result of seepage and/or mounding from ponds. The study is to be informed by the baseline characterisation studies and will include conceptual water balance.	5.5, Appendix 6
114	Desktop water supply assessment to identify a contingency fresh water supply source for the Proposal (in addition to desalination) and estimate potential yields and impacts based on the available hydrogeological information.	N/A, refer to 2.3.5
115	Pump-testing of existing groundwater supply bores identified in the desktop study, and collection of baseline data. Verify impact predictions provided in desktop study.	N/A, refer to 2.3.5
116	Characterise the baseline hydrological and hydrogeological regimes and water quality, both in a local and regional context, including, but not limited to water levels, stream flows, flood patterns and water quantity and quality.	5.3
117	Undertake baseline surface water quality sampling of the ephemeral creek lines that run through the development envelopes (i.e. if surface water is present).	N/A due to no surface water flows, refer to 5.3.4
118	Identify and characterise any environmental receptors that may be impacted by changes to inland waters as a result of this Proposal.	5.3, 5.4
119	Provide a detailed description of the Proposal aspects that have the potential to impact inland waters.	5.4, 5.5
120	Discuss the proposed management, monitoring and mitigation to avoid and minimise impacts to inland waters, and potential flow-on effects on the surrounding environment as a result of implementing the proposal. If management plans are to be developed to address specific impacts they are to comply with the Instructions on how to prepare EP Act Part IV Environmental Management Plans (EPA, 2018a) and Environmental Management Plan Guidelines (Cth DotE, 2014a, DotEE, 2018a).	5.6
121	Discuss closure and rehabilitation management measures, outcomes / objectives to be implemented. If a Mine Closure Plan is to be developed to address specific impacts then it is to be developed in accordance with Guidelines for Preparing Mine Closure Plans (DMP and EPA, 2015).	5.6.3

Task No.	Required work	Relevant section
122	Detail management, monitoring and mitigation measures to ensure residual impacts on inland waters are not greater than predicted.	5.6
123	Determine and quantify any significant residual impacts by applying the Residual Impact Significance Model (page 11) and WA Offset Template (Appendix 1) in the WA Environmental Offsets Guidelines (2014), the EPBC Act Environmental Offsets Policy (2012) and include reference to the Commonwealth Offsets Assessment Guide for any MNES.	12, Appendix 10
124	Where significant residual impacts remain, propose an appropriate offsets package that is consistent with the WA Environmental Offsets Policy and Guidelines and the EPBC Act Environmental Offsets Policy. Any proposed offsets package will be assessed against the six offsets principles in the WA Environmental Offsets Policy. Spatial data defining the area of significant residual impacts will also be provided.	12, Appendix 10
125	Demonstrate in the ERD how the EPA's objective for this factor will be met.	5.7
126	Demonstrate and document in the ERD information sufficient to allow the Commonwealth Minister to make an informed decision on whether or not to approve, under Part 9 of the EPBC Act, the taking of the action for the purposes of each controlling provision.	5.4, 5.5, 5.6, 5.7, 13
Social Surroundings		
127	Undertake a community impact study to identify what public access areas (i.e. camping and fishing areas) will have restricted access once the Proposal is implemented. If areas are identified as being impacted, then additional work may be required to identify the number of people that use the area and whether access can be maintained.	11.3.1
128	Undertake a heritage assessment (European and Aboriginal), utilising desktop information, and archaeological and ethnographic heritage surveys as required in order to: a. Make an assessment of listed heritage sites; b. Determine the importance of the site from an Aboriginal perspective (including heritage sites, and traditional uses such as bush tucker and medicine); and c. Assess the likelihood of significant European or Aboriginal heritage sites being present on site, including early shipwrecks	11.3.3, 11.3.4, 11.3.5, 11.3.6
129	Conduct consultation with traditional owners during the assessment process to determine the heritage values of the development envelopes.	3.3
130	Conduct community consultation to determine if there are any recreational areas that can be retained.	3.3
131	Characterise the values and significance of social surroundings in the vicinity of the Proposal.	11.3.6
132	Identify the proposed activities and the potential scale and significance of direct and indirect impacts to social surrounding.	11.4
133	Ensure sufficient measures are taken in design, construction and operation to limit impacts to social surroundings, including: a. Conduct Aboriginal heritage surveys and avoid significant sites if practicable; b. Consult with relevant stakeholders and seek approval under Section 18 of the *Aboriginal Heritage Act 1972* if significant sites cannot be avoided; c. Incorporate bush tucker and medicine information to allow avoidance and minimisation of impacts; and d. Continue consultation with the Traditional Owners regarding the minimisation of impacts to traditional uses of the area.	2.2.2, 3.3, 11.5
134	Discuss the proposed management, monitoring and mitigation to prevent impacts to social surroundings as a result of implementing the proposal.	11.6
135	Discuss closure and rehabilitation management measures, outcomes / objectives to be implemented. If a Mine Closure Plan is to be developed to address specific impacts then it is to be developed in accordance with Guidelines for Preparing Mine Closure Plans (DMP and EPA, 2015).	11.6.3
136	Demonstrate how the EPA's objective for this factor will be met.	11.7

EXECUTIVE SUMMARY

THE PROPOSAL

Mardie Minerals Pty Ltd (Mardie Minerals) is seeking to develop the Mardie Project (the Proposal) located in the western Pilbara region of Western Australia (WA), approximately 80 kilometres (km) south west of Karratha (Figure 1). Mardie Minerals is a wholly-owned subsidiary of BCI Minerals Limited.

The development envelopes for the Proposal are shown in Figure 2 and an indicative Proposal layout is provided in Figure 3.

A summary of the Proposal is provided in Table ES1 and the key proposal elements (e.g. development, action, activities or processes) which have potential to cause an impact on the environment are summarised in Table ES2.

Table ES1: Key characteristics of the Proposal

Proposal Title	Mardie Project
Proponent Name	Mardie Minerals Pty Ltd
Short Description	Mardie Minerals Pty Ltd seeks to develop a greenfields high quality salt and sulphate of potash (SoP) project and associated export facility at Mardie, approximately 80 km south west of Karratha, in the Pilbara region of WA. The proposal will produce a high purity salt product, SoP and other products that can be derived from sea water. The Proposal includes the development of seawater intakes, concentrator and crystalliser ponds, processing plants, bitterns disposal pipeline and outfall diffuser, trestle jetty export facility, dredge channel, causeway, drainage channels, access / haul roads, desalination (reverse osmosis) facilities, borrow pits, pipelines, and associated infrastructure including: power supply, communications equipment, offices, workshops, accommodation village, laydown areas, sewage treatment plant, landfill facility.

Table ES2: Location and proposed extent of physical and operational elements

Element	Location	Proposed Extent
Physical Elements		
1. **Ponds and Terrestrial Infrastructure Development Envelope –** concentrator and crystalliser ponds, processing plant, access / haul road, desalination facilities, causeway and stockyards, small boat launching facility, administration, laydown, other associated infrastructure.	Figure 2	Disturbance of no more than 11,142 ha within the 15,667 ha Ponds and Terrestrial Infrastructure Development Envelope.
2. **Marine Development Envelope –** trestle jetty, seawater intake and pipelines.	Figure 2	Disturbance of no more than 7 ha, within the 53 ha Marine Development Envelope. The northern end of the causeway will not extend onto or past the sandy beach.
3. Dredge Channel Development Envelope – berth pocket, channel to allow access for transhipment vessels, bitterns outfall diffuser.	Figure 2	Disturbance of no more than 55 ha within the 304 ha Dredge Channel Development Envelope.

Element	Location	Proposed Extent
4. Mangrove Disturbance	Figure 2	Disturbance of mangrove communities limited to 17 ha of Scattered Canopy mangroves.
Operational Elements		
Desalination Plant discharge	Figure 2	Discharge into ponds or bitterns stream only.
Dredge volume	Figure 2	Dredging is only to occur within the Dredge Channel Development Envelope. Dredging of no more than 800,000 m^3 of material from the berth pocket and high points within the dredge channel, with the material to be deposited onshore within the Ponds and Terrestrial Infrastructure Development Envelope.
Bitterns discharge	Figure 2	Discharge of up to 3.6 gigalitres (GL) per annum of bitterns with a specific gravity no more than 1.25 via a diffuser, within a Low Ecological Protection Area. Bitterns is to be diluted with seawater prior to discharge.
Pond seawater intake	Figure 2	Up to 150 GL per annum, from a screened intake with a maximum average intake flowrate at the screen of less than 0.15 m/s. Seawater abstraction will only occur when water levels are at mean sea level or higher,

PRELIMINARY KEY ENVIRONMENTAL FACTORS

The Environmental Protection Authority (EPA) identified the following preliminary key environmental factors for this Proposal:

- Inland Waters
- Marine environmental quality;
- Benthic communities and habitats;
- Marine fauna;
- Flora and vegetation;
- Terrestrial fauna; and
- Social surroundings.

Table ES3 summarises relevant information on the potential impacts, mitigation and outcomes for each of the preliminary key environmental factors identified by the EPA. The appendices provide supporting studies and investigations undertaken to inform this Environmental Review, the key elements of which are included in this document.

Table ES3: Summary of potential impacts, proposed mitigation and outcomes

Inland Waters	
EPA objective	The EPA Objective for this key environmental factor is to maintain the hydrological regimes and quality of groundwater and surface water so that environmental values are protected.
Policy and guidance	• Statement of Environmental Principles, Factors and Objectives (EPA, 2016a) • Statutory Guidelines for Mine Closure Plans (Department of Mines, Industry Regulation and Safety (DMIRS)), 2020) • Environmental Impact Assessment (EIA) (Part IV Divisions 1 and 2) Administrative Procedures 2016 • EIA (Part IV Divisions 1 and 2) Procedures Manual 2016 • Instructions on how to prepare *EP Act* Part IV Environmental Management Plans (EPA, 2018a) • Environmental Factor Guideline – Inland Waters (EPA, 2018b) • 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) • WA Water in Mining Guideline. Water licensing delivery report series. Report No. 12. (Department of Water (DoW), 2013) • Operational Policy 5.12 – Hydrogeological reporting associated with a groundwater well licence (DoW, 2009) • WA Environmental Offsets Policy (EPA, 2011) • WA Environmental Offsets Guidelines (EPA, 2014) • WA Offsets Template (EPA, 2014) • Generic guidelines for the content of a draft EPBC Act PER/Environmental Impact Statement (EIS) (including the objects and principles of the EPBC Act 1999) (DotEE, 2016b) • Other Minister of the Environment (Cth) approval decision making considerations • EPBC Act Environmental Offsets Policy (Department of Sustainability, Environment, Water, Population and Communities, 2012) (DSEWPaC, now DAWE) – including the Offset Assessment guide • Environmental Management Plan Guidelines (DotE, 2014a) • Environmental Management Plan Guidelines, - template (DotEE, 2018a) • EPBC Act Condition Setting Policy (DotE, 2016b) • EPBC Act Outcomes-based conditions policy (DotE, 2016c) • Relevant EPBC listed species specific survey guidelines and protocols • Relevant EPBC listed species specific Recovery plans, Threat Abatement Plans, Approved Conservation Advices and other documents
Potential impacts	**Groundwater** • Potential mounding and surface expression of fresh groundwater inland of the ponds • Seepage from ponds resulting in elevated salinity in underlying groundwater • Changes in groundwater salinity regimes due to mounding **Inland surface waters** • Realignment of drainage lines • Alteration or changes in surface water flows and flooding regimes • Reduction in surface water flows due to the capture of rainfall within the ponds • Indirect surface water quality impacts **Mardie Pool** • Changes to intermittent intertidal water inflows • Reduction in surface water inflows due to the capture of rainfall within the ponds • Indirect surface water quality impacts • Ongoing impacts associated with pastoral activities **Intertidal zone** • Alteration of tidal regimes due to a reduction in intertidal zone and installation of a causeway • Abstraction of 150 GL/yr of seawater from a tidal creek • Coastal erosion as a result of runoff from constructed landforms including bunding and infrastructure • Indirect surface water quality impacts • Restriction of inland movement of zone due to sea level rise

Mitigation	**Avoid:**
	• The Proposal and its development envelopes boundaries have been designed to avoid the following:
	  ○ The majority of the intertidal zone where environmental values are present, such as mangrove and algal mats
	  ○ Crossing of Mardie tributaries, by relocating the causeway alignment to the east
	  ○ 13 of the 15 tidal creeks
	  ○ Peter Creek – the southern-most pond wall was relocated to avoid Peter Creek and retain flows into the intertidal zone
	  ○ Mardie Pool
	• A trestle jetty has been proposed which avoids impacts to the water movement within the offshore intertidal zone, thereby preserving coastal processes
	• Impacts associated with groundwater abstraction have been avoided by the use of seawater desalination and the use of a third party water supply as an interim measure
	• Impacts associated with the reverse osmosis waste have been avoided by utilising the waste brine in the salt production process (pumped to a concentrator pond or discharged through the bitterns stream)
	Minimise
	• Obtain and comply with approvals under Part IV and V of the EP Act, *Mining Act 1978* and *Port Authorities Act 1999*
	• Monitor groundwater levels and quality down-gradient of the concentrator and crystalliser ponds
	• Install cut-off bores, sumps and / or trenches and pump the water to the appropriate salinity pond if the levels or quality are out of an acceptable range
	• Prepare and implement a Mardie Pool Monitoring and Management Plan (MPMMP)

	• Install a combination of engineered floodways and culverts along the causeway alignment to ensure intertidal flow regimes are maintained either side of the causeway • All existing inland drainage lines are to be diverted around the ponds or through one of the drainage channels • The drainage system will include overflow structures to safely direct surface water flow from rainfall events greater than 1 in 50 ARI into the concentrator ponds • Prepare and implement an Erosion and Sediment Control Plan (ESCP) for the construction phase, to ensure that erosion and sediment control strategies and measures are implemented consistent with industry best practice guidelines • Verify inundation modelling results after construction to ensure potential indirect impacts to the tidal regimes of the intertidal zone are within predicted outcomes • Concentrator and crystalliser ponds will be designed and constructed to be safe and stable • Routinely inspect the condition and performance of pond walls, pipelines, containment systems and internal drainage structures • Implement a series of controls to further reduce the risk of impact from unintentional brine pipeline spills • Monitor erosion at the outlets of the surface water corridors after each significant flow event • Comply with Water Quality Protection Guidelines and guidance notes • Collect and assess additional soil samples regularly for Acid Sulfate Soils (ASS) during construction of the pond walls and during dredging; • Limit seawater abstraction to 150 GL/yr by including the limit in the Key Characteristics Table • Abstract seawater from the designated tidal creek only when tides are above Mean Sea Level (MSL) **Rehabilitate** • Implement Mine Closure Plan (MCP) to be approved under the *Mining Act 1978* • Salts will be harvested from each pond prior to closure • Concentrator pond walls will be opened up to allow tidal flows to enter the ponds • All infrastructure, including the causeway will be removed if not retained by Mardie Station or PPA • Key surface water drainage systems will be reinstated
Outcomes	The presence of the causeway and concentrator and crystalliser ponds will result in changes to hydrological regimes, both tidal and overland. Mardie Minerals has incorporated floodways and culverts into the causeway design, significant drainage corridors (>200 m) into the pond design, and has relocated the development envelopes inland to minimise impacts to tidal regimes within the intertidal zone. As a result the Proposal is predicted to be able to be developed without significant impacts to hydrological regimes. Potential impacts to inland water quality can be appropriately managed under Part V of the EP Act via a works approval and licence, as the Proposal will be considered under the 'solar salt manufacturing' category in Schedule 1 of the Environmental Protection Regulations 1987. A Mining Proposal issued under the *Mining Act 1978* will also provide additional regulation for activities that are considered under that Act, such as pond wall geotechnical design and erosion. The seawater intake is considered to be adequately managed under Part V of the EP Act via a works approval and licence however an intake volume limit is expected to be required under Part IV of the EP Act to enforce the commitments made above. Sea level rise is predicted to completely alter the intertidal zone west of the development envelopes and modelling predicts that the Proposal will not add to these alterations, however it will bring the timing of the changes forward by an estimated 20 years. Based on the above, the Proposal is expected to be able to be implemented in a way that maintains hydrological regimes and quality of groundwater and surface water so that environmental values are protected. The EPA objective for this factor is therefore able to be met.
Marine Environmental Quality	
EPA objective	The EPA Objective for this key environmental factor is to maintain the quality of water, sediment and biota so that environmental values are protected.
Policy and guidance	• Statement of Environmental Principles, Factors and Objectives 2016 (EPA, 2016a) • Statutory Guidelines for Mine Closure Plans (DMIRS, 2020) • EIA (Part IV Divisions 1 and 2) Administrative Procedures 2016 • EIA (Part IV Divisions 1 and 2) Procedures Manual 2016 • Instructions on how to prepare Environmental Protection Act Part IV Environmental Management Plans (EPA, 2018a) • Environmental Factor Guideline – Marine Environmental Quality (EPA, 2016f) • Technical Guidance – Protection of BCH (EPA, 2016c) • Technical Guidance – Protecting the Quality of Western Australia's Marine Environment (EPA, 2016d) • Technical Guidance – Environmental Impact Assessment of Marine Dredging Proposals (EPA, 2016e) • Identification and investigation of acid sulphate soils and acidic landscapes (DoER, 2015a) • Treatment and management of soil and water in acid sulphate soil landscapes (DoER, 2015b)

	• Pilbara Coastal Water Quality Consultation Outcomes – Environmental Values and Environmental Quality Objectives, DoE, Government of WA, Marine Series Report No. 1 (DoE, 2006) • Australian and New Zealand Guidelines for Fresh and Marine Water Quality (ANZG, 2018) • WA Environmental Offsets Policy (EPA, 2011) • WA Environmental Offsets Guidelines (EPA, 2014) • WA Offsets Template • Generic guidelines for the content of a draft EPBC Act PER/EIS (including the objects and principles of the EPBC Act 1999) (DotEE, 2016b) • Other Minister of the Environment (Cth) approval decision making considerations • EPBC Act Environmental Offsets Policy (DSEWPaC, 2012) – including the Offset Assessment guide • Environmental Management Plan Guidelines (DotE, 2014a) • Environmental Management Plan Guidelines, - template (DotEE, 2018a) • EPBC Act Condition Setting Policy (DotE, 2016b) • EPBC Act Outcomes-based conditions policy (DotE, 2016c) • *Environment Protection (Sea Dumping) Act 1981* • National Assessment Guidelines for Dredging (DEWHA, 2009b) • Relevant EPBC listed species specific survey guidelines and protocols • Relevant EPBC listed species specific Recovery plans, Threat Abatement Plans, Approved Conservation Advices and other documents • Marine bioregional plan for the North-west Marine Region (DSEWPaC, 2012b) • Environmental best practice port development: an analysis of international approaches (GHD, 2013)
Potential impacts	**Marine waters surrounding port infrastructure** • Discharge of up to 3.6 GL/yr of bitterns • Increased turbidity caused by dredging activities (construction) or vessel movements (propeller churn) • Spills of salt products during transfer to port vessels • Hydrocarbon spills from vessels **Tidal creeks** • Hydrocarbon spills associated with seawater intake or small boat launching facility • Increase in salinity due to leaks or spills of brine from ponds or pipelines • Sedimentation due to runoff during construction or during construction of seawater intake or small boat launching facility
Mitigation	**Avoid** • Bitterns will not be discharged within the intertidal zone by requiring the outfall to be located offshore within the Dredge Channel Development Envelope • Dredging will not occur within the intertidal zone by proposing dredging only within the Dredge Channel Development Envelope • The disposal of dredge material offshore has been avoided by bringing the material to shore for use in construction **Minimise** • Obtain and comply with approvals under Part IV and V of the EP Act, *Mining Act 1978* and *Port Authorities Act 1999* • The Key Proposal Characteristics (Section 2.3.2) provide several limits that were included to minimise impacts to marine environmental quality • Implement the Marine Environmental Quality Monitoring and Management Plan (MEQMMP; Appendix 3.1) • Finalise and implement the Dredge Spoil Disposal Management Plan (DSDMP; Appendix 4.1) • Dredge material is to be placed into a container to allow a crane to transfer the container to trucks via the trestle jetty • Ensure fuel is stored within self-bunded tanks or within a bunded area • Concentrator and crystalliser ponds will be designed and constructed to be safe and stable according to DMIRS requirements • A series of controls will be used to minimise the risk of impact from unintentional brine pipeline spills • Monitor erosion at the outlets of the drainage corridors after significant flow events and install erosion protection (i.e. rock baffles etc.) if required • Visually monitor sediment plumes during the construction of the seawater intake and small boat launching facility **Rehabilitate:** • Implement MCP approved under the *Mining Act 1978* • All marine infrastructure including the jetty, wharf, seawater intakes, boat launching facility and navigation infrastructure will be removed and taken offsite • The dredge channel will be left to gradually fill with sediment.

<table>
<tr><td>Outcomes</td><td>The Proposal will require dredging to develop the transhipment corridor, which will result in impacts on water quality in the vicinity of the dredging activities during dredging and for a short period afterwards. These impacts may result in moderate to high short term impacts to water quality over several kilometres on a modelled worst case scenario (Figure 22; Baird, 2020b). The dredging will be carefully managed via a DSDMP to ensure these impacts are limited to the areas predicted (Section 7.6). A DSDMP has been prepared and provided in Appendix 4.1. The DSDMP was finalised in consultation with DWER to ensure that all potential impacts to marine environmental quality associated with dredging will be within the impact predictions presented in this ERD.

The Proposal includes the discharge of bitterns into the marine environment on outgoing tides. The bitterns will be diluted prior to discharge by mixing with seawater taken from a seawater intake located within the port boundaries (but outside the area influenced by the bitterns disposal to avoid drawing in bitterns), and discharged through a multi-port diffuser to promote mixing. This discharge will result in unavoidable water quality impacts in the vicinity of the diffuser. Given the pre-dilution method proposed, the use of a diffuser and the siting of the diffuser within the port area will limit the Low Ecological Protection Area (LEPA) within the dredge channel and Moderate Ecological Protection Area (MEPA) to within 250 m of the dredge channel, the impacts to marine environmental quality from bitterns disposal are not considered to be significant if managed appropriately. Bitterns disposal will be regulated by a Licence issued under Part V of the EP Act and managed by DWER. A MEQMMP Plan is attached in Appendix 3, which details the monitoring and management measures proposed to ensure the bitterns discharges meet appropriate criteria.

The development of an export facility and export operations will increase the risk of water quality impacts (i.e. from oil spills, product loss). The proposed export activities at the Proposal are however small in scale (4 Mtpa) in comparison to other bulk export ports in the Pilbara. The potential risks associated with export operations are mitigated using a number of well-established measures, in this case it will be managed under a Works Approval and the Port Authorities Act 1999. A Moderate LEP is requested to be applied around the port operating areas as per other ports in the Pilbara.

The MEQMMP has been prepared and provided in Appendix 3. The MEQMMP was developed in consultation with EPA Services at DWER to verify and ensure that all potential impacts to marine environmental quality associated with the operation of the Proposal will be within the predicted levels.

In summary, the resultant potential impacts to marine environmental quality are not expected to be significant given that:
• The development envelope boundaries restrict the location of dredging and bitterns disposal;
• The Key Characteristics Table will restrict the total volume of dredging and bitterns discharge;
• Dredging activities have been minimised by using a transhipment method and following existing low points on the seabed;
• Dredging will be conducted using a front-end loader instead of a dredging vessel;
• Additional products (SoP and others) will be abstracted from the bitterns which reduces the total volume;
• Bitterns will be diluted with seawater prior to discharge;
• Bitterns will be discharged within a LEPA and the LEPA will be limited to within the already disturbed dredge channel;
• Port operations will be located within a MEPA; and
• Operations within tidal creeks are limited to low impact items, i.e. a seawater intake and a small boat launching facility.

It is expected that the Ministerial Statement will include the limits described above in the Key Characteristics Table. The MEQMMP and DSDMP are expected to be requirements under the Ministerial Statement. Solar salt manufacturing (including bitterns disposal) and bulk material loading are prescribed activities and therefore all emissions and discharges associated with those activities will be managed under Part V of the EP Act including bitterns, oil spills and brine spills.

With the implementation of controls, the Proposal is able to be implemented while maintaining the quality of water, sediment and biota so that environmental values are protected. The Proposal is therefore able to meet the EPA's objective for this factor.</td></tr>
<tr><td colspan="2">Benthic Communities and Habitats (BCH)</td></tr>
<tr><td>EPA objective</td><td>The EPA Objective for this key environmental factor is to protect BCH so that biological diversity and ecological integrity are maintained.</td></tr>
<tr><td>Policy and guidance</td><td>• Statement of Environmental Principles, Factors and Objectives 2016 (EPA, 2016a)
• Statutory Guidelines for Mine Closure Plans (DMIRS, 2020)
• EIA (Part IV Divisions 1 and 2) Administrative Procedures 2016;
• EIA (Part IV Divisions 1 and 2) Procedures Manual 2016
• Instructions on how to prepare Environmental Protection Act Part IV Environmental Management Plans (EPA, 2018a)
• Environmental Factor Guideline – BCH (EPA, 2016b)
• Technical Guidance – Protection of BCH (EPA, 2016c)
• Technical Guidance – Protecting the Quality of WA's Marine Environment (EPA, 2016d)</td></tr>
</table>

	• Technical Guidance – Environmental Impact Assessment of Marine Dredging Proposals (EPA, 2016e) • Guidance Statement No. 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 (DoE), Government of WA, Marine Series Report No. 1 (DoE, 2006) • Australian and New Zealand Guidelines for Fresh and Marine Water Quality (ANZG, 2018) • WA Environmental Offsets Policy (EPA, 2011) • WA Environmental Offsets Guidelines (EPA, 2014) • WA Offsets Template • Generic guidelines for the content of a draft EPBC Act PER/EIS (including the objects and principles of the EPBC Act) (DotEE, 2016b) • Other Minister of the Environment (Cth) approval decision making considerations • Environmental Management Plan Guidelines (DotE, 2014a) • Environmental Management Plan Guidelines, - template (DotEE, 2018a) • EPBC Act Condition Setting Policy (DotE, 2016b) • EPBC Act Outcomes-based conditions policy (DotE, 2016c) • EPBC Act Environmental Offsets Policy (DSEWPaC, 2012) – including the Offset Assessment guide. • Relevant EPBC listed species specific survey guidelines and protocols • Relevant EPBC listed species-specific Recovery plans, Threat Abatement Plans, Approved Conservation Advices and other documents • Marine bioregional plan for the North-west Marine Region (DSEWPaC, 2012b) • National Assessment Guidelines for Dredging (DEWHA, 2009b) • Environmental best practice port development: an analysis of international approaches (GHD, 2013)
Potential impacts	**General Intertidal BCH** • 8,282 ha of direct disturbance • Potential indirect impacts associated with changes to water quality and the risk of introducing marine pests **Mangrove Habitat** • Up to 17 ha of total cumulative disturbance, including up to 1 ha in LAU 2, 12 ha in LAU 4 and 4 ha in LAU 6 • Some potential indirect impacts **Algal Mat Habitat** • Up to 880 ha of direct disturbance, including up to 10 ha in LAU 1, 452 ha in LAU 3, 416 ha in LAU 5 and 1 ha in LAU 6 • Some potential indirect impacts **Samphire / Samphire Mudflat Habitat** • Up to 954 ha of total cumulative disturbance, including up to 8 ha in LAU 1, 15 ha in LAU 2, 216 ha in LAU 3, 57 ha in LAU 4, 322 ha in LAU 5, and 335 ha in LAU 6. • Some potential indirect impacts. **Sub-tidal BCH** Up to 183 ha of sub-tidal BCH to be disturbed (dredged) to develop the dredge channel with 284 ha of indirect impacts (202 ha recoverable)
Mitigation	**Avoid** The Proposal and its development envelope boundaries have been designed to avoid impacts to CC Mangrove BCH and the majority of SC Mangrove, algal mat and high value samphire BCH as they were identified as having a higher ecological value. **Minimise** • Obtain and comply with approvals under Part IV and V of the EP Act, *Mining Act 1978* and *Port Authorities Act 1999* • The Key Proposal Characteristics (Section 2.3.2) provide several limits that were included to minimise impacts to BCH • Minimise disturbance within mangrove, samphire and algal mat communities • Construct the jetty using a top-down approach where appropriate • Install engineered floodways and culverts along the causeway alignment to ensure intertidal flow regimes are maintained either side of the causeway • Implement the MEQMMP (Appendix 3) • Implement the DSDMP (Appendix 4.1) • Develop and implement an Oil Spill Response Plan • Implement 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 • Implement measures to minimise the risk of introducing marine pests

	• Include 200 m wide drainage corridors through the ponds at a minimum two locations • Monitor erosion at the outlets of the drainage corridors after significant flow events and install erosion protection (i.e. rock baffles etc.) if required • Verify inundation model within twelve months of the completion of the western pond walls to confirm indirect impact predictions associated with changes to tidal regimes • Monitor groundwater levels west of the ponds to verify that the ponds will not result in the movement of hypersaline groundwater toward areas inhabited by mangrove communities • Develop and implement a BCH Monitoring Plan **Rehabilitate** • Implement MCP approved under the *Mining Act 1978* • Salts will be harvested from each pond prior to closure • Concentrator pond walls will be opened up to allow tidal flows to enter the ponds • All infrastructure will be removed (including the causeway) if not retained by Mardie Station or PPA • All crystalliser ponds will be rehabilitated to an acceptable landform
Outcomes	BCH was identified by Mardie Minerals as being a key constraint during the planning process for the Proposal. As a result extensive design changes were made to minimise impacts to significant BCH, including: • Relocating the ponds further inland, to minimise impacts to the significant BCH that occurs along the coastline (mangroves, algal mats and the denser samphire habitats) • Bitterns disposal will occur within the area of the dredge footprint • A transhipment export method was proposed which reduces dredging requirements by an order of magnitude. Given the scale of the Proposal impacts to BCH are unavoidable. The Proposal will result in the direct disturbance of approximately 8,282 ha of intertidal BCH and 183 ha of sub-tidal BCH. Bare substrate has been targeted in both zones, 6,412ha (77%) of the intertidal BCH to be disturbed is bare mudflat / salt flat BCH, and 104 ha (57%) of the sub-tidal BCH to be disturbed is bare unvegetated substrate. More substantial losses of high intertidal zone BCH are required in order to construct the ponds. The BCH that will be lost in these areas is dominated by mudflat / saltflat habitat which is largely devoid of either primary producers or associated faunal communities. There will also be losses of areas of samphire and associated mudflats. These losses, while substantial in terms of total area, and as a percentage of the mapped total, are not considered to be significant in the context of the maintenance of local ecological functions such as primary productivity, biodiversity and nutrient transport. There will also be losses of areas of algal mats comprising some 25% of the total of this habitat class across all intertidal LAUs. This loss is not considered to be significant as there is unlikely to be substantial impairment of the range of ecological functions provided by algal mats either locally or regionally (O2 Marine, 2020c). Across the shoreline gradient the higher value habitat classes are lower on the shoreline where primary productivity, biodiversity and biomass are much higher, primarily because of frequent tidal inundation which maintains lower soil salinities. The primary productivity, biodiversity and biomass of the SC mangroves, samphires and algal mats is much lower due to higher salinities that increase with increasing elevation in the tidal zone. Any contribution of nutrients and organic carbon from these higher elevation habitat classes to habitats lower on the shoreline is considered to be negligible. All types of BCH where losses will occur are found elsewhere nearby and are also widespread throughout the region (O2 Marine, 2020a, 2020b). With the implementation of controls other indirect impacts are not predicted to be significant. Emissions from the construction and operation of the concentrator and crystalliser ponds and export facilities will be regulated under Part V of the EP Act (works approval and licence). Vessel hygiene (to prevent Introduced Marine Pests (IMPs)) is regulated by DPIRD. Indirect impacts to BCH from dredging will be managed by a DSDMP. This plan is provided in Appendix 4.1. It is anticipated that the requirement for a DSDMP will be a condition applied to the Proposal and the plan will be updated through that process. Mardie Minerals has committed to model verification monitoring and ongoing BCH monitoring to ensure the findings of the assessments in Section 7.5 are accurate. In summary, the resultant potential impacts to BCH are not expected to be significant given that: • The Proposal is located in an area with very little existing disturbance; • The development envelopes exclude majority of the significant BCH; • The Proposal has been able to avoid all CC Mangroves; • The sub-tidal BCH to be impacted is of a significantly lower ecological value than other similar BCH in the region; • The direct disturbance of intertidal BCH occurs higher in the landscape where the intertidal BCH is of lower ecological significance and has a negligible contribution to the lower high productivity of BCH (such as CC Mangroves); • Discharges associated with the production and export of salt will be regulated under Part V of the EP Act;

	• Other indirect impacts are not expected to be significant and the majority are easily mitigated; • Rehabilitation will occur as described in the MCP to be assessed under the *Mining Act 1978* or as required under the *Port Authorities Act 1999*; and • Hydrological processes will gradually return to existing conditions post-closure. The EPA's environmental objective for this factor is "to protect BCH so that biological diversity and ecological integrity are maintained". While portions of several BCH types will be disturbed to implement the Proposal, the siting of the ponds within areas of lower value BCH and the implementation of mitigations measures is predicted to ensure that biological diversity and ecological integrity of the local and regional system are maintained. The implementation of the proposed mitigation is expected to ensure that there are no significant residual impacts to BCH. Based on the above the Proposal is expected to be able to meet the EPA's objective for this factor.
Marine Fauna	
EPA objective	The EPA Objective for this key environmental factor is to protect marine fauna so that biological diversity and ecological integrity are maintained.
Policy and guidance	• Statement of Environmental Principles, Factors and Objectives 2016 (EPA, 2016a) • EIA (Part IV Divisions 1 and 2) Administrative Procedures 2016 • EIA (Part IV Divisions 1 and 2) Procedures Manual 2016 • Instructions on how to prepare EP Act Part IV Environmental Management Plans (EPA, 2018a) • Environmental Factor Guideline - Marine Fauna (EPA, 2016g) • Technical Guidance – Protection of BCH (EPA, 2016c) • Technical Guidance – Protecting the Quality of WA's Marine Environment (EPA, 2016d) • Technical Guidance – Environmental Impact Assessment of Marine Dredging Proposals (EPA, 2016e) • National Light Pollution Guidelines for Wildlife Including Marine Turtles, Seabirds and Migratory Shorebirds (DotEE, 2020) • Environmental Assessment Guideline No 5 – Protecting Marine Turtles from Light Impacts (EPA, 2010) • Status reports of the fisheries and aquatic resources of WA 2015/16: State of the Fisheries (Department of Fisheries, 2017) • WA Environmental Offsets Policy (EPA, 2011) • WA Environmental Offsets Guidelines (EPA, 2014) • WA Offsets Template • Generic guidelines for the content of a draft EPBC Act PER/EIS (including the objects and principles of the EPBC Act) (DotEE, 2016b) • Other Minister of the Environment (Cth) approval decision making considerations • EPBC Act Environmental Offsets Policy (DSEWPaC, 2012) – including the Offset Assessment guide • Environmental Management Plan Guidelines (DotE, 2014a) • Environmental Management Plan Guidelines, - template (DotEE, 2018a) • EPBC Act Condition Setting Policy (DotE, 2016b) • EPBC Act Outcomes-based conditions policy (DotE, 2016c) • National Assessment Guidelines for Dredging (DEWHA, 2009b) • Relevant EPBC listed species specific survey guidelines and protocols • Relevant EPBC listed species specific Recovery plans, Threat Abatement Plans, Approved Conservation Advices and other documents • Marine bioregional plan for the North-west Marine Region (DSEWPaC, 2012b) • Environmental best practice port development: an analysis of international approaches (GHD, 2013) • National Strategy for Reducing Vessel Strike on Cetaceans and other Marine Megafauna (DotEE, 2017d)
Potential impacts	**General marine fauna** • Disturbance of up to 183 ha of sub-tidal marine fauna habitat in addition to gas pipeline disturbance • Disturbance of up to 5 ha of intertidal marine fauna habitat in addition to gas pipeline disturbance • Death or injury as a result of vessel strike, dredging or entrapment in seawater intakes • Potential indirect impacts **Marine Turtles** • Disturbance of up to 183 ha of sub-tidal marine fauna habitat and 5 ha intertidal habitat in addition to gas pipeline disturbance • Direct disturbance of 50 m width of a low-quality turtle nesting beach • Death or injury as a result of vessel strike, dredging or entrapment in seawater intakes • Potential indirect impacts **Marine Mammals** • Disturbance of up to 183 ha of sub-tidal marine fauna habitat in addition to gas pipeline disturbance • Death or injury as a result of vessel strike or dredging

	• Potential indirect impacts **Sawfish** • Disturbance of up to 188 ha of habitat (in addition to gas pipeline disturbance), including within two tidal creeks • Death or injury as a result of vessel strike, dredging or entrapment in seawater intakes • Potential indirect impacts **Short-nosed seasnake** • Disturbance of up to 188 ha of habitat in addition to gas pipeline disturbance • Death or injury as a result of vessel strike, dredging or entrapment in seawater intakes • Potential indirect impacts **OPMF Nursery Area** • Disturbance of up to 183 ha of the Fortescue Nursery Area • Death or injury as a result of vessel strike, dredging or entrapment in seawater intakes • Potential indirect impacts
Mitigation	**Avoid** • The majority of the sandy beach at the north of the Proposal has been avoided • The majority of mangrove and tidal creek habitats have been avoided • Impacts associated with significant dredging activities and ocean-going vessel movements close to shore have been avoided by the use of a transhipment loading method • Impacts associated with the use of a cutter-suction dredge have been avoided by utilising a simpler barge-mounted long-reach excavator method • Vessels will not be permitted to venture or operate outside of port operational waters unless conducting monitoring or rescue operations • Impacts associated with marine barriers have been avoided by the use of a trestle jetty instead of a marine causeway **Minimise** • Implement a DSDMP • Minimise potential noise impacts to marine fauna for the duration of the marine pile-driving operations by implementing marine noise controls • Minimise the risk of introducing marine pests by implementing control measures • Minimise the risk of fatal vessel strikes to marine fauna through training of vessel operators and implementing of control measures • Report any sightings of large marine fauna (i.e. mammals, turtles, sawfish) to all Mardie Minerals vessels in order to minimise vessel strike incidents • Implement the MEQMMP (Appendix 3) • Obtain and comply with a Works Approval and Licence under Part V of the EP Act • Seawater intakes are to be fitted with intake screens designed to prevent marine fauna from being drawn into the intake, and designed such that intake speeds are limited to a maximum of 0.15 m/s • Develop an 'illumination plan' for coastal and marine infrastructure • Ensure key environmental windows (Section 8.3.12) are considered when planning construction activities • Implement measures to minimise indirect impacts to marine fauna habitat **Rehabilitate** • All marine infrastructure including the jetty, wharf, seawater intakes, boat launching facility and navigation infrastructure will be removed and taken offsite if not retained by PPA • The dredge channel will be left to gradually fill with sediment
Outcomes	The assessment conducted in Section 8.5 determined that there were a number of potential impacts that required controls to ensure they were made acceptable: • Vessel strike • Entrapment in seawater intakes • IMPs • Marine noise emissions, particularly during pile driving activities • Light impacts on marine turtles The mitigation for these potential impacts are well understood and established for marine projects. Speed limits will be implemented for all construction and operational support vessels to reduce vessel strike risk. In addition vessel operators will be required to report the location of any sightings of large marine fauna (in particular marine turtles, mammals and sawfish) to other vessel operators in the area to allow them to be tracked (if visible) and avoided. Given the low numbers of vessels to be used at the Proposal and the implementation of controls the Proposal is expected to be able to be implemented without significant vessel strike impacts to marine fauna.

	The Proposal will have two seawater intakes and both pose a risk of marine fauna entrapment if not designed and operated appropriately. Mardie Minerals has committed to two specific mitigation measures for these intakes; screens will be installed to prevent all but the smallest of marine fauna from being drawn into the intake pipe, and the intake has been designed such that the intake velocity is maintained below 0.15 m/s at all times. This velocity is recommended by the US Environmental Protection Agency (2001) as it ensures the protection of 96% of fish species, and is lower than the swim speed of marine turtles. With the implementation of these two controls the risk of marine fauna entrapment is expected to be lowered to an acceptable level. With the application of regulated controls, the Proposal was identified as being of 'low risk' of introducing marine pests to Mardie marine waters. Standard industry controls (enforced by the Department of Agriculture (DA) (Cth)) relating to ballast water and vessel hygiene provide a level of confidence that IMPs will not be introduced. The commitment to additional mitigation measures described above is expected to reduce the risks of marine pest introduction to acceptable levels. Modelled marine noise from dredging activities is not significant, and marine noise mitigation is now well established within the marine construction industry for pile driving activities. Mardie Minerals has committed to measures that were applied as Ministerial conditions for the Balla Balla Export Facilities (Ministerial Statement 945) and it is expected that similar conditions will be applied to this Proposal. With the application of these measures it is expected that pile driving will be able to be conducted without significant impacts on marine fauna. The Proposal is located more than 8 km from the nearest significant turtle nesting beach and therefore a darkness zone of at least 1.5 km will be maintained as recommended in EPA (2010). There is a nesting beach at the north of the Proposal however this was determined to be rarely used and low-quality (Pendoley, 2019). Nevertheless, given the presence of marine turtles in the area, light mitigation will be implemented to reduce the risk of light interfering with turtle navigation. Water quality impacts from dredging and bitterns disposal (assessed in Section 6) and direct and indirect BCH impacts (assessed in Section 7) are assessed as not being significant under those factors with the implementation of mitigation measures. Consequently the impacts on marine fauna are subsequently not expected to be significant. Bitterns disposal and emissions from the port loading facilities and the salt production process will be managed under Part V of the EP Act via a Works Approval and Licence. Several significant fauna species listed under the BC Act and EPBC Act are known or expected to inhabit the waters surrounding the Proposal. Mardie Minerals considered these species when incorporating mitigation measures into the design, and has proposed operational commitments to ensure that potential impacts on these species are not significant. With the implementation of controls, Mardie Minerals considers that the Proposal can be implemented in a manner that meets the EPA's objective for this factor.
Flora and Vegetation	
EPA objective	The EPA Objective for this key environmental factor is to protect flora and vegetation so that biological diversity and ecological integrity are maintained.
Policy and guidance	• Statement of Environmental Principles, Factors and Objectives 2016 (EPA, 2016a) • Statutory Guidelines for Mine Closure Plans (DMIRS, 2020) • EIA (Part IV Divisions 1 and 2) Administrative Procedures 2016 • EIA (Part IV Divisions 1 and 2) Procedures Manual 2016 • Instructions on how to prepare EP Act Part IV Environmental Management Plans (EPA, 2018a) • Environmental Factor Guideline - Flora and Vegetation (EPA, 2016h) • Technical Guidance – Flora and Vegetation Surveys for EIA (EPA, 2016i) • Guidance Statement 6 – Rehabilitation of Terrestrial Ecosystems (EPA, 2006) • Environmental Protection Bulletin 20 – Protection of naturally vegetated areas through planning and development (EPA, 2013) • Checklist for documents submitted for EIA of proposals that have the potential to significantly impact on Sea and Land factors (EPA, 2016j) • *Biosecurity and Agriculture Management Act 2007* • Technical Guide – Flora and Vegetation Surveys for EIA (EPA & Department of Parks and Wildlife (DPaW), 2015) • WA Environmental Offsets Policy (EPA, 2011) • WA Environmental Offsets Guidelines (EPA, 2014) • WA Offsets Template • Generic guidelines for the content of a draft EPBC Act PER/EIS (including the objects and principles of the EPBC Act, 1999) (DotEE, 2016b) • Other Minister of the Environment (Cth) approval decision making considerations • EPBC Act Environmental Offsets Policy (DSEWPaC, 2012) – including the Offset Assessment guide • Environmental Management Plan Guidelines (DotE, 2014a) • Environmental Management Plan Guidelines, - template (DotEE, 2018a) • EPBC Act Condition Setting Policy (DotE, 2016b)

	• EPBC Act Outcomes-based conditions policy (DotE, 2016c) • Relevant EPBC listed species specific survey guidelines and protocols • Relevant EPBC listed species specific Recovery plans, Threat Abatement Plans, Approved Conservation Advices and other documents
Potential impacts	**General terrestrial flora and vegetation** • Approximately 4,000 ha of direct cumulative disturbance of native vegetation with some potential indirect vegetation health impacts • Approximately 7,456 ha direct disturbance of bare mud flats ***Minuria tridens*** • No known records to be disturbed • No disturbance to the area of AcAjTe vegetation type that includes the *Minuria tridens* record • Up to 592 ha of disturbance to potential habitat (46% of local extent) with some potential indirect vegetation health impacts ***Goodenia nuda*** • No known records to be disturbed • Up to 5.4 ha disturbance to potential habitat (7.5% of local extent) with some potential indirect vegetation health impacts **Seven other potential Priority Flora species** • No known records to be disturbed • Approximately 4,898 ha disturbance to general flora habitat with some potential indirect vegetation health impacts ***Tecticornia* spp. shrubland vegetation** • Up to 1,152 ha disturbance (22% of mapped extent), including up to 2.6 ha of the TtSvTc vegetation type (19.3% of mapped extent) • Some potential indirect health impacts **Unidentified and potentially undescribed *Tecticornia* species** • Up to 1,152 ha disturbance to potential *Tecticornia* spp. habitat (refer above) • Some potential indirect health impacts **Horseflat Land System of the Roebourne Plains PEC** • 231 ha disturbance (0.47% of total mapped extent) • Some minor potential indirect health impacts **Locally significant vegetation type AjSlTe** • Up to 4.0 ha disturbance (62% of mapped extent) • Some minor potential indirect health impacts
Mitigation	**Avoid:** • The majority of coastal vegetation will be avoided as it was identified as having a higher ecological value • All records of Threatened and Priority Flora will be avoided • All records of range extension Flora will be avoided • The majority of records of undescribed or unidentified *Tecticornia* species • The location of the concentrator ponds has targeted areas of bare clay pan to avoid clearing of vegetation • The development envelope boundaries have been developed to allow the use of existing tracks wherever practicable **Minimise:** • Implement industry best-practice management measures for flora and vegetation • Obtain and comply with approvals under Part IV and V of the EP Act, *Mining Act 1978* and *Port Authorities Act 1999* • Manage mesquite in accordance with the Mesquite Management Strategy developed by PMMC. Develop / implement a Mesquite Management Plan in conjunction or consultation with PMMC and Mardie Station • Conduct additional field surveys of the extrapolated areas of the Study Area to confirm vegetation descriptions and boundaries are correct, and to verify the presence of AcAjTe (Soak) vegetation type outside the development envelopes • Conduct pre-clearance targeted Threatened and Priority Flora surveys within areas of potential habitat that is to be disturbed • Avoid any new records of Threatened and Priority Flora identified where practicable; • Minimise clearing within Horseflat Land System of the Roebourne Plains PEC • Minimise clearing within AcAjTe vegetation type which may provide habitat for the EPBC Threatened Flora *Minuria Tridens* • Minimise clearing of the AtAjTe vegetation type, and limit disturbance to a maximum of 8.3 ha

	• Maintain as large a buffer as practicable around unidentified or undescribed flora species in order to maintain suitable surrounding habitat • Develop and implement a *Tecticornia* Monitoring and Management Plan • Monitor the potential changes to tidal inundation regimes • Design and construct concentrator and crystalliser ponds to be safe and stable according to DMIRS requirements • Implement controls to reduce the risk of impact from brine pipeline spills **Rehabilitate** • Implement MCP approved under the *Mining Act 1978* • Salts will be harvested from each pond prior to closure • Concentrator pond walls will be flattened or opened up to allow tidal flows to enter the ponds • All infrastructure will be removed if not retained by Mardie Station or PPA • All disturbance areas to be revegetated will be respread with topsoil (or ripped and seeded if suitable topsoil is not available e.g. infested with Mesquite) and rehabilitated • All crystalliser ponds will be rehabilitated to an acceptable landform
Outcomes	Mardie Minerals has incorporated extensive avoidance and minimisation measures into the Proposal design and operational processes, however direct impacts to flora and vegetation are unavoidable. The Proposal will result in the estimated direct disturbance of up to 3,772 ha of terrestrial vegetation, 869 ha of algal mats and 6,580 ha of bare mud flats. All vegetation associations to be disturbed will have more than 80% of their pre-European extent remaining, even once cumulative disturbance has been deducted. This means that all of the vegetation associations will remain in the 'Least Concern' category. Direct impacts to significant flora and vegetation are not considered to be significant once mitigation measures are implemented. All significant flora records will be avoided, and disturbance within significant vegetation has been avoided or minimised such that impacts are not significant when assessing at an appropriate scale (i.e. regional scale for vegetation associations, local scale for significant vegetation types). The key potential indirect impacts to flora and vegetation are associated with hydrological changes and the risk of spreading mesquite: • The risk of mesquite spread will be appropriately managed through the introduction of weed and soil hygiene controls developed in consultation with the PMMC, and as such, the Proposal is not expected to result in additional mesquite impacts; and • Hydrological changes are not expected to impact the majority of susceptible vegetation given the drainage features incorporated into the design and the predicted minimal changes to tidal regimes. Some areas of *Tecticornia* spp. shrubland vegetation may be indirectly impacted as a result of reduced fresh water flow or being cut off from tidal inundation, however Mardie Minerals will develop and implement a *Tecticornia* Monitoring and Management Plan, which will include adaptive management measures that are intended to reduce this impact. Given the small size of the potentially affected areas compared to their local extent and distribution, and the implementation of a *Tecticornia* Monitoring and Management Plan, these indirect impacts are expected to be able to be mitigated such that they are not considered to be significant. The Proposal includes large areas of ponds that contain salts or brine and as such revegetation may be impeded for some time post-closure, although the majority of areas affected are claypans and 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 MCP being revised every three years), with the purpose of refining the closure strategies already identified in the MCP (Appendix 12.1), including: • Salts will be harvested from the concentrator ponds and the walls flattened or opened up to allow tidal flows to reinstate within the former pond areas. Over time this is expected to return the area to a state where current salt-tolerant species can revegetate the pond areas; and • Similarly, salts will be recovered from the crystalliser ponds, which are to be located on terrestrial vegetation (typically infested with Mesquite) and the pond areas revegetated in a typical manner. In summary, the resultant potential impacts to flora and vegetation are not expected to be significant given that: • The Proposal is located in an area with very little existing disturbance • The development envelopes exclude all significant flora records and the majority of significant vegetation types • The presences and potential for spread of mesquite will be managed in conjunction with PMMC and the pastoralist through a Mesquite Management Plan • Emissions and Discharges associated with the production and export of salt will be regulated under Part V of the EP Act • Indirect impacts are not expected to be significant and the majority are easily mitigated • Rehabilitation will occur as described in the MCP to be assessed under the *Mining Act 1978* (Appendix 12.1)

	• Hydrological processes will gradually return to existing conditions post closure 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 measures is expected to ensure that there are no significant residual impacts to flora and vegetation.
Terrestrial Fauna	
EPA objective	The EPA Objective for this key environmental factor is to protect terrestrial fauna so that biological diversity and ecological integrity are maintained.
Policy and guidance	• Statement of Environmental Principles, Factors and Objectives 2016 (EPA, 2016a) • Statutory Guidelines for Mine Closure Plans (DMIRS, 2020) • EIA (Part IV Divisions 1 and 2) Administrative Procedures 2016 • EIA (Part IV Divisions 1 and 2) Procedures Manual 2016 • Instructions on how to prepare EP Act Part IV Environmental Management Plans (EPA, 2018a) • Environmental Factor Guideline – Terrestrial Fauna (EPA, 2016l) • Technical Guidance – Sampling methods for terrestrial vertebrate fauna (EPA, 2016m) • Technical Guidance – Terrestrial fauna surveys (EPA, 2016n) • Technical Guidance – Sampling of short range endemic invertebrate fauna (EPA, 2016o • WA Environmental Offsets Policy (EPA, 2011 • WA Environmental Offsets Guidelines (EPA, 2014) • WA Offsets Template (EPA, 2014) • Generic guidelines for the content of a draft EPBC Act PER/EIS (including the objects and principles of the EPBC Act, 1999) (DotEE, 2016b) • Other Minister of the Environment (Cth) approval decision making considerations • EPBC Act Environmental Offsets Policy (DSEWPaC, 2012) – including the Offset Assessment guide • Environmental Management Plan Guidelines (DotE, 2014a) • Environmental Management Plan Guidelines, - template (DotEE, 2018a) • EPBC Act Condition Setting Policy (DotE, 2016b) • EPBC Act Outcomes-based conditions policy (DotE, 2016c) • Relevant EPBC listed species specific survey guidelines and protocols • Relevant EPBC listed species specific Recovery plans, Threat Abatement Plans, Approved Conservation Advices and other documents • Marine bioregional plan for the North-west Marine Region (DSEWPaC, 2012b)
Potential impacts	**General Fauna Species and Habitat** Approximately 11,142 ha of direct disturbance of fauna habitat with some potential indirect vegetation health impacts **Tidal samphire mudflats habitat** Up to 1,115 ha of disturbance with some potential indirect impacts **Open woodland (riparian habitat)** Up to 6 ha of disturbance with some potential for indirect habitat health impacts **Pilbara Leaf-nosed Bat** Up to 2,396 ha of disturbance to *Triodia* grasslands foraging habitat, with some minor indirect habitat health impacts **Northern Coastal Free-tailed Bat** Up to 22 ha of disturbance of mangal community habitat and 1,115 ha of tidal samphire shrubland habitat, with some minor indirect habitat health impacts **Pilbara Olive Python** Up to 6 ha of disturbance of potential habitat, with some indirect impacts **Northern Quoll** Up to 64.5 ha of disturbance of potential foraging habitat, with some indirect impacts **Migratory birds** Disturbance of up to: • 17 ha of mangrove communities • 1,115 ha of the tidal samphire mudflats • 72 ha of tidal channel and ocean habitat Some potential indirect impacts
Mitigation	**Avoid**

	• The majority of coastal habitats will be avoided as these were identified as having a higher ecological value • The majority of mapped open woodland (riparian) habitat will be avoided • Mardie Pool and associated habitats will be avoided • The location of the concentrator ponds has targeted areas of mudflats and saltflats which is considered a lower value fauna habitat • The jetty and causeway/flooding crossing have been relocated to the east to avoid mangrove and samphire communities, as well as tidal creeks **Minimise** • Implement industry best-practice management measures for fauna • Obtain and comply with approvals under Part IV and V of the EP Act, *Mining Act 1978* and *Port Authorities Act* 1999 • Limit total mangal communities habitat disturbance to 17 ha in the Key Characteristics Table • Develop and implement a BCH health monitoring program • Verify inundation modelling results after construction to ensure potential indirect impacts to coastal habitats is within predicted outcomes • Monitor erosion at the outlets of the surface water corridors after each significant flow event • Implement off take drainage to Open Woodland (Riparian) habitat if required to provide surface water flows into this habitat • Monitor and control seepage from the eastern crystalliser ponds to prevent seepage reaching Mardie Pool • Manage mesquite in accordance with the Mesquite Management Strategy developed by PMMC • Conduct annual migratory shorebird surveys within the MSSA • Record the usage of the concentrator and crystalliser ponds by fauna species; • 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 • Controls will be used to further reduce the risk of impact from unintentional brine pipeline spills **Rehabilitate**: • Implement MCP approved under the *Mining Act 1978* • Salts will be harvested from each pond prior to closure • Concentrator pond walls will be flattened or opened up to allow tidal flows to enter the ponds • All infrastructure will be removed if not retained by Mardie Station or PPA • All disturbance areas to be revegetated will be respread with topsoil (or ripped and seeded if topsoil is no longer viable) and rehabilitated • All crystalliser ponds will be rehabilitated to an acceptable landform
Outcomes	The Proposal will result in the direct disturbance of up to 11,142 ha of fauna habitat, which includes some habitat types that may be utilised by significant fauna species. Mardie Minerals has however incorporated extensive avoidance and minimisation measures into the Proposal design and operational processes. The avoidance and minimisation measures significantly reduced the direct disturbance of the fauna habitats that may be utilised by significant fauna, including mangrove community, tidal samphire mudflats, tidal channel and ocean and open woodland (riparian) habitat (including freshwater pool habitat). With the implementation of mitigation measures the majority of the potential impacts identified were assessed as able to be avoided or minimised such that they were not considered significant. There were however three potential impacts that required greater consideration: • The direct disturbance of 11,142 ha of general terrestrial fauna habitat and potential indirect impacts • Disturbance of 17 ha of mangrove community habitat, which is utilised by migratory shorebirds within the MSSA, and potential indirect impacts associated with hydrological changes • Disturbance of tidal samphire mudflats habitat, which was noted as the most significant habitat utilised by migratory shorebirds within the MSSA Given the scale of the Proposal, the disturbance of 11,142 ha (in addition to the 243 ha disturbed for the development of two gas pipelines in the TFSA) was considered in the context of the broader landscape. All vegetation associations to be disturbed will have more than 80% of their pre-European extent remaining, even once cumulative disturbance associated with the Proposal and the Eramurra Industrial Salt Projects have been deducted. This means that all of the vegetation associations will remain in the 'Least Concern' category. While this focusses on vegetation, it provides a suitable regional assessment of fauna habitats in this context. None of the habitat types mapped with the TFSA and broader MSSA were noted as having a high percentage of their extent impacted by the Proposal, with the exception of mudflat/samphire habitat, which has minimal value to fauna species, and grasslanad habitats, which are likely to extend east of the TFSA. The key potential indirect impacts to fauna habitats are associated with hydrological changes and the risk of spreading mesquite:

	• The risk of mesquite spread will be appropriately managed through the introduction of weed and soil hygiene controls developed in consultation with the PMMC, and as such, the Proposal is not expected to result in additional mesquite impacts • Hydrological changes are not expected to impact the majority of susceptible vegetation given the drainage features incorporated into the design and the predicted minimal changes to tidal regimes. Some small areas of tidal samphire zone habitat may be indirectly impacted as a result of being cut off from tidal inundation, however adaptive management measures may reduce this impact. Given the small size of the potentially affected areas compared to their extent and distribution locally, these indirect impacts are not considered to be significant The Proposal will result in the disturbance of 17 ha of mangrove habitat. All efforts have been made during the Proposal design phase to maintain maximum mangrove biomass which would be of more importance to fauna, with none of the denser CC mangroves identified for direct removal and no net predicted indirect effects. While a 17 ha area of SC mangroves will be lost, this still represents less than 1% of this assemblage and will not impact on the integrity of the assemblage in terms of contributions to local and regional ecological function and connectivity. Mangroves are well represented regionally and the cumulative loss of 21 ha (including 4 ha of existing gas pipeline disturbance) is not deemed to significantly impact any fauna that depend on their use for habitat. The cumulative direct disturbance of tidal samphire mudflat habitat is best assessed in the context of the MSSA, as it is of most significance to migratory shorebirds. There have been numerous design revisions in order to minimise disturbance to this habitat type and keep indirect impacts as low as practicable. As a result, the Proposal is able to be implemented while retaining almost all of the higher value coastal portions of this habitat within the MSSA. Based on the above, the Proposal is considered unlikely to significantly impact migratory bird habitats such that its use by migratory shorebirds would be detrimentally affected. The presence of the ponds may also provide additional habitat for some birds. Annual migratory shorebird monitoring will be conducted to provide further information about the use of the MSSA and any potential changes to bird behaviour or usage as a result of the presence of the ponds or reduction in habitat availability. The Proposal includes 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 claypans and 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 identified in the MCP (Appendix 12.1), including: • All residual salts will be harvested from the concentrator ponds and the walls opened up to allow tidal flows to reinstate within the former pond areas. Over time this is expected to return the area to a state where current salt-tolerant species can revegetate the pond areas • Similarly, salts will be recovered from the crystalliser ponds, which are to be located on terrestrial vegetation (typically infested with Mesquite) and the pond areas revegetated in a typical manner Sea level rise associated with climate change was discussed in Inland Waters however it is worth noting in this section, specifically to review how it will affect the habitats utilised by migratory shorebirds. Sea level rise is predicted to result in a gradual inland migration of coastal habitats and the increasingly frequent submergence of the tidal samphire mudflat habitat assessed in this ERD, until it no longer becomes viable for the presence of samphire species. The Proposal will prevent the inland migration past the point of the pond walls, however given sea level rise calculations the inland migration of the habitats would have been prevented from migrating further inland by higher ground, only 20 years after reaching the pond wall limits. 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 is expected to ensure that there are no significant residual impacts to terrestrial fauna or their habitats.
Social Surroundings	
EPA objective	The EPA Objective for this key environmental factor is 'to protect social surroundings from significant harm'.
Policy and guidance	• Statement of Environmental Principles, Factors and Objectives (EPA, 2016a) • EIA (Part IV Divisions 1 and 2) Administrative Procedures 2016 • EIA (Part IV Divisions 1 and 2) Procedures Manual 2016 • Instructions on how to prepare EP Act Part IV Environmental Management Plans (EPA, 2018a) • Environmental Factor Guideline – Social Surroundings (EPA, 2016q) • Guidance Statement 41 – Assessment of Aboriginal Heritage (EPA, 2004) • Generic guidelines for the content of a draft EPBC Act PER/EIS (including the objects and principles of the EPBC Act) (DotEE, 2016b) • Environmental Management Plan Guidelines (DotE, 2014a) • Environmental Management Plan Guidelines, - template (DotEE, 2018a)

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

EPBC Act Condition Setting Policy (DotE, 2016b)
EPBC Act Outcomes-based conditions policy (DotE, 2016c)
Engage Early - Guidance for proponents on best practice Indigenous engagement for environmental assessments under the EPBC Act (DotE, 2016a)

</td></tr>
<tr><td>Potential impacts</td><td>
Recreational uses of marine and coastal waters
Direct and indirect loss of 188 ha of coastal and marine habitat.
Amenity of Mardie Homestead residents and visitors
Visual amenity impacts as the SoP Plant may be visible from the Homestead.
Registered Aboriginal Heritage Sites
Disturbance within the boundary of two Registered Aboriginal Heritage Sites, and changes to the flow path associated with one of these sites.
Demarcated YM Aboriginal Heritage areas
Decline in the quality of the areas due to inundation and unauthorised access.
Land used for traditional purposes
Cumulative loss of mangrove communities within YM and KM land is difficult to estimate however it is likely to be a fraction of 1% of the total extent. All vegetation associations that contain spinifex grassland, shrubland or woodland within the development envelopes will have >80% of their pre-European extent remaining.
</td></tr>
<tr><td>Mitigation</td><td>
Avoid

Two Registered Aboriginal Heritage Sites have been avoided
Two Demarcated Aboriginal Heritage Areas have been avoided
The Mardie homestead and woolshed complex have been avoided
The majority of the coastal zone has been avoided
Mardie Pool has been avoided
'Island 5' – a Demarcated Aboriginal Heritage Area, will not be inundated
The location of the concentrator ponds has targeted areas of bare clay pan, which typically has lower levels of Aboriginal Heritage Sites

Minimise

Obtain Access Agreement with PMPL
Implement industry best-practice management measures for Aboriginal Heritage
Obtain and comply with Section 18 approvals under the Aboriginal Heritage Act 1978 for any Aboriginal Heritage sites (or Other Heritage Places that are likely to be sites) that are to be disturbed
Ensure Aboriginal 'cultural salvage areas' are appropriately salvaged prior to disturbance
Minimise clearing and access restrictions within areas used for traditional purposes
Maintain and improve Traditional Owners' access to land for traditional uses
Develop and implement a Cultural Heritage Management Plan in consultation with the YM and KM People

Rehabilitate

Implement MCP approved under the Mining Act 1978
Salts will be harvested from each pond prior to closure
Concentrator pond walls will be flattened or opened up to allow tidal flows to enter the ponds
All infrastructure will be removed if not retained by Mardie Station or PPA
All disturbance areas to be revegetated will be respread with topsoil and rehabilitated
All crystalliser ponds will be rehabilitated to an acceptable landform
Mardie Minerals will examine inundated demarcation sites and remediate to the satisfaction of the YM and KM People

</td></tr>
<tr><td>Outcomes</td><td>
The Proposal is expected to result in negligible impacts to the recreational or community uses of the area. This is because the area is almost inaccessible for camping and boating; and fishing generally targets the offshore islands rather than the shallow and barren mainland beaches. Nevertheless, the Proposal only has a limited marine footprint, with low numbers of vessels and vessel movements. As a result of the above, the Proposal is not expected to result in significant 'harm' to this social value.
Mardie Homestead is outside of the development envelopes and Mardie Minerals and PMPL are currently negotiating an access agreement that will address any indirect impacts and benefits to the homestead and its participants.
Mardie Minerals has avoided two of the four Registered Aboriginal Heritage sites and has determined through examination of records and site investigations that the other two sites are likely to be outside the Development Envelopes. Mardie Minerals will demarcate and protect the Other Heritage Places identified prior to and during the recent 2018 heritage surveys. This will be done in line with Mardie Minerals Land Access Deed obligations and the recommendations of the 2019 Horizon Heritage report.
</td></tr>
</table>

	The Proposal avoids the majority of the coastal zone, which was considered to be a traditional food source for Traditional Owners. Mardie Pool is outside the development envelopes and will not be directly impacted, and terrestrial vegetation will not be significantly impacted in a regional context. Mardie Minerals has also committed to maintaining access to land for the Traditional Owners, and minimising disturbance within the areas noted to be used for traditional purposes. As a result of the above, the Proposal is not expected to significantly impact the traditional uses of the land. 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 is expected to ensure that there are no significant residual impacts to social surroundings.

HOLISTIC IMPACT ASSESSMENT

The Proposal relies on solar evaporation to produce product and as such the large-scale inundation of habitats is unavoidable. Given the location of the Proposal, Mardie Minerals identified that environmental constraints should be the primary input into the design and commissioned initial BCH surveys to map the boundaries of significant BCH such as mangroves and algal mats. The Proposal design was then revised significantly to avoid almost all mangrove habitat, and the majority of algal mat and coastal samphire habitat. This exercise resulted in the initial Proposal design that was referred to the EPA.

Mardie Minerals has since commissioned significant additional environmental survey work and studies, which were used to further revise and refine the Proposal design and operational requirements to avoid and minimise environmental impacts. These revisions and refinements included:

- Reshaping the western pond walls to target lower-value BCH using detailed BCH mapping;
- Significantly reducing the scale of the southern-most pond to avoid hydrological impacts to Peter's Creek drainage;
- Siting PPA infrastructure and the causeway crossing outside areas of significant BCH;
- The use of a trestle jetty to avoid impacts to offshore coastal processes and intertidal flows;
- The incorporation of a top-down jetty construction approach to reduce direct disturbance;
- The incorporation of a specific seawater intake design to reduce intake rates and avoid associated fauna entrapment;
- The incorporation of a multi-port bitterns outfall diffuser with pre-dilution to minimise water quality impacts, and locating the diffuser within the ZoHI dredging activities to avoid any additional BCH impacts;
- Using a desalination plant instead of groundwater bores;
- Using a transhipment method to minimise dredging volumes;
- Using a simple mechanical excavation dredging method instead of a typical cutter-suction dredge;
- Using dredged material for construction instead of dumping offshore; and
- Excluding Mardie Pool from the development envelopes.

With the implementation of avoidance measures the Proposal disturbance is now almost completely located within a large area of low value BCH and terrestrial habitat, including bare mudflats and low biomass BCH.

There are some potential impacts that require management and monitoring to ensure that the impacts are not significant. Many of these potential impacts are adequately regulated under other legislation:

- Bitterns discharge, product loss during export, brine spills and leaks, and sewage will be regulated under Part V of the EP Act;
- General environmental management will be regulated through a Mining Proposal assessed under the *Mining Act 1978* or a Development Application and Construction Approval under the *Port Authorities Act 1999*;
- Closure and rehabilitation on *Mining Act 1978* tenure will be regulated through a Mine Closure Plan assessed under the *Mining Act 1978*;

There are some potential impacts however that are expected to require limits or conditions in the Ministerial Statement, including:

- Limits on total disturbance within each development envelope;
- Limits on total seawater abstraction, bitterns discharge and dredging volumes;
- The development and implementation of a DSDMP to regulate dredging;
- Marine noise conditions during jetty construction;
- The development and implementation of a MEQMMP to outline marine environmental quality boundaries, management and monitoring requirements for bitterns discharge and port operations; and
- Monitoring of impact predictions to ensure that they are not significant and trigger contingency actions if required.

With the application of the avoidance mechanisms in Proposal design and operations, and the limits and regulation of potential impacts discussed above, Mardie Minerals considers that potential impacts to key environmental values have been reduced to an acceptable level.

Mardie Minerals understands that this conclusion is in part based on studies and modelling. While the findings of these studies were based on best-available information, monitoring has been committed to in order to verify the study and model outputs, in order to ensure the outcomes presented in this ERD are accurate.

Mardie Minerals has completed a WA Offsets Template as per the requirements of the WA Environmental Offsets Guideline (Government of WA, 2014), provided in Section 12.

Based on the above, and the assessment provided in Sections 5 – 11, the Proposal is expected to be able to meet the EPA's objectives for Inland Waters, BCH, Marine Fauna, Marine Environmental Quality, Flora and Vegetation, Terrestrial Fauna and Social Surroundings.

CONTENTS

LIST OF TABLES

LIST OF FIGURES

LIST OF APPENDICES

1 INTRODUCTION

1.1 Purpose and Scope

The purpose of this Environmental Review Document (ERD) is to provide a detailed description of the Mardie Project (the Proposal) and to enable assessment of the potential environmental impacts that may result, should the Proposal be implemented. The ERD also outlines the key elements (characteristics) required for the construction and operation of the Proposal. The assessment will be completed by the Environmental Protection Authority (EPA) under the provisions of Part IV of the *Environmental Protection Act 1986* (Western Australia (WA); EP Act).

This ERD has been prepared in accordance with the following EPA guidance:

- *Environmental Impact Assessment (Part IV divisions 1 and 2) Procedures Manual* (EPA, 2018a);
- *Statement of Environmental Principles, Factors and Objectives* (EPA, 2018b);
- *Instructions on how to prepare an Environmental Review Document* (EPA, 2018c); and
- *Instructions on how to define the key characteristics of a proposal* (EPA, 2017).

This ERD focuses on the environmental factors that were deemed to be 'key' environmental factors by the EPA; those with the potential to be significantly impacted and could not be appropriately managed under other existing legislation. Potential impacts to these key environmental factors are described in detail and assessed using relevant studies specific to the Proposal. Therefore, this ERD describes the most relevant characteristics and impacts of the Proposal for environmental impact assessment (EIA) and provides all relevant biological and technical reports and survey results as Appendices (Appendix 1 – 12).

1.2 Proponent

The Proponent for the Proposal is Mardie Minerals Pty Ltd (Mardie Minerals) (ABN: 50 152 574 457), a wholly-owned subsidiary of BCI Minerals Limited.

Contact Person:	Michael Klvac –General Manager Corporate Affairs
Email:	michael.klvac@bciminerals.com.au
Phone:	(08) 6311 3400
Address:	Level 2, 1 Altona Street, West Perth WA 6005

1.3 Environmental Impact Assessment Process

1.3.1 Part IV of the *Environmental Protection Act 1986*

Part IV of the EP Act makes provisions for the EPA to undertake EIA of significant proposals, strategic proposals and land use planning schemes. The Proposal was considered to be a significant proposal and as such requires assessment under Part IV of the EP Act.

The EPA uses environmental principles, factors and associated objectives as the basis for assessing whether a proposal or land use planning scheme's impact on the environment is acceptable. The environmental principles, factors and objectives, therefore, underpin the EIA process.

The Proposal was referred under Section 38 of the EP Act on 17 April 2018. The EPA released its decision to assess the Proposal as a Public Environmental Review (s. 40(2) (b) and s. 40(4)) on 18 June 2018. A proponent-prepared Environmental Scoping Document (ESD) was then submitted to the EPA and formally approved on 28 November 2018.

A Section 43A application has also been submitted to formally request a change to the Proposal that was originally referred (refer to Section 2.2.5 for a description of the changes).

1.3.2 Section 87 of the *Environment Protection and Biodiversity Conservation Act 1999*

The Proposal was referred to the Department of the Agriculture, Water and the Environment (DAWE) (formally the Department of the Environment and Energy) on 15 June 2018 (EPBC 2018/8236). DAWE determined that the Proposal was a 'controlled action' and required assessment and approval under the *Environment Protection and Biodiversity Conservation Act 1999* (Cth) (EPBC Act), due to the potential impacts on the following relevant controlling provisions:

- Listed threatened species and communities (sections 18 & 18A);
- Listed migratory species (sections 20 & 20A); and
- Commonwealth marine areas (sections 23 & 24A).

DAWE provided comment and input into the content of the ESD.

The Proposal will be assessed as an 'accredited assessment' under Part IV of the EP Act. Section 87 of the EPBC Act makes provisions for the EPA to undertake this accredited assessment of the potential impacts to Matters of National Environmental Significance (MNES) on behalf of DAWE.

1.4 Other Approvals and Regulation

The majority of the aspects of the Proposal lie within Exploration Licences (E's) held by Mardie Minerals (E08/1849, E 08/2741, E 08/2943, E 08/2740 and E 08/2836). Mardie Minerals will transfer these exploration leases to Mining leases prior to construction. There are also some portions of the development envelopes that currently lie outside of the lease boundaries listed above. Mardie Minerals will obtain appropriate tenure under the *Mining Act 1978* (WA), *Port Authorities Act 1999* (WA) or *Land Administration Act 1997* (WA) for these areas prior to construction.

Table 1 identifies the other approvals and legislation relevant to the Proposal, as well as the decision-making authorities associated with these approvals.

Table 1: Other approvals and regulation

Proposal activities	Land tenure / access	Type of approval	Legislation regulating the activity	Decision-making authority
All activities	*Mining Act 1978* tenure; *Land Administration Act 1997*	Part IV approval	EP Act (Part IV)	Department of Water and Environmental Regulation (DWER)
		EPBC Act approval	EPBC Act	DAWE
		Mining Proposal	*Mining Act 1978*	Department of Mines, Industry Regulation and Safety (DMIRS)
Solar salt manufacturing, sewage treatment and disposal, crushing and screening and ship loading / unloading	*Mining Act 1978* tenure; *Land Administration Act 1997*	Works Approval and Licence	EP Act (Part V)	DWER
Marine export facility and stockyards	*Land Administration Act 1997*	Development and Construction Approvals	*Port Authorities Act 1999*	Pilbara Ports Authority
Disturbance of Aboriginal Heritage sites (if unavoidable)	*Mining Act 1978* tenure	Section 18 consent if any Heritage sites are unavoidable	*Aboriginal Heritage Act 1972* (AH Act; WA)	Department of Planning, Lands and Heritage (DPLH)
Closure and rehabilitation	*Mining Act 1978* tenure; *Land Administration Act 1997*	Mine Closure Plan (MCP)	*Mining Act 1978 (WA)*	DMIRS
Development and operation of export jetty	*Mining Act 1978* tenure; *Land Administration Act 1997*	Development Application	*Port Authorities Act 1999* (WA)	Pilbara Ports Authority (PPA)
		Jetty Licence	*Jetties Act 1926* (WA)	Department of Transport
Storage of dangerous goods (e.g. diesel) on site	*Mining Act 1978* tenure; *Land Administration Act 1997*	Dangerous Goods Site Licence Security Risk Substance Storage Licence	*Dangerous Goods Safety Act 2004* (WA)	DMIRS
Transport of heavy equipment on public roads	*Land Administration Act 1997*	Heavy Haulage Approval	*Main Roads Act 1930* (WA)	Main RoadsWA, City of Karratha
Safety Management	*Mining Act 1978* tenure	Project Management Plan	*Mines Safety and Inspection Act 1994* (WA)	DMIRS
Accommodation Village	*Mining Act 1978* tenure	Approval to construct or install an apparatus for the treatment of sewage	*Health Act 1911* (WA)	Department of Health
		Building Licence	*Building Act 2011* (WA)	City of Karratha

2 THE PROPOSAL

2.1 BACKGROUND

The Proposal was referred to the EPA on 17 April 2018. The level of assessment was set as Public Environmental Review (s.40(2)(b) and s.40(4)) on 18 June 2018. A proponent-prepared ESD was then submitted to the EPA and formally approved on 28 November 2018.

2.2 PROPOSAL DESCRIPTION

2.2.1 PROPOSAL LOCATION

The Proposal is located in the western Pilbara region of WA, approximately 80 km south west of Karratha. The regional location of the Proposal is shown in Figure 1. Access to the Proposal is via the North West Coastal Highway.

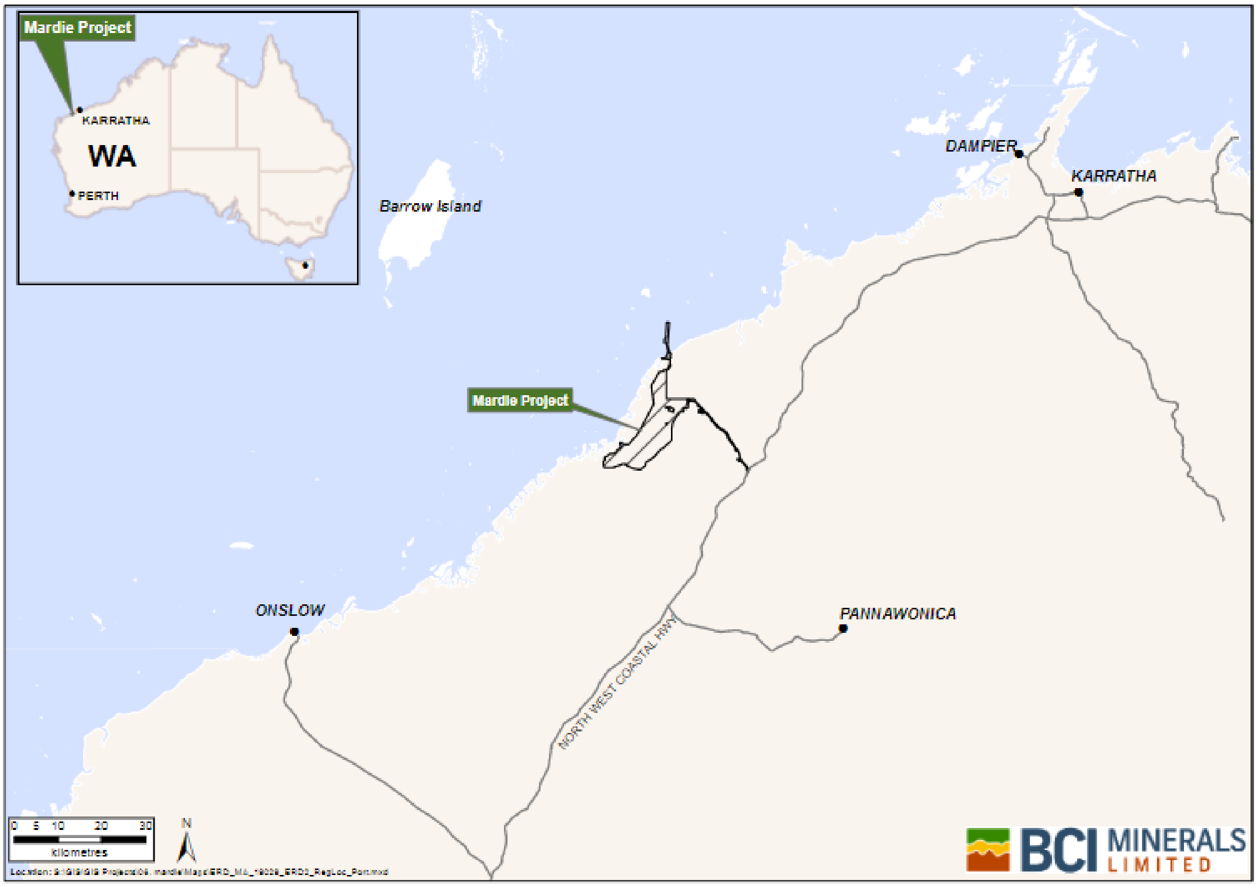


Figure 1: Regional location of the Proposal

2.2.2 Key Proposal Characteristics

Mardie Minerals has referred to the EPA's *Instructions on how to define the key characteristics of a proposal* (EPA, 2017) - which focuses on how to define the key characteristics of proposals for the purposes of an EIA under Part IV of the EP Act. In accordance with these instructions, a summary of the Proposal is provided in Table 2 and the key proposal elements (e.g. development, action, activities or processes) which have potential to cause an impact on the environment are summarised in Table 3. Shape files for the Development Envelopes are provided in Appendix 11.1.

Table 2: Key characteristics of the Proposal

Proposal Title	Mardie Project
Proponent Name	Mardie Minerals Pty Ltd
Short Description	Mardie Minerals Pty Ltd seeks to develop a greenfields high quality salt and SoP project and associated export facility at Mardie, approximately 80 km south west of Karratha, in the Pilbara region of WA. The proposal will produce a high purity salt product, SoP and other products that can be derived from sea water. The Proposal includes the development of seawater intakes, concentrator and crystalliser ponds, processing plants, bitterns disposal pipeline and outfall diffuser, trestle jetty export facility, dredge channel, causeway, drainage channels, access / haul roads, desalination (reverse osmosis) facilities, borrow pits, pipelines, and associated infrastructure including: power supply, communications equipment, offices, workshops, accommodation village, laydown areas, sewage treatment plant, landfill facility.

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

Element	Location	Proposed Extent
Physical Elements		
1. **Ponds and Terrestrial Infrastructure Development Envelope –** concentrator and crystalliser ponds, processing plant, access / haul road, desalination facilities, causeway and stockyards, small boat launching facility, administration, laydown, other associated infrastructure.	Figure 2	Disturbance of no more than 11,142ha within the 15,667 ha Ponds and Terrestrial Infrastructure Development Envelope.
2. **Marine Development Envelope –** trestle jetty, seawater intake and pipelines.	Figure 2	Disturbance of no more than 7 ha within the 53 ha Marine Development Envelope. The northern end of the causeway will not extend onto or past the sandy beach.
3. Dredge Channel Development Envelope – berth pocket, channel to allow access for transhipment vessels, bitterns outfall diffuser.	Figure 2	Disturbance of no more than 55 ha within the 304 ha Dredge Channel Development Envelope.
4. Mangrove Disturbance	Figure 2	Disturbance of mangrove communities limited to 17 ha of Scattered Canopy mangroves
Operational Elements		
Desalination Plant discharge	Figure 3	Discharge into ponds or bitterns stream only.
Dredge volume	Figure 3	Dredging is only to occur within the Dredge Channel Development Envelope. Dredging of no more than 800,000 m^3 of material from the berth pocket and high points within the dredge channel, with the material to be deposited onshore within

Element	Location	Proposed Extent
		the Ponds and Terrestrial Infrastructure Development Envelope.
Bitterns discharge	Figure 3	Discharge of up to 3.6 gigalitres (GL) per annum of bitterns with a specific gravity no more than 1.25 via a diffuser, within a Low Ecological Protection Area. Bitterns is to be diluted with seawater prior to discharge.
Pond seawater intake	Figure 3	Up to 150 GL per annum, from a screened intake with a maximum average intake flowrate at the screen of less than 0.15 m/s. Seawater abstraction will only occur when water levels are at mean sea level or higher.

2.2.3 Detailed Description

Mardie Minerals seeks to develop the Mardie Project (the Proposal), a greenfields high-quality salt and potash project in the Pilbara region of Western Australia (Figure 1). Mardie Minerals is a wholly-owned subsidiary of BCI Minerals Limited.

The Proposal is an evaporative solar project that utilises seawater to produce raw salts as a feedstock for dedicated processing facilities that will produce a high purity salt, fertiliser grade SoP product, and potentially other commercial by-products. Production rates of 4.0 million tonnes per annum (Mtpa) of salt (NaCl), 100 kilotonnes per annum (ktpa) of SoP, and up to 300 ktpa of other salt products are being targeted, sourced from a 150 GL/yr seawater intake. To meet this production, the following infrastructure will be developed:

- Primary seawater intake pump station;
- Concentrator ponds;
- Crystalliser ponds;
- Processing facilities and stockpiles;
- Causeway, trestle jetty and transhipment berth/channel;
- Bitterns disposal pipeline, seawater intake (for dilution) and diffuser;
- Drainage channels and flood protection ;
- Administration buildings;
- Accommodation village,
- Access / haul roads;
- Desalination plant for fresh water production, ;
- Boat launching facility and port stockyard; and
- Associated infrastructure including: power supply, communications, workshop, laydown, landfill facility, sewage treatment plant.

Figure 3 shows the indicative location of the ponds and infrastructure described above.

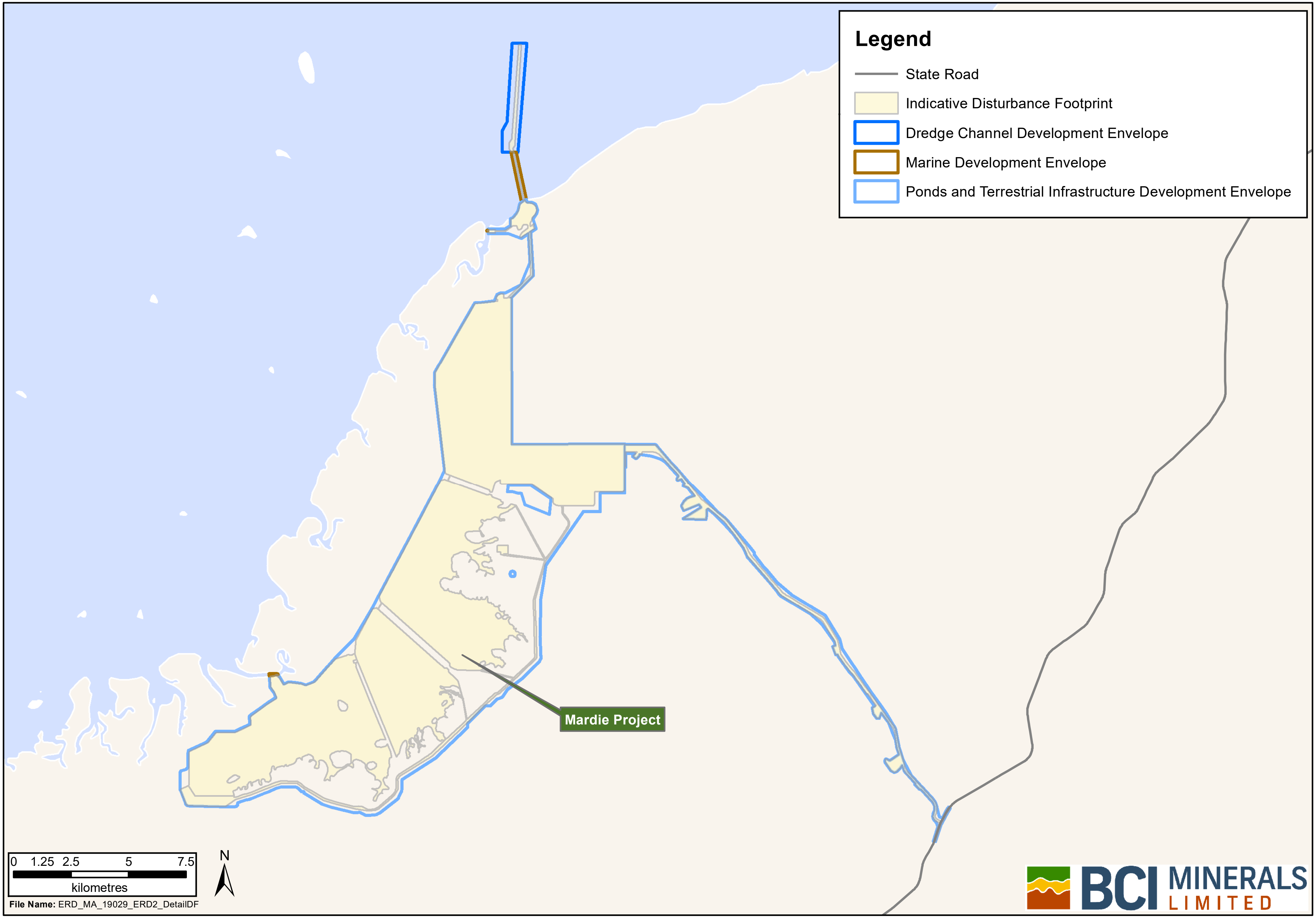


Figure 2: Proposal Development Envelopes and indicative disturbance footprint

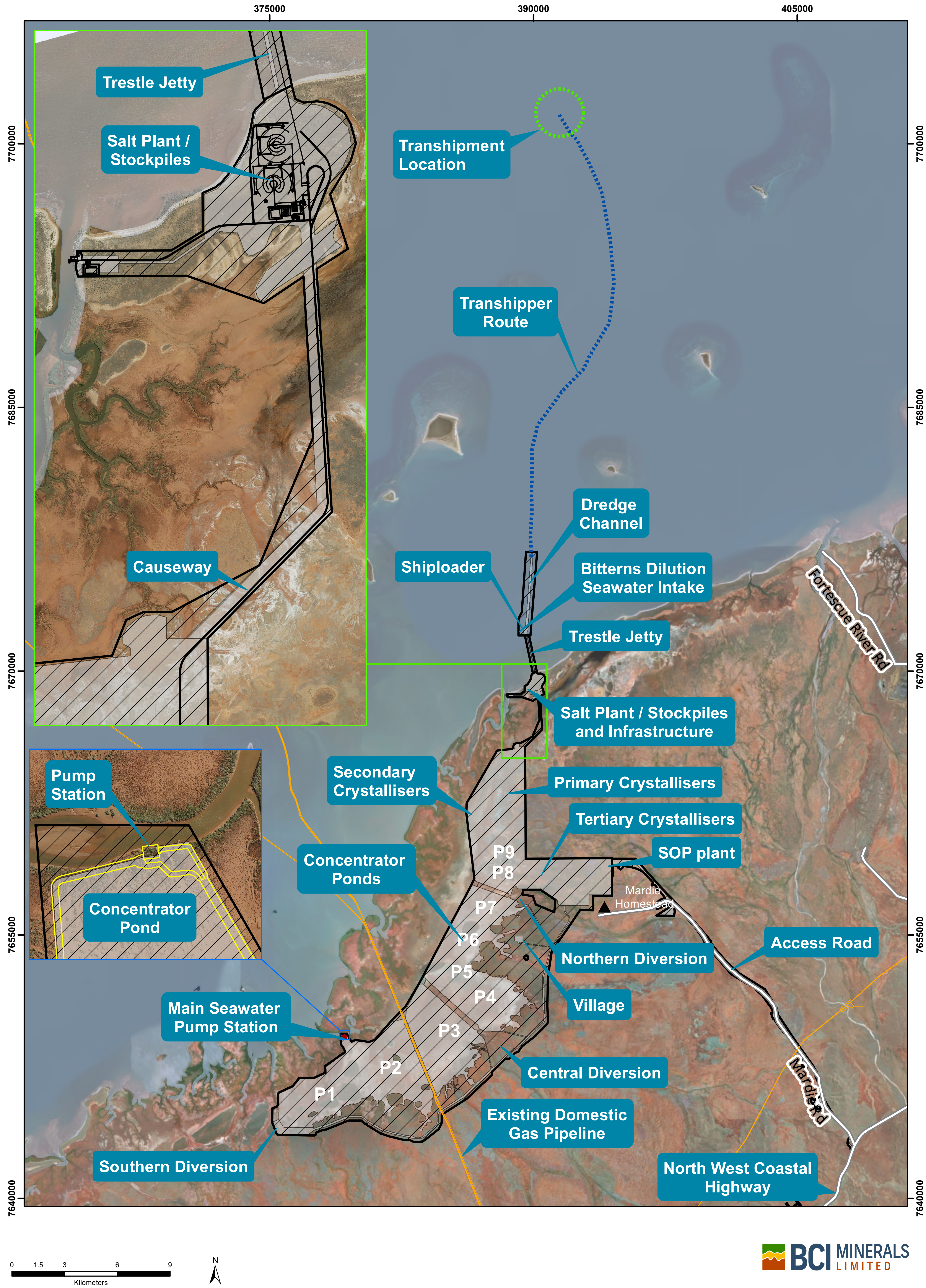


Figure 3: Indicative location of ponds and infrastructure

Coordinate System: GDA 1994 MGA Zone 50
Projection: Transverse Mercator
Datum: GDA 1994

Primary Seawater Intake

Seawater provides the feed source for the Proposal. Up to 150 GL/yr of seawater will be pumped from a large tidal creek into the first concentrator pond (Pond 1). The location of this intake is shown on Figure 3. The intake is to be located approximately 2.2 km upstream of the creek mouth, in an area where the width of the creek measures approximately 80 – 165 m, depending on tide levels (Figure 4 and Figure 5).

The seawater intake structure will be installed on the southern bank of this tidal creek, and will consist of several intake pipes housed within a screened enclosure (Figure 6). The screened enclosure provides a minimum 162 m^2 of screen within the water column when the seawater intake is operational (refer below and Figure 7).

The seawater intake will operate when water levels are above mean sea level (MSL), which will:

- Ensure that there is sufficient water volume within the creek; and
- Ensure that the flow rate through the screen surrounding the enclosure does not exceed 0.15 m/s (designed to minimise marine fauna entrapment - refer to Section 8).

A 162 m^2 screen at MSL equates to an average peak velocity of 0.12 m/s. As the sea level rises above MSL the wet area of the screen increases, resulting in a reduction in flow rates.

The cross-sectional design of the seawater intake screen and structure is provided in Figure 7.

Figure 4: Photo of intake creek, showing channel between the ocean and intake location

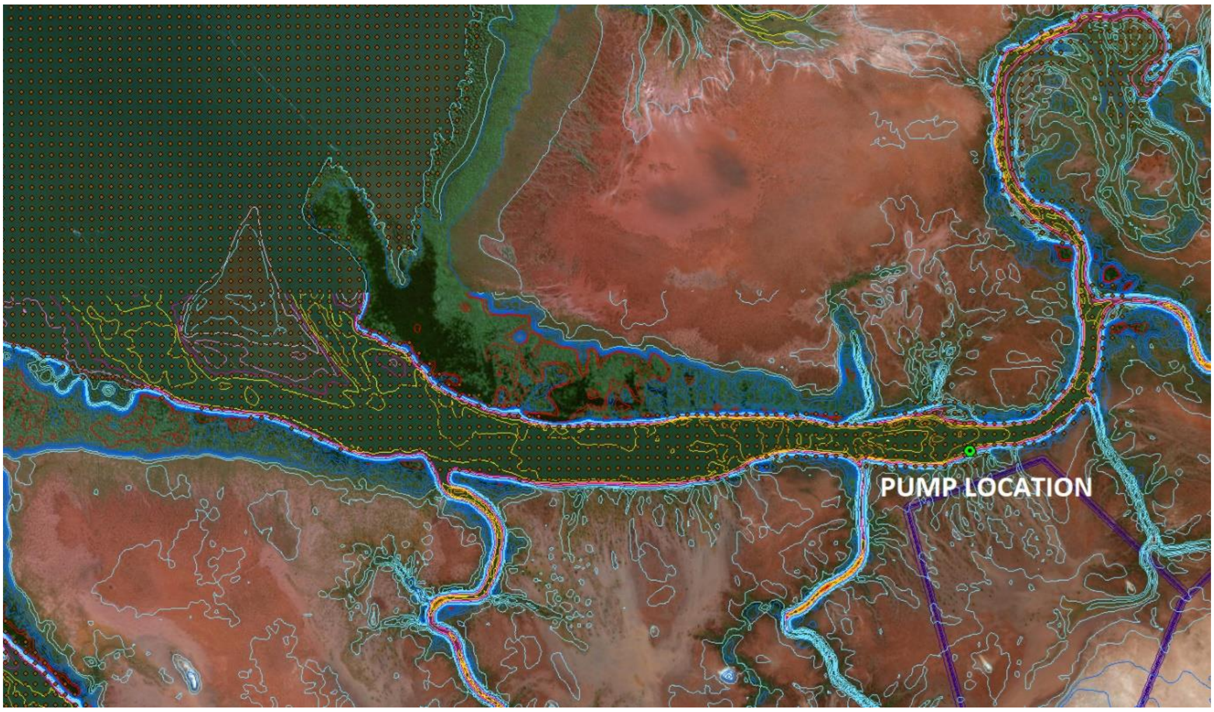


Figure 5: Bathymetry and location of the proposed seawater intake creek

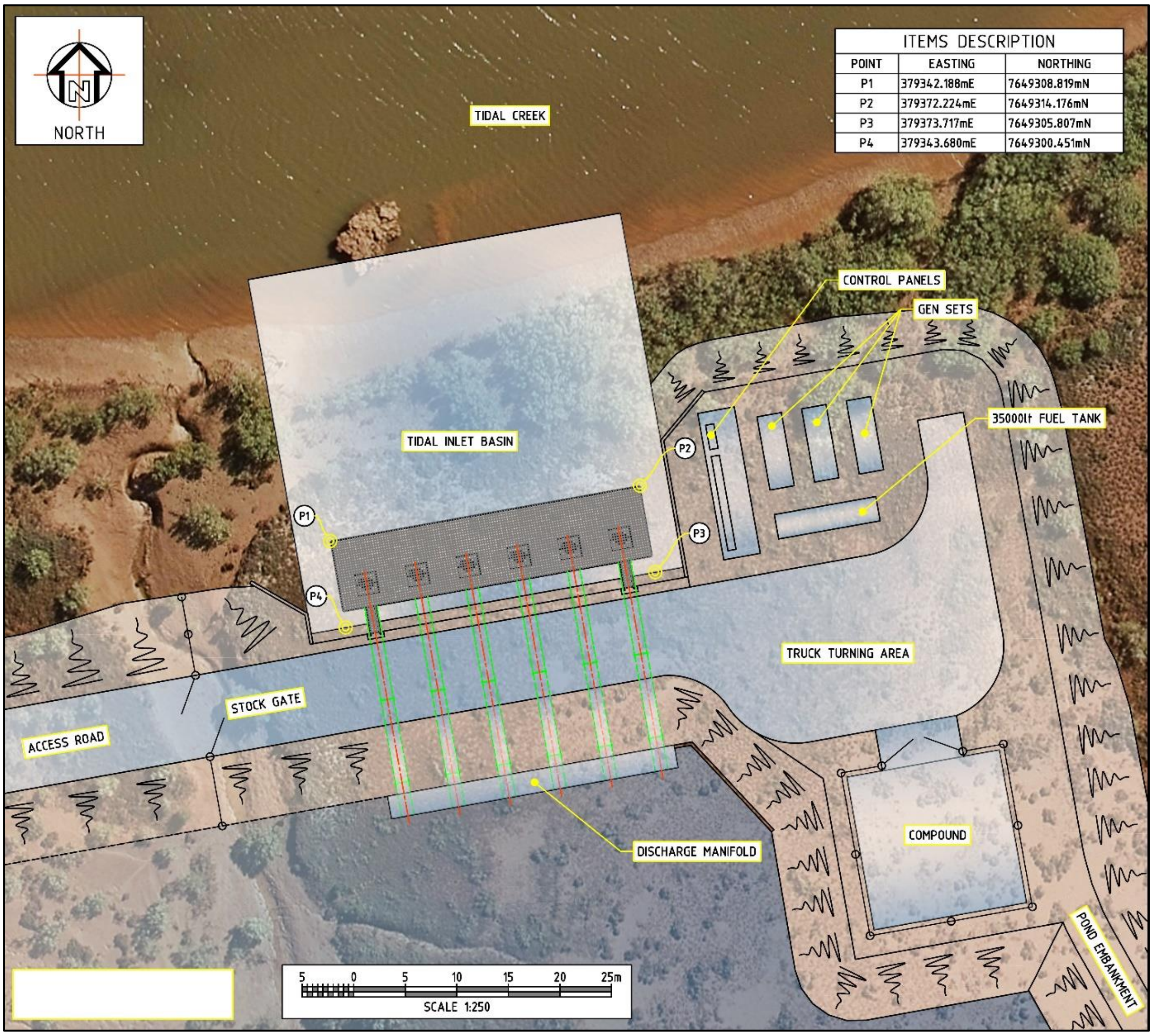


Figure 6: General layout of seawater intake

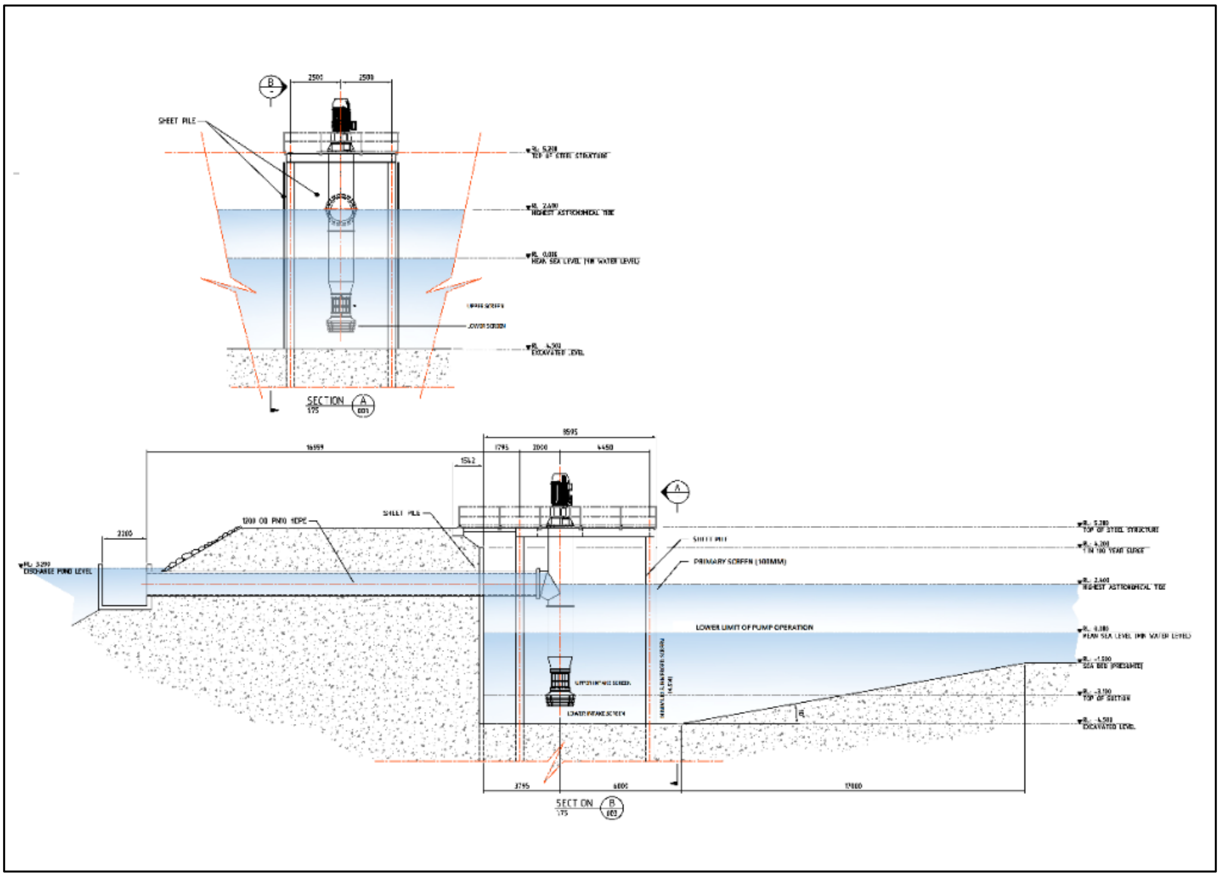


Figure 7: Indicative cross section design of seawater intake

Evaporation (Concentration and Crystalliser) Ponds

The pumped seawater will be progressively concentrated in a series of concentrator ponds, before being transferred to a series of crystalliser ponds (Figure 3), which crystallise the salts as a feed for the processing facilities. The concentrator and crystalliser ponds will be constructed using low permeability walls engineered from local clays and soils and rock armoured to protect against erosion. The height of the external walls will be 4.20 mAHD, which matches the storm surge level of a 1 in 100-year storm even (RPS, 2019a; Appendix 1.1). This equates to a relative wall height of 2.4 m above ground level, or lower.

The inland edge of the ponds will generally follow natural topography (i.e. walls will not be required).

General cross-sections of the concentrator and crystalliser ponds are provided in Figure 8.

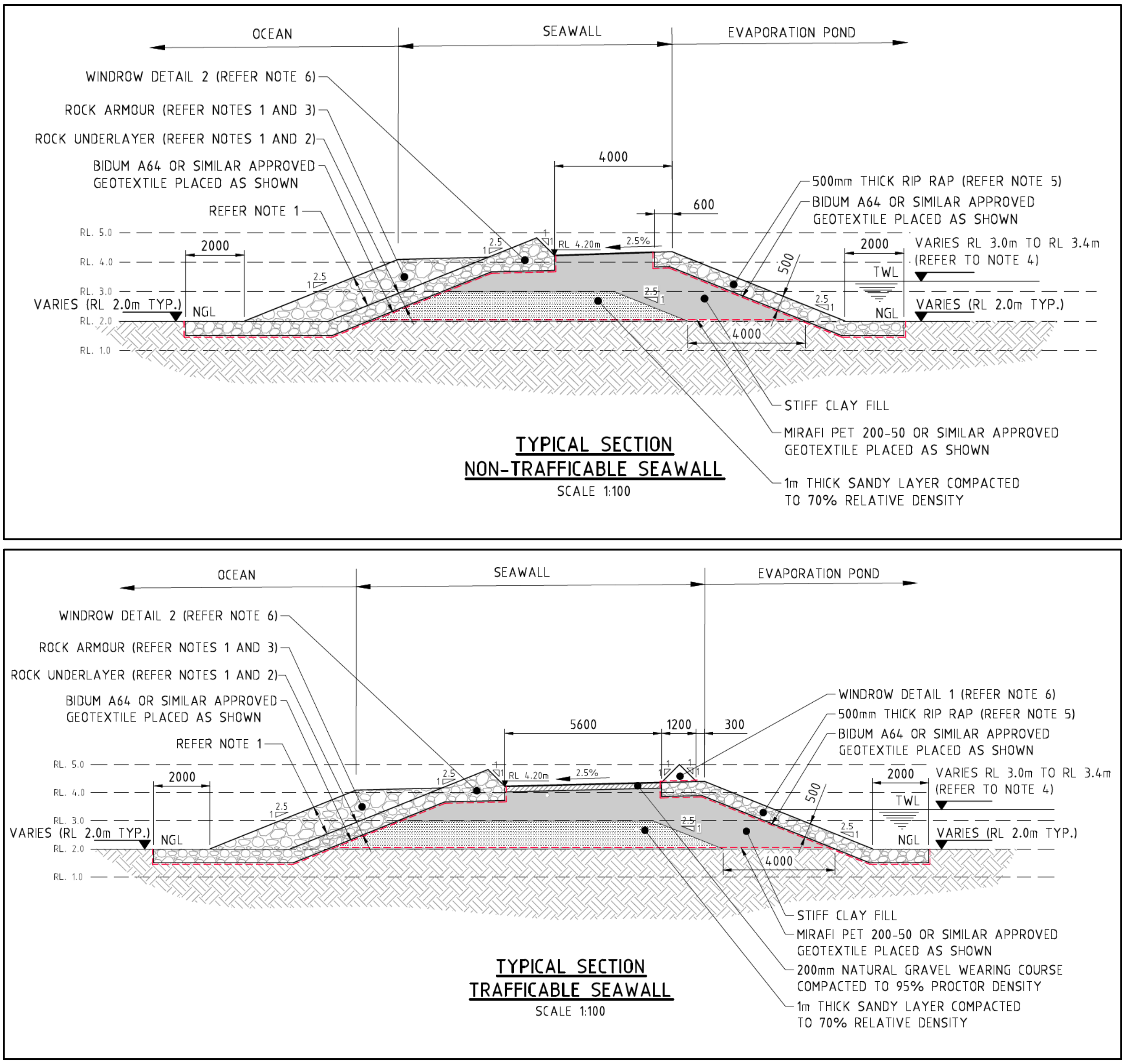


Figure 8: General cross-section of evaporation pond walls

Processing

Processing facilities will produce salt and SoP products, and other potential salt by-products if viable. Figure 9 and Figure 10 provide general processing flow diagrams for salt and SOP respectively.

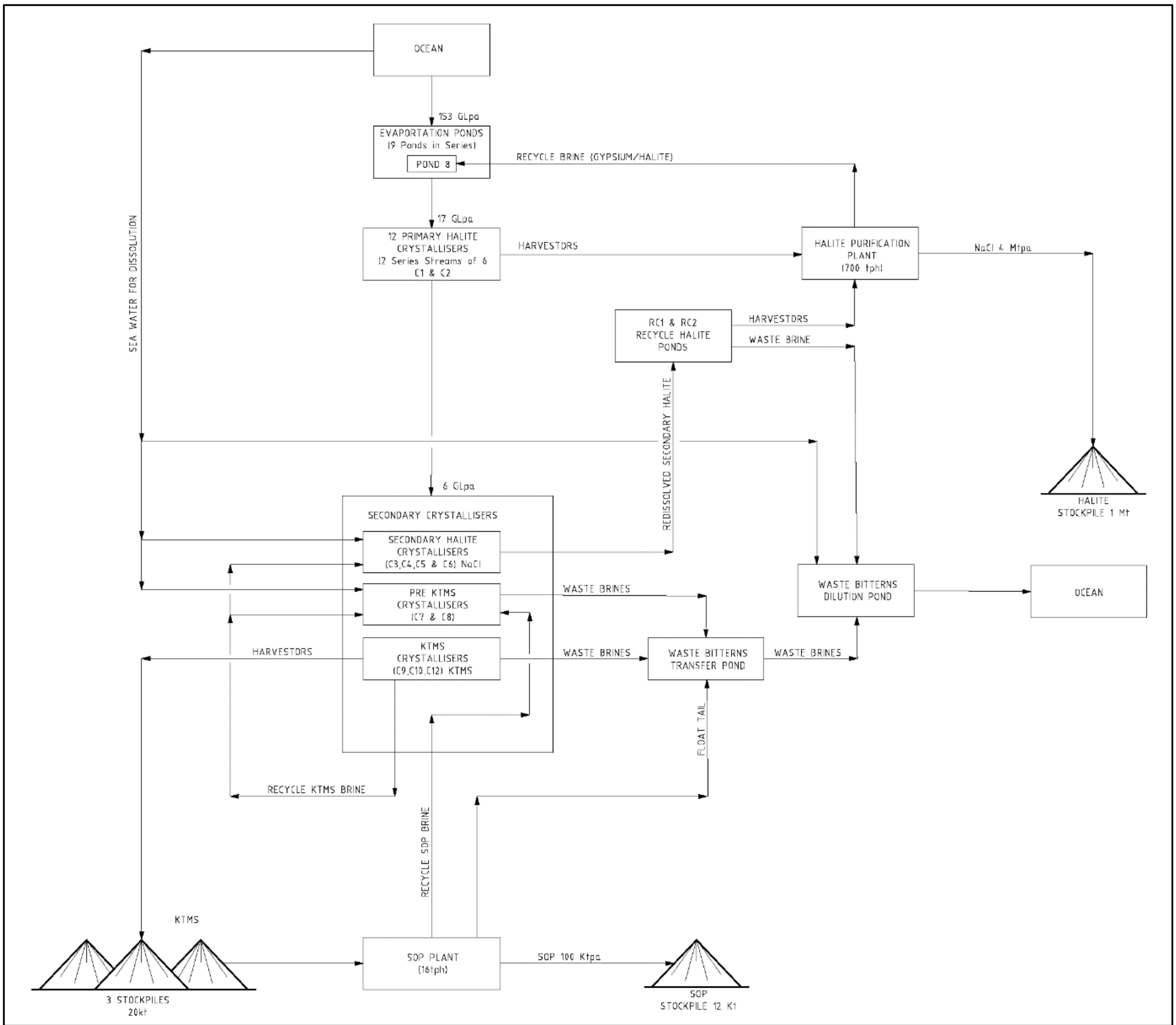


Figure 9: Salt processing general flow diagram

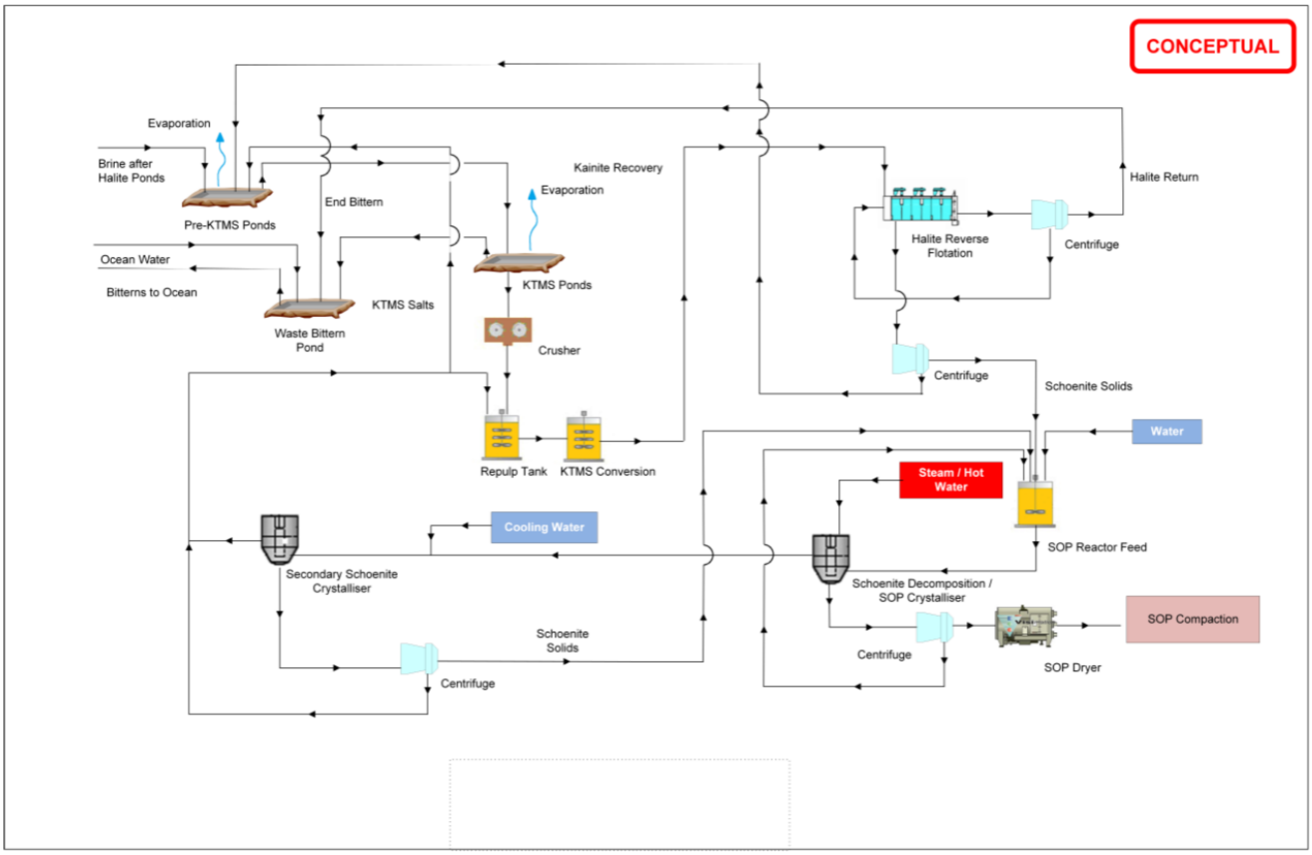


Figure 10: SOP processing general flow diagram

Causeway / Floodway

A 3.3 km causeway will be constructed across the intertidal zone to accommodate the transport of raw salt to the salt wash plant and processed SOP to the SOP stockyard. The causeway will accommodate a duel carriageway road and pipelines, and will include culverts and floodways positioned at natural ground level to ensure the occasional low tides that flow across the area are maintained (refer to section 5 for more detail).

The causeway has been relocated east of the original alignment in order to avoid direct impacts to tidal creeks and associated mangrove communities.

Salt Washplant and Stockyards

Raw salt is delivered to the salt washplant where impurities are removed and returned to the concentrator pond circuit for recycling. The final high-grade salt product is stockpiled adjacent to the jetty and then reclaimed as required for loading onto the jetty conveyor.

Processed SOP product that has been stockpiled is also reclaimed as required for loading onto the jetty conveyor.

Jetty

The 2.2 km long trestle jetty will be approximately 8 m wide to accommodate a roadway, conveyor and other services. It will be constructed with 18 m spans across twin 900 mm diameter piles using a 'top-down' method, whereby the piles are driven from above, using the previous piles as support. This eliminates the requirement for a construction access road or construction vessels and reduces the direct disturbance to just the footprint of each pile (900 mm). A general design drawing is provided in Figure 12.

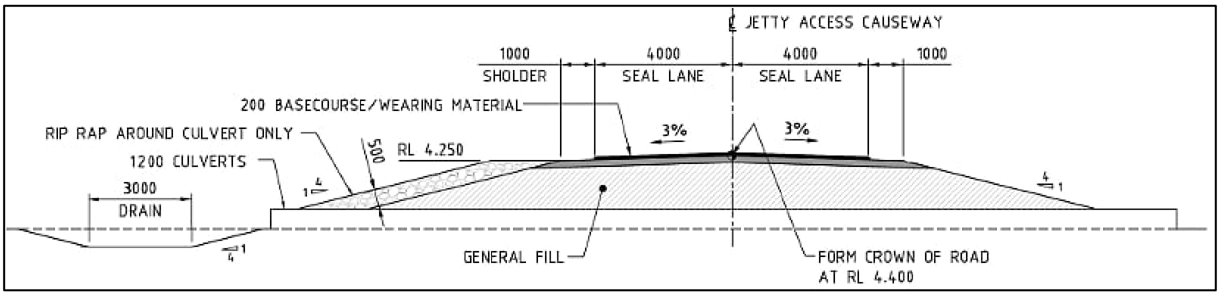


Figure 11: Causeway alignment and cross section

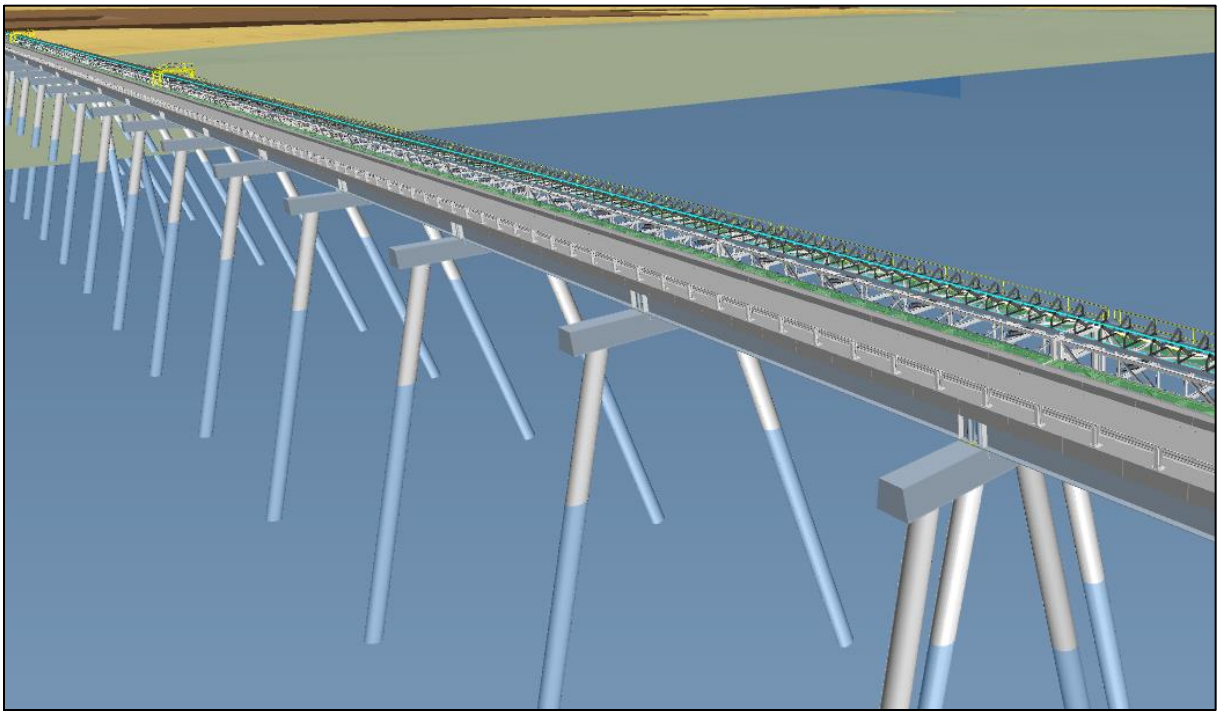


Figure 12: General design of the trestle jetty

Loading and Transhipping

Salt will be reclaimed from the salt stockpile and transferred by conveyor along the trestle jetty to the barge-loading facility. Salt will then be transferred from the conveyor to the transhipment vessel using a standard ship-loading conveyor and discharge chute (Figure 14).

SoP will be exported in containers which will be transported by truck to the barge-loading facility. The containers will be lifted by a crane and placed into the transhipment barge (Figure 14). SoP and other by-products may alternatively be transported by road to third-party delivery points, such as Dampier Port.

Transhipment barges will travel offshore to dedicated anchorages where they will dock with ocean-going vessels and transfer product from the barge into the vessels. An estimated 100 ocean-going vessel movements are predicted per year.

Figure 15 shows the transhipment vessel route and anchorages for ocean-going vessels.

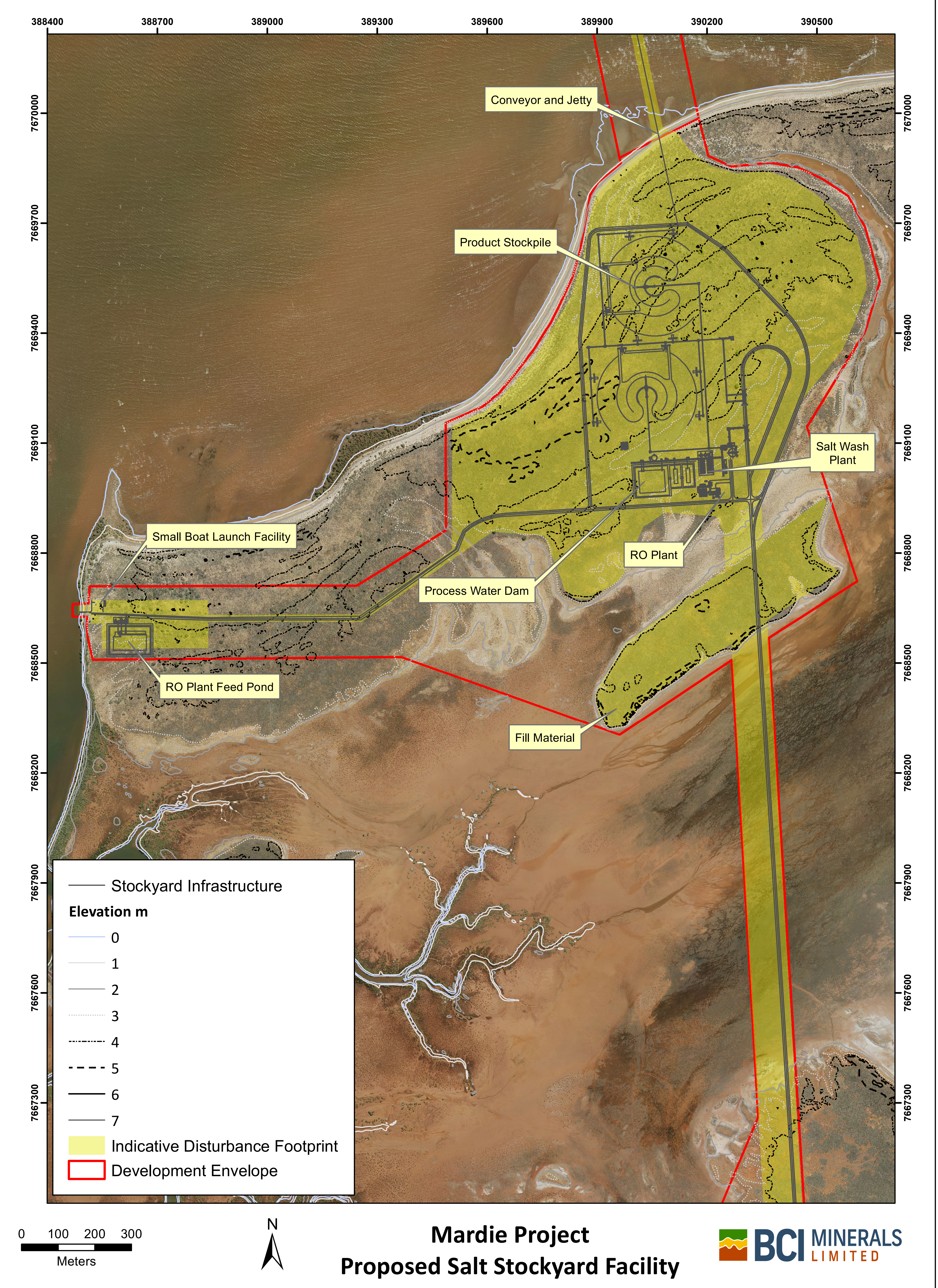


Figure 13: General design of the Port Stockyard

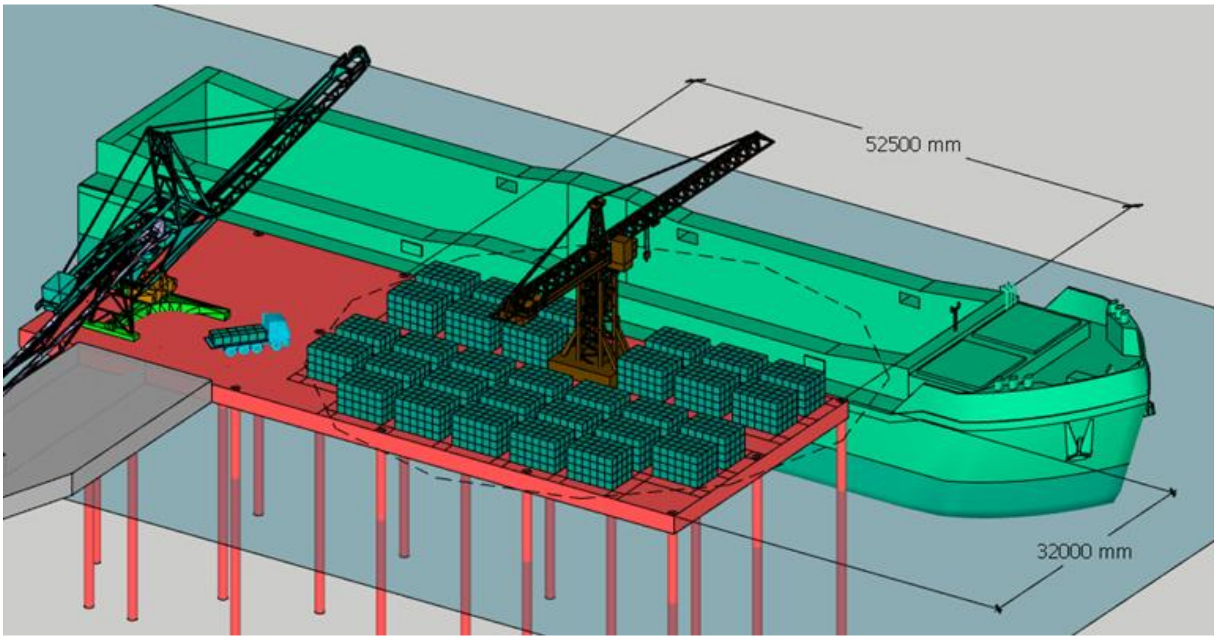


Figure 14: Ship loading facility

Boat Launching Facility

A small boat launching facility will be installed at Mardie Creek, west of the Port Stockyard (Figure 3). The use of this facility will be limited by tide levels and will only be used on rare occasions (i.e. emergency). It will consist of either a crane lift mounted on a small jetty or a soft boat ramp.

Dredging

Up to 800,000 m^3 of material will need to be dredged to ensure sufficient depth for the transhipment barge berth pocket at the end of the trestle jetty, as well as along a 4 km long channel out to deeper water (Figure 2). The average dredging depth is approximately 1 m below the current sea floor. Dredging will be conducted over a twelve month period using a barge-mounted long-reach excavator instead of a cutter-suction vessel. No offshore dumping of material is proposed. Material will be dug up and placed into a container within a hopper barge. The barge will then transport the container to the trestle jetty, where it will be lifted by crane onto a truck and taken to a bunded containment cell adjacent to the stockyard area (Figure 13). Decant water from the cell will be pumped through a series of settling ponds and discharged to the intertidal zone. The dredging will occur during daylight hours over a 12-hour shift, with actual dredge operation times expected for 10 hours per day.

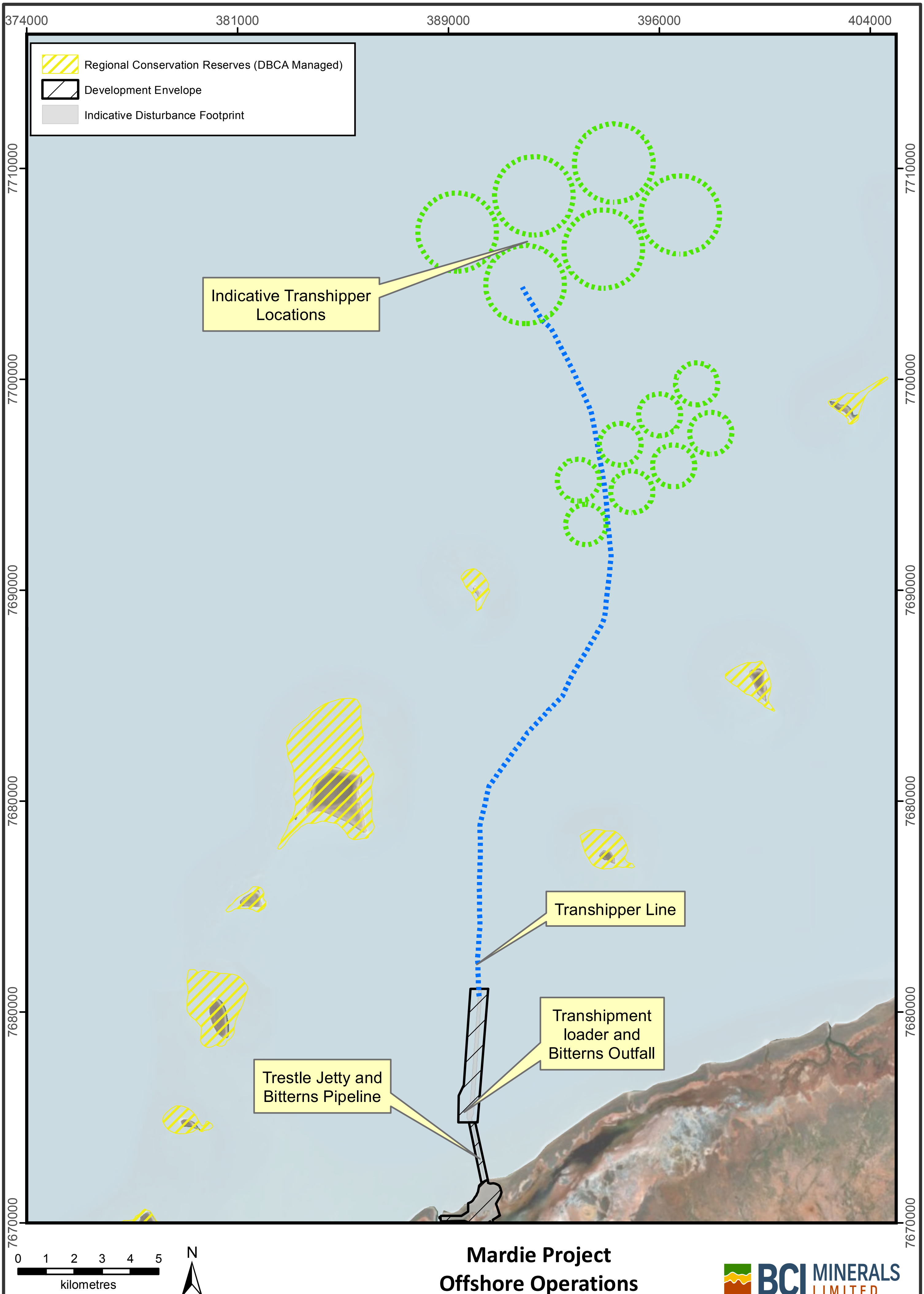


Figure 15: Transhipment vessel route and ocean going vessel anchorage

Bitterns

The production process will produce a high-salinity bittern (3.6 GL/yr) that will be diluted and discharged through a diffuser at the end of the trestle jetty (refer to Section 7 for more information).

A screened seawater intake will be installed underneath the jetty structure (refer to Figure 3 for location) to allow the dilution of these bitterns, in order to reduce its salinity prior to its discharge to the receiving environment. The seawater intake will have the same screen design as the primary seawater intake; however, the pumps extracting water will be surrounded by four screens (one on each side) and one screen underneath the pumps). The four vertical screens will be connected to the screen beneath the pumps and extend to a height above highest astronomical tide. The velocity of the water crossing the screens will not exceed 0.15 m/s.

Stormwater Management Strategy

The Proposal includes an extensive network of levees, channels and culverts designed to ensure catchment flows are maintained; and that extreme flows resulting from tropical cyclones and storms do not flood into the concentrator and crystalliser ponds or damage pond walls and other project infrastructure. The network is shown in Figure 3 and includes a 250 m-wide and a 300 m-wide lateral drainage channel through the centre of the concentrator ponds; a southern diversion channel associated with Peter Creek; and a storm levee and channel along the northern and eastern sides of the crystallisers for protection against flooding from the Fortescue River. No catchment flows will be directed down the gas pipeline corridor, to ensure the integrity of the pipelines.

The drainage control structures will be designed to accommodate a 100 year ARI event, and will consist of the following:

- Two wide lateral drainage channels and the southern (Peter Creek) diversion;
- Two diversion bunds along the north-south service road, designed to divert inflows along associated 28 m-wide drains through the two lateral channels or towards Peter Creek; and
- Floodways to feed flows greater than the 50-year ARI into ponds 2 – 4.

A floodway level set to the equivalent to the 50 year ARI flood elevation was determined through modelling (RPS, 2019a) as the optimum balance between minimising discharges to the concentrator ponds and also minimising the upstream impacts of the bunds. Modelling also indicated that discharges to the concentrator ponds resulting from a 100 year ARI event would be 20 m3/s or less, resulting in a rise in pond levels of between 2 and 4 cm during a 24-hour storm event (RPS, 2019a), making overflows from the ponds themselves very unlikely.

Site Access and Resources

Access to the Proposal will be from North West Coastal Highway and will follow an existing road alignment that services the Mardie Station homestead. This road will require upgrading to City of Karratha requirements.

Potable water will be required for the processing facilities and the accommodation camp, which will be sourced from a desalination plant located inland of the ponds (Figure 3). The higher salinity output from the desalination plant will be directed to a concentrator pond or to the bitterns stream. Potable water will be trucked to site until the desalination plant is fully operational or in the case of maintenance or breakdown.

The majority of the energy inputs required for the Proposal (i.e. approximately 95%) is provided by the sun and the wind, which drives the evaporation and crystallisation processes. In addition, the Proposal will require diesel and/or gas to provide additional energy for infrastructure, support services and processing plant requirements.

Post-Construction Rehabilitation

The construction methodology for the Proposal has been devised to minimise unnecessary disturbance and subsequent post-construction rehabilitation requirements. Concentrator and crystalliser pond walls will be constructed utilising materials from within the pond wall boundary and construction will be on an advancing front from atop the walls that have just been constructed. The jetty will also be constructed using a top-down methodology. This means that the construction from the jetty on an advancing front basis using the most recently constructed part of the jetty as the base for the advancing construction front, which eliminates the need for a construction access track. Other infrastructure will be constructed utilising the infrastructure footprint with minor buffers for road construction.

2.2.4 Disturbance and Development Envelopes

A total disturbance limit of 11,142 ha is proposed, within a total development envelope of 15,667 ha. Three separate development envelopes are proposed, as the type of disturbance varies greatly between activity types (Figure 2):

- The Ponds and Terrestrial Infrastructure Development Envelope contains the majority of the disturbance , including the ponds, processing facilities, causeway, boat launching facility, stockyards and access roads;
- The Marine Development Envelope occurs mostly within the offshore intertidal zone, and contains the trestle jetty, seawater intake and pipeline; and
- The Dredge Channel Development Envelope occurs in the sub-tidal zone, and was separated from the Marine Development Envelope as it contains higher impact activities such as dredging and bitterns disposal, which needed to be restricted to an offshore location.

Mardie Minerals has completed a series of environmental surveys and has established the key environmental values of the study area. The boundaries of the proposed development envelopes identified in Figure 2 have been adjusted to avoid and minimise potential environmental impacts relevant to mangroves, algal mats and other sensitive biological receptors.

Table 3 provides a breakdown of the anticipated areas of disturbance associated with the Proposal, within the three specified development envelopes.

2.2.5 Changes to the Proposal

The recent completion of the Definitive Feasibility Study (DFS) for the Proposal has included several optimisations to the design and several key Proposal elements have changed as a result. The changes to the Proposal are described in Table 4. Mardie Minerals met with EPA Services (on 1 April 2019) and DAWE (on 21 March 2019) to discuss the changes to the Proposal and a Section 43A application has been submitted to formally request a change to the Proposal.

Table 4: Changes to the Proposal since referral

Proposal Element	Original referral	Current proposal	Rationale for the changes
Development Envelopes and proposed disturbance	Disturbance of no more than 9,200 ha within the 15,002 ha Ponds Development Envelope	Disturbance of no more than 11,142ha within the 15,667 ha Ponds and Terrestrial Infrastructure Development Envelope.	Changes to the development envelopes and proposed disturbance are either due to project design changes or the exclusion of key environmental features. The changes to the Development Envelopes that are due to design changes are: • Increase in the size of concentrator and crystalliser ponds; • Finalisation of the design of the north-south service road; • Finalisation of the design of drainage channels ; • Replacement of the intertidal portion of the trestle jetty with a causeway; • Inclusion of a port salt stockyard and small boat launch facility; • Realignment of the export jetty, berthing pocket and dredge channel; and • Removal of one dredge channel option. The proposed changes to the development envelopes will allow the Proposal to achieve the 4 Mt/yr production volume required for project viability. The changes to the Development Envelopes that are due to environmental considerations are: • Redesign of Pond 1 boundaries to reduce overlap with the Robe River Delta Mangrove Management Area; • Reduction in the disturbance footprint required for the pond seawater intake; • Exclusion of Mardie Pool with an associated buffer; • Realignment of the causeway to the east to avoid impacts to tidal creeks and associated mangrove communities; • Reduction in clearing of intertidal islands to reduce impacts to SRE habitats and Aboriginal Heritage sites; • Reduction in disturbance within Peters Creek (Aboriginal heritage site); and • Exclusion of significant flora records. Mardie Minerals has also combined the Ponds Development Envelope and Terrestrial Infrastructure Development Envelope into a single development envelope. This will simplify assessment and reporting requirements. Figure 1 provides a comparison between the original and revised development envelope boundaries. The disturbance limits for the development envelopes have been revised as follows: • An increase of 1,856 ha within the Ponds and Terrestrial Infrastructure Development Envelope (increased from 9,365 ha to 11,142 ha), which now incorporates disturbance limits previously associated with the Roads and Infrastructure Development Envelope (165 ha) and part of the Marine Development Envelope (30 ha). The bulk of the increase is to accommodate an expansion of pond areas, an allowance for construction-related disturbances outside of the pond walls, and the requirements of up-slope surface water drainage controls;
	Disturbance of no more than 165 ha within the 338 ha Terrestrial Infrastructure Development Envelope		
	Disturbance of no more than 40 ha within the 280 ha Marine Development Envelope	Disturbance of no more than 7 ha within the 53 ha Marine Development Envelope	
	Disturbance of no more than 146 ha within the 1,317 ha Dredge Channel Development Envelope.	Disturbance of no more than 55 ha within the 304 ha Dredge Channel Development Envelope	

Proposal Element	Original referral	Current proposal	Rationale for the changes
			• A reduction of 80 ha within the Dredge Channel Development Envelope (from 146 ha to 55 ha), which is an outcome of moving to the detailed design phase; and • A reduction of 33 ha within the Marine Development Envelope (from 40 ha to 7 ha), as a result of excluding terrestrial activities (e.g. causeway and stockyard) from the Marine Development Envelope, and from realigning and shortening the export jetty.
	No reference	Disturbance of mangrove communities limited to 17 ha of SC mangroves with no direct impacts to CC mangroves.	Benthic habitat and community surveys have now been completed and Mardie Minerals proposes to set a limit on mangrove disturbance to ensure that impacts to mangrove communities are capped.
Dredge spoil disposal	500,000 m^3 of dredge spoil to be disposed of onshore	No more than 800,000 m^3 of dredge spoil to be disposed of onshore	More detailed bathymetry surveys have now been completed, revealing that an increase in dredging is required, As a result Mardie Minerals proposed to increase the limit of dredge spoil to be disposed of onshore by 300,000 m^3.
Bitterns disposal	Discharge of up to 3.6 GL/yr of bitterns within a dedicated offshore mixing zone	Discharge of up to 3.6 GL/yr of bitterns (maximum Specific Gravity of 1.25) within a dedicated offshore mixing zone. Bitterns is to be diluted with seawater prior to discharge.	Mardie Minerals commits to pre-diluting the bitterns in order to reduce their salinity prior to its discharge to the receiving environment. A seawater intake will be installed along the trestle jetty (outside the influence of the bitterns discharge diffuser) to provide sufficient mixing volume for the dilution. The same screening and screen velocity commitments for the primary seawater intake will also apply to this intake.
Groundwater abstraction	Abstraction of no more than 2 GL/yr	No groundwater abstraction required	Fresh water supplies for the Proposal will now be sourced from desalination plants rather than groundwater abstraction, with water being trucked in if required. The reference to abstraction limits in the Key Characteristics Table is therefore able to be deleted.
Rock causeway	No reference	Rock causeway to be included within the Marine Development Envelope	Mardie Minerals proposes to replace and realign the onshore section of the trestle jetty with a rock causeway, fitted with floodways and culverts and designed to limit the restriction of tidal movements. The rock causeway will terminate at the port stockyard and will not extend across the sandy beach into the offshore marine environment. The costs and construction schedule implications of a full trestle jetty were prohibitive to the viability of the Proposal and therefore the inclusion of a rock causeway section was deemed to be the only option. The chosen alignment avoids direct impacts to mangroves that were associated with the original Proposal. Mardie Minerals has completed a number of additional studies (Section 5) to both optimise the design of the causeway and to quantify and assess its direct and indirect impacts on the receiving environment.
Seawater abstraction for ponds	No limit	Seawater abstraction will only occur when water levels are at mean sea level or higher, from a screened intake with a maximum flow rate at the screen of less than 0.15 m/s	Mardie Minerals proposes to restrict the timing of seawater abstraction and the maximum flow rate at the intake screen for the ponds. These restrictions relate to mitigation measures designed to minimise environmental impacts.

Proposal Element	Original referral	Current proposal	Rationale for the changes
Boat launching facility and port stockyard	No reference	Boat launching facility and port stockyard to be included within the Ponds and Terrestrial Infrastructure Development Envelope	A small boat launching facility is proposed to be installed on Mardie Creek, to allow for small boat access on high tide (e.g. survey and environmental monitoring vessels). No dredging is proposed for this facility, which may either be a small ramp or a boat lift. Recent project design work has determined that moving the salt stockyard area closer to the export jetty would significantly reduce construction costs (less fill requirements) as well as operational costs associated with the transport and handling of the product.

2.3 JUSTIFICATION

2.3.1 DO NOTHING APPROACH TO THE PROPOSAL

Mardie Minerals has conducted a review of the current salt and Sulphate of Potash (SoP) markets, utilising leading industry market research reports and market enquiries. It was identified that the salt and SoP markets both have a positive long-term outlook. Strong Asian demand growth for salt, driven by demand from the growing industrial and chemical sectors, is forecast to result in a supply gap emerging over the next decade. This positive outlook is linked to an increasing Asian population driving food demand, lifestyle changes requiring high quality food, and the requirement for environmentally-friendly fertilisers delivering high crop yields.

Based on this outlook, Mardie Minerals predicts a strong demand for its salt and SoP products. The 'do nothing' approach to the Proposal represents a lost commercial opportunity to Mardie Minerals, the Pilbara Region and the State.

2.3.2 ALTERNATIVE LOCATIONS AND DESIGNS CONSIDERED

Mardie Minerals identified during the initial planning phase of the Proposal that environmental factors should have a significant influence on the design and location of the Proposal's ponds and infrastructure. A number of baseline environmental surveys were conducted during the planning phase, which enabled Mardie Minerals to incorporate avoidance and mitigation measures into the Proposal design. As a result, the location and design of the Proposal presented in this ERD differs greatly from the initial plans. The key changes made to the Proposal are:

- Redesign of the development envelopes to reduce impacts to the Robe River Delta Mangrove Management Area. Mardie Minerals has redesigned the pond layouts to remove as much of the development envelope as possible from this management area. Further exclusions could not be achieved as the exclusions required rebalancing of the pond footprint to ensure that sufficient surface area remained available for evaporation;
- **Relocation of ponds to reduce impacts to mangrove and algal mat habitat**. The concentrator and crystalliser ponds were originally planned to be located closer to the coast, in order to maximise the use of existing topography and minimise wall length and heights (Figure 16). Initial ecological surveys identified areas of high ecological value due to the presence of mangrove, samphire and algal mat habitats. The ponds and subsequent development envelope were then relocated to the east, to exclude the majority of these higher value habitat areas. Ponds have been located primarily on areas of bare clay pans.

Mardie Minerals notes that the primary crystalliser ponds require the disturbance of algal mat habitat; this disturbance cannot be avoided as Mardie Minerals is currently constrained by tenure to the east (Figure 2)

- **Widening of primary drainage line corridors**. The final Proposal design includes two 300 m wide drainage corridors to maintain the overall hydrological regime of the drainage catchments. The corridors are similar in width to the main channel of the nearby Fortescue River. The original design included narrow drainage corridors (Figure 16).
- **Maintenance of Peter's Creek flow**. The southern-most pond has been reduced in size and redesigned to retain the current Peters Creek discharge to the clay pan;
- **Development envelope exclusion zones.** The development envelopes have been redesigned to exclude an Aboriginal Heritage site and several significant flora records; and
- **Additional processing and dilution of bitterns**. The processing plant was redesigned and expanded to extract additional salt and conduct secondary processing, with the added benefit of reducing the volumes of bitterns. Mardie Minerals has also incorporated a seawater intake along the jetty to allow sea water to be abstracted and used for the dilution of the bitterns before discharge.
- **Alternate Causeway alignment**. The original alignment across the intertidal area intersected several tidal creeks, with their associated fringing mangrove communities. Mardie Minerals, through negotiation with the PPA, has modified the alignment of the causeway towards the east, thereby avoiding the creeklines and mangroves. Additionally, the realignment dramatically improves the capability of the causeway culverts to conduct natural tidal flows through the structure.

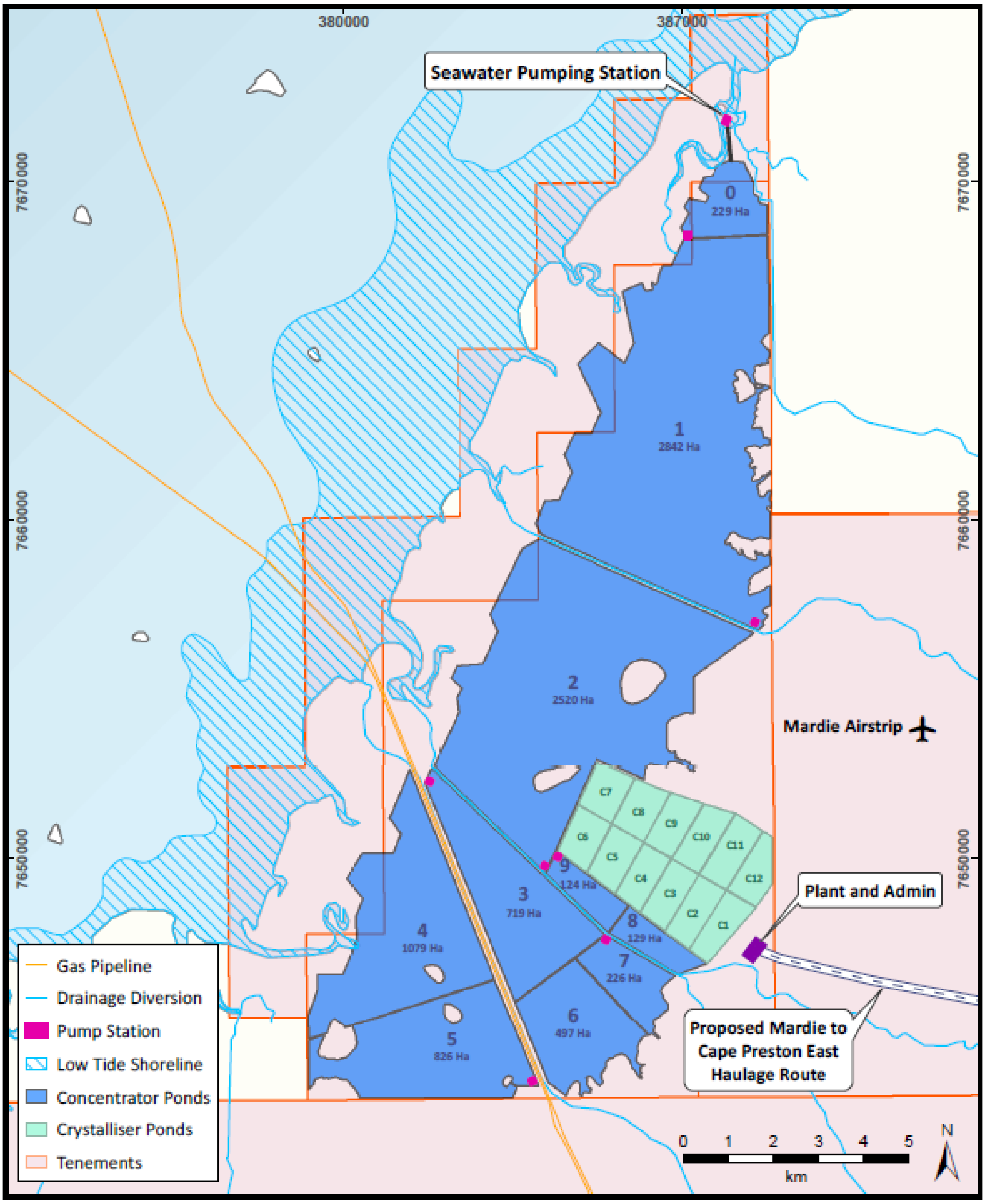


Figure 16: Original design of the Proposal

2.4 Local and Regional Context

The Proposal is approximately 80 km south west of Karratha, between the towns of Onslow and Dampier on the Pilbara coast, in the north-west of WA (Figure 1). The proposed concentrator ponds are located on mud flats on the landward side of the coastal mangrove areas and stretch over 20 km.

The following sections have been sourced from State Government reports describing the regions characteristics and values.

2.4.1 Land Use

The Proposal lies within the Pilbara bioregion and almost entirely within the Roebourne (PIL4) Interim Biogeographic Regionalisation for Australia (IBRA) subregion. This subregion is described as coastal and subcoastal plains with a grass savannah and undulating granite and basal plains (Kendrick & Stanley, 2001).

The Proposal extends across terrestrial, coastal and marine ecosystems. The terrestrial land forms part of Mardie Station, which is primarily used for cattle. The coastal and marine areas of the Proposal are not particularly used for any purpose other than recreation (fishing and boating) on rare occasions. The coast is not readily accessible from the land due to the extensive clay pans and mangrove systems. The closest recognised recreational area is located at the mouth of the Fortescue River, 19 km to the northeast.

2.4.2 Environmental Assets

Conservation Reserves

No conservation reserves or other Environmentally Sensitive Areas, as defined under section 51B of the EP Act are located within any of the development envelopes. The closest conservation reserves are the numerous offshore islands within the Passage Island Archipelago, associated with the Great Sandy Island Nature Reserve (Class B). The closest of these islands, Cowle Island and Solitary Island, are located approximately 6 km west of the development envelopes (Figure 17). These islands are managed by the Department of Biodiversity, Conservation and Attractions (DBCA) for the conservation of flora and fauna and are vested with the Conservation Commission of WA.

Other conservation reserves in the area, including:

- Weld Island Nature Reserve (Class C), located 31 km to the south-west;
- Barrow Island Nature Reserve (Class A), located 50 km to the north-west;
- Cane River Conservation Park (Class C), located 70 km to the south; and
- Exmouth Gulf East (Wetland of National Importance), located 150 km to the south-west.

EPA Management Areas

EPA Guidance Statement No. 1 for protection of tropical arid zone mangroves along the Pilbara coastline (2001) has identified that mangroves are an important component of the coastal ecosystem. Consistent with this the EPA has identified several areas containing regionally significant mangroves. One of these areas (Mangrove Management Area No. 7: Robe River Delta) overlaps the southernmost portion of the Proposal (Figure 17).

Important Wetlands

The Proposal does not overlap any listed or proposed wetlands of national or international importance.

Montebello Marine Park (Commonwealth)

The Montebello Marine Park lies more than 40 km from the Proposal (Figure 17) and shipping or other activities will not occur within the boundaries of the marine park.

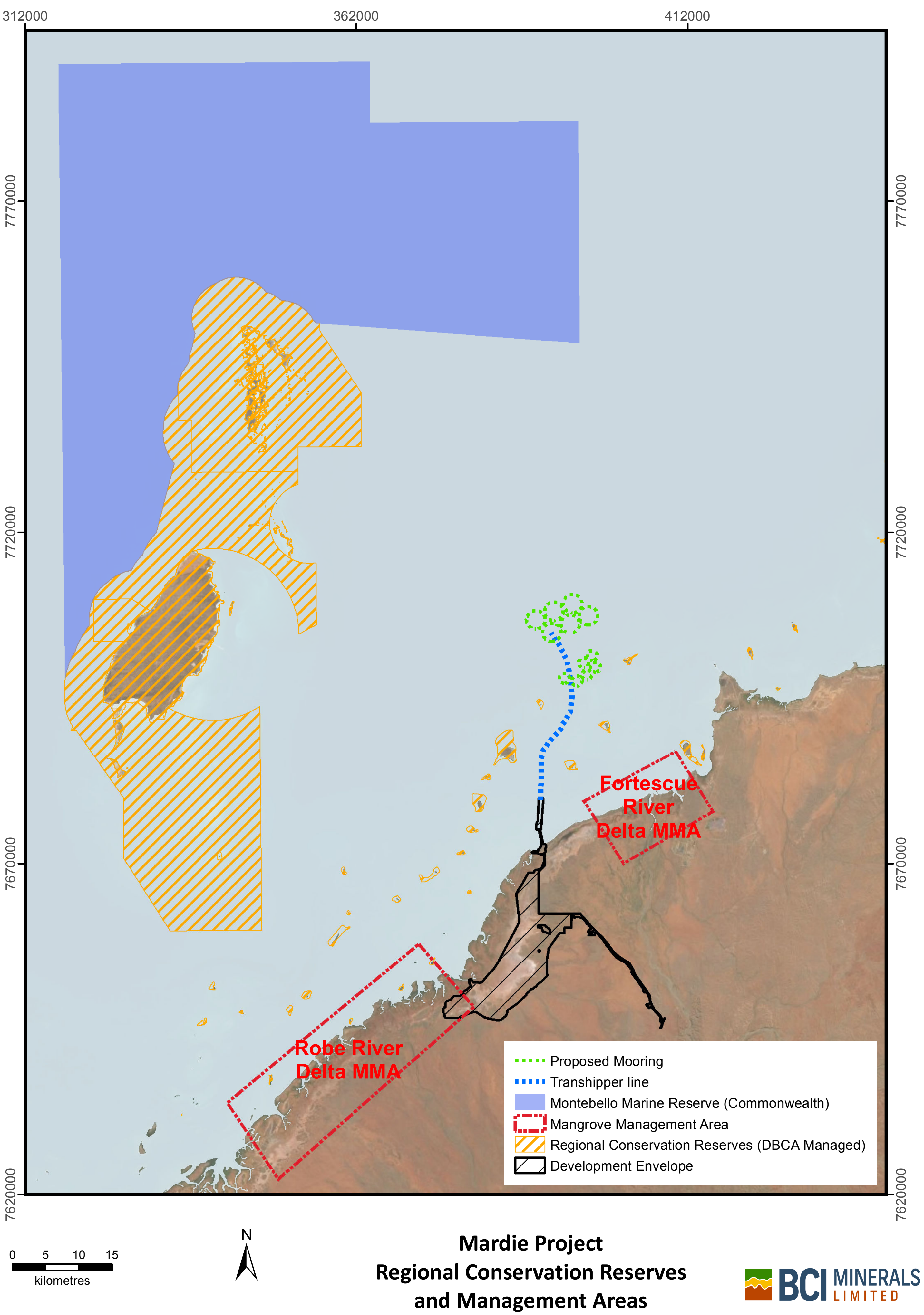


Figure 17: Conservation reserves and management areas

3 STAKEHOLDER ENGAGEMENT

3.1 Key Stakeholders

3.1.1 Government Stakeholders

Commonwealth, State and Local Government authorities have been briefed on the Proposal to ensure any issues, concerns or suggestions are identified and, where appropriate, addressed or responded to by Mardie Minerals. The consultations have resulted in some changes to the Proposal design; however, in most cases the purpose was to provide the Government stakeholder with relevant information.

The following Government stakeholders have been consulted:

- Commonwealth:
  - DAWE;
  - Department of Industry Innovation and Science (DIIS);
  - Minister for Resources and Northern Australia;
  - Minister for the Environment
- State:
  - DWER (EPA Services, Industry Regulation, Water);
  - Department of Jobs, Tourism, Science and Innovation (DJTSI);
  - DMIRS;
  - Department of Biodiversity, Conservation and Attractions (DBCA);
  - Department of Transport (DoT);
  - Department of Planning, Lands and Heritage (DPLH);
  - Department of Primary Industries and Regional Development (DPIRD);
  - PPA;
  - Minister for Mines;
  - Minister for Regional Development;
  - Minister for State Development;
  - Minister for Ports
  - Minister for Environment ;
  - Minister for Water
  - Vince Catania - WA National Member for North West; and
  - Main Roads WA.
- Local:
  - City of Karratha; and
  - Pilbara Development Commission

3.1.2 Corporate and Community Stakeholders

Mardie Minerals recognises that individuals, companies and communities may also be interested in the impacts of the Proposal. The following corporate and community stakeholders were deemed to be relevant to this Proposal:

- Yaburara Mardudhunera People (YM People);
- Kuruma Marthudunera People (KM People);
- Pilbara Mesquite Management Committee (PMMC);

- Conservation Council WA;
- Threatened Species Scientific Committee (part of DAWE)
- WA Marine Science Institute (WAMSI);
- Australian and New Zealand Environment and Conservation Council;
- Australian Nature Conservation Agency / Australian Wildlife Conservancy;
- Birds Australia / Birdlife Australia;
- Greening Australia;
- Pilbara Corridors;
- Rangelands Natural Resource Management WA;
- Wildflower Society;
- CITIC Pacific Mining;
- Pastoral Management Pty Ltd (PMPL);
- SANTOS Limited;
- Chevron Australia Pty Ltd;
- Wesfarmers Limited;
- WA Fishing Industry Council;
- King Bay Sporting Fishing Club;
- Nickol Bay Sporting Fishing Club; and
- Hampton Harbour Boat and Sailing Club.

3.2 Stakeholder Engagement Process

Mardie Minerals has a Consultation Strategy which identifies key external stakeholders and determines how they will be impacted by the Proposal and what influence they have over its implementation. The aim of such extensive consultation is to develop productive relationships that ensure the Proposal is underwritten by sustainable agreements and necessary statutory approvals. The Consultation Strategy has also been developed to secure the approvals necessary for the construction and operation of the Proposal, which will require consultation with the following stakeholders:

- Local Government (including Shire);
- State Government;
- Commonwealth Government;
- Aboriginal groups with a connection to the Project lands; and
- Corporate and community stakeholders.

3.3 Stakeholder Consultation

Mardie Minerals has a Stakeholder Consultation Register which maintains records of all consultations with stakeholders. The Register summarises key issues raised by stakeholders during the consultation process and describes how Mardie Minerals has responded to those issues. A summarised version of the Stakeholder Consultation Register is provided in Table 5 to provide details of the stakeholder consultation undertaken to-date for the Proposal. Generic discussions with decision-making authorities have not been included in Table 5 as per the guidance provided in EPA (2016q).

A Stakeholder Consultation Plan is maintained by Mardie Minerals. This plan outlines the key stakeholders, type of consultation, purpose of the engagement, issues/subjects to be raised and the timing of those engagements. A summarised version of this Plan is provided in Table 6 to provide details of the planned future and ongoing stakeholder consultation relevant to the Proposal and this ERD.

Table 5: Stakeholder Consultation Register

Stakeholder	Date/s	Relevant issues / topics raised	Proponent response / outcome
Government Stakeholders			
DAWE	16/12/2017 – Meeting 04/04/2018 – Letter 07/05/2018 – Letter 14/06/2018 - Email 06/07/2018 – Letter 12/09/2018 – Letter 23/11/2018 – Email 13/12/2018 – Meeting 21/03/2019 – Meeting 19/08/2019 – Site visit 20/9/2019 - Meeting	• Mardie Project briefing • Level of assessment • EPBC Referral Process • Cost recovery process • ESD input • Provide the DAWE with a preview of the Proposal ERD with specific reference to MNES • Flew/walked over proposal area • Meet to discuss feedback on draft ERD provided on 13 June 2019, with additional departmental representatives • Section 156A amendment request.	• Project referred to DAWE • ESD provided to DAWE for their review • ESD accepted with notes for consideration. • Mardie Minerals complete draft ERD and provide briefing to the DAWE • DAWE request that commentary regarding "non-status quo" events should be considered in the ERD • Mardie Minerals to respond to any additional queries from DAWE during their assessment • BCI provided written responses to draft ERD feedback points.
DIIS	22/12/18 - Meeting	Proposal briefing – benefits of the Proposal, and environmental approvals process.	Mardie Minerals seeking support from DIIS during approvals process if any significant delays occur with DAWE. DIIS were supportive and will endeavour to support if required.
Minister for Resources and Northern Australia	13/03/2019 – Meeting	Proposal briefing – benefits of the Proposal, and environmental approvals process.	Mardie Minerals seeking support from DIIS during approvals process if any significant delays occur with DAWE. Minister referred to Northern Australian Infrastructure Fund regarding its applicability to the Proposal.
DWER – EPA Services	15/03/2018 – Meeting 17/04/2018 – Email 07/05/2018 – Email & Letter 18/05/2018 - Meeting 28/06/2018 – Email 14/08/2018 – Email 04/09/2018 – Letter 26/09/2018 – Email 04/10/2018 – Email	• Proposal briefing and environmental design criteria discussion • Pre-referral meeting, level of assessment and Part IV assessment process • Environmental survey effort to meet EPA guidelines and other requirements • Briefing on survey results • ESD discussion and drafting • Pre-ESD briefing • Submission of ESD • Pre- ERD briefing and discussion regarding environmental factors and status of survey work	• Mardie Minerals to continue to liaise with EPA Services during Part IV approval process • ERD to include recommended information and discussed management approaches • Mardie Minerals to organise site visit for the EPA in 2019 • Mardie Minerals to ensure that all guidance is addressed in ERD through survey and modelling work

Stakeholder	Date/s	Relevant issues / topics raised	Proponent response / outcome
	08/10/2018 – Email 11/10/2018 – Email 31/10/2018 – Email 02/11/2018 – Email 15/11/2018 – Meeting 27/11/2018 – Email 28/11/2018 – Email 30/11/2018 – Letter 01/04/2019 – Meeting 19/08/2019 – EPA/DWER site visit 03/09/2019 – Meeting 17/03/2020 - Meeting	• Draft Local Assessment Units – no objections received • ERD submission • Flew/walked over proposal area • Several discussions and meetings regarding formal feedback on draft ERD that was submitted in June 2019 • Meetings regarding s.43A request and content	
DWER - Water	21/01/2019 – Meeting 28/03/2019 – Meeting 15/08/2019 - Meeting	• Proposal briefing and discussion regarding water requirements • 26D and 5C requirements • Provision of groundwater reports • Pre-referral discussions • Fresh water abstraction and stygofauna management	• Mardie Minerals to continue liaison during Part IV approval process • Mardie Minerals to provide information for 26D and 5C licences
DJTSI	27/08/2018 - Telephone 05/09/2018 – Meeting 24/10/2018 - Meeting 26/11/2018 - Meeting 22/01/2019 – Meeting 11/03/2019 – Meeting 18/03/2019 – Meeting 17/07/2019 – Meeting 31/10/2019 – Meeting 12/12/2019 - Meeting	• Proposal briefing and discussion regarding establishment of port adjacent to production facility and regulatory costs applicable to the Proposal • Further meetings regarding Proposal viability and the Mardie Port solution • Cross-departmental meeting regarding Mardie Port • DJTSI appointed lead agency status for Proposal • EPA and EPBC referral documentation provided • BCI provide project update and discussion regarding proposal to dedicate Mardie Road • BCI provided a project update, focussing on regulatory cost issues.	• Mardie Minerals completed extensive project financial analysis to illustrate the financial challenges with a port at Cape Preston East • Mardie Minerals, DJTSI and other Government departments agree to support the development of a Port adjacent to the Mardie Production Facilities • Mardie Minerals and DJSTI to address regulatory cost issues during 2019 with DMIRS and DWER EPA Services. • DJTSI to schedule meeting with Minister for Mines Office and Premier's Office to discuss outstanding regulatory cost issues. • Regulatory costs issues advice received from the Minister for Mines

Stakeholder	Date/s	Relevant issues / topics raised	Proponent response / outcome
DMIRS	09/10/2018 - Meeting 07/02/2019 – Meeting 20/02/2019 – Meeting 14/06/2019 – Meeting (with AMEC) 05/07/2019 – Meeting 25/07/2019 – Meeting 24/9/2019 – Meeting (Regional Inspector) 21/01/2020 - Meeting	• Proposal assessment requirements • Future tenure and approvals • Mining tenure application requirements • Mining Proposal and closure planning • Pre-referral discussions • Potash industry briefing regarding mining lease requirements for minerals dissolved in brine • Mining lease application supporting documentation discussion • Discuss large scale trial pond POW • PMP discussion regarding large-scale trial pond	• Mining Proposal and Mine Closure Plan (MCP) to be prepared in accordance with DMIRS guidelines • Mining Proposal and MCP to be submitted to allow parallel assessment with the Part IV EP Act process • A mining lease to be applied for Production Facilities, Ponds and Crystallisers • BCI confirming with DMIRS that the project is considered by the department to be a mineral derived from brine – NFA • DMIRS to advise BCI whether Mardie SP ML applications can be accompanied by a mineralisation report • BCI to submit POW in format of detailed mining proposal • BCI to update and amend existing PMP for site pilot study and resubmit.
DBCA	29/03/2018 - Meeting	• Pre-referral discussions • Initial findings of flora and fauna surveys • Bitterns disposal • Guidance regarding upcoming surveys	• DBCA input considered in ESD preparation • All surveys to consider appropriate DBCA guidance • Bitterns disposal modelling conducted to alleviate concerns
DoT	19/11/2018 – Meeting 26/11/2018 - Meeting 25/02/2019 – Meeting 26/03/2019 - Meeting	• Proposal briefing and discussion regarding establishment of Port adjacent to Mardie production facility and applicable regulatory costs • Further meetings regarding Proposal viability and the Mardie Port solution • Cross-departmental meeting regarding Mardie Port	• Mardie Minerals to brief Minister for Ports on Mardie export facility proposal • Mardie Minerals to work with PPA on development approval process for Mardie Port
DPLH	01/05/19 – Meeting 06/06/2019 – Meeting 05/07/2019 – Meeting 22/10/2019 – Meeting 27/11/2019 - Meeting	• Taking process for the Port Land required for the Mardie Project • Heritage landscape and value of the Project lands • Consultation regarding scope of S18 application • Draft S18 application provided for review and comment • Finalisation of S18 application prior to submission • Meeting to finalise dedication of Mardie Road.	• Mardie Minerals to undertake appropriate Heritage surveys across the development envelopes • Section 18 documentation to be prepared and lodged with DPLH • DPLH to provide written feedback on draft application • BCI to submit s18 application accommodating feedback from DPLH. • DPLH committed to preparing a process and timeline for dedication of Mardie Road and taking of the land at Cape Preston West
DPIRD	20/11/2018 – Meeting	• Proposal benefits to the State	• Minister to discuss support for Mardie Port with DJTSI and PPA

Stakeholder	Date/s	Relevant issues / topics raised	Proponent response / outcome
	01/10/2019 – Telephone Conference	• Viability of Proposal with competing Port options (Cape Preston East vs Mardie) – including project economic analysis • Regulatory cost regime for Proposal • Discussion (update) regarding Mesquite control and management at Mardie	• Pending discussion above, Minister to write to Mardie Minerals providing support for the Mardie Port • Letter received from Minister Ports supporting development of a port at Mardie on 15 March 2019 • BCI to continue working with Pilbara Mesquite Management Committee
PPA	19/11/2018 – Meeting 26/11/2018 - Meeting 25/02/2019 – Meeting 26/03/2019 – Meeting 21/06/2019 – Meeting 27/09/2019 – Meeting 18/10/2019 – Meeting 30/10/2019 – Site visit 28/11/2019 – Meeting 13/12/2019 - Meeting	• Proposal briefing and discussion regarding establishment of Port adjacent to Mardie production facility and regulatory costs applicable to the Project • Further meetings regarding Proposal viability and the Mardie Port solution • Cross-departmental meeting regarding Mardie Port • Mardie Port Design • Briefing on L08/179 misc licence application • Met to commence Term Sheet negotiations (first draft provided by BCI) • BCI CEO provided briefing on project to PPA CEO • BCI visited site with PPA to review Port Lands for future taking. • Term Sheet discussion, with PPA providing feedback on the version previously provided by BCI • Discussion around port marine infrastructure requirements of the PPA	• Mardie Port approvals process to be agreed with PPA via Letter Agreement • Mardie Minerals and PPA to work together to agree port lands required at Mardie • Mardie Minerals and PPA to work together to agree design principles for the Port • PPA operational areas incorporated into Proposal design presented in this ERD • PPA to consider implications of L application and overlap with proposed port taking area • PPA to review and provide feedback on draft Term Sheet • BCI to incorporate PPA design requirements in Project Definition
Cth. Major Projects Facilitation Agency	1/11/2019 – Telephone conference 30/01/20 - Meeting	• MPFA provided overview of the Major Projects application process • BCI and MPFA discussed finalisation of the MPS	• MPFA provided Mardie Minerals with Major Project application forms. • Application submitted on 31 January 20
Premier of WA	5/9/2019 – Meeting 12/11/2019 - Meeting	• Project briefing and discussion regarding regulatory costs • Further discussions regarding Minister for Mines response regarding Mardie Minerals position on regulatory cost for the project	• Positive response to project and Premier would consider regulatory cost issues rained and discuss directly with Minister for Mines prior to Mardie Minerals receiving formal response.
Minister of Mines and Petroleum; Commerce and Industrial Relations; Electoral Affairs; Asian Engagement.	18/06/2018 – Meeting 23/7/19 - Meeting	• Mardie Project briefing and Port options discussion • Tenure and approvals discussion • Briefing regarding regulatory cost regime under Mining Act for the Mardie Project	• Mardie Minerals to provide further updates to the Minister in 2019 • Mardie Minerals to write to the Minister outlining Mardie Minerals position on royalties MRF rents and rates for Mardie

Stakeholder	Date/s	Relevant issues / topics raised	Proponent response / outcome
Minister for Regional Development and Ports	20/11/2018 - Meeting	• Proposal benefits to the State • Viability of Proposal with competing Port options (Cape Preston East vs Mardie) – including project economic analysis • Regulatory cost regime for Proposal	• Minister to discuss support for Mardie Port with DJTSI and PPA • Pending discussion above, Minister to write to Mardie Minerals providing support for the Mardie Port • Letter received from Minister Ports supporting development of a port at Mardie on 15 March 2019
Minister for State Development	05/12/2018 - Meeting	• Proposal briefing • Proposal benefits to the State • Viability of Proposal with competing Port options (Cape Preston East vs Mardie) – including project economic analysis • Regulatory cost regime for Proposal	• Minister to discuss the support for Mardie Port with Minister for Mines and Minister for Ports • Mardie Minerals to establish contact with the Minister if Port facility is not support by the Minister for Ports
Minister for the Environment and Water	05/07/2018 – Meeting	Mardie Project briefing	• Mardie Minerals to liaise with Minister as necessary during EPA assessment process • Next Ministerial briefing in June 2019 following acceptance of the ERD
Local Government Authorities (City of Karratha)	10/09/2018 – Meeting 28/03/2019 – Meeting 08/04/2019 – Meeting 19/11/2019 - Meeting	• Proposal briefing • Mardie Road Access • Council briefing – benefits of the Proposal to the City, timing of Proposal development. Construction and operations, synergies between the Proposal and the City • Discuss conditions for the dedication of Mardie Road.	• Mardie Minerals to further investigate status of Mardie road as the main access road to the Proposal • Mardie Minerals to continue to brief the Council on a six-monthly basis to provide Proposal updates • BCI to complete stakeholder engagement and draft a Maintenance Agreement with City of Karratha for Mardie Road.
Pilbara Development Commission	28/03/2019 – Meeting	• Proposal briefing • Employment and contracting opportunities for City of Karratha residents • Family-friendly rosters	Mardie Minerals to further consider capability of businesses based in Karratha and rosters for the Proposal
Community and Corporate Stakeholders			
Pastoral Management Pty Ltd (PMPL) (Mardie Station)	Multiple meetings with Pastoralists throughout 2018 and ongoing 15/10/2018 – Meeting Pastoralist & CITIC Pacific Mining 22/11/2018 – Meeting 16/01/2020 - Meeting	• Proposal briefing • Access to pastoral lease • Negotiation of access agreement for Proposal development construction and operations • Further discussions regarding access agreement terms	• Mardie Minerals have had a close relationship with the pastoralist and meet with the station manager on a monthly basis and will continue to liaison • Mardie Minerals and PMPL/CITIC Pacific Mining to negotiate an access agreement • BCI provided updated access agreement to PMPL

Stakeholder	Date/s	Relevant issues / topics raised	Proponent response / outcome
KM Native Title Claim Group	05/09/2017 - Meeting 06/09/2018 - Meeting 06/11/2019 - Meeting	• Proposal briefing • Site clearance Heritage Surveys • Disturbance to Aboriginal Heritage Sites • Minimisation of impacts to traditional uses of the area • Impacts to bush medicine plants • Impacts to bush tucker • Review of environmental approval applications • Implementation Committee meeting	• Mardie Minerals to coordinate and schedule Heritage surveys for the Proposal footprint within KM Lands • Mardie Minerals and KM completed surveys in April 2019 • Mardie Minerals to provide draft copies of approval applications for review • Mardie Minerals and KM to discuss applicability for Royalty payments for SoP and salt production • Mardie Minerals provided update on company's activities an d reviewed Land Access Deed obligations status. • KM to respond to Mardie Minerals's letter regarding the relationship between Mardie Project and Land Access Deed.
YM Native Title Claim Group	22/08/2017 – Meeting 25/01/2019 – Telephone 29/01/2019 - Telephone 11/04/2019 - Telephone 17/04/2019 – Telephone 07/10/2019 – Meeting 10/12/2020 - Meeting	• Proposal briefing • Site clearance Heritage Surveys • Disturbance to Aboriginal Heritage Sites • Minimisation of impacts to traditional uses of the area • Impacts to bush medicine plants • Impacts to bush tucker • Review of environmental approval applications • BCI and YM completed an Implementation Committee meeting; large focus on project update. • BCI and WAC chairman discussed employment and contracting opportunities and the process to make them available to WAC members and businesses	• Mardie Minerals coordinated and completed Heritage surveys for the Proposal footprint within YM claim Lands • Mardie Minerals and YM completed surveys in November and December 2018 • Mardie Minerals to provide draft copies of approval applications for review • Mardie Minerals and YM to discuss applicability for Royalty payments for SoP and salt production • Commitment to finalise negotiations regarding SOP and salt royalties. Review compliance with land access deed. • BCI supplied pre-employment forms to WAC chairman
Santos Limited	03/04/2019 – Meeting 05/06/2019 – Meeting 11/9/2019 – Meeting 18/12/19 – Letter 31/01/20 – Letter 06/02/20 - Letter	• Proposal briefing • Gas pipeline and Proposal interactions were discussed • Key issues raised were operability of Proposal and integrity of the gas pipeline • Provision of technical solutions to gas pipeline crossing • BCI provided detailed overview of technical design of the Mardie Project infrastructure where it interacts with gas pipeline alignments and easements • Exchange of letters regarding exploration, trial pond and permanent access and associated agreements	• Both parties agreed to commence negotiation of an access agreement to ensure interest of both businesses are protected. • BCI to prepare and provide DFS level engineering for pipeline crossings • Santos receptive to technical designs and requested that DFS-level designs be provided once available. • Letters exchanged regarding access to gas pipeline corridor for exploration trial and project construction and operations access.

Stakeholder	Date/s	Relevant issues / topics raised	Proponent response / outcome
Chevron	09/05/2019 – Meeting 05/06/2019 – Meeting 11/09/2019 – Meeting 18/9/2019 – Meeting 18/12/2019 – Letter 31/01/2020 – Letter 06/02/2020 - Letter	• Proposal briefing • Gas pipeline and Proposal interactions were discussed • Key issues raised were operability of Proposal and integrity of the gas pipeline • Access Agreement discussions • BCI provided detailed overview of technical design of the Mardie Project infrastructure where it interacts with gas pipeline alignments and easements • Discussed trial pond activities and vehicular crossing of the Chevron gas pipelines • Exchange of letters regarding exploration, trial pond and permanent access and associated agreements	• Both parties agreed to commence negotiation of an access agreement to ensure interest of both businesses are protected • Chevron receptive to technical designs and requested that DFS-level designs be provided once available. • Chevron provided BCI with gas pipeline crossing template document to be completed and submitted to Chevron for approval. • Letters exchanged regarding access to gas pipeline corridor for exploration trial and project construction and operations access.
CITIC Pacific Mining	20/02/2019 – Meeting 14/08/2019 - Meeting	• Proposal briefing and overlap with the pastoral lease • Pastoral lease interaction with the Proposal • CITIC Pacific Mining's magnetite mining operation and Proposal synergies • Discussion re preparation of pastoral lease access agreement	• Both Parties agreed to commence negotiation of an access agreement to ensure interest of both businesses are protected • CITIC Pacific Mining provided first draft of access agreement on 15 April 2019
PMMC	10/09/2018 – Meeting 18/11/2020 - Meeting	• Proposal briefing • Discussed the PMMC role and potential collaboration with Mardie Minerals regarding Mesquite management	• Mardie Minerals purchased a Holman Plough to assist with effective removal of Mesquite for Proposal development and trial activities at the site • Mardie Minerals has made the plough available to the Mardie Station and PMMC for use as required • Mardie Minerals, PMMC and the pastoralist continue to liaise regarding mesquite management on the pastoral lease
Conservation Council WA	15/05/2019 - Letter	Proposal overview Offer to provide in-person presentation	Pending stakeholder response
Threatened Species Scientific Committee (part of DAWE)	15/05/2019 - Letter	Proposal overview Offer to provide in-person presentation	Pending stakeholder response
WA Marine Science Institute	15/05/2019 - Letter	Proposal overview Offer to provide in-person presentation	Pending stakeholder response

Stakeholder	Date/s	Relevant issues / topics raised	Proponent response / outcome
Murdoch University Fish Health Unit (Dr David Morgan)	01/10/2019 - Meeting	Meeting to discuss potential for sawfish to be found within tidal creeks along Mardie coastline	BCI advised that sawfish were highly unlikely to be found within the upstream reaches of tidal creeks such as where the seawater intake will be located.
Australian and New Zealand Environment and Conservation Council	15/05/2019 - Letter	Proposal overview Offer to provide in-person presentation	Pending stakeholder response
Australian Nature Conservation Agency / Australian Wildlife Conservancy	15/05/2019 - Letter	Proposal overview Offer to provide in-person presentation	Pending stakeholder response
WA Fishing Industry Council	29/05/2019 – Email 01/10/2019 - Meeting	• Proposal overview • Offer to provide in-person presentation • Potential impacts on commercial and recreational fishing • BCI provided project briefing and confirmed terms for the engagement of WAFIC to undertake fishing industry consultation on behalf of Mardie Minerals.	• Offer for in-person presentation was declined, further research and consultation to be conducted prior to implementation. • Terms of engagement and next steps agreed.
Birds Australia / Birdlife Australia	15/05/2019 - Letter	Proposal overview Offer to provide in-person presentation	Pending stakeholder response
Greening Australia	15/05/2019 - Letter	Proposal overview Offer to provide in-person presentation	Pending stakeholder response
Pilbara Corridors	15/05/2019 - Letter	Proposal overview Offer to provide in-person presentation	Pending stakeholder response
Rangelands Natural Resource Management WA	15/05/2019 – Letter 08/05/2020 - Meeting	Proposal overview and discussion of opportunities for collaboration	Commitment to maintain contact and inform each other of potential opportunities to collaborate
Wildflower Society	15/05/2019 - Letter	Proposal overview Offer to provide in-person presentation	Pending stakeholder response
King Bay Sporting Fishing Club	09/04/2019 - Email	Proposal overview Offer to provide in-person presentation	No issues with Proposal – Mardie Minerals to provide updates on an annual basis
Nickol Bay Sporting Fishing Club	09/04/2019 - Email	Proposal overview Offer to provide in-person presentation	No issues with Proposal – Mardie Minerals to provide updates on an annual basis

Stakeholder	Date/s	Relevant issues / topics raised	Proponent response / outcome
Association of Mining and Exploration Companies	04/12/2019 – Meeting	MM Discussed application of MRF to brine-derived product projects.	All industry reps to provide own interpretation on how the MRF should apply to project domains.
Leichhardt Industrial Minerals Pty Ltd	05/06/2019 – meeting 30/07/2019 – Meeting 02/08/2019 – Meeting 09/08/2019 – Meeting 16/08/2019	• Discussion regarding opportunities to work together on respective salt projects • Mardie project layouts presented to Leichhardt and continued discussions re project interactions\ • Continued negotiation of agreement	• Agree to formally commence negotiation of Agreement • BCI to provide further information on project and commence negotiation with them on stuff
Cyril Geech (holder of E08/2647)	13/08/2019 – Meeting 12/09/2019 – Meeting 24/10/2019 – Meeting 21/11/2019 - Meeting	• BCI met to discuss access to E47/2647 • Further negotiations regarding purchase of E08/2647 • Finalise negotiations and terms for purchase of L08/2647 • Execute agreement to purchase E08/2647.	Execute agreement to purchase E08/2647
Wesfarmers Limited	04/10/2019 - Meeting	• Presented overview of Mardie project.	None required at this stage

Table 6: Stakeholder Consultation Plan

Timing	Stakeholder	Type	Purpose of planned engagement	Issues to be raised
2020 - ongoing	DAWE	Telephone, email and meetings	Correspondence to obtain approval under the EPBC Act	• Potential impacts to MNES • Additional information requirements • Approval conditions • Management Plans • Ongoing monitoring of Migratory birds
2020 - ongoing	EPA Services - DWER	Telephone, email and meetings	• Correspondence to obtain approval under Part IV of the EP Act • EPA Board meeting	• Minor or Preliminary Works approval (if required) • Mangrove Management Area • Presentation of EIA • Review of draft ERD • Response to public comments • Draft conditions • EPA Board meeting
2020 - ongoing	Industry Regulation - DWER	Telephone, email and meetings	Correspondence to obtain works approvals under Part V of the EP Act.	• Future Works Approvals and Licence requirements (concentrator and crystalliser ponds, bulk material export, landfill etc.) • Project timing (i.e. construction) • Potential environmental impacts
2020 - ongoing	DMIRS	Telephone, email and meetings	• Correspondence to obtain grant of mining tenements and approval of Programme of Works (PoWs), Mining Proposal, MCP and Project Management Plan • Agreement on salt and SoP royalty rates	• Tenement applications • Mining Proposal and MCP assessment • Timing • Project specific requirements • Closure requirements • Project Management Plan assessment • Salt and SoP royalty rates
2020 – 2021	Main Roads WA	Letter	Letter summarising the Proposal status and future planning.	• Future applications • Site access • Timing (i.e. construction & operation) • Operating hours • Site access/routes
2020 - ongoing	PPA	Letters and meetings	Correspondence to: negotiate terms of port leases; gain port Development and Construction Application approvals and support the Taking of the Lands required for the Port.	• Future applications • Export options • Path forward for the Proposal

Timing	Stakeholder	Type	Purpose of planned engagement	Issues to be raised
2020 – 2021	Relevant Ministers	Letters and meetings	Letter summarising the Proposal status (i.e. approvals to date and path forward).	• Approvals and tenure status • Future applications • Studies undertaken • Key findings • Path forward for the Proposal
2020 - ongoing	City of Karratha	Letters and meetings	Letter summarising the Proposal status (i.e. approvals to date and path forward). Meetings to agree City of Karratha support for establishment of a public road to access the Proposal.	• Approvals required for the City (e.g. building) • Approvals required to support the gazetting of Mardie Road • Future applications • Path forward for the Proposal
2020 - ongoing	KM and YM Native Title Claim Groups	Letter and copies of draft approval documents	Feedback on Proposal design.	• Approvals to date • Future applications • Studies undertaken and key findings • Path forward for the Proposal • Potential for indigenous contracting and employment opportunities • Bush tucker/ bush medicine management
2020 - ongoing	Mardie Station	Ongoing meetings and formal access agreement	Letters summarising the Proposal status and timing on pathway forward. Formal access agreement.	• Proposal summary, status, timing • Invitation for comment • Tenement applications • Access agreement
2020 – ongoing	WA Fishing Industry Council	Letters and meetings	Correspondence to ensure Proposal has minimal impacts on commercial and recreational fishing.	• Proposal summary, status, timing • Invitation for comment / discussion • Proposal operations to minimise impacts
2020 - ongoing	Affected mining and infrastructure companies	Letters and access agreements	Letters summarising the Proposal status and timing on pathway forward.	• Proposal summary, status, timing • Invitation for comment • Tenement applications

4 ENVIRONMENTAL PRINCIPLES

The EP Act identifies a series of principles for environmental management (Section 4a, EP Act, as amended). Mardie Minerals has considered these principles in relation to the development and implementation of the Proposal. Table 7 outlines how the principles relate to the Proposal.

Table 7: *Environmental Protection Act 1986* Principles

Principle	How it will be addressed by the Proposal
1. The precautionary principle Where there are threats of serious irreversible damage, lack of full scientific certainty should not be used as a reason for postponing measures to prevent environmental degradation. In the application of the 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.	While Mardie Minerals has commissioned numerous studies in order to inform the design of the Proposal, there are still several examples where a precautionary approach has been taken, such as: • Relocation of the Proposal away from significant benthic communities and habitats along the coastline, reducing impacts on areas with greater biodiversity; • Utilising a desalination plant for fresh water supply, which avoids all potential impacts associated with groundwater abstraction; • Diluting bitterns with seawater prior to discharge; and • Maintaining two wide corridors for the main drainage lines through the ponds.
2. The principle of intergenerational equity The present generation should ensure that the health, diversity and productivity of the environment is maintained or enhanced for the benefit of future generations.	The Proposal targets a relatively infinite seawater resource and as such it has been designed as a long-term project. There are few if any permanent landscape alterations of significance and all impacts are expected to be reversible or almost so. The Proposal has been designed to specifically target areas of lower biological significance in order to ensure the health, diversity and productivity of the current environment is maintained.
3. The principle of the conservation of biological diversity and ecological integrity Conservation of biological diversity and ecological integration should be a fundamental consideration.	Survey work has been used to confirm the range and status of environmental values within the vicinity of the Proposal. Disturbance within areas of noted higher biological diversity (i.e. mangroves, algal mats, benthic primary producer habitat etc.) has been avoided or minimised. Priority has been given to maintaining natural ecological and landscape processes.
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 principle – those who generate pollution and waste should bear the cost of containment, avoidance or 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 structures, including market mechanisms, which benefit and/or minimise costs to develop their own solutions and responses to environmental problems.	As discussed in Section 2.3.2, the Proposal design and management controls have been revised to reduce the potential impacts to environmental factors. These revisions resulted in additional costs that have been considered in the Proposal costing phases and this will continue through the final feasibility stages of the Proposal.

Principle	How it will be addressed by the 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	Waste will be minimised by adopting the hierarchy of waste controls; avoid, minimise, re-use, recycle and safe disposal. There are several examples of how the Proposal will minimise the generation of waste and its discharge to the environment: • Processing of the bitterns to extract SoP and other by-products; • Utilising the desalination plant waste brine by adding it to the evaporation pond sequence, where suitable; • Targeting land with low permeability soils to avoid the requirement for pond liners at all concentrator and crystalliser ponds; • Utilising dredged material for construction of elevated facilities; and • Utilising cut-and-fill construction methods for the pond walls.

5 INLAND WATERS

The Inland Waters factor was noted as being linked to several other key environmental factors such as Benthic Communities and Habitats (BCH), Marine Environmental Quality, Flora and Vegetation, and Terrestrial Fauna. As such this section was moved ahead of these other factors to provide a logical flow to this ERD.

5.1 EPA OBJECTIVE

The EPA Objective for this key environmental factor is to maintain the hydrological regimes and quality of groundwater and surface water so that environmental values are protected.

5.2 POLICY AND GUIDANCE

Relevant guidance documents for inland waters are listed below:

Western Australian Government

Key EPA Documents

- Statement of Environmental Principles, Factors and Objectives (EPA, 2016a);
- Statutory Guidelines for Mine Closure Plans (DMIRS, 2020); EIA (Part IV Divisions 1 and 2) Administrative Procedures 2016;
- EIA (Part IV Divisions 1 and 2) Procedures Manual 2016; and
- Instructions on how to prepare *EP Act* Part IV Environmental Management Plans (EPA, 2018a).

Relevant EPA Factor Guidelines

Environmental Factor Guideline – Inland Waters (EPA, 2018b).

Other Policy and Guidance

- 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);
- WA Water in Mining Guideline. Water licensing delivery report series. Report No. 12. (Department of Water (DoW), 2013);
- Operational Policy 5.12 – Hydrogeological reporting associated with a groundwater well licence (DoW, 2009);
- WA Environmental Offsets Policy (EPA, 2011);
- WA Environmental Offsets Guidelines (EPA, 2014); and
- WA Offsets Template (EPA, 2014).

Commonwealth Government

Key Documents

- Generic guidelines for the content of a draft EPBC Act PER/Environmental Impact Statement (EIS) (including the objects and principles of the EPBC Act 1999) (DotEE, 2016);
- Other Minister of the Environment (Cth) approval decision making considerations;
- EPBC Act Environmental Offsets Policy (Department of Sustainability, Environment, Water, Population and Communities, 2012) (DSEWPaC, now DAWE) – including the Offset Assessment guide;
- Environmental Management Plan Guidelines (DotE, 2018a);
- Environmental Management Plan Guidelines, - template (DotEE, 2018a);
- EPBC Act Condition Setting Policy (DAWE, 2020);
- EPBC Act Outcomes-based conditions policy (DotE, 2016); and
- EPBC Act Environmental Offsets Policy (DSEWPaC, 2012a).

Relevant Technical Guidance

- Relevant EPBC listed species specific survey guidelines and protocols; and
- Relevant EPBC listed species specific Recovery plans, Threat Abatement Plans, Approved Conservation Advices and other documents.

5.3 Receiving Environment

5.3.1 Study Effort

Baseline data relevant to this section has been sourced from the following:

- Climate data from the Bureau of Meteorology (BoM), in particular the Mardie Station certified weather station (IDW60801), as well as on site temperature and humidity loggers;
- Topographical data (land contours) was sourced from Landgate and subsequently corrected and expanded using on-ground and LIDAR aerial surveys;
- Bathymetry (including for accessible intertidal areas) was sourced from government and commercial charts, and subsequently added to and adjusted following extensive bathymetric surveys undertaken by O2 Marine;
- Tidal data was sourced from nearby Department of Transport (DoT) tidal stations, including Fortescue River mouth and Barrow Island Tanker Mooring, with tidal loggers also being installed by O2 Marine;
- Soil samples were collected as part of ongoing geotechnical studies, with relevant samples being analysed for acid sulfate soil (ASS) indicators, and other soil samples tested for permeability (following compaction to field specification);
- Marine sediments from areas to be dredged (with the spoil to be disposed on land) and samples along the causeway alignment were also assessed for ASS indicators;
- Groundwater samples were collected from existing pastoral wells and bores (identified with the assistance of the pastoralist), as well as from monitoring bores established as part of the geotechnical program; and

- Due to the lack of surface water flows over the previous two years, surface water sampling to date has been restricted to a single permanent pool near the Mardie Station woolsheds (Mardie Pool), as well as a pool at Peters Creek, and small creeks that held water following recent rains.

The collected data was used to calibrate a number of predictive models developed to inform Proposal design and this ERD:

- RPS Group (RPS) developed a coastal inundation model for illustrating tidal variation and then applied that model to test the effect of:
    - Placement of the pond walls;
    - Sea level rise, based on a predicted increase of 0.9 m over 100 years (RPS, 2019; Appendix 1.1); and
    - The location and design of the causeway (RPS, 2020; Appendix 1.2).
- RPS modelled storm surge and potential flood flows from inland catchments (2019b; Appendix 1.3, and 2019a) to inform engineering design and to provide numerical outputs and maps of changes to water levels and inundation frequencies to enable an assessment of indirect impacts to terrestrial habitats and BCH (e.g. O2 Marine, 2020c; Appendix 2.1);
- Baird prepared a hydrodynamic nearshore model (water and wave levels, current velocity and direction, wind effects and seasonal effects), which incorporated O2 Marine's bathymetric and metocean information (Baird, 2020a; Appendix 6.1);
- Soilwater Group modelled seepage of brine from the concentrator and crystalliser ponds, and the impacts that this might have on underlying groundwater systems (SWG, 2019a; Appendix 10.1); and
- ASS risk assessments of materials to be disturbed by terrestrial construction and marine dredging were conducted by Stantec (2017a; Appendix 10.4) and O2 Marine (2019a; Appendix 5.1), respectively. Additional chemical analysis, including ASS indicators, was also undertaken by Soilwater Group (2019b; Appendix 10.2, 2020; Appendix 10.3) including additional sampling and analysis of ASS risks along the causeway alignment.

5.3.2 Climate

The Pilbara bioregion has an arid to tropical climate with average maximum temperatures over 40°C from November to February and an average maximum of 25°C during the winter months (Leighton, 2004; McKenzie *et al.,* 2009). Annual rainfall across the broader Pilbara region averages approximately 290 mm and is most prevalent over the summer months in association with cyclonic activity to the north and northwest, though annual rainfall is highly variable (McKenzie *et al*., 2009). The climate of the Roebourne subregion, in which the Proposal is located, is defined as arid (semi-desert) tropical with highly variable rainfall and cyclonic activity, primarily over summer (Kendrick & McKenzie, 2001).

A BoM weather station is located at Mardie Homestead (Site number IDW60801), immediately east of the Proposal. Mardie records its highest maximum mean monthly temperature (37.9°C) in January and lowest (25.3°C) in February, with its highest minimum mean (27.7°C) and lowest (11.8°C) in July. Average annual rainfall is 278.7 mm, with highest monthly average rainfall recorded in February (62.7 mm) (BoM, 2018) (Figure 18). Recent years have seen very low rainfall at Mardie, with 101 mm being recorded in total for 2018, and 81 mm for 2019.

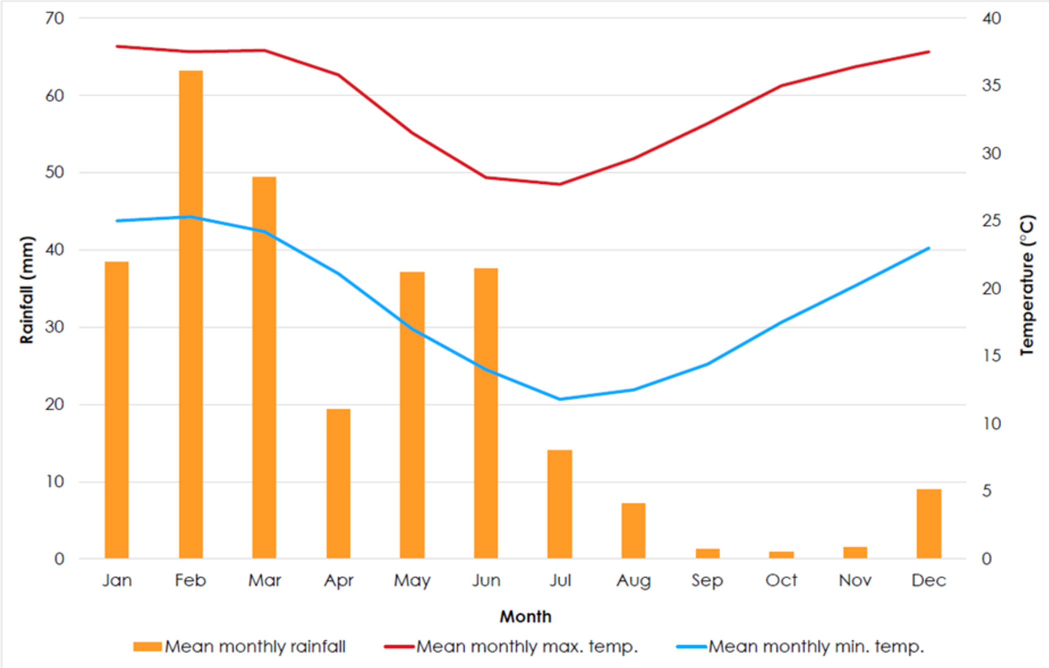


Figure 18: Mardie climate data (average monthly temperature and rainfall records)

Rainfall intensity-frequency-duration

Intensity-Frequency-Duration (IFD) data to characterise the storm intensity in the area under consideration has been compiled by RPS (2019) and are shown in Table 8.

Table 8: Intensity-Frequency-Duration Data (rainfall depth in mm)

Average rainfall intensity (ARI)	1 Yr	5 Yr	10 Yr	50 Yr	100 Yr	1000 Yr	Probable maximum flood (PMP)
1-Hour	23	41	50	73	83	141	274
2-Hour	29	51	64	95	109	185	360
6-Hour	39	75	95	149	174	296	574
12-Hour	47	95	124	198	233	396	769
24-Hour	57	119	156	251	296	503	977
72-Hour	71	148	192	301	354	602	1,168

Cyclones and tropical lows

Tropical cyclones are the controlling storm type for return periods of a few years and longer in the study region RPS (2019b). The Mardie region is subject to severe tropical cyclone activity (in terms of both strength and frequency of occurrence) in the predominant summer months of December to April, with extremely rare occurrences also possible in November and May. Tropical cyclones tend to be most severe in late March and April, when sea surface temperatures typically reach a peak, and they are most frequent in the months of January to March.

5.3.3 Groundwater

Since the finalisation of the ESD, it has been decided that interim potable water requirements for the Proposal will be sourced from appropriately licensed third-party providers instead of groundwater bores. Once commissioned, reverse osmosis plants will be used to supply potable water requirements. Potential impacts from groundwater drawdown are therefore no longer applicable to the Proposal.

The hydrogeological study by Soilwater Group (2019b) has instead focused on:

- Characterising the existing hydrogeological systems, and describing their relationships with key surface water processes; and
- Determining the extent and nature of changes to those systems as a result of seepage and/or mounding from the proposed ponds.

Geology and Geomorphology

Geologically, the Proposal occurs predominately within the Onslow Plain Zone regional land system (SWG, 2019a), which is described as "Coastal mudflats (with some sandplains and coastal dunes) on coastal deposits over sedimentary rocks of the Carnarvon Basin with Tidal soils, Calcareous deeps sands and some Red deeps sands, Red/brown non-cracking clays and Salt lake soils". Within this zone, there are two land systems that together cover the majority of the development envelopes (Table 9).

Table 9: Land Systems

Land System & Code	Description	Geology	Geomorphology
Littoral System 201Li	Bare coastal mudflats with mangroves on seaward fringes, samphire flats, sandy islands, coastal dunes and beaches.	Quaternary mudflat deposits, clay, salt and sand, eolian sand	Depositional surfaces; saline coastal flats; estuarine and littoral surfaces with extensive bare saline tidal flats subject to infrequent tidal inundation, slightly higher samphire flats and alluvial plains, mangrove seaward fringes with dense branching patterns of shallow tidal creeks, minor coastal dunes, limestone ridges, sandy plains and beaches; relief up to 8 m.
Onslow System 201On	Sandplains, dunes and clay plains supporting soft spinifex grasslands and minor tussock grasslands	Sandplains, dunes and clay plains supporting soft spinifex grasslands and minor tussock grasslands	Depositional surfaces; sandy plains formed by eolian and fluvial processes - gently undulating sandplains with intervening non-saline clay plains subject to sheet flow, narrow drainage zones receiving more concentrated flow, minor depressions subject to inundation; coastal fringes of low sandplain, interspersed with slightly lower saline samphire flats; also minor claypans, coastal dunes and beaches; relief up to 20 m.

Hydrogeology

The information provided in this section has been sourced from Soilwater Group (2019a), provided in Appendix 10.1.

A Conceptual Hydrogeological Site Model (CHGSM) was developed for the Proposal, based on a review of the following information:

- Published regional hydrogeological reports (Haig, 2009; Fugro, 2011);

- CMW (2019a) Geotechnical Drilling Program;
- CMW (2019b) Deep Borehole Drilling Program;
- CMW (2019c) Supratidal Flats Test Pit Program; and
- Stantec (2017a) Acid Sulphate Soil Investigation - Mardie Salt Project.

The Proposal is located on the northern portion of the Peedamullah Shelf, which forms the south-eastern-most division of the Northern Carnarvon Basin, fringing the western margin of the Pilbara Craton. Sediments in the Peedamullah Shelf range in age from Ordovician to Pleistocene, with a total basin depth up to 5 km.

The area in which the Proposal is located is generally underlain by a moderately to highly calcreted shelly calcarenite layer (Figure 19), likely equivalent to the regionally extensive Quaternary Bibra Limestone and older Tertiary Bundera Calcarenite. On the eastern side of the Supratidal Flats, the calcarenite is unconformably overlain by Pleistocene to Holocene aeolian, alluvial and colluvial sediments forming the current surface of the Onslow Land System. The calcarenite layer dips westerly under the Supratidal Flats (corresponding to the Littoral Land System), creating an undulating surface onto which the mudflats were deposited. In areas where the calcarenite layer outcrops the mudflat surface, or where significant secondary agglomeration of calcirudite and / or calcisiltite occurs, it anchors a thin veneer of eolian (dunal) sand (Figure 20).

The Supratidal Flats that occur extensively across area, on top of the calcarenite layer, have formed by prolonged deposition of terrestrial and marine sediments. Several large creek systems, including Peter Creek (catchment area 422 km^2), Gerald Creek (catchment area 153 km^2), Trevarton Creek (catchment area 172 km^2) and 6 Mile Creek (catchment area 164 km^2), discharge directly into the Supratidal Flats. Depending on the rainfall intensity within the various creek catchments, and the distance from the discharge point, the sediments making-up the Supratidal Flats will vary from heavy clays to sands to gravels, with each deposition event interfingering with the last deposition event.

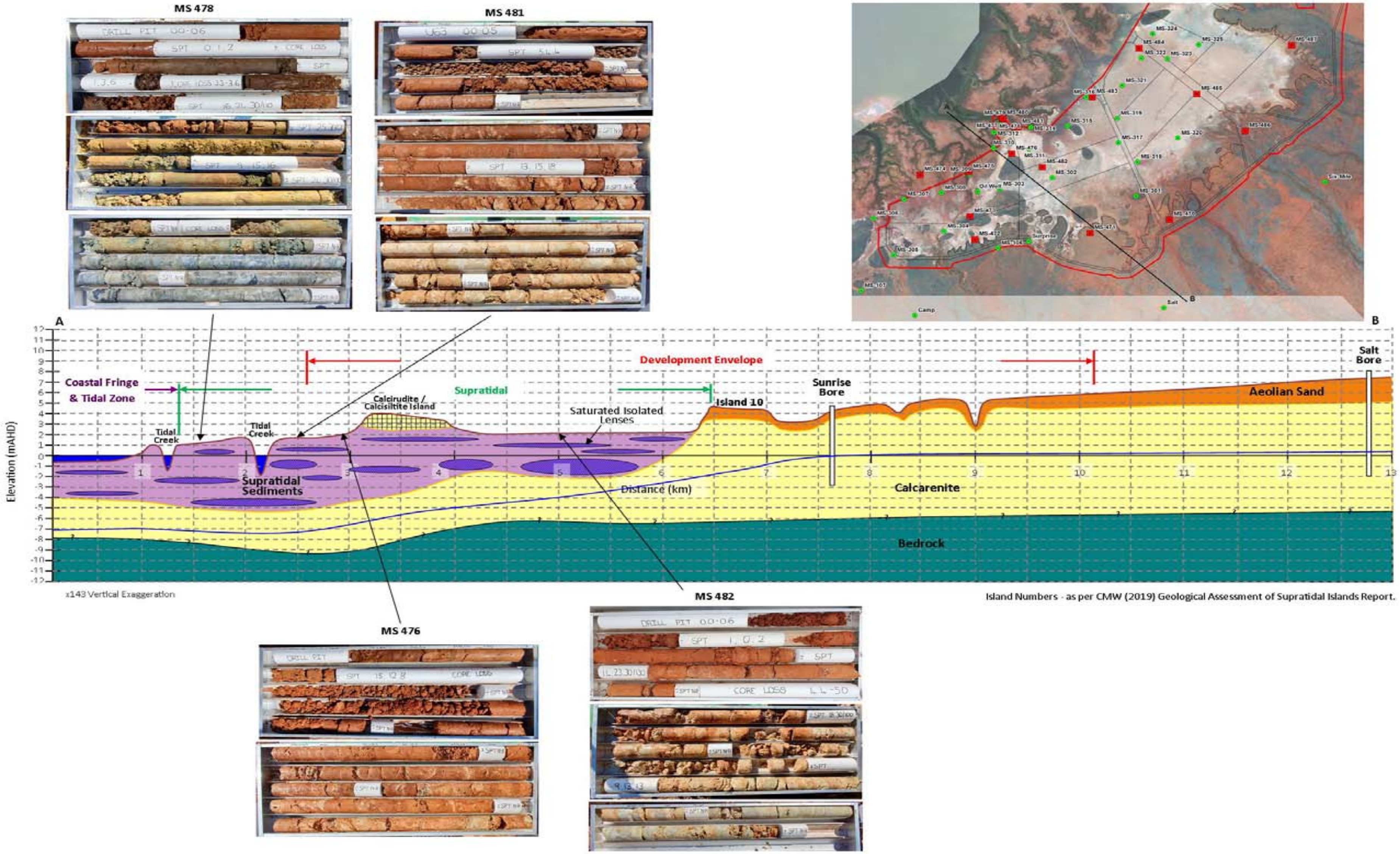
Schematic cross-sections through the development envelopes are provided in Figure 21 and Figure 22.

The quality of the groundwater within the isolated gravel lenses in the Supratidal Flats and the underlying calcarenite aquifer is summarised below:

- Groundwater within the Supratidal Flats is generally neutral, whilst the groundwater in the calcarenite aquifer is more alkaline, likely reflecting the presence of the calcarenite. The majority of the alkalinity is in the form of Bicarbonate, with minor Carbonate alkalinity;
- Groundwater within the Supratidal Flats is hypersaline, with 2 – 5 times higher salinity than seawater; likely due to its sluggish permeability and resulting evaporative concentration of salts. The groundwater in the calcarenite aquifer is brackish to saline. All groundwater is generally classified as NaCl type, although groundwater in the Supratidal Flats may also be considered $CaSO_4$ type, likely reflecting the formation of gypsum;
- All groundwater in the development envelopes has low to very low nutrient levels; and
- All groundwater in the development envelopes has low levels of measured metals, although some bores contain elevated Zn and minor Cd and Cu.

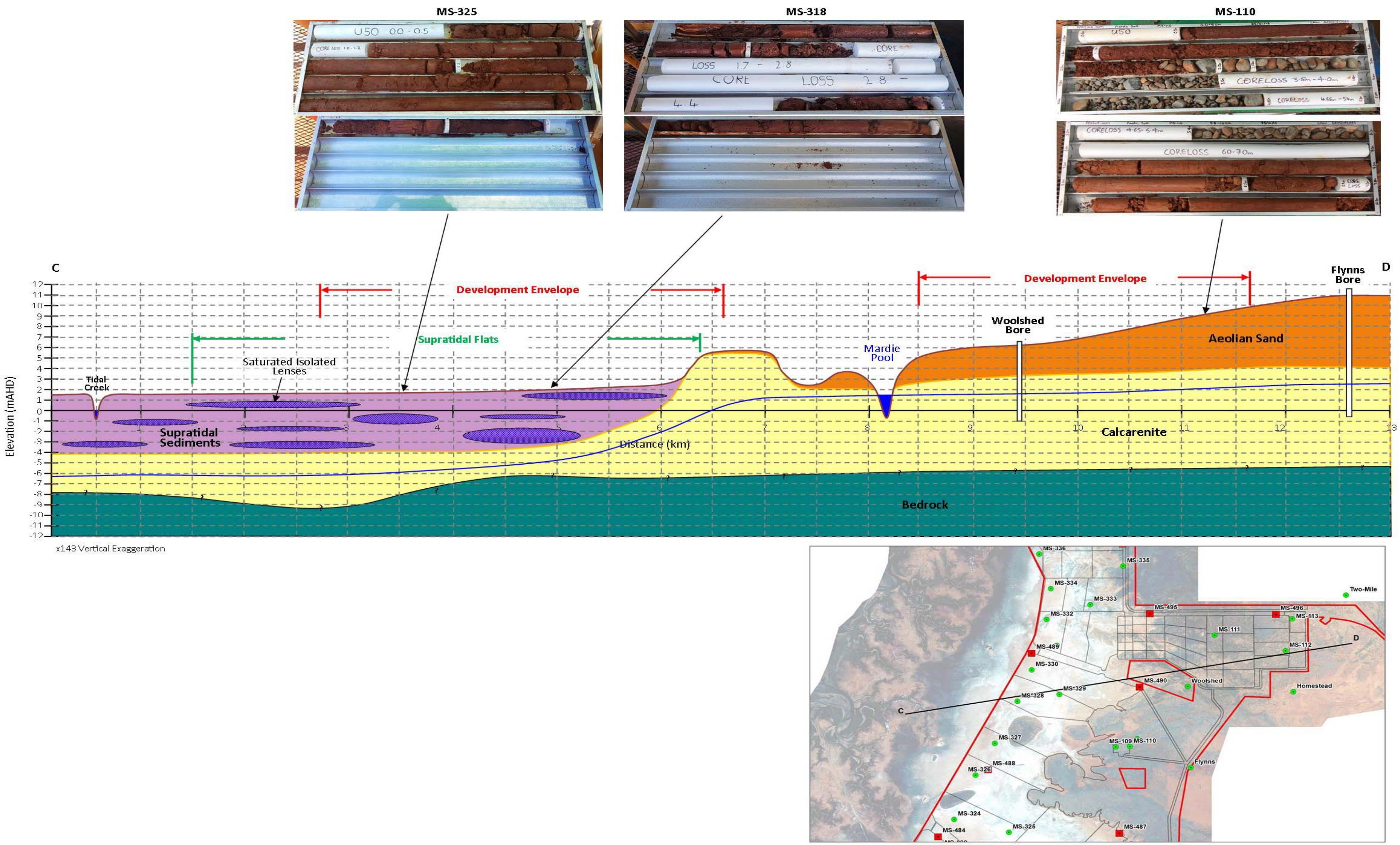
Figure 19: Outcrop of calcarenite on the eastern side of the Supratidal Flats with the Project Area (surface of calcarenite dips below the mudflats)

Figure 20: Outcropping calcarenite layer within the Supratidal Flats



BCI MINERALS LIMITED		soilwater GROUP
MARDIE SALT AND SOP PROJECT		

Figure 21: Schematic cross-section in the south of the Proposal area



BCI MINERALS LIMITED

MARDIE SALT AND SOP PROJECT

Figure 22: Schematic cross-section in the north of the Project area

5.3.4 Inland Surface Water

Catchment characteristics

The Proposal lies between the large deltas of the Fortescue and Robe Rivers, and is itself associated with the outflows of several local catchments (Figure 23). The claypans that make up most of the development envelopes receive episodic surface water inflows from these catchments as well as tidal inflows from the nearby ocean.

RPS has undertaken a series of increasingly detailed assessments of the upstream surface water catchments and calculated benchmark discharge figures as part of assessing flood risks and potential hydrological impacts to downstream sensitive environments (Table 10). As a comparison, the largest site catchment (Peter Creek) is approximately 2% of the size of the Fortescue River catchment, and discharges at a rate of around 2 - 3% of that for the Fortescue River mouth. The width of the Fortescue River channel at the North West Coastal Highway, just before it abraids across its flood delta, is approximately 400 m. The mouth at Peter Creek is less than 100 m wide, and is expected to flow 3 - 4 m deep in a 100-year flood event (RPS, 2019a).

Table 10: Surface water catchments and discharges (RPS, 2019a)

Catchment	Area (km^2)	10-year ARI discharge (m^3/sec)	100-year ARI discharge (m^3/sec)
Fortescue River	18,360	5,000	20,000
Peter Creek	422	149	533
Gerald Creek	153	91	324
Trevarton Creek	172	103	367
Six-Mile Creek	164	104	372

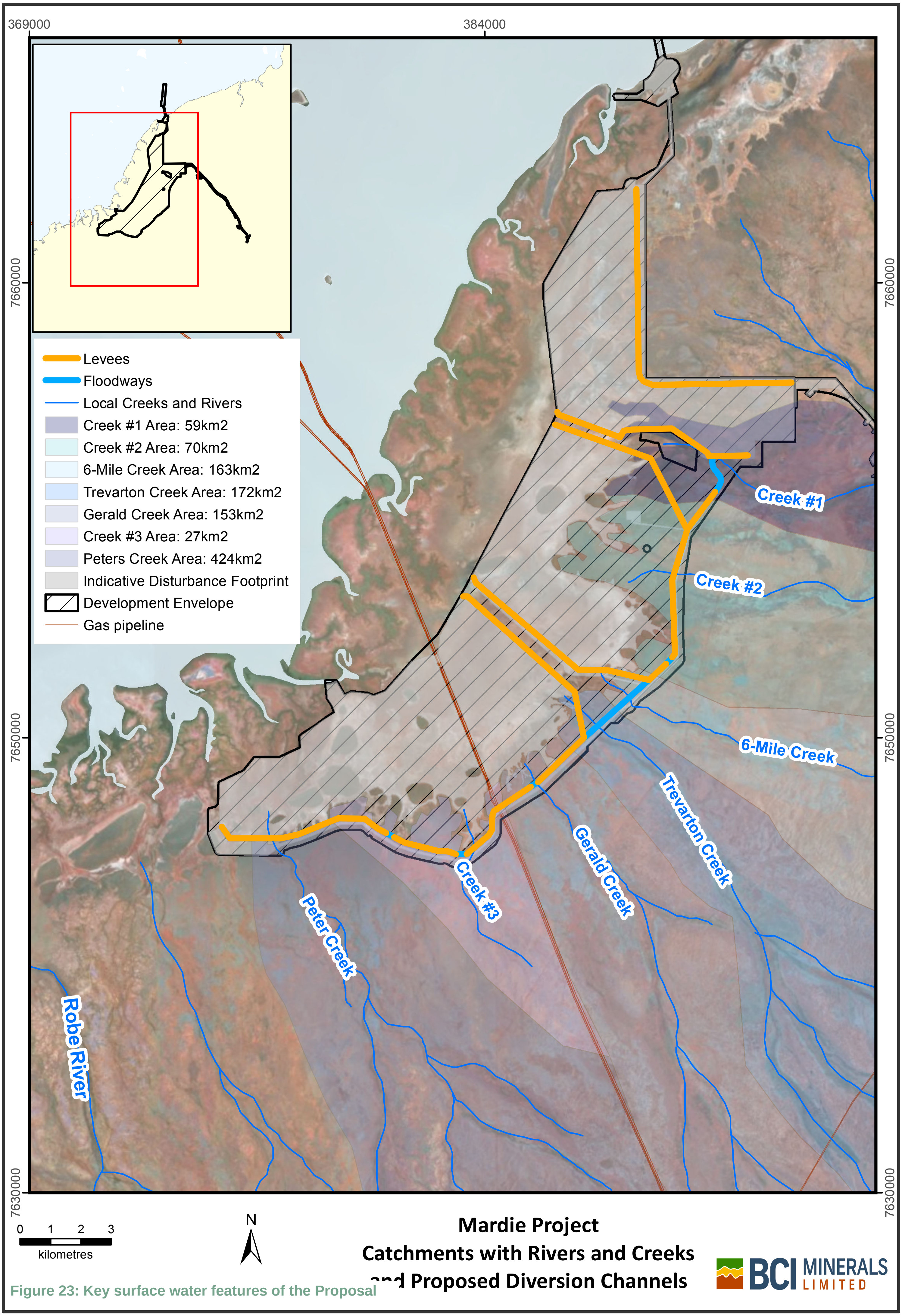


Figure 23: Key surface water features of the Proposal

Key Surface Water Features

Mardie Pool is the colloquial name for a permanent waterhole approximately 3 km westward of the Mardie Homestead (Figure 23). It is approximately 500 m long and is close to half a hectare in size. The waterhole is accessed by stock and other fauna. It is considered to be of cultural and historical importance and is one of the few permanent water bodies in the wider area, but has no recreational use. Its low position in the landscape (approximately 1.5 mAHD) and proximity to the intertidal area means that it is susceptible to storm surges. Mardie Pool has been excluded from the development envelopes.

Figure 24: Photo of Mardie Pool

Peter Creek is a listed heritage site named heritage place (not a heritage site pursuant to the AHA) and intersects the southern extremity of the development envelopes (Figure 23). It also forms the boundary of Mardie and Yarraloola Stations. Peter Creek is described as a smaller, ephemeral channel that drains from the Hammersley Ranges into the mudflats and saltflats of the Proposal (Stantec, 2018; Appendix 2.2). Flows are dependent on seasonal rains within the catchment, while the creek's delta onto the mudflats appears to support periodic waterholes, presumably where the bed of the creek intersects the shallow groundwater.

Surface Water Quality

The opportunity to collect surface water quality samples has been limited by extended periods of drought in the area; however, samples were taken when sufficient run-off water was present. Table 11 provides as summary of the surface water quality from Mardie Pool, as well as two locations were water was present after rainfall; Peter Creek and Pool 2.

Table 11: Surface water quality sampling results

Parameter	Mardie Pool #1	Mardie Pool #2	Mardie Pool #3	Peter Creek	Pool 2
Date	15/02/2020	15/02/2020	15/02/2020	24/02/2020	24/02/2020
Easting	390834	391807	393620	377453	388899
Northing	7657049	7656709	7655438	7643530	7648404
Filtered?	No	No	No	No	No
pH Units	7.3	8	7.5	7.8	7.1
EC25 (µS/cm)	960	370	370	130,000	200,000
TSS (mg/L)	22	49	15	74	240
TN (mg/L)	1.7	0.8	1	1.7	5.9
TKN (mg/L)	1.7	0.8	1	1.7	5.1
NO_3-N (mg/L)	<0.005	<0.005	<0.005	<0.025	0.56
NO_2-N (mg/L)	<0.005	<0.005	<0.005	<0.025	0.05
NOx-N (mg/L)	<0.005	<0.005	<0.005	<0.025	0.79
NH_3-N (mg/L)	0.23	<0.005	0.053	0.091	3.7
TP (mg/L)	0.07	<0.05	<0.05	<0.5	<2.5
PO_4-P (mg/L)	<0.005	<0.005	<0.005	<0.025	<0.025
Ca (mg/L)	47	36	32	1,000	6,000
K (mg/L)	13	9.4	10	1,300	460
Mg (mg/L)	32	8.9	11	4,000	6,800
Na (mg/L)	81	21	22	42,000	78,000
HCO_3 (mg/L $CaCO_3$)	99	100	110	280	44
CO_3^{2-} (mg/L $CaCO_3$)	<5	<5	<5	<5	<5
OH- (mg/L $CaCO_3$)	<5	<5	<5	<5	<5
Total Alk. (mg/L $CaCO_3$)	99	100	110	280	44
Cl (mg/L)	200	38	39	62,000	150,000
SO_4 (mg/L)	77	27	22	9,300	2,300
Ionic Balance	-1.4	0.24	0.21	6.6	-0.59
Hardness (mg/L $CaCO_3$)	250	130	120	19,000	43,000

5.3.5 Tidal Characteristics and Influences

Tidal Cycle

The Proposal location experiences a semi-diurnal tide (two highs and two lows a day) and the tidal planes have been defined by the National Tide Centre (NTC) based on field measurements completed for the Proposal in late 2018 (Baird, 2020a).

The Mardi Gauge (MardiLAT18) datum definition completed by the NTC shows that the offset between Lowest Astronomical Tide (LAT) and Mean Sea Level (MSL) is 2.75 m and the total tidal range is 5.185 m. The mean tide range is 3.6 m in springs and 1 m in neaps.

Measured data from an inshore Aquadopp in November 2018 is shown in Figure 25 illustrating the water level time series through the spring and neap cycles. It is noted that the instrument could not measure tide levels below -2m MSL, owing to its location.

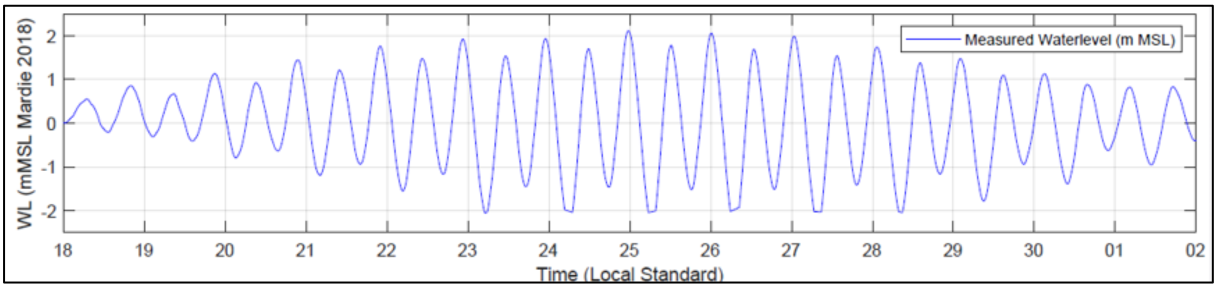


Figure 25: Measured water level data from inshore Aquadopp location November 2018

Intertidal Zone Flow Regimes – Western Coastline

Along the western section of the coastline within the proposal area, seawater floods the intertidal areas through the mangrove zone or out of the tidal creeks via multiple low points that occur along the full length of the creeks (Figure 26). This occurs when tidal levels offshore are approaching +1.2 m MSL or higher (RPS, 2019a).

The seawater delivered from the multiple pathways tends to merge over the land surrounding the creeks and then flood out to form a shallow lake over the clay pan area (Figure 26 and Figure 27). The water floods out over the clay pan as a surge. The extent of the flooded area varies with:

- Tidal level offshore, which generates the head of water to force the surge;
- The rate at which the water can flood out over the surrounding land (e.g. the tidal water moves faster if the soils have been wetted by previous tidal flows); and
- The elevation of the landscape, relative to the level of the tidal surge.

Conversely, as the tide offshore begins to drop, so do water levels in the tidal creeks, and water in the intertidal zone begins to drain back to the creeks via the multiple drainage channels or evaporates, leaving extensive visible salt crusts. The evaporation of the seawater in the intertidal zone results in elevated salinities within the tidal creeks on outgoing tides (O2 Marine, 2020e; Appendix 3.1)

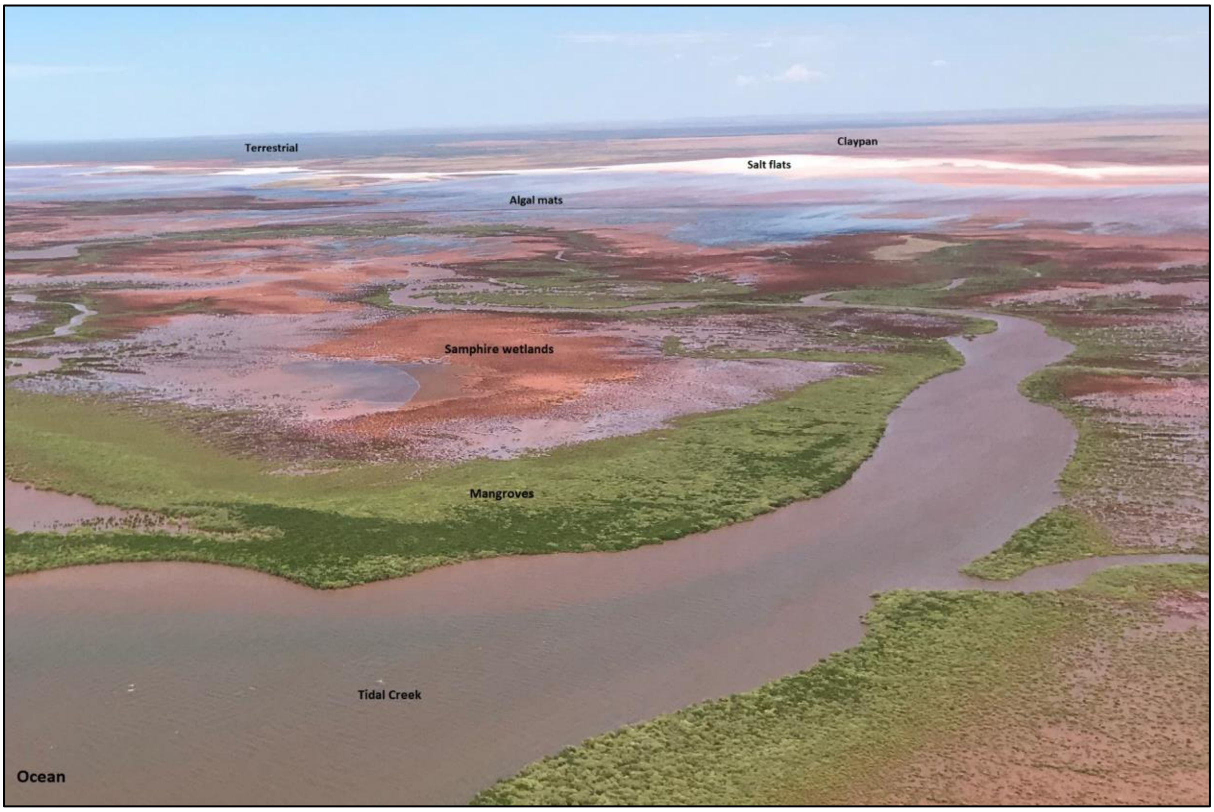


Figure 26: Example of a tidal creek and intertidal areas at Mardie, with views inland towards the east

Computer model simulations developed by RPS (2019; Figure 28 and Figure 29) indicate that:

- Flood surges commence just as the tide is peaking during higher tides and that if sufficient water volume is released onto the flood plain, the flood waters surge out over the clay pan area over a period of the order of 40 - 45 minutes;
- Most of the water drains back on a receding tide, although remnants of the water may be retained in localised dips in the topography;
- Near the coast, the drainage of water back towards the sea begins immediately after the tidal peak passes; hence, the inland flood surge is still occurring after the peak tide;
- Water drains back from the clay pan areas more slowly than the flood surge arrives, requiring 3 - 5 hours depending upon the tide level;
- Drainage is complete by the time that low tide is reached at the coast and as a consequence, most of the flooding area does not appear to hold surface water over subsequent tides;
- During the highest spring tides, the claypan areas were overtopped by water for periods of 4 - 6 hours every 12 hours; and
- During the lowest neap tides, no flooding occurs and these conditions can last for 7 – 10 days straight.

RPS (2019a) showed that, in addition to the fluctuations in water depth over the claypans, fluctuations in tidal levels would have consequences for the retention of moisture in the soil within the algal mat areas. A review of time-lapse imagery also indicated that salt precipitates over the ground surface when the ground does not wet after 2 - 3 days, including those areas supporting algal mats.

Rising tide, 1:35 pm. Note water still draining from flats into the creek from previous high tide.

Rising tide, 2:05 pm, with creek at bank-full level.

Rising tide, 2:35 pm, with seawater beginning to inundate the intertidal claypan and mangrove areas.

Rising tide, 3:05 pm, approximately 45 min. before high tide of 3.73m above Lowest Astronomical Tide (LAT).

High tide, approximately 3:50 pm

Falling tide, 5:50 pm, with sea level now below bank-full level.

Figure 27: Time-lapse photographs of tidal inundation of the claypan areas

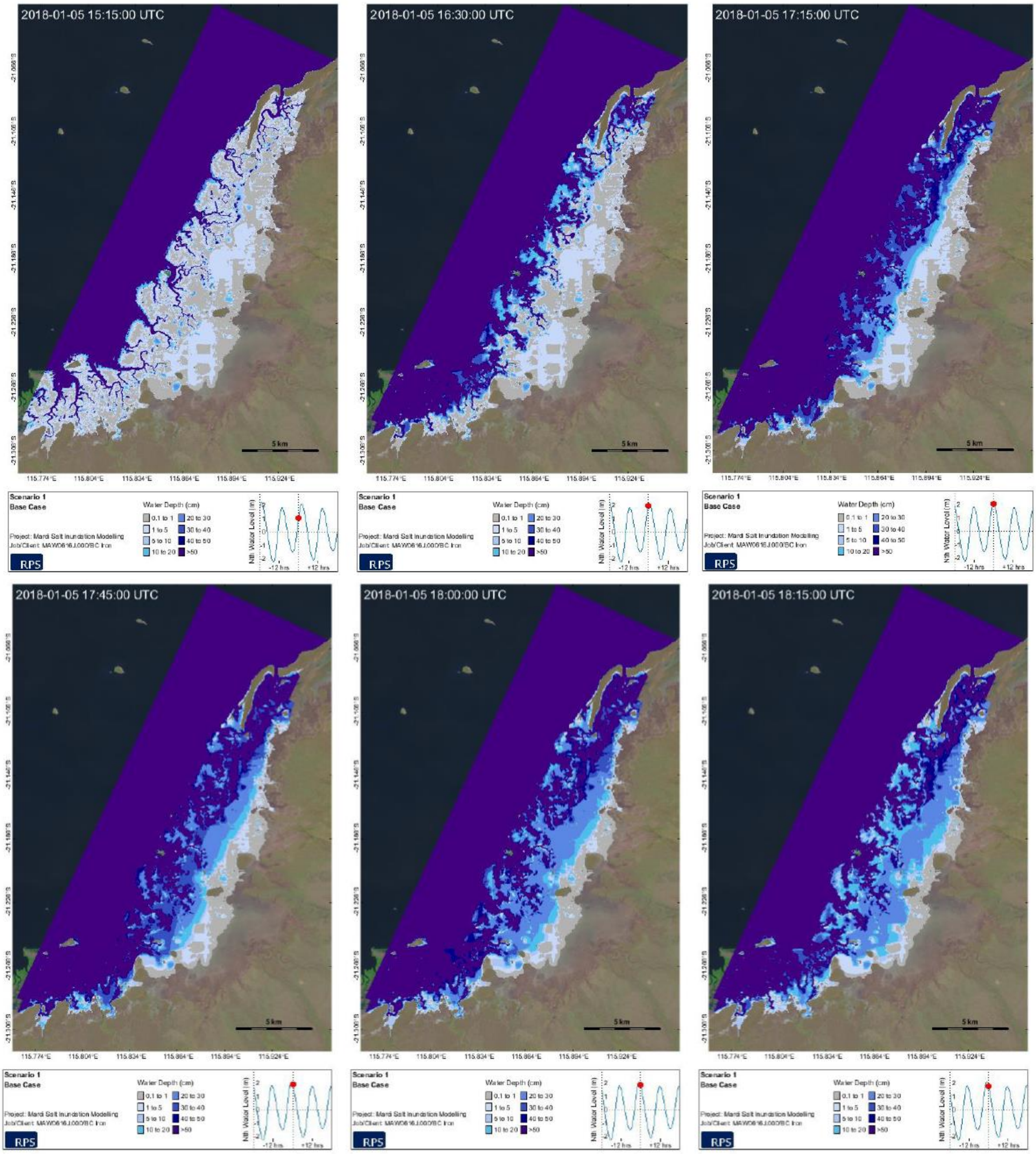


Figure 28: Predicted inundation on incoming tide – western coastline (RPS, 2019a)

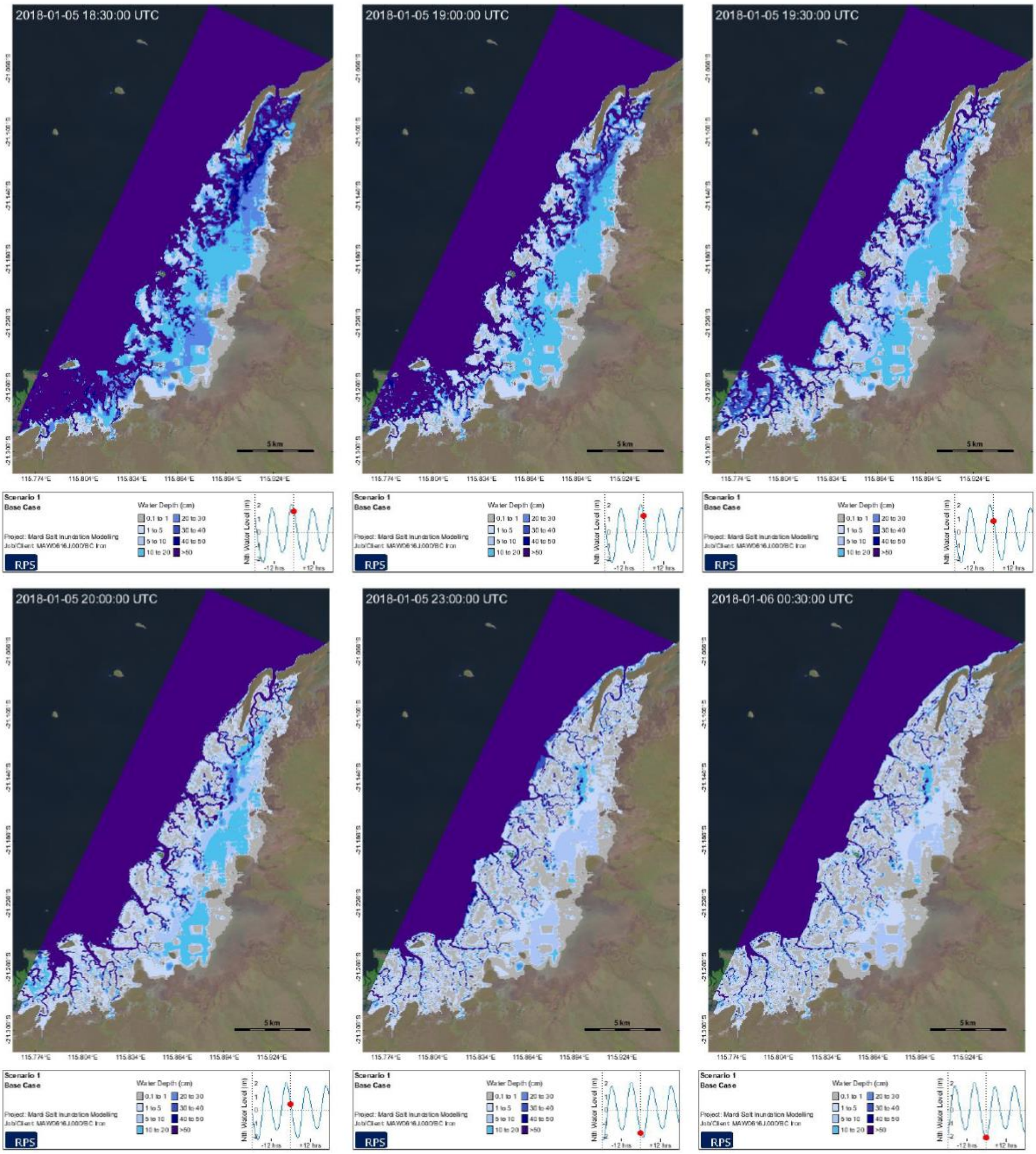


Figure 29: Predicted inundation on outgoing tide – western coastline (RPS, 2019a)

Intertidal Zone Flow Regimes – Northern Coastline

RPS was commissioned by Mardie Minerals to extend and apply the existing inundation model described above to a clay pan area that extends some 25 - 30 km along the north-east coast, inshore of a coastal dune system. Field observations and review of satellite imagery indicated that the clay pan is extensively inundated during higher spring tides with the only inflow and outflow path being Mardie Creek at the western end. The topography and local landforms indicate that during large flood and storm events, water from the claypan can also drain to the north-east, or break out across low-lying sections of the coastal foredune.

Simulation over the natural topography indicated that inundation over parts of the clay-pans would occur with a relatively low spring tide level, as indicated by flooding that was triggered by the first 1.4 m tidal peak (Figure 30). The simulation indicated that water would flood out from the sides and ends of the creek to form a shallow lake that flowed as a wide sheet. This sheet flow would build up momentum as the tidal height offshore reached the peak and the front of the sheet-flow would continue to flow into the claypan while the water at the back of the flow would begin to retard and flow back towards the creeks. A ridge of marginally higher ground is present immediately inland from Mardie Creek tributaries and water that flows over this ridge sheets out over the lower land beyond. The combination of the timing of the floods relative to the peak tide and the effect of the ridge in accelerating water inland if the water passes over the ridge appears to be the driver of the wider sheet flow (RPS, 2020).

These effects are magnified during higher spring tides, as indicated by the simulation period covering the 2nd and 4th spring tidal peak. The sheet flow over these higher peaks was deeper, in general, wider and penetrated further along the clay-pan. The front of the flood arrives at a similar time across the width of the clay-pan but accumulates to deeper depths (25-40 cm) beyond the ridge along the path where the ground level is 15-30 cm lower (Figure 31; RPS, 2020).

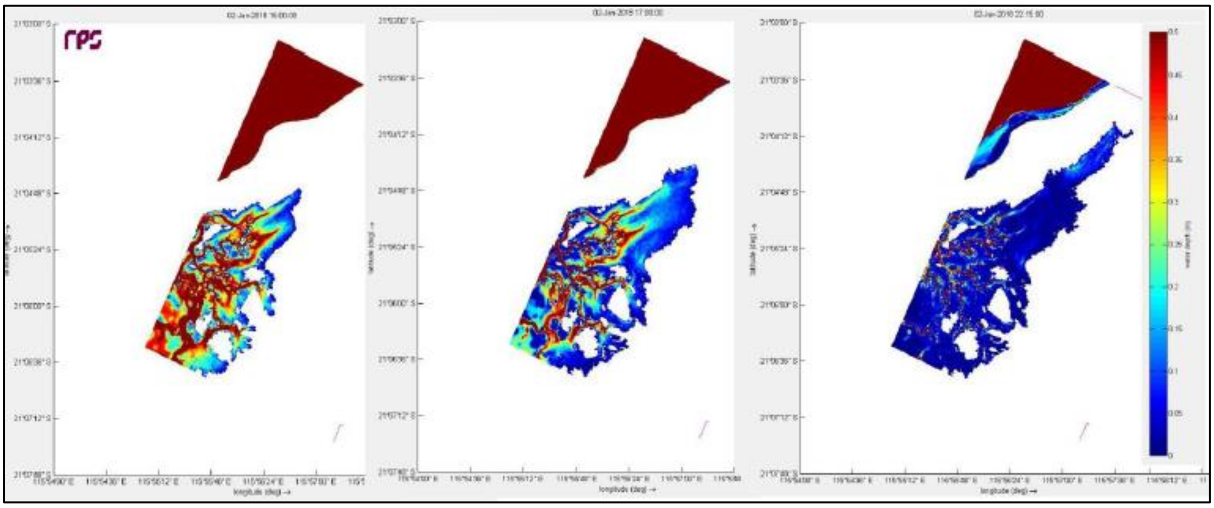


Figure 30: Predicted local water depths during a relatively low (1.4 m) spring tide. Time differences between the images are 1 hour and then 5 hours

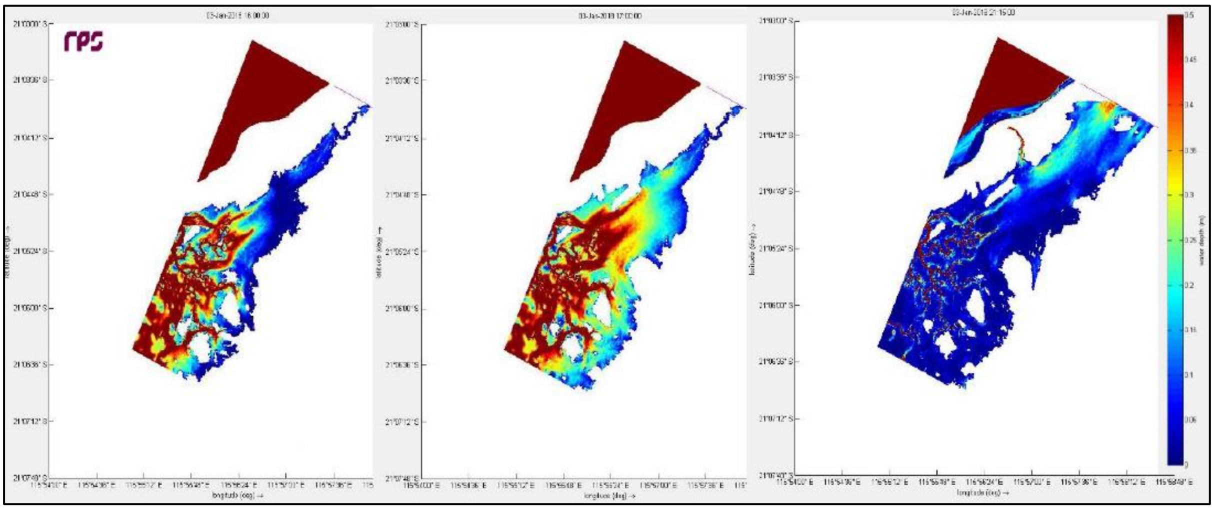


Figure 31: Predicted local water depths during a relatively high (2.2 m) spring tide. Time differences between the images are 1 hour and then 5 hours

Influence of Cyclones and Tropical Lows

In addition to strong winds and significant rainfall, tropical cyclones also result in storm surges that are an important feature of the Mardie landscape. The Mardie coastline is protected from strong tropical cyclone swell by the Monte Bello Islands to the north, Barrow Island to the northwest, and the very extensive Barrow Shoals to the west and southwest. The only tropical cyclone swell of significance which would influence the Mardie coastline, would arrive from the north-northeast after having refracted past the Dampier Archipelago and Cape Preston RPS (2019b).

Just off the Mardie coast, there are several islets and reefs which offer further protection from wave attack, and mitigation of storm surge. Official bathymetry in the nearshore zone is in areas classified as unsurveyed and is likely to vary under the occasional cyclone.

Storm Surges

A storm surge is a rise above the normal water level along a shore resulting from strong onshore winds and / or reduced atmospheric pressure. Storm surges accompany a tropical cyclone as it comes ashore. The combination of storm surge and normal (astronomical) tide is known as a 'storm tide' (BoM, 2018). The worst impacts occur when the storm surge arrives on top of a high tide. Storm surge influences are often amplified by pounding waves generated by the powerful winds.

RPS (2019b) analysed available data to calculate storm surge and extreme water levels for the Proposal. The outcomes from that study indicated the following return period guidance:

- 100-year still water sea level is 4.2 - 4.3 m above MSL, which is about 2 m higher than Highest Astronomical Tide (HAT); and
- 10-year sea level is in the range 3.5 - 3.7 m above MSL, which is about 1.3 m higher than HAT.

These levels incorporate an allowance of 0.2 m for sea level rise to 2050. Based on the terrain a storm surge would flood the coastline for several kilometres inland.

Tidal Creeks

Tidal creeks are meandering and bifurcating drainage channels that connect the landward inter-tidal flat basins (claypans) with the ocean, through a series of banks and washes, and play an important role in the movement of water and sediment. Tidal creek systems and associated tidal flats display the majority of tide-driven coastal changes in the Pilbara, with rapid switching between erosion and accretion in response to changing metocean conditions (DPLH, 2013).

Freshwater inputs are virtually absent in tidal creeks and marine water is largely contained within channels on inundating adjacent mudflats during spring tides. These systems are dominated by high levels of tidal energy. Catchment derived sediments and nutrients are limited in tidal flats and creeks, with fine material only delivered by sheet runoff during rain events and coarser material during extreme storms. Marine sediments and nutrients dominate and are deposited in inter-tidal habitats, while strong tidal energy leads to erosion of finer sediments in sub-tidal habitats (Hadwen *et al*., 2012).

Tidal channels are frequently interconnected and flanked by large areas of low-gradient intertidal flats, mangroves, saltmarsh, and salt flat environments. The coastal mudflats that generally surround tidal creeks tend to be at or above the limit of high tide, and seawater is mainly confined to the tidal channel, except during spring tides (Ryan *et al*., 2003).

Evaporation is a significant process in tidal creeks due to the extensive intertidal area and extreme climatic conditions. Saltflats environments are inundated rarely (e.g. 3 - 4 days per month), resulting in hypersaline groundwater and often a saline crust on the surface. Ebb flows from these areas can cause tidal creeks to become hypersaline, but typically only for short periods of time, due to strong tidal flushing (Ryan *et al.,* 2003).

There are 15 tidal creeks of varying size that can be identified along the 26 km coastline west of the Proposal, which is typical of the region (DPLH, 2013). The smaller creeks are 1 – 2 km long, while the largest creek (known colloquially as Mardie Creek or Mardie Creek East; Figure 32) contains over 100 ha of open water at MSL. Only those creeks with a bed level below about -1.5 to -2 m MSL retain water during low tides, except where the creek bed is blocked by mobile sediments, allowing tidal pools to form.

Some of the creeks, such as the one where the seawater intake is proposed (Figure 3), is connected to other tidal creeks by way of its main channel; however, almost all of the tidal creeks in the area become connected during spring tides when they flood their banks and spread over the tidal flats.

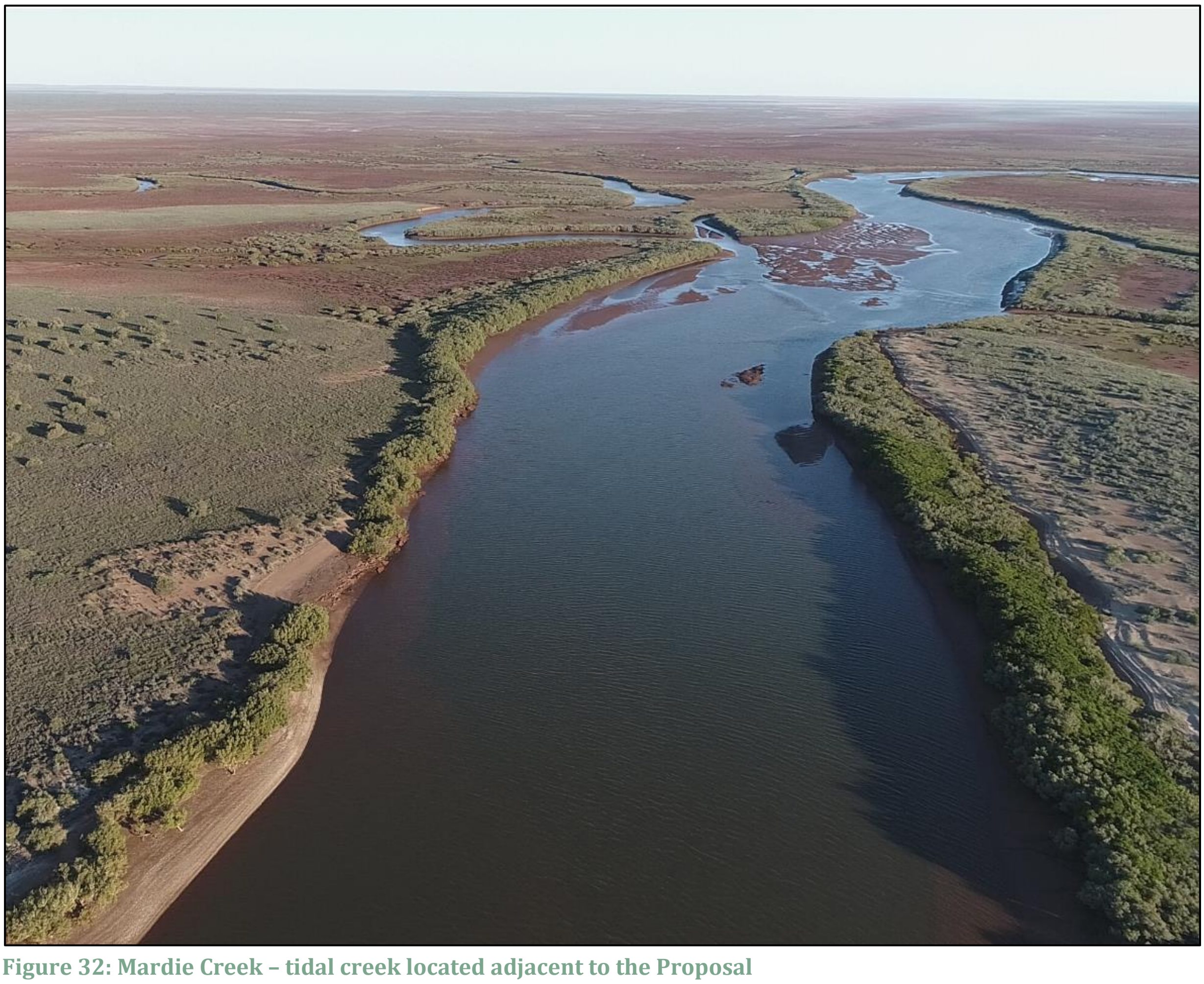


Figure 32: Mardie Creek – tidal creek located adjacent to the Proposal

Sea Level Rise

Simulations of coastal inundation by RPS (2019a) imposing an additional 0.9 m of sea level rise (following EPA recommendations for allowance over 100 years for coastal hazard assessment) indicates that the intertidal zone would still wet and dry, exposing the existing mangrove area at lower tides but inundation of the clay pans would occur more frequently. For example, the current high tide that is reached annually during a King Tide (2.2 m MSL in January 2018) would occur at the frequency of the current lower limit for inundation of the clay pans (1.2 m MSL), a level that occurs > 15 days per month over the Spring tidal phase. This outcome suggests that the clay pan area would remain wet at a higher frequency of the time, with a reduced time between flooding events over a reduced neap, dry, period.

Conversely, water flooding onto the land under the same astronomical tides would flood further inland during more high tide events. There is a natural limit to the distance that water would flood inland that is imposed by the higher ground of the hinterland. Higher ground occurs closer to the coastline over the northern part of the Proposal area and extends further away further south. Consequently, the simulations show that water would flood out further inland over the more southern portion of the Proposal area at a given tidal level compared to the contemporary Base Case (Figure 33). This result suggests that there would be an inland extension to the areas that would be inundated at the rate that currently occurs over the algal mats. The limits to water spread imposed by higher ground would also force greater water depth over the area that currently supports algal mats during spring tides.

Projections concerning extreme events are highly uncertain but suggest:

- A potential increase in the number of tropical cyclones in categories 3 – 5;
- An overall decline in the total number of cyclones;
- A poleward shift in the regions of cyclone genesis and decay; and
- A possible increase in coastal winds associated with extreme events as well as in response to increased ocean surface temperatures (Hawden, 2012).

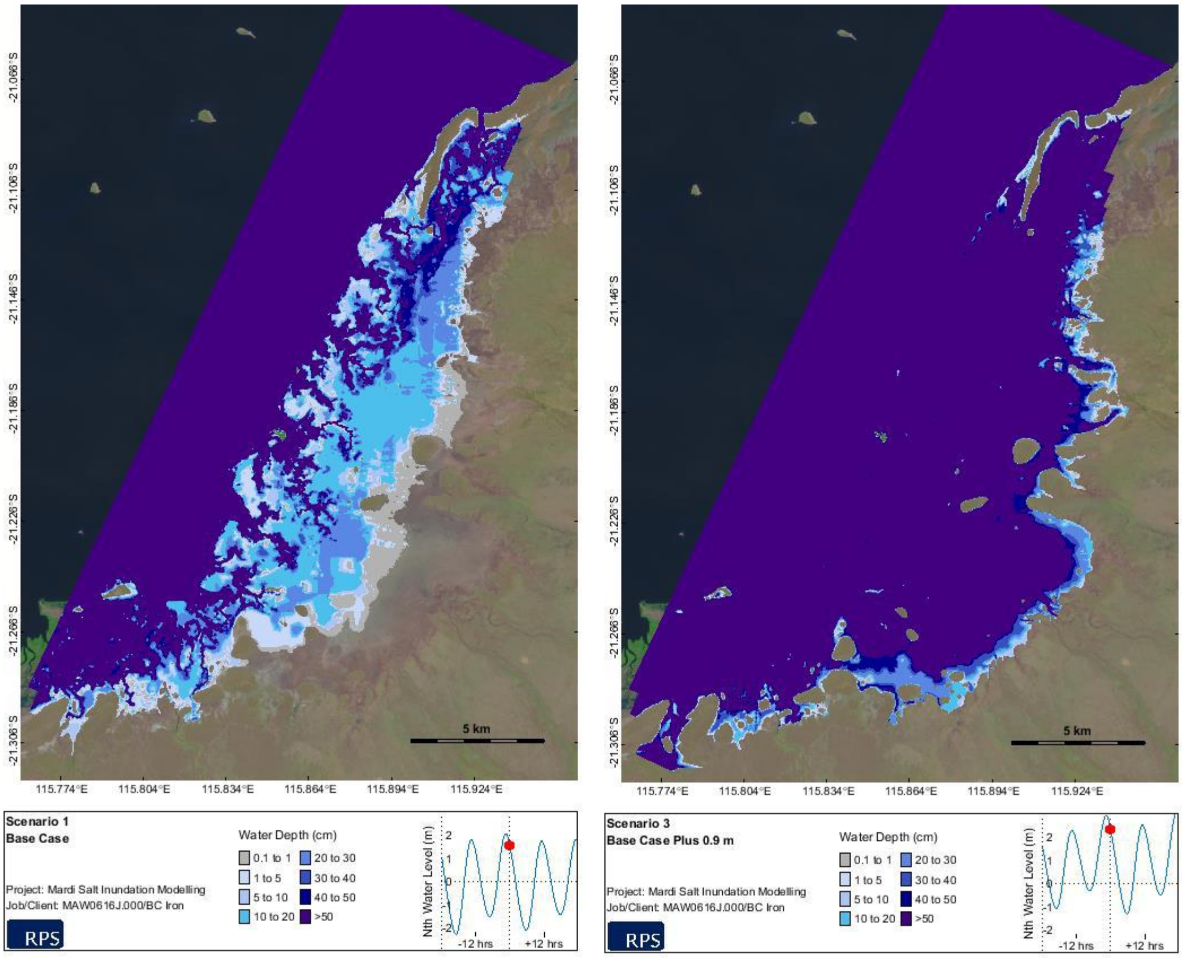


Figure 33: Comparison of tidal levels of current high Spring Tide against projected future (+100 yrs) high Spring Tide (RPS, 2019a)

5.3.6 Flood Level Joint Probability

The intertidal areas can be simultaneously flooded from the upstream catchment as well as coastal inundation from storm surges. Generally, both events are associated with cyclonic activity; however, a cyclone-related flood in the upstream catchment would occur sometime after any associated abnormal sea level (the height of which can vary greatly), as the cyclone tracked across the coast and moved inland. Hence significant storm surge and upstream flooding are not dependent, and generally do not occur simultaneously RPS (2019b).

A common way of handling this joint probability between the two flood mechanisms is provided in the 'Flood Risk Management Guide' (New South Wales (NSW) Department of Environment, Climate Change and Water 2010/759, 2010). This approach adopts a probability ratio for the two flood mechanisms of 1:5, i.e. assuming 20-year ARI catchment flooding in conjunction with 100-year sea levels, or 100 year catchment flooding in conjunction with 20 year sea levels. The 'Karratha Coastal Vulnerability Study' (JDA, 2012) studied the joint probability between river flood levels and storm surge in the Karratha area and found no obvious correlation; that study therefore adopted the 100 year catchment flood flow in conjunction with the 20 year sea level (estimated as RL 3.9m) as the downstream boundary condition.

5.3.7 Potential Acid Sulfate Soils

The assessment of ASS risk has been undertaken separately for the different material types:

- Clays and other soils used for the construction of the pond walls were assessed by Stantec Australia (Stantec, 2017);
- Soilwater Group (2019a) reviewed 19 samples collected and analysed during a more intensive geotechnical soil survey;
- Soilwater Group (2020) reviewed 55 samples from 9 locations along the proposed causeway and floodway alignment; and
- Marine sediments that will be disturbed by dredging and disposed of on land as fill for the salt product stockpile area were assessed by O2 Marine (2019a).

Both assessments were conducted in accordance with the 2015 *Guidelines for Identification and Investigation of Acid Sulfate Soils and Acidic Landscapes* (DER, 2015a).

ASS Risk Mapping

Shallow ASS are widespread across coastal regions of WA, and are known to occur in tidal, intertidal and supratidal flats along the northern coastline, including the Pilbara and Kimberley coasts (DER, 2015a). As a result, the vast majority of the lower-lying (intertidal) claypan area has been assigned an initial risk category by the WA Government of ‘high to moderate’, except for small isolated areas associated with sand mounds that are located within the development envelopes - these have been classed as ‘moderate to low’ risk. The Proposal’s upland areas are not mapped under the Class 1 and 2 ratings, and are considered to be of ‘low ASS probability’ based on data sourced from Australian Soil Resource Information System (ASRIS) (2014).

Assessment of Construction Materials

In 2017, Stantec undertook a preliminary site inspection that involved logging, sampling and analysis (field pH (pH_F) and field pH peroxide (pH_{FOX})) of 18 ‘near surface’ soil profiles within potential disturbance areas associated with a previous Proposal layout (Figure 34). The profiles were sampled to a maximum depth of 1 m below ground level (mbgl). The targeted soil sampling locations were derived from previous geotechnical sampling points located within the development envelopes.

The soils sampled were generally found to be red-brown silty sands to silty clays with no visible signs of mottling. The pH_F of all samples analysed ranged from circum-neutral to strongly alkaline (pH 6.96 - 9.8). As soil depth increased, pH_F was generally found to either increase slightly or remain unchanged. Only one site reported a decline in pH_F with depth, declining from pH 9.8 at 0.5 mbgl to pH 8.5 at 0.75 mbgl then increasing back to pH 9.5 at 1.0 mbgl.

Of the 18 soil profiles assessed, 11 profiles reported a pH_{FOX} that was substantially higher than pH_F at all depths. The remaining seven profiles reported a pH_{FOX} higher than pH_F near the surface of the profile, and a lower pH_{FOX} relative to pH_F as depth increased. The differences between pH_{FOX} and pH_F ranged between a negative pH unit change of -0.2 to -1.8. However, all pH_{FOX} results for these samples remained above pH 6. Consequently, Stantec’s assessment of the soils tested was that the soils were unlikely to be ASS, and that laboratory analysis was not required.

More recently, Soilwater Group (2019a) reviewed 19 samples collected and analysed during a more intensive geotechnical soil survey (Figure 34). The review determined that all samples were moderately alkaline owing to the widespread presence of gypsum ($CaSO_4.2H_20$), which also resulted in elevated inorganic sulphur (S) being reported. The nature of the site, with its constant rewetting with tidal seawater, makes it a very low risk for ASS (Tulau, 2007; Yau *et al.,* 2016).

Additionally, Soilwater Group (2020) reviewed 55 samples taken at nine locations the along proposed causeway and floodway alignment (SWG01 – SWG09) (Figure 44). The review determined that both in-situ pH and the pH following forced oxidation of all samples collected remained above pH 7, indicating the presence of sulphides or ASS within soils along the causeway and floodway alignment is unlikely.

Assessment of Dredge Materials

O2 Marine undertook an assessment of sediments in the proposed dredging areas (O2 Marine, 2019a). Sediment sampling locations were randomly distributed (Figure 35), with the top 1 m of sediment collected for testing and analysis (the average depth of dredging is 1 m). Samples were collected using a vibrocorer, Ponar Grab or push corers. Analysis of field pH tests indicated that across all sites pH_F values in deionised water ranged from 7.4 - 9.3, reflecting seawater influence (pH 8.2) and possibly dissolved carbonates typical of sediments in marine systems. The maximum change in pH_F and pH_{FOX} values was 1.7. The reaction to hydrogen peroxide was recorded as 'Extreme' in ten samples. Whilst 'Extreme' reactions were recorded in a reasonable number of samples from the site, this test forms only one of the three combining factors required to identify a 'positive field sulphide identification'. Results from the other two combining factors were not triggered and it was therefore considered that potentially acid sulphate soils (PASS) was not detected and further laboratory analysis was not required. The reactions observed were possibly caused from organic material within the sample.

Analysis of deeper cores from the nearby Cape Preston East project (SKM, 2013) shows the sediments consist of sand and loose, course gravels, with decreasing fines content with depth. These indications of 'reworking' are consistent with the subtidal sediments of the area often being significantly mobilised by cyclone events.

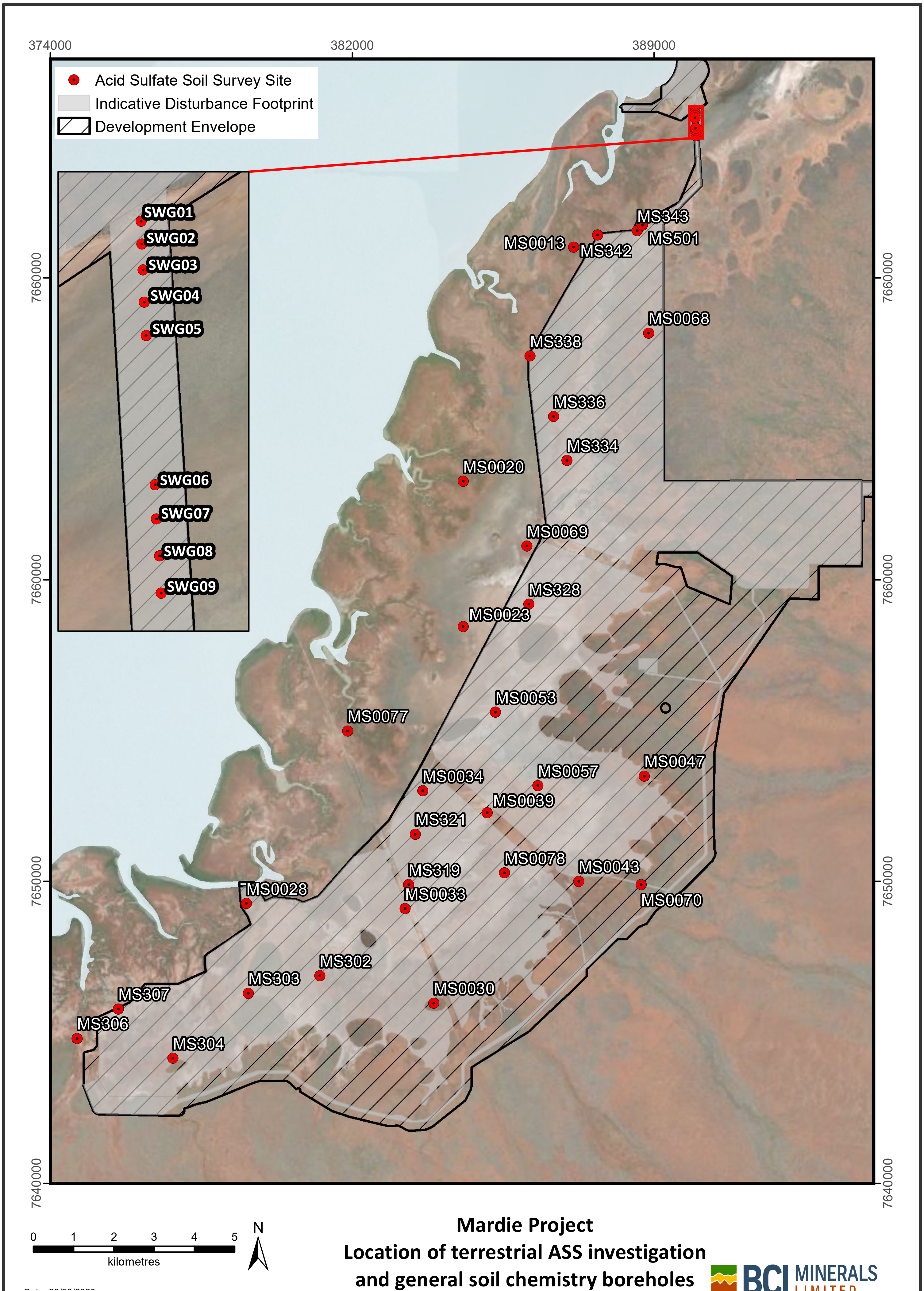


Figure 34: Location of terrestrial ASS investigation and general soil chemistry boreholes

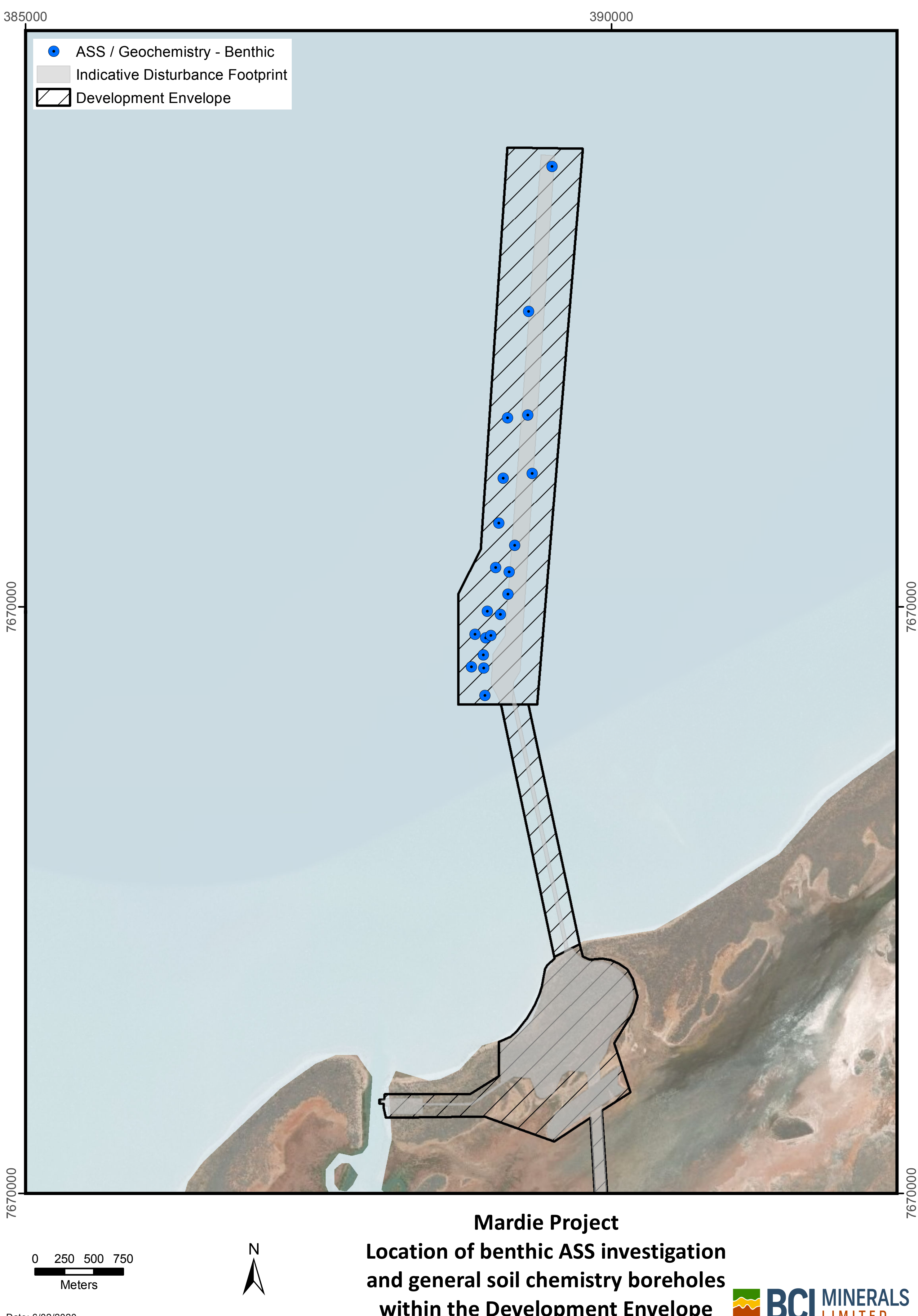


Figure 35: Location of marine ASS investigation sample locations

5.3.8 Environmental Values

Based on the information provided in Section 5.3, the following environmental values were determined to require assessment for this factor:

- Groundwater beneath and surrounding the concentrator and crystalliser ponds;
- Inland surface waters;
- Mardie Pool; and
- Intertidal zone.

5.4 Potential Impacts

Table 12 defines the potential impacts (direct, indirect and cumulative) on the environmental values for this factor in a local and regional context.

Table 12: Potential impacts on inland waters environmental quality

Environmental value and current extent	Potential direct impact	Potential indirect impact	Impacts associated with other proposals	Total cumulative impact
Groundwater Underlying groundwater is hypersaline and relatively close to the surface in the vicinity of the concentrator and crystalliser ponds.	No direct impact. Groundwater is not proposed to be abstracted for the Proposal.	• Potential mounding and surface expression of fresh groundwater inland of the ponds • Seepage from ponds resulting in elevated salinity in underlying groundwater • Changes in groundwater salinity regimes due to mounding	No similar impacts associated with other proposals in the area.	• Potential mounding and surface expression of fresh groundwater inland of the ponds • Seepage from ponds resulting in elevated salinity in underlying groundwater • Changes in groundwater salinity regimes due to mounding

Inland surface waters
15 primary drainage lines intersect with the development envelopes, as well as several minor drainage lines.
	Realignment of drainage lines.	• Alteration or changes in surface water flows and flooding regimes
		• Reduction in surface water flows due to the capture of rainfall within the ponds
		• Surface water quality impacts associated with:
		  ○ Potential leaks or overflow of brine from concentrator and crystalliser ponds or pipelines
		  ○ Sediment loss
		  ○ Acidification of surface or groundwater as a result of the disturbance of ASS (if present)
			Drainage line alterations associated with the two gas pipelines.	• Realignment of drainage lines
				• Alteration or changes in surface water flows and flooding regimes
				• Reduction in surface water flows due to the capture of rainfall within the ponds
				• Indirect surface water quality impacts

Environmental value and current extent	Potential direct impact	Potential indirect impact	Impacts associated with other proposals	Total cumulative impact
		◦ Hydrocarbon spills		
Mardie Pool	None proposed	• Changes to intermittent intertidal water inflows • Reduction in surface water inflows due to the capture of rainfall within the ponds • Surface water quality impacts associated with: ◦ Potential seepage, leaks or overflow of brine from crystalliser ponds or pipelines ◦ Sediment loss ◦ Hydrocarbon spills	Mardie Pool has been heavily impacted by pastoral activities, specifically cattle use and mesquite infestation	• Changes to intermittent intertidal water inflows • Reduction in surface water flows due to the capture of rainfall within the ponds • Indirect surface water quality impacts • Ongoing impacts associated with pastoral activities
Intertidal zone The intertidal system extends along the western edge of the Proposal.	Alteration of tidal regimes due to a reduction in intertidal zone and installation of a causeway. Abstraction of 150 GL/yr of seawater from a tidal creek.	• Coastal erosion as a result of runoff from constructed landforms including bunding and infrastructure • Surface water quality impacts associated with: ◦ Potential leaks or overflow of brine from concentrator and crystalliser ponds or pipelines ◦ Sediment loss ◦ Acidification of surface or groundwater as a result of the disturbance of ASS (if present) • Restriction of inland movement of zone due to sea level rise	Minor drainage alterations associated with the two gas pipelines.	• Alteration of tidal regimes due to a reduction in intertidal zone and installation of a causeway • Abstraction of 150 GL/yr of seawater from a tidal creek • Coastal erosion as a result of runoff from constructed landforms including bunding and infrastructure • Indirect surface water quality impacts • Restriction of inland movement of zone due to sea level rise

5.5 Assessment of Impacts

5.5.1 Groundwater

Groundwater abstraction is not proposed as part of this Proposal. Fresh water will be sourced from a reverse osmosis plant, with interim water sourced from external third parties. Impacts to groundwater are therefore limited to seepage and mounding impacts.

Seepage

SWG (2019a) modelled predicted matric potential below the proposed concentrator and crystalliser ponds. The -100 m matric potential starting point represents the likely moisture content at the beginning of the operation, but once it is in use the starting matric potential will be around -10 m (or less). The shallow (1 m) soil profile wets up rapidly as a result of seepage below the ponds, even with a clay liner with a 10^{-9} m/s saturated permeability, such that it only takes 42 days to saturate if the clays below the liner are at -10 m matric potential.

If the depth of the clay or to the water table below the proposed ponds is 2 m, then the profile is unlikely to become saturated and will remain in a semi-wet, unsaturated condition for at least one year after operations commence.

Based on the results, groundwater mounding will likely occur below the proposed concentrator and crystalliser ponds, even when a 10^{-9} m/s clay liner is installed. The degree of mounding is influenced by the initial depth to groundwater and the starting matric potential of the clays, and saturated conditions are expected below the ponds if the depth to groundwater is 1 m below the pond floor and the in situ clays are relatively 'wet'; hence it doesn't take much seepage to fully saturate the small macro- and meso-porosity of the clays.

Further, the SWG (2019a) results show that over time the seepage from the concentrator and crystalliser pond/s slowly displaces the stored moisture in the underlying sediments, resulting in the downward movement of the wetting front.

For a 10^{-9} m/s seepage rate, positive matric potentials (i.e. > 0 kPa) will likely develop to around 25 cm depth over the entire evaporation pond floor after six months of operation. After one year, fully saturated conditions will extend to 50 cm depth, whereas at 18 months it will reach 75 cm depth, where it will remain. Although seepage from the ponds will likely cause a redistribution of stored soil moisture in the Supratidal Flats, a total of only 2 mm of seepage is expected to reach the calcarenite aquifer, which equates to a seepage rate of 0.003 mm/day.

Even if the potential seepage from the ponds is increased by an order of magnitude, to 10^{-8} m/s, resulting in a significant saturation of the Supratidal Flats to a depth of over 3 m (after two years; Figure 19), negligible seepage reaches the calcarenite sediments and very little actually interacts with the calcarenite aquifer (6.8 mm after two years; or 0.009 mm/day).

Modelling results for the 80 year (i.e. LoM) period, assuming a 10^{-9} and 10^{-8} m/s seepage rate show that it takes approximately 20 years for the seepage front from the ponds to reach the calcarenite aquifer, and that after 80 years only 25 cm of seepage into the water table has occurred. When this rate (i.e. 25 cm seepage over 80 years) is expressed in m/s, it equates to 9.91

× 10^{-11} m/s, which is two orders of magnitude lower than the accepted 10^{-9} m/s seepage rate for clay liners (DoW, 2013).

With the exception of Mardie Pool (discussed in Section 5.5.3), any surface expressions and subsurface seepage within down-gradient areas will occur within areas that are already subject to hypersaline conditions. The predicted salinity levels for the process solution within the concentrator ponds, which occupy the largest land area, are within the measured range of salinity for the isolated groundwater within the supratidal flats. Similarly, the predicted major cation (Ca, Mg, Na, K) and anion (Cl and SO_4) concentration of the process water in the concentrator ponds are within the measured range for the groundwater in the supratidal flats (Soilwater Group, 2019b). Tidal waters that flow into these areas regularly saturate the upper soil profile and concentrate in the surface layers. .

Mounding

The predicted matric suctions modelled in this scenario are presented in Figure 36 to Figure 38. These results assume a 2 m depth to groundwater and a starting matric potential of -100 m. The results show that surface evaporation of the supratidal mudflats surrounding the concentrator and crystalliser ponds will play a significant role in determining the extent to which groundwater mounding under the ponds is likely to impact on the downstream soils. It is important to recognise that although the pan evaporation rate for the Pilbara Region is around 3,100 mm per year, the actual evaporation from the surface of the mudflats will be appreciably lower as the dry soil conditions at the surface will effectively impede the upward movement of water from the soil; hence the permeability of the dry soils at the surface become rate-limiting.

If no evaporation is considered, then groundwater mounding will spread downstream, such that at Day 640 the entire surficial soil profile, to at least 30 - 40 m from the embankment wall toe, will become saturated (Figure 36). If an actual evaporation rate of 1,000 mm per year is considered, then the spread of the groundwater mound is reduced such that at after two years of continuous operation (i.e. Day 730) the surface soils downstream of the embankment wall remain unsaturated (Figure 37). Under this evaporation scenario, the surface soils at distances greater than 10 m from the embankment wall, only become saturated after ten years of continuous operation.

If an actual surface evaporation rate of 2,000 mm per year is used, then the surface soil profile will remain unsaturated, likely over the life of the operation (Figure 38).

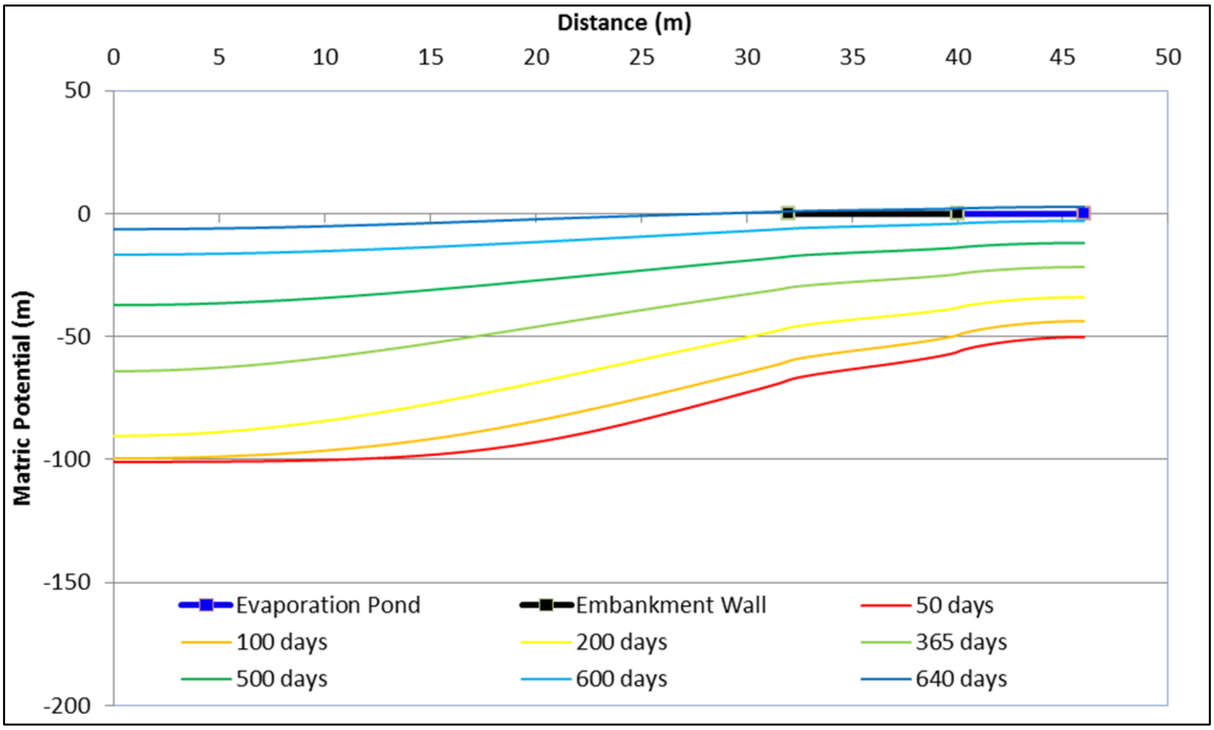


Figure 36: Predicted matric suction of the in situ soils (at 5 cm below the surface) under the concentrator and crystalliser ponds, embankment walls and adjacent areas, assuming no surface evaporation

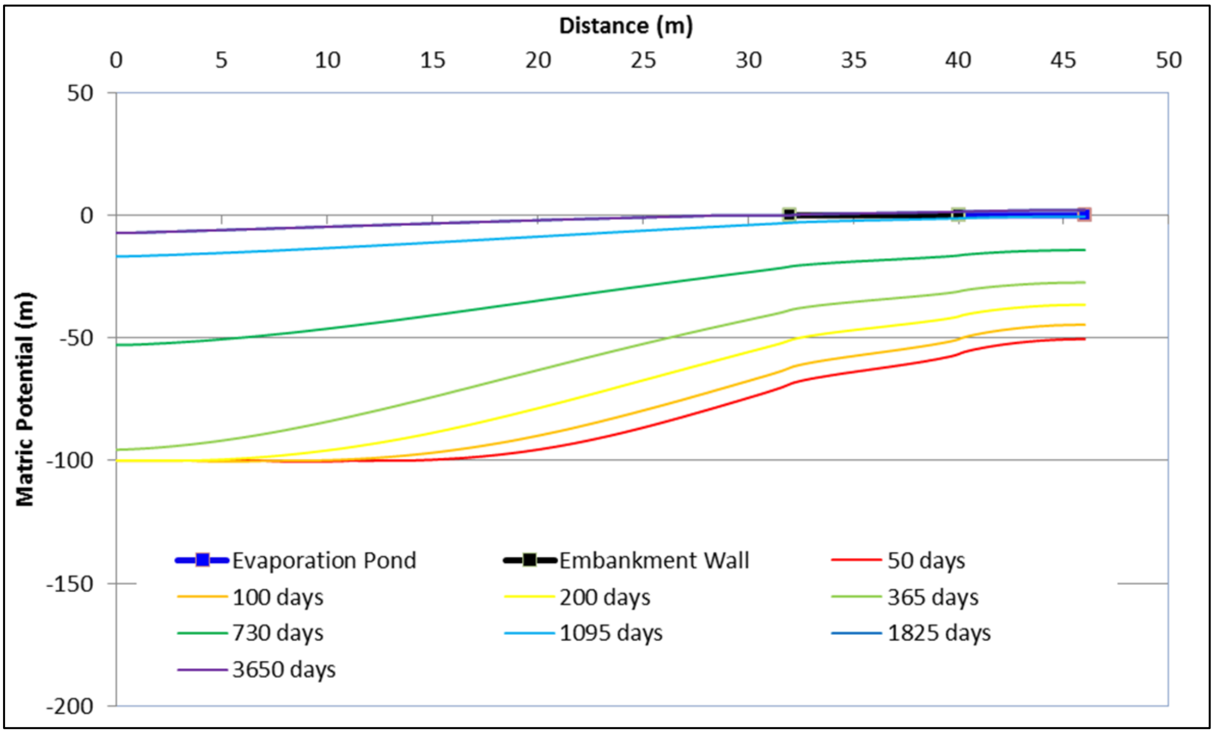


Figure 37: Predicted matric suction of the in situ soils (at 5 cm below the surface) under the concentrator and crystalliser ponds, embankment walls and adjacent areas, assuming actual evaporation rates from the surface

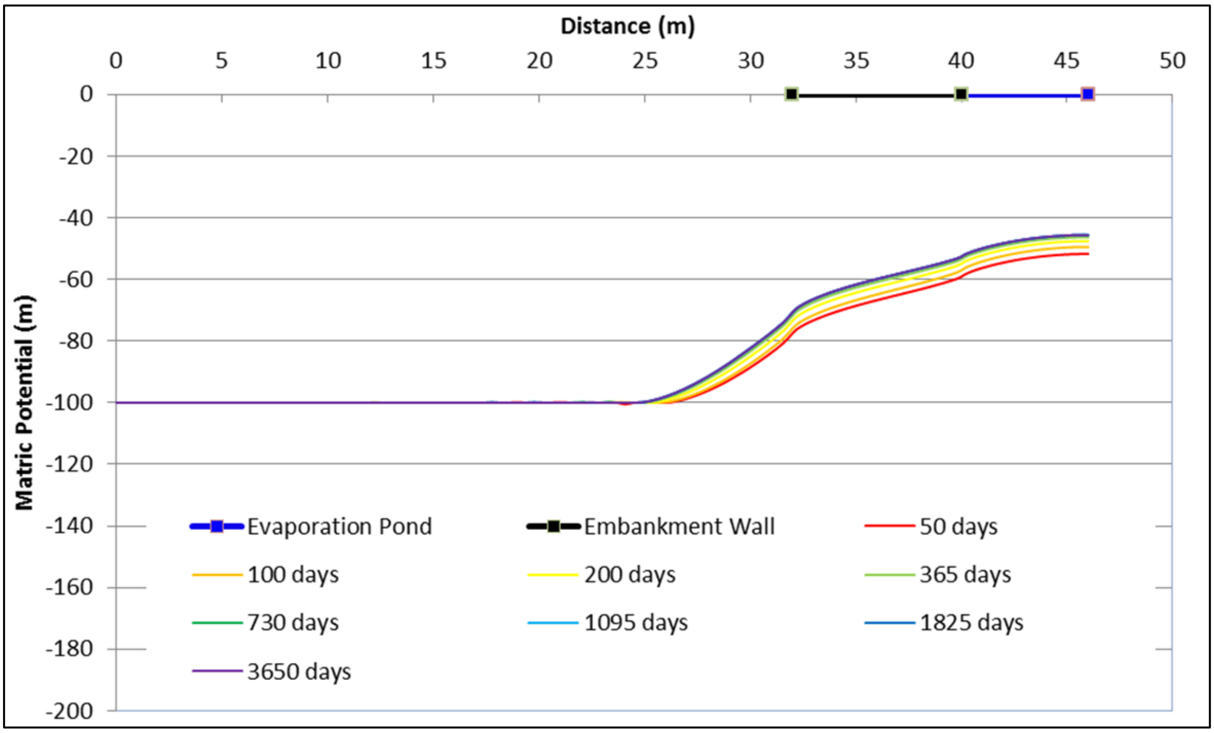


Figure 38: Predicted matric suction of the in situ soils (at 5 cm below the surface) under the concentrator and crystalliser ponds, embankment walls and adjacent areas, assuming high surface evaporation rates

Given the importance of actual evaporation from the surface soils in the Supratidal Flats on the spread of groundwater mounding and likely impact on the surrounding soils, it would be beneficial to accurately measure these rates to constrain the model results. If lower than expected surface evaporation rates are identified, which may result in the downstream spread of the groundwater mound, then seepage capture bores or trenches may be considered to help restrict this spread. The likely efficacy of using this management strategy is shown in Figure 39 and Figure 40, assuming a seepage capture rate of 3 and 30 L/day/m^2, respectively. This mitigation measure is described in Section 5.6.

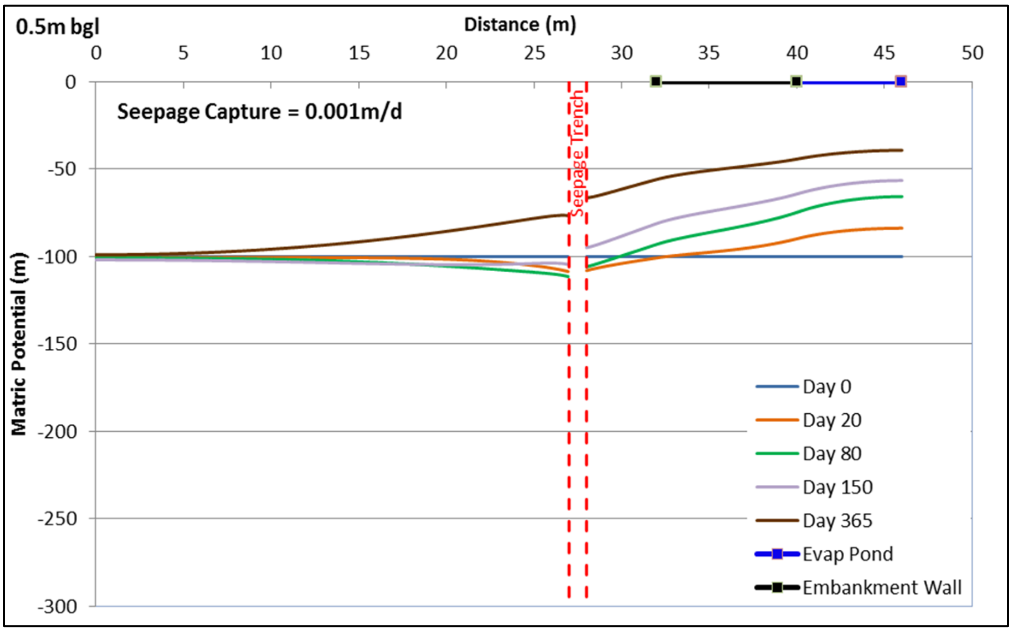


Figure 39: Predicted matric potential of in situ soils (at a depth of 0.5 m bgl), with a seepage capture trench installed, dewatering at a rate of 3 L/day per linear metre of trench

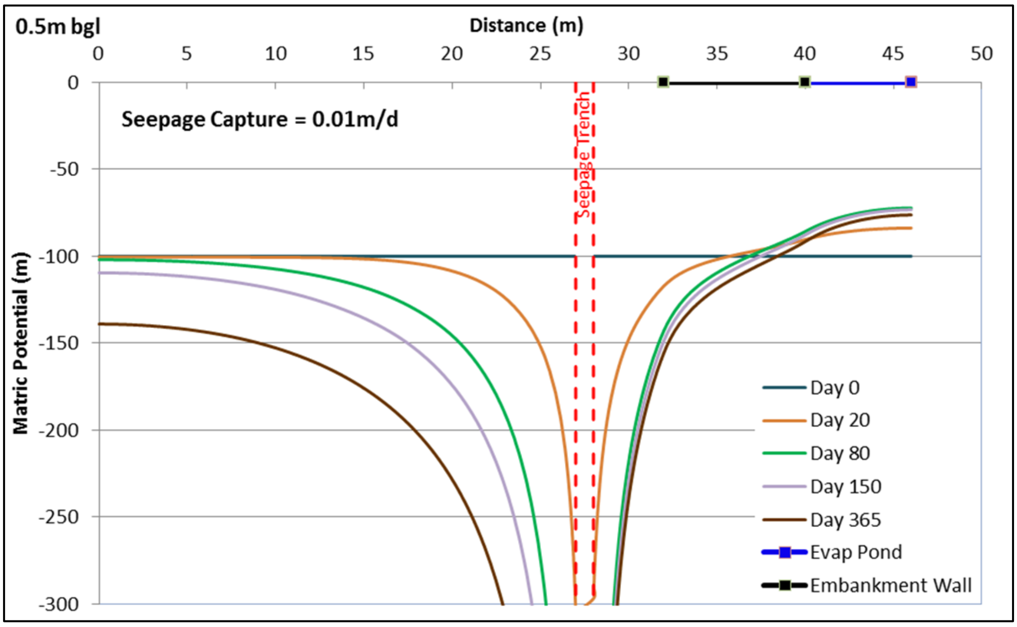


Figure 40: Predicted matric potential of in situ soils (at a depth of 0.5 m bgl), with a seepage capture trench installed, dewatering at a rate of 30 L / day per linear metre of trench

Summary

The pertinent findings from the SWG (2019a) investigation are:

- The groundwater system within the supratidal flats is effectively a closed system, which has experienced prolonged evaporative concentration of salts resulting in hypersaline conditions. This system is not connected to the marine environment or the underlying calcarenite aquifer;
- The elevated 'natural' salinities within the supratidal flats restrict the landward extension of mangroves, and thus the impacts from the Proposal are expected to be minimal;
- The seepage rates from the Concentrator Ponds due to the clay content of the Supratidal flats are very low. In addition, predicted process water quality, and hence potential seepage water quality, from the Concentrator Ponds, which represents the largest footprint area, is similar to the existing groundwater quality. Therefore, the combination of low seepage rates and process water quality results in expected negligible impacts on groundwater quality in the Supratidal Flats is expected;
- Process water quality within the crystalliser ponds does exceed the surrounding natural environment, but the extent of seepage from these areas is significantly reduced by the precipitation of salts;
- Based on the data presented, the Proposal is not expected to alter the local or regional groundwater quality;
- Under realistic actual evaporation conditions, the spread of the groundwater mound under the concentrator ponds will not interact with the algal mats that occur downstream , and no change in soil water dynamics is expected in the top 2 cm of the soil profile, which is the depth of soil that the algal mats depend on (Paling, 1990); and
- If evaporation rates are lower than expected, resulting in a greater spread of the groundwater mound, then modelling has shown that seepage capture bores or trenches could be effectively used, with potential extraction rates of up to 30 L/s/m^2 shown to significantly reduce any downstream impacts.

5.5.2 Inland Surface Waters

Realignment of Drainage Lines

An integrated service corridor and surface water diversion network will be constructed along the eastern margins of the Ponds and Terrestrial Infrastructure Development Envelope as described in Section 2.2.3.

The construction of these access roads and diversion drains up-gradient of the ponds (Figure 3) has the potential to alter and even impede natural flows, particularly during extreme weather events and if drainage is inadequate for the scale of flows. This may result in flooding of areas to a greater extent or longer duration that would be naturally encountered, thereby creating the potential for existing vegetation and fauna habitat to be adversely impacted.

To ensure that the roads and diversion drains that form part of the Proposal do not result in unnecessary impacts and that the risk of flooding is minimised, Mardie Minerals has worked with RPS and engineering design consultants to develop a drainage system and management strategy that builds on studies conducted to date (e.g. RPS, 2017a) and achieves the following objectives:

- Maintain net catchment discharges to the intertidal areas;
- Ensure the drainage system is designed to accommodate flows up to a 50-year ARI, 72-hour event;
- Overflows from the catchment (i.e. in events >50-year ARI) will be allowed to flow into the ponds. Overflow water will be retained in the pond. This is particularly relevant to the protection of the gas pipeline, with ponds adjacent to the pipeline the most likely to receive overflows from the drainage system;
- Not impede drainage from undisturbed catchment areas by more than 18 hours longer than baseline; and
- Prioritise discharges of freshwater runoff towards the Peter Creek intertidal area, which supports part of the Robe River Mangrove Management Area (refer to Section 7).

Drains and culverts will be designed and constructed in accordance with Main Roads WA General Standards. In addition, drains and channels will be appropriately designed to reduce flow velocities and armoured to minimise erosion, and will be integrated with existing features.

The drainage system is designed to maintain the overall volume of flows from the catchments entering the intertidal floodplain. Figure 44 - Figure 46 show the flow paths and flood depths predicted at 1, 10, 20, 50 and 100 ARI rainfall events, demonstrating that the main catchments and subsequently the majority of surface water flows are directed through to the intertidal zone.

There are some inland drainage lines and depressions that will not report into the drainage system (given the construction disturbance required to allow this to occur). These are shown on Figure 41 and may be up to 75 cm deep during a 1 year ARI rainfall event, and up to 2 – 3 m deep during a 100 year ARI rainfall event. This water will gradually evaporate or seep into the underlying sediments over an expected period of days to weeks. Inundation for this time period is unlikely to significantly alter the values of these depressions.

The portions of these drainage lines and depressions that lie on the western side of the access road / drainage corridor will no longer receive surface water inflows from the upper catchment. Any drainage within these areas will therefore be reduced to only local run-off from the western side of the corridor. These areas however only form a small part of the overall drainage system and are at the extreme downstream extent of each drainage line.

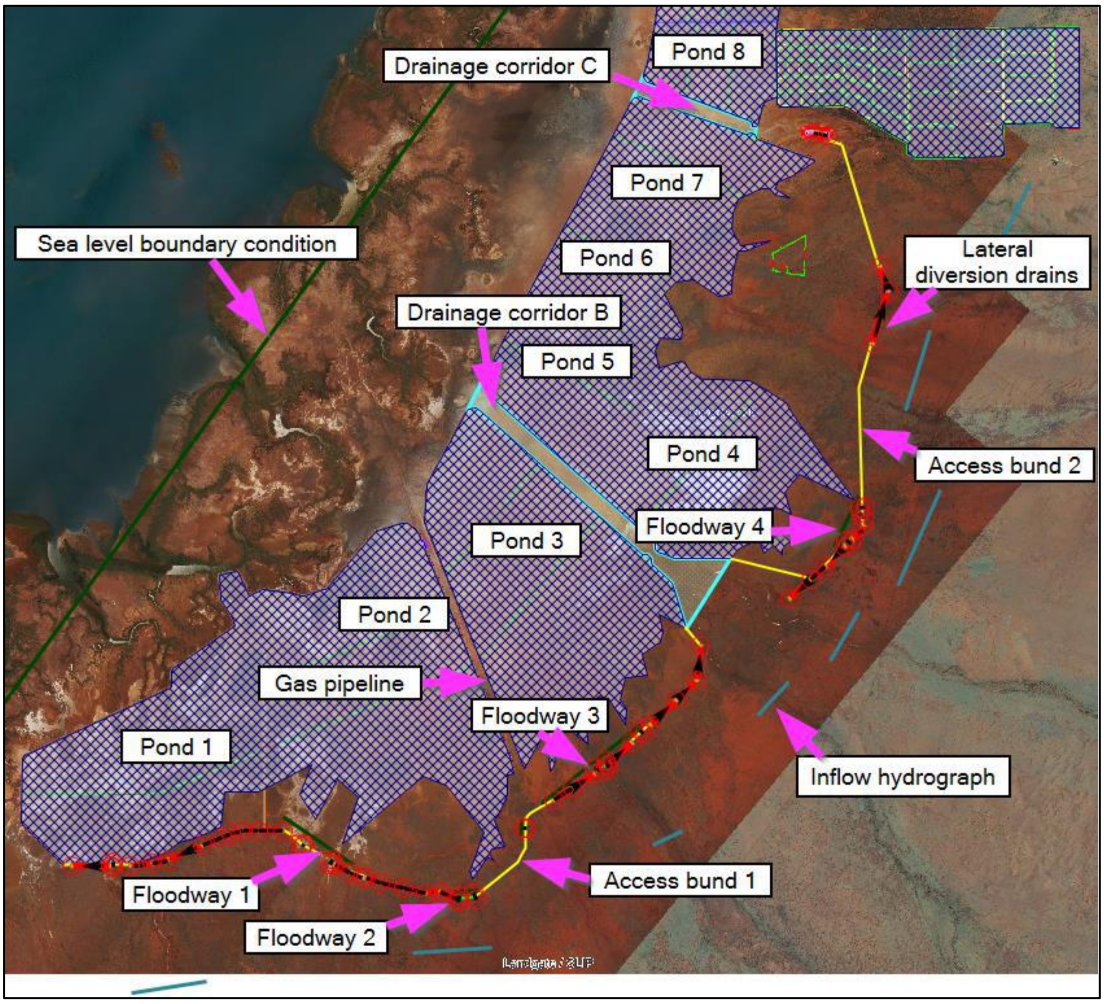


Figure 41: Surface water drainage network

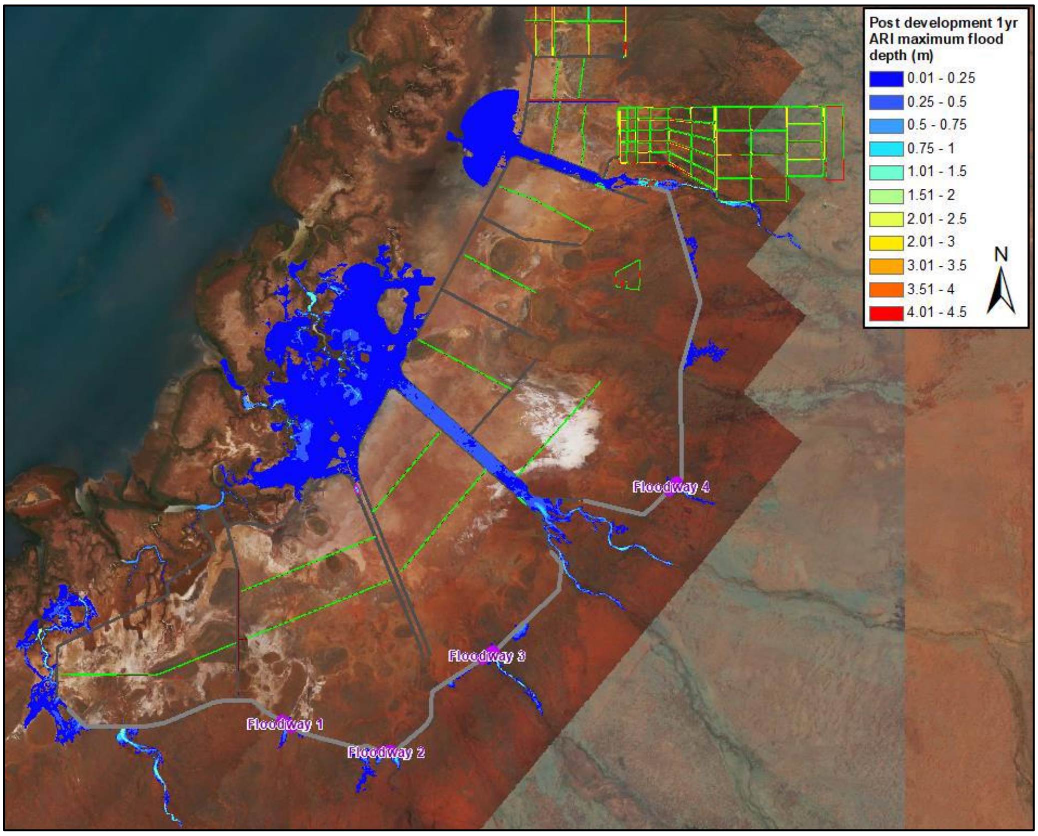


Figure 42: Post-development 1 year ARI maximum flood depth (m)

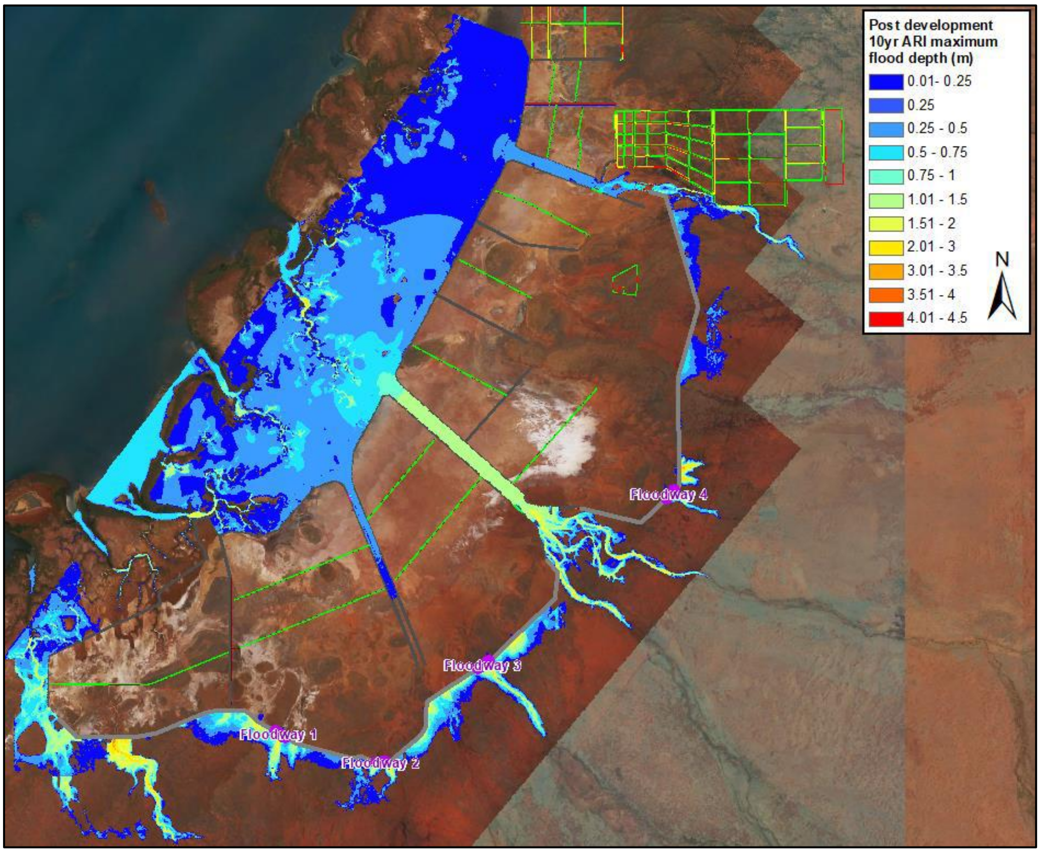


Figure 43: Post-development 10 year ARI maximum flood depth

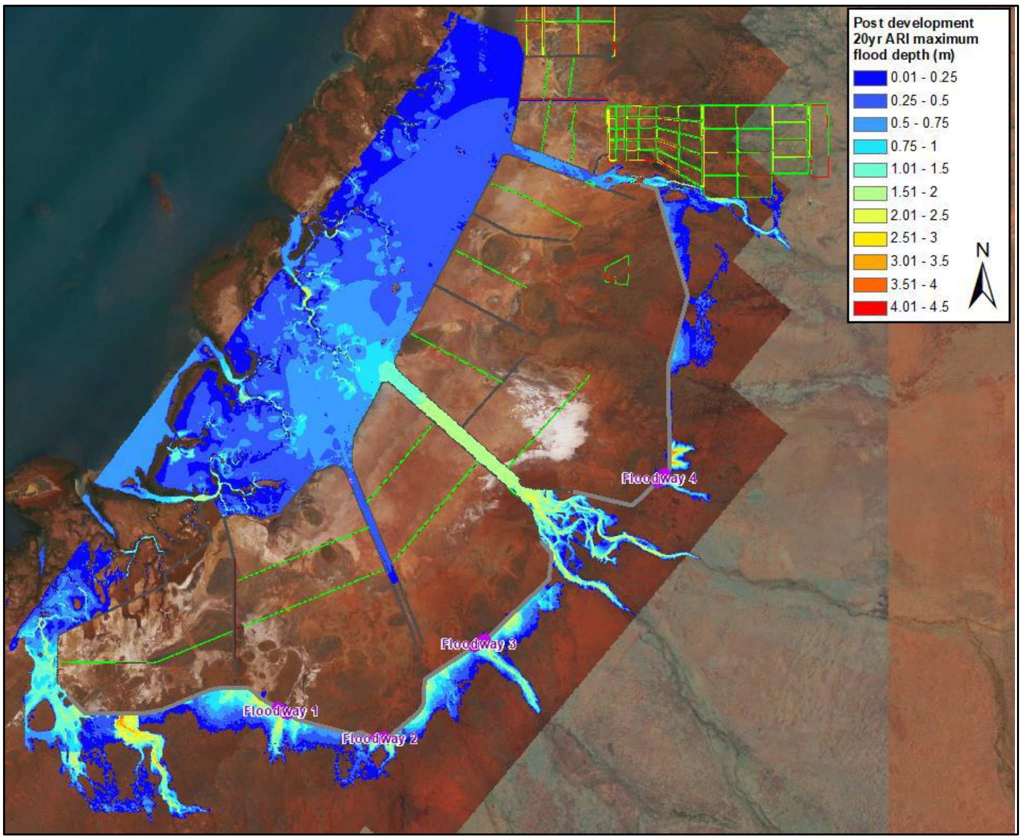


Figure 44: Post development 20 year ARI maximum flood depth (m)

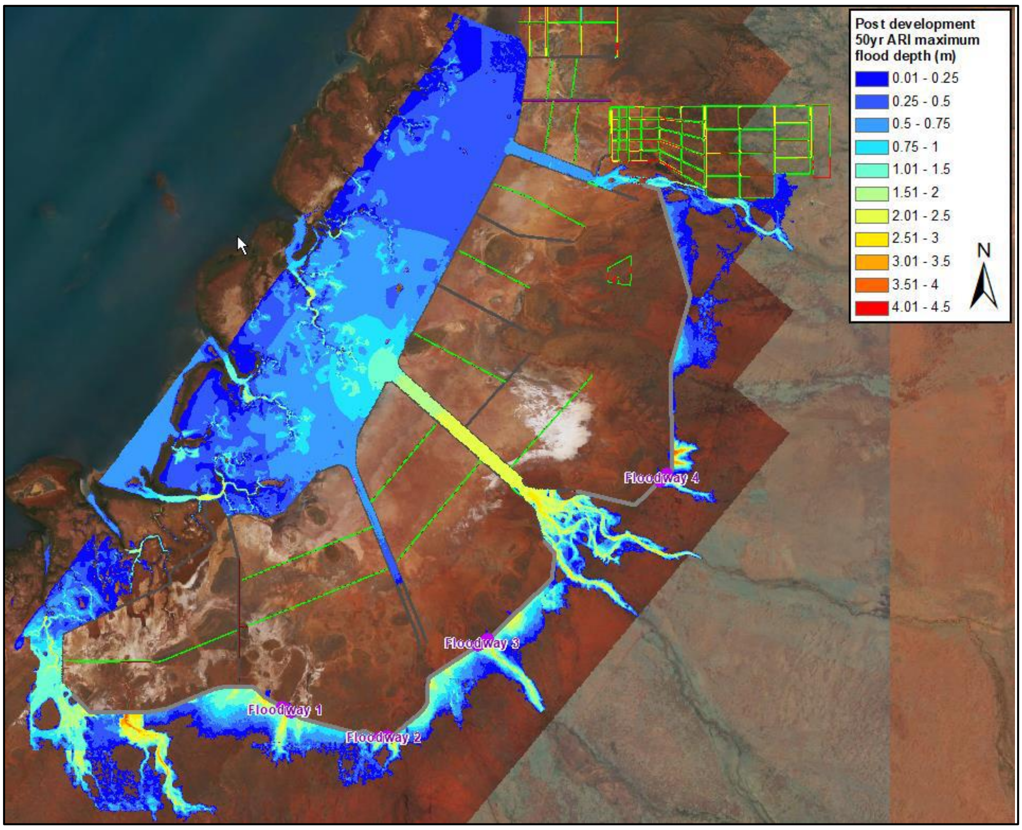


Figure 45: Post development 50 year ARI maximum flood depth (m)

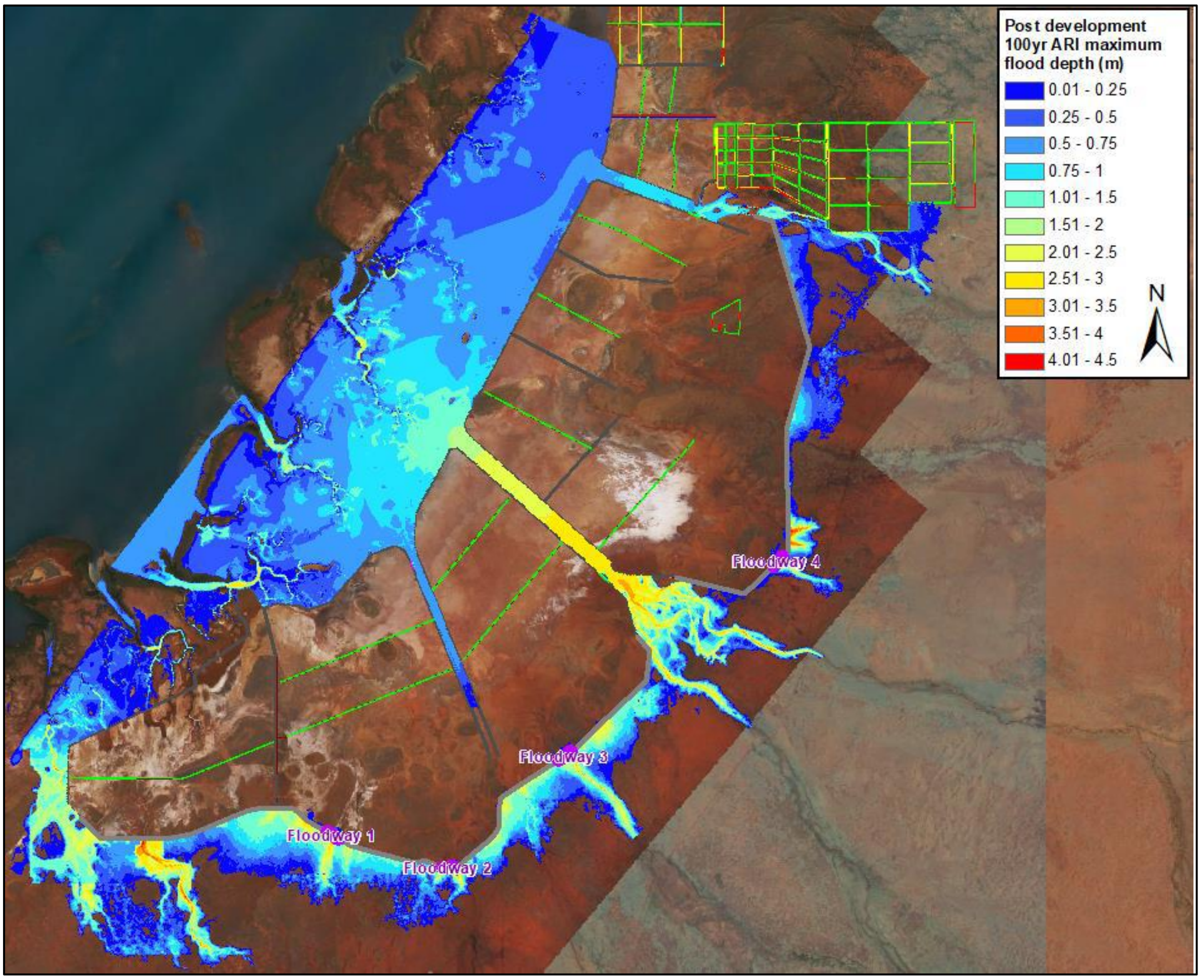


Figure 46: Post development 100 year ARI maximum flood depth (m)

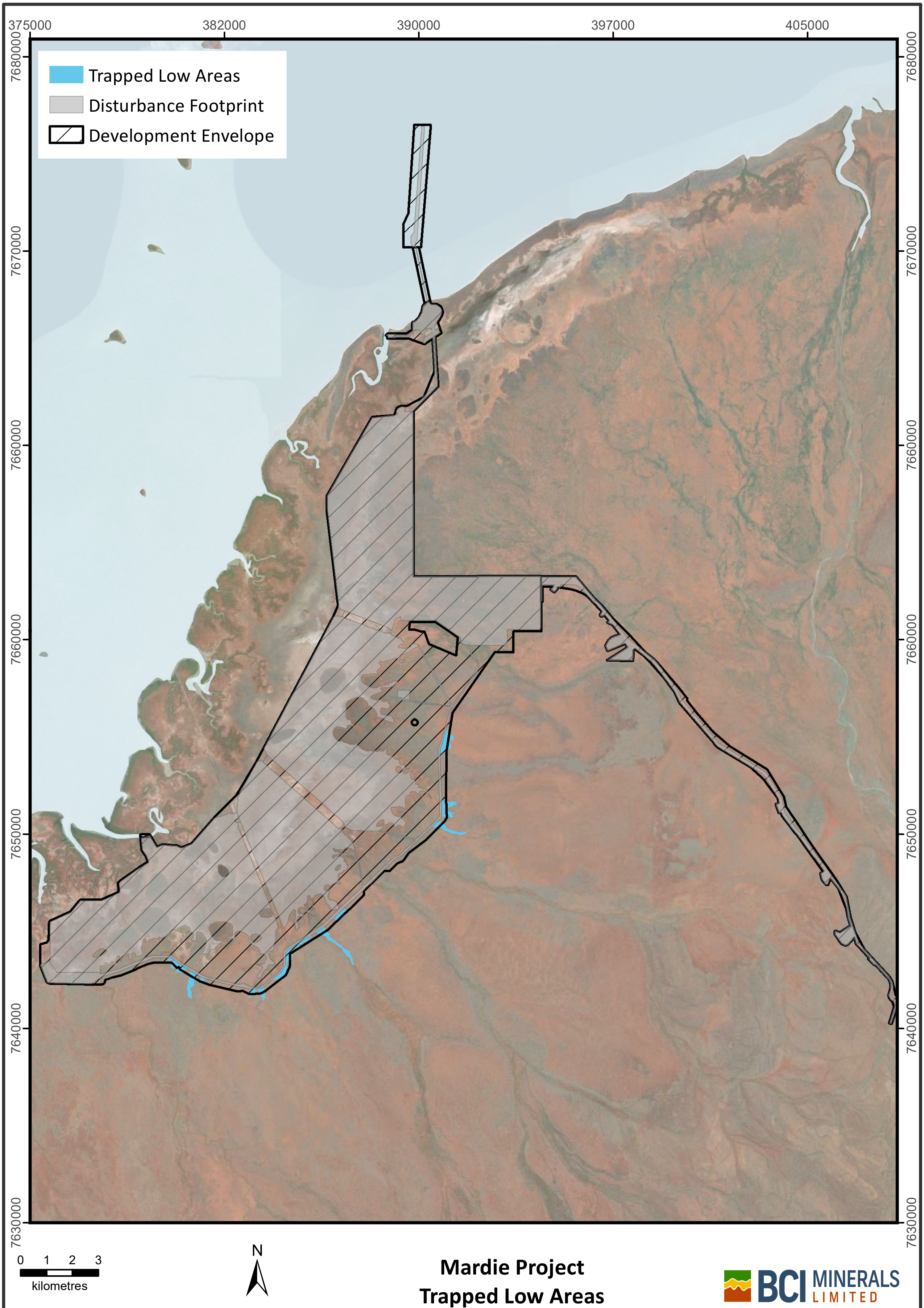


Figure 47: Surface water drainage and depressions trapped (100 year ARI shown)

Rainfall Capture within the Ponds

While the proposed drainage diversions and lateral channels around and between the ponds will ensure catchment flows to the intertidal and coastal areas are maintained, rainfall that falls within the ponds will be captured and will not discharge to the intertidal zone.

These drainage lines currently end at the intertidal flats, and flows are spread across the mudflats, creating an interconnected system during large flow events. The ponds therefore will affect the volume of water in this interconnected system. The impact on the receiving environment is expected to be negligible overall, as the ponds form only small proportions of the catchments and all of the catchments discharge to the same connected area of intertidal flats (i.e. forms a much larger catchment).

Brine Leaks and Spills

A spill or leak of brine from the ponds or pipelines could result in impacts to the quality of the inland surface waters. 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 5.6). Ponds have been designed with adequate freeboard and overflow features to minimise the risk of unplanned overflows and wall breaches. 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.

If a spill was to occur, in most cases it would either be discharged into the saline intertidal zone (discussed in Section 5.5.4). The eastern crystalliser ponds (Figure 3) are however located in an area that is not subject to tidal inundation and is also in proximity to Mardie Pool, consequently, there is a potential for brine leaks and spills from these crystalliser ponds to affect water quality within Mardie Pool. This is discussed in Section 5.5.3.

Erosion and Sediment Loss

There is the potential for erosion of creek diversion and discharge areas and scouring of constructed walls and drains. The majority of the disturbance for the Proposal is associated with the flooding of an existing landscape rather than vegetation clearing. Any sediment would be captured within the ponds during this activity. Sediment may be released during construction of the pond walls, however these walls are generally low and as such contain relatively low volumes of fill material. The wall material is generally high in clay content and will be compacted in place, which means the walls will consolidate quickly and therefore sediment losses will be minimal. Mardie Minerals have committed to mitigation measures to reduce the risk of sedimentation (refer to Section 5.6.2).

Hydrocarbon Spills

The Proposal does not include the storage or use of large volumes of hydrocarbons or chemicals, and the implementation of industry-standard mitigation measures (Section 5.6) is expected to ensure that spills (if they occur) are controlled, contained and cleaned up to minimise impacts to inland waters.

Acid Sulfate Soils

Potential impacts to surface water from the disturbance of ASS is not expected, based on the results that have been collected and analysed to date that all show the local soils and sediments to be alkaline and of low to no reactivity. Mardie Minerals will collect and assess additional samples regularly for ASS during construction of the pond walls and causeway and also during dredging, to ensure the ongoing reliability of the original assessments (refer to Section 5.6.2).

5.5.3 Mardie Pool

Changes to Intermittent Intertidal Water Inflows

Mardie Pool lies on the far eastern edge of the intertidal zone and as such storm surges and extremely high king tides are predicted to currently reach Mardie Pool, albeit on extremely rare occasions (RPS, 2019), as confirmed by water quality monitoring, which shows Mardie Pool as fresh-brackish (Section 5.3.4). These occasional inflows would be the only source of saline water into Mardie Pool. The inundation modelling conducted by RPS (2019a) confirmed that tidal inundation levels along the 300 m-wide lateral drainage corridor that links Mardie Pool to the intertidal areas would not change as a result of the proposal (section 5.3.5).Despite the likelihood of periodic tidal pulses, the ecological values of Mardie Pool are likely to be almost completely reliant on fresh water inflows from groundwater and catchment sources, indicating that any seawater inflows are quickly diluted or flushed from the pool. Reduction in Catchment Area

Minor Creek 1 (Figure 41), which flows into Mardie Pool, has a catchment of 61 km^2 or 6,100 ha. There is potential for rainfall that falls within the eastern crystalliser ponds to be captured and therefore reduce catchment discharges through to Minor Creek 1. .

The se eastern crystalliser ponds cover only a small proportion (330 ha or 5%) of the upstream catchment and therefore only affect the volume of water that flows into Mardie Pool by a similar percentage. As indicated by its permanency, Mardie Pool is almost completely reliant on groundwater inflows (SWG, 2019a) and therefore the ecological value of Mardie Pool is unlikely to be significantly impacted by a minor reduction in surface water inflows.

Brine Seepage from Crystalliser Ponds

The crystalliser ponds on the eastern side of the Proposal are located within the Cane River Zone Regional Land System, which consists of 3 – 6 m of Aeolian sands and sandy loam soils overlying the calcarenite material which dips below the western supratidal flats). The southern margin of the crystalliser ponds is located approximately 250 m north of Mardie Pool (Figure 48 and Figure 49).

To establish whether hypersaline seepage from the eastern crystalliser ponds might impact on the water quality of Mardie Pool, SWG modelled seepage using the setup shown in Figure 50(SWG, 2020b). Owing to the uncertainties in predicting the hydraulic properties of the crystalliser pond floors, which in addition to an underlying clay basement, will also have a 300 mm or greater solid halite pavement capable of supporting harvesting equipment, the model used a range of seepage rates based on test results from natural soils in the area (SWG 2019a).

The model results for the 10^{-9}, 10^{-8} and 10^{-7} m/s seepage rates are provided in Figure 51 to Figure 53. The results show the chloride (Cl-) concentration (in $mmol/m^3$), such that 5,600 $mmol/m^3$ is equivalent to a Cl- concentration of 200,000 mg/L. It was assumed that the Cl- was an inert trace and did not undergo chemical reaction or retardation during transport.

If the seepage below the crystalliser ponds remains at 10^{-9} m/s, then after two years of operation the salinity / seepage front would have only moved approximately 1 m below the pond floor (Figure 51). The reason for this negligible transport is that according to the hydraulic conductivity function the permeability of the aeolian sand at field capacity (i.e. 10 kPa or 1 m matric suction) is itself around 10^{-9} m/s and thus as the wetting front moves through the aeolian sand it continually encounters dry, low permeability soil which impedes its downward movement.

If the seepage rate below the crystalliser ponds increases to 10^{-8} m/s, possibly in response to osmotic suction 'pulling' seepage water downward, then the salinity front is expected to reach the underlying calcarenite aquifer in around 1.5 years (Figure 52), after which time it will rapidly move towards Mardie Pool at a rate of around 1 m/day. It is expected that the salinity front from the crystalliser ponds would reach Mardie Pool by Year 3. If in the unlikely event that the seepage rate below the crystalliser ponds is around to 10^{-7} m/s, then the salinity front will reach the Calcarenite Aquifer in six months and by 1.2 years it would have reached Mardie Pool (Figure 53).

Based on the above model results, there is a potential that saline seepage from the eastern crystalliser ponds may intersect and impact Mardie Pool depending on the long-term seepage rates achieved. Mardie Minerals therefore proposes to install groundwater monitoring bores along the southern margin of the crystalliser ponds to establish whether such seepage is occurring and to determine the rate at which it is moving towards Mardie Pool. If salinity front is detected, and it is considered that there is a risk to the quality of Mardie Pool, then seepage capture bores will be installed to halt the progress of the salinity front, in addition to other measures, including supplementation with local groundwater.

Further information on the proposed management measures is provided in Section 5.6.

Based on the established capacities of groundwater and soil conductance monitoring to provide early warning of saline seeps, the availability of established interception and intervention management measures, and that Mardie Pool has some tolerance to occasional saline inflows from the sea, Mardie Minerals expects that it can adequately protect the environmental values of Mardie Pool from the potential for seepage from the ponds.

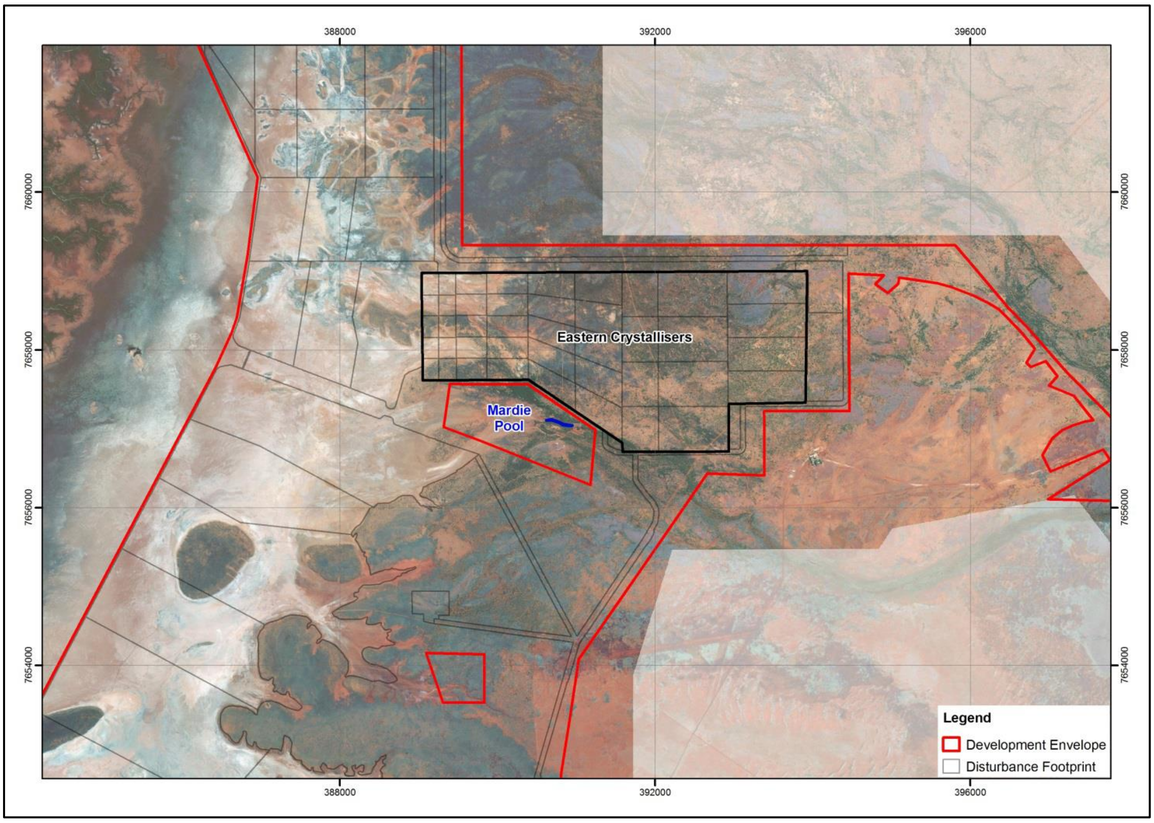


Figure 48: Location of the eastern crystallisers and Mardie Pool

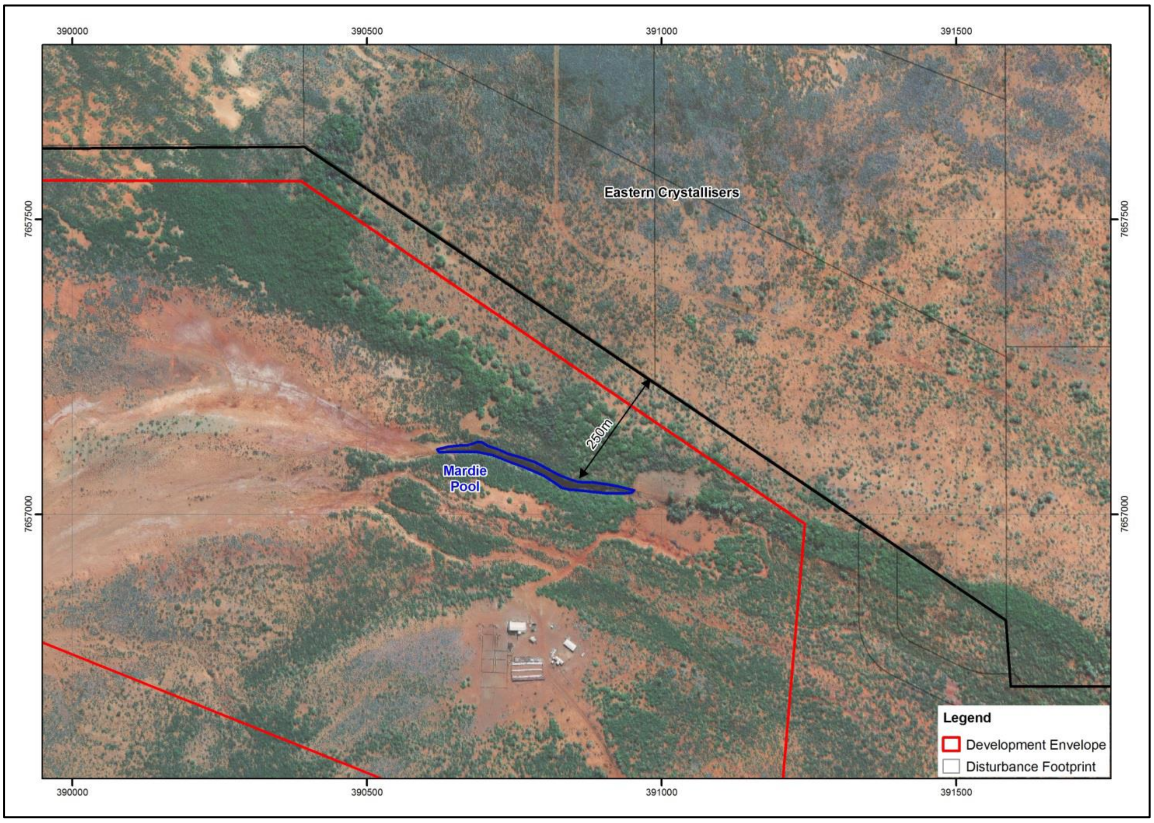


Figure 49: Distance of the eastern crystallisers from Mardie Pool

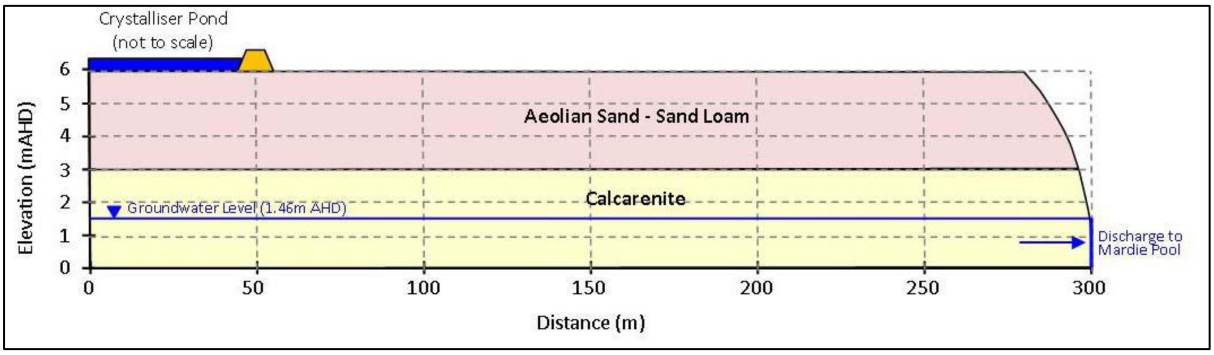


Figure 50: Stratographic profile underlying the eastern crystalliser ponds

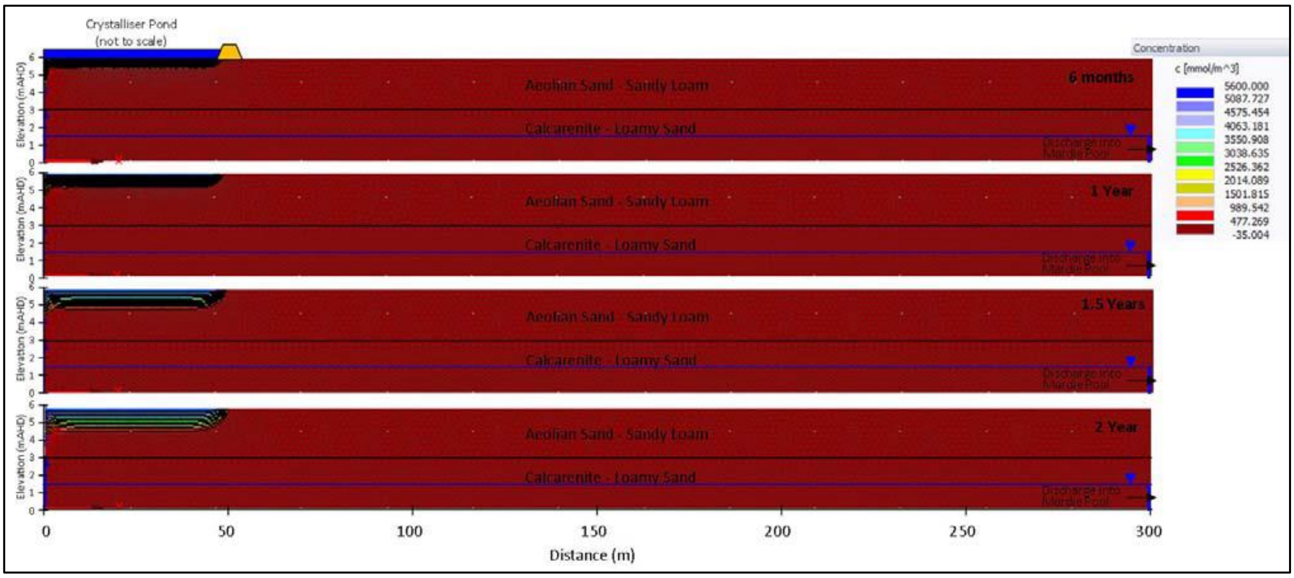


Figure 51: Salt seepage below the crystalliser pond/s assuming a seepage rate of 10^{-9} m/s

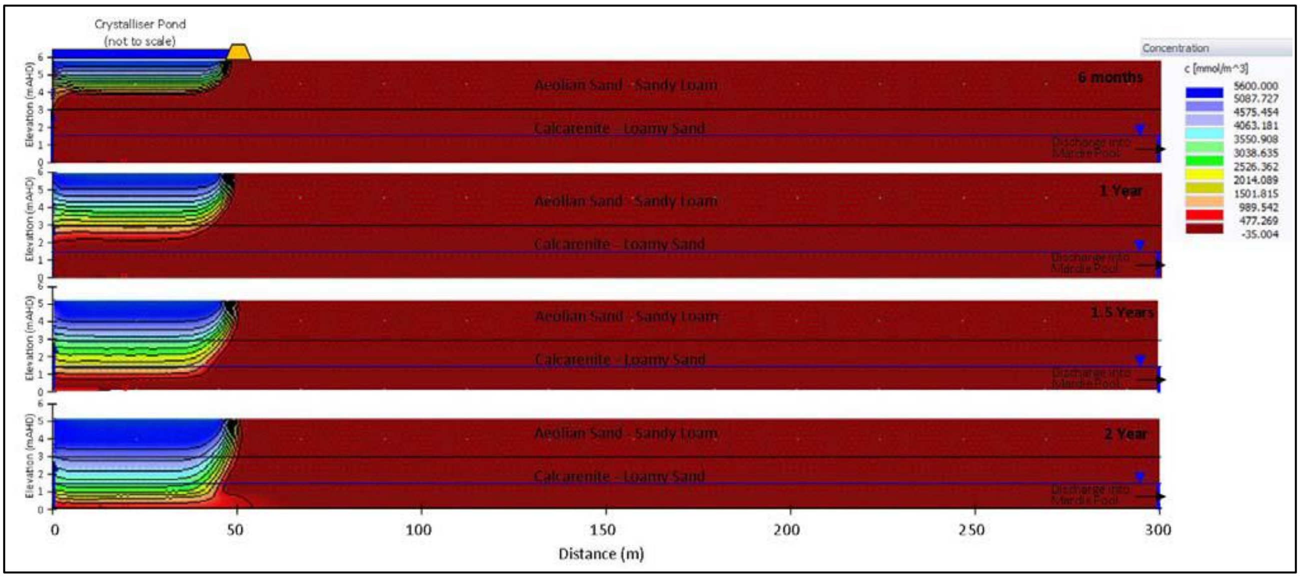


Figure 52: Salt seepage below the crystalliser pond/s assuming a seepage rate of 10^{-8} m/s

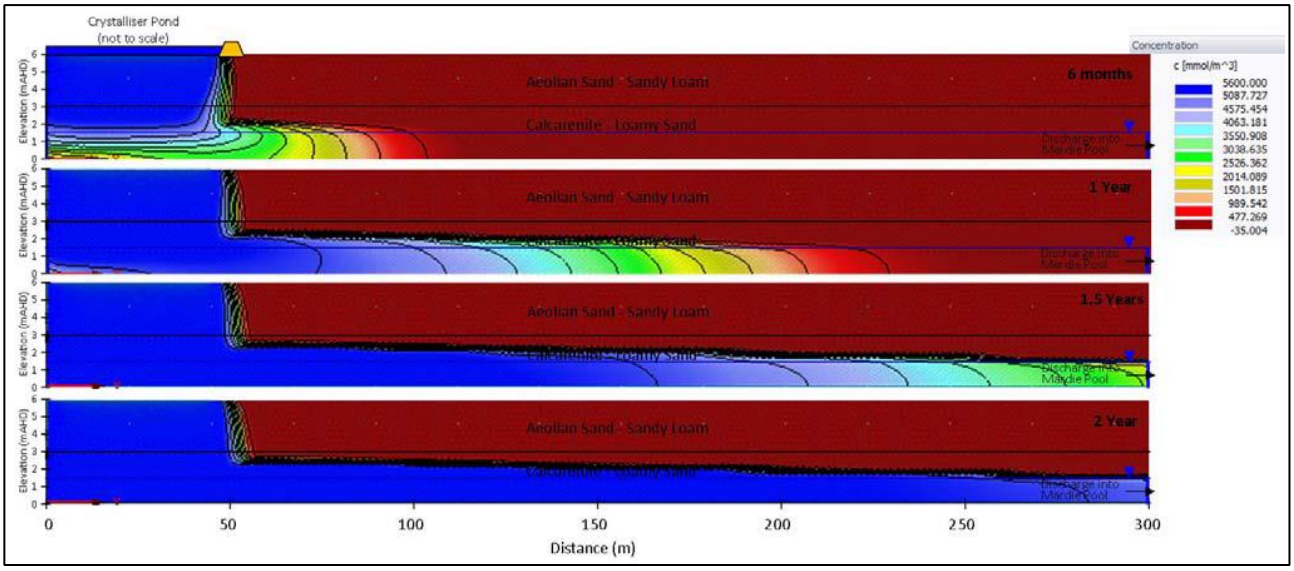


Figure 53: Salt seepage below the crystalliser pond/s assuming a seepage rate 10^{-7} m/s

Accidental Brine Spills and Leaks from Crystalliser Ponds

The eastern crystalliser ponds (Figure 3) are located in proximity to Mardie Pool, consequently, there is a potential for accidental brine leaks and spills from these crystalliser ponds to affect water quality within Mardie Pool.

The primary safeguard to minimise the potential for leaks and spills will be to incorporate appropriate freeboard into the pond designs, and ensure structurally stable pond walls. The eastern crystalliser ponds are quite elevated and are located on the catchment divide (Figure 41) and are not expected to be at risk of overtopping from extreme catchment flows or storm surges.

In addition to environmental protection the prevention of leaks and spills from the crystalliser ponds is of significant economic importance, as brine with the ponds is highly concentrated and contains high amounts of SOP product.

Based on the above, accidental brine leaks and spills are unlikely to occur with sufficient regularity or scale to impact the water quality within Mardie Pool.

Sediment Loss

There is the potential for vegetation clearing and pond construction in areas adjacent to Mardie Pool to result in sediment loss to Mardie Pool.

The majority of the disturbance upslope of Mardie Pool will be associated with development of the crystalliser ponds. Any sediment would be captured within the ponds during this construction period. Sediment may be released during construction of the pond walls, however these walls are generally low and as such contain relatively low volumes of fill material. The wall material is generally high in clay content and will be compacted in place, which means the walls will consolidate quickly and therefore sediment losses will be minimal. Where necessary, the walls will be armoured with rock or geotextile to minimise erosion during high flows. Mardie Minerals have committed to mitigation measures to reduce the risk of sedimentation (refer to Section 5.6.2).

Hydrocarbon Spills

Large volumes of hydrocarbons or chemicals will not be stored in proximity to Mardie Pool, and the implementation of industry-standard mitigation measures (Section 5.6) is expected to ensure that spills (if they occur) are controlled, contained and cleaned up to minimise impacts to Mardie Pool. Intertidal Zone

Alteration of Tidal Regimes - Ponds

Simulation of tidal inundation with the pond walls in place (Pond Case) indicates an effect on the landward movement of water at the northern and southern parts that commences at tidal peaks exceeding around 1.2 m. This is because the pond walls would extend up to the terminal points of the creeks in these areas. The effect is expressed as a block of the water that would normally flow inland onto the low-lying land beyond the walls. Due to the multiple flow paths for water, there are no apparent effects of the wall on the wetting of land on the seaward side of the walls. None of the areas on the seaward side of the walls that flooded in the Base Case became dry in the Pond Case.

The movement of water over the central part of the Proposal (where the pond walls are further inland) remains similar to the Base Case at tide levels lower than ~ 1.8 m MSL because water can freely flood in and drain out along the same pathways and the flooding level does not reach the pond walls. During more extreme spring-tides however, water is calculated to flood out and reach the pond walls which will act to block the progress of water onto portions of the land beyond. The floodwaters reach the walls closer to the north and south at lower tides and the central walls at higher tides.

The effect of the pond walls was further investigated by calculating differences in water depth at each time-step in the simulations for the Base Case and the Pond Case, under the influence of the same sequence of tidal elevations (Figure 54 and Figure 55). The barrier effect of the walls was shown to cause a relatively small increase in the depth of water calculated for the clay pan area during the flooding phase, however only at the higher tides experienced during the spring tide phase. The largest increases in depth were predicted for the areas that are within a few hundred metres of the walls at the far northern and southern sections. These differences are short-lived, persisting for 15 - 30 minutes at most, as the increased water depth is shed to surrounding areas. The shedding of water is evident as the propagation of water over the clay pans in the centre of the Proposal area.

Another effect of the pond walls demonstrated by the simulation is that the water held up by the walls would drain away faster than in the Base Case. This is because water would otherwise drain back over a large portion of the land beyond the walls – a slower process than drainage from a freestanding body of water. The largest effect on the drainage of water is indicated for the same areas where the pond walls are expected to cause the largest, short-lived, rise in the water depth. This pattern suggests a slight shift in the timing of inundation over a full tidal cycle, with the largest effect expressed at the sections of wall at the far north and south, where the pond walls extend further west.

The magnitude of the shift was investigated further by calculating a time-series of water depth for three locations immediately in front of the walls: locations at the far north and far south where the largest changes to the flooding and draining depth where illustrated and at a central location

(Figure 56). The plot was generated for the highest tide during the sample period (~2.2 m MSL), i.e. an extreme, annual, event. These plots confirm that the phase and magnitude of water depth remains similar and that differences are of the order of 10 - 20 cm water depth.

RPS (2019a) also modelled the influence of the ponds for a sea level rise scenario. If the pond walls were in place, they would block the inland flow of water over areas that would otherwise be flooded, resulting in higher water depths over the seaward land area during spring tides. Simulations indicate that there would remain an area of clay pan that wets and dries and that the whole of the Proposal area would fill to a depth > 0.5 m during the annual King Tide (Figure 57).

The inundation frequency analysis was repeated for the sea level rise scenario. The effect of sea level rise on the inundation frequency for the algal mat zone was calculated for the Base Case (Figure 3.15) and the Pond Case (Figure 3.16). Similarly, the effect of sea level rise on the inundation frequency for the mangrove zone was calculated for the Base Case (Figure 3.16) and the Pond Case (Figure 3.17).

To quantify the potential impacts of these changes to tidal regimes it is important to focus on areas inhabited by BCH (refer to Section 6).

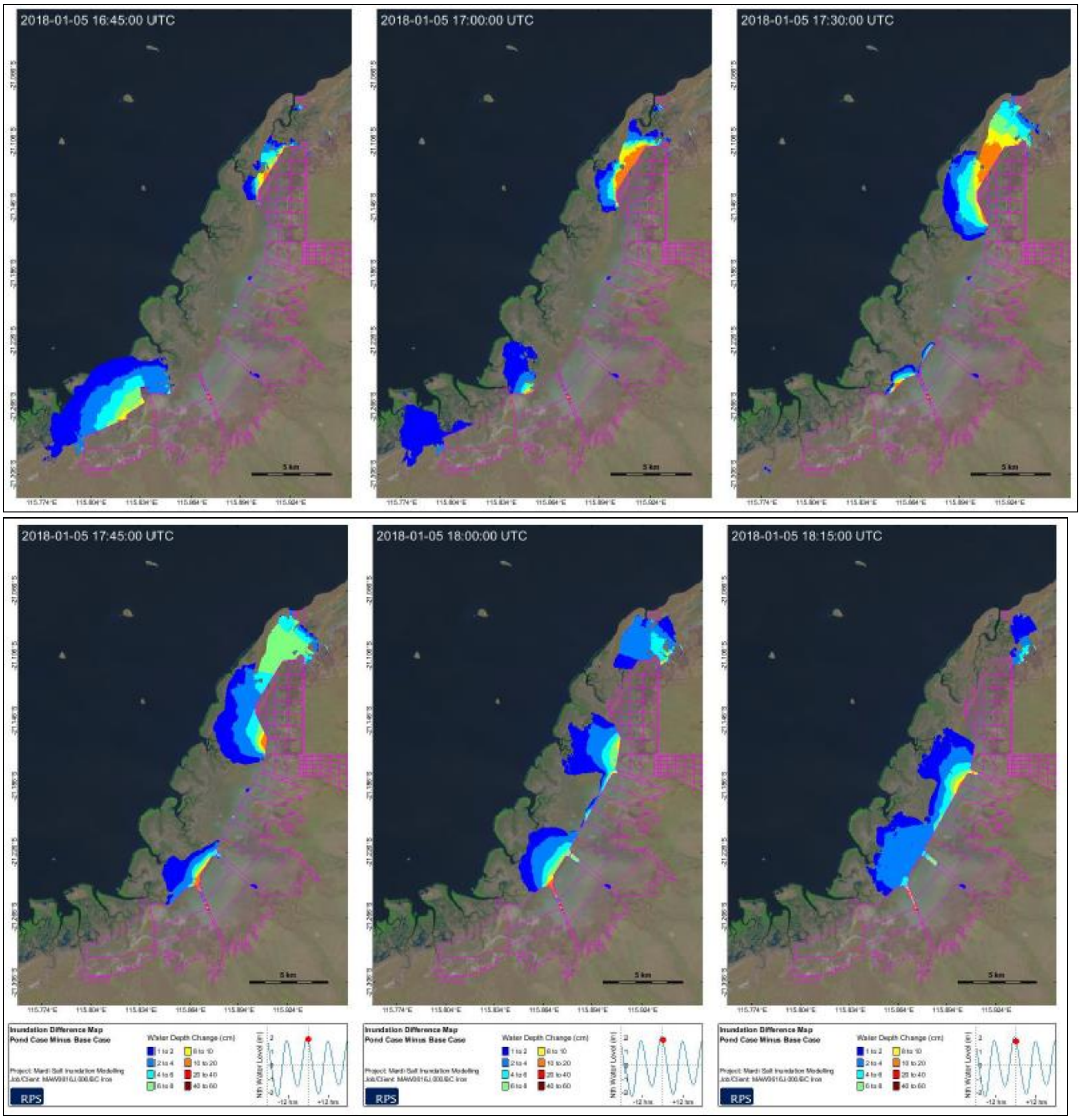


Figure 54: Calculations for increased water depth as the tide rises to a high spring tide (2.2 m MSL) with the pond walls in place

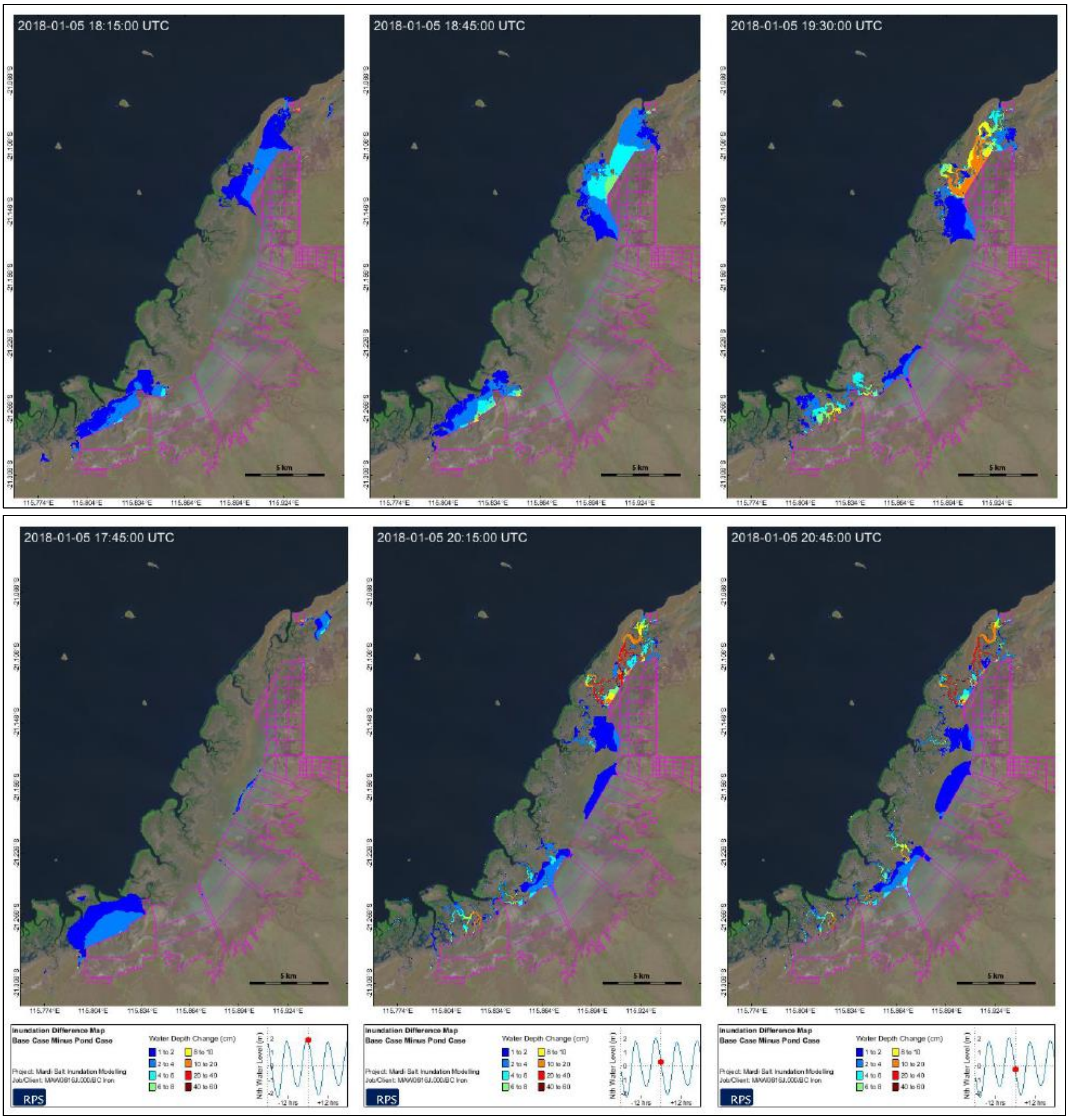


Figure 55: Calculations for decreased water depth as the tide falls after a high spring tide (2.2 m MSL) with the pond walls in place

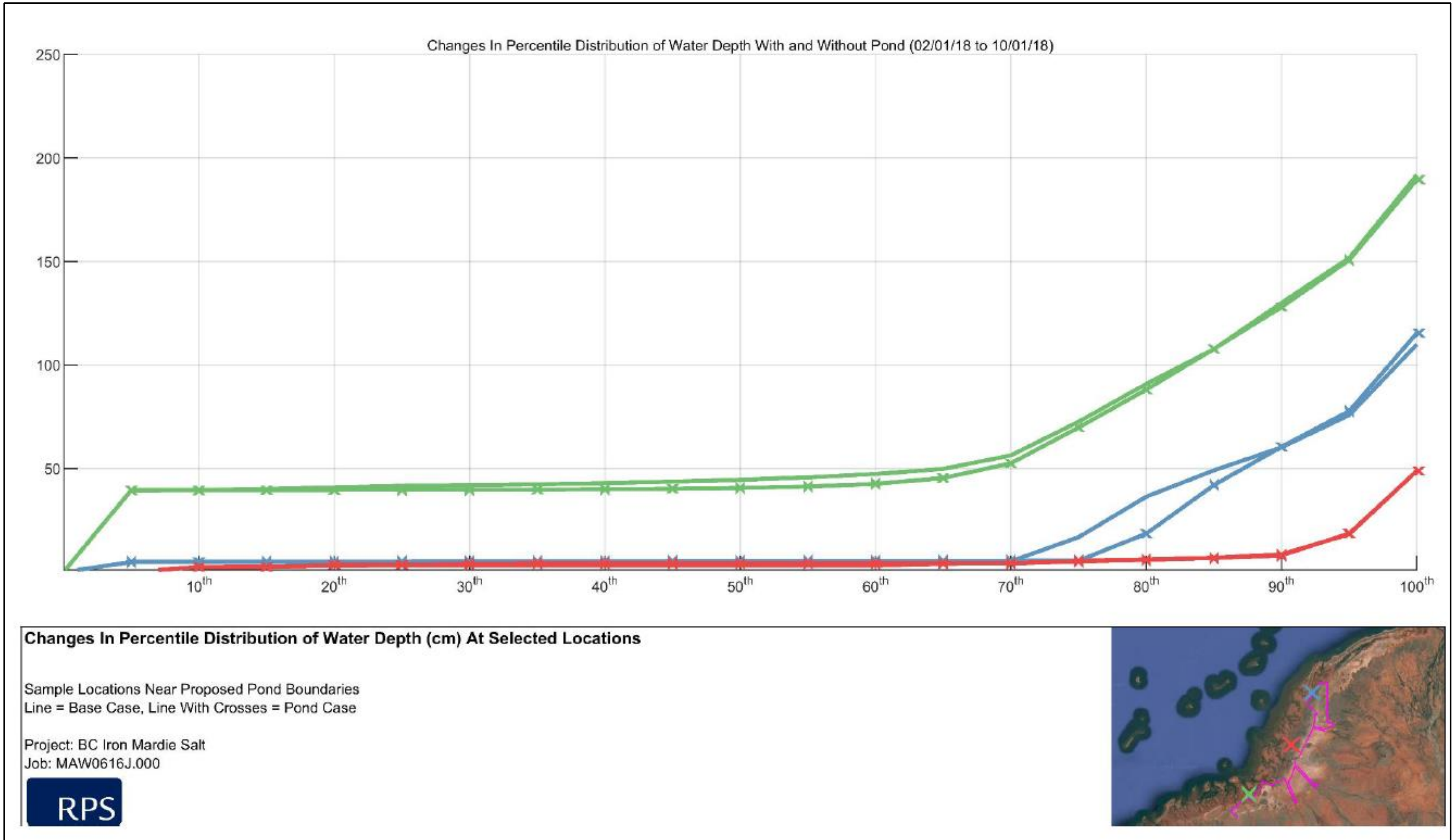


Figure 56: Comparison of the frequency of different water depths between the Pond Case and Base Case at locations near the walls. The Y-axis shows water depth in cm. The X-axis shows the percentile exceedance (e.g. the 90th percentile would be exceeded 10% of the time; the 60th percentile would be exceeded 40% of the time). Line colours correspond to X marks on the map. Lines with crosses represent the Pond Case

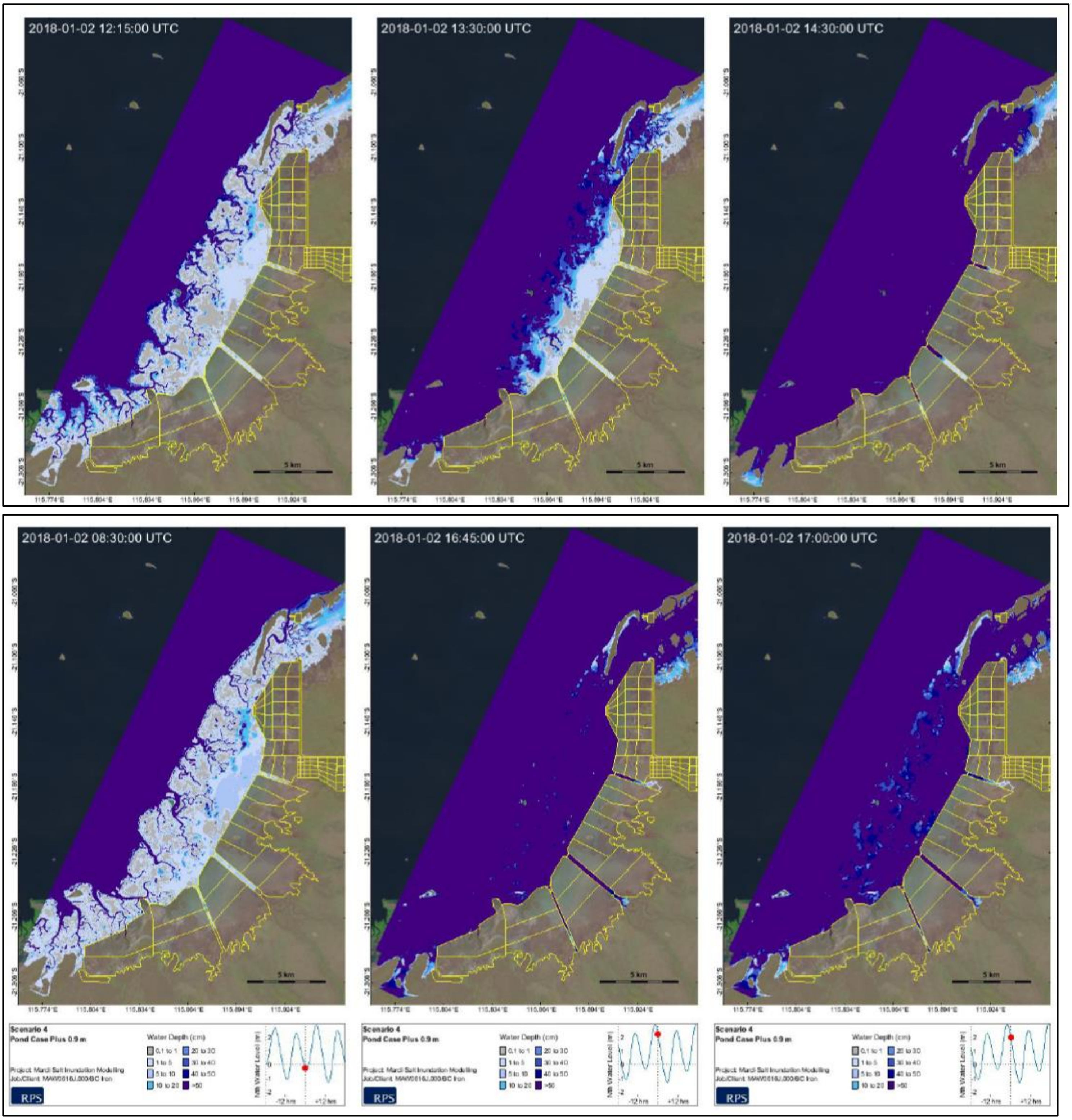


Figure 57: Calculation of water depth over the Proposal area as the tide rises to a tidal level of 2.9 m MSL, with the pond walls in place

Alteration of Tidal Regimes – Causeway / Floodway

A 3.5 km causeway is proposed to be installed across the intertidal area between the main pond area and the Port Stockyard (Figure 58). The design and alignment of the causeway is detailed in Section 2.2.3. . Engineered culverts and floodways will be installed at defined locations along the causeway to allow flows to be maintained (Figure 58).

RPS (2020) undertook modelling to evaluate the impact of the proposed causeway on tidal regimes. Modelling of tidal inundation under an example spring tide sequence was first undertaken for the natural topography without any ponds, causeway or other infrastructure in place. Twenty-two variations of culvert, floodway and alignment designs were then assessed.

Modelling of the natural situation indicted that tidal floods sheet out over the causeway alignment, which represents a local topographical high point, under the momentum generated by the head of water building up offshore over flood tides. This water arrives relatively late to the causeway alignment, corresponding to the time when the tide is beginning to drop offshore. The momentum of the flood tide is sufficient to cause inundation across the high point and into the northeast.

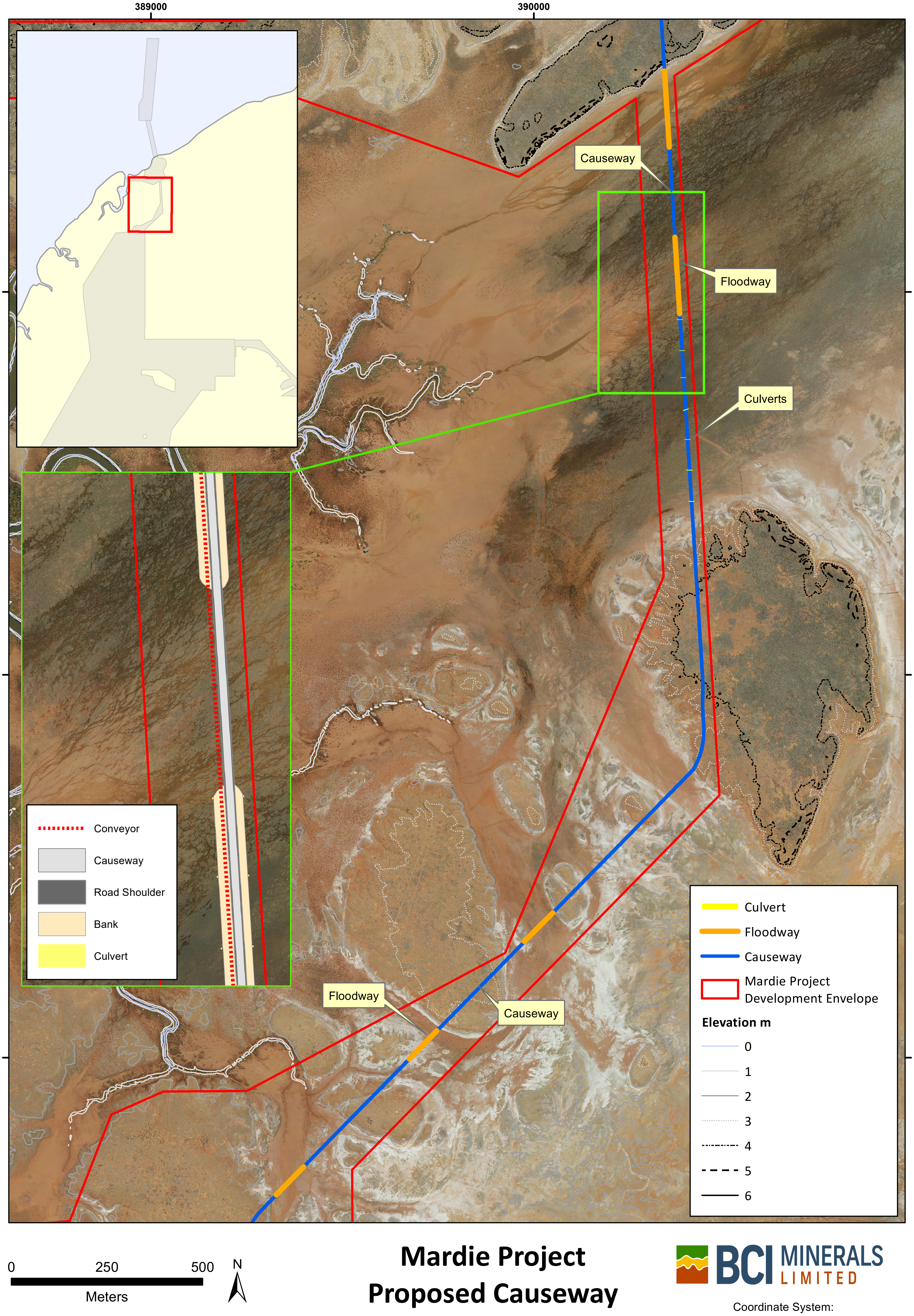
The case that best reproduced the inundation patterns calculated for the base case (no causeway) was test 22, which involved opening the causeway to natural flows over five, 200 m wide, floodways along the proposed alignment, supplemented by additional box culverts and lowering of a high plateau at the northern end of the alignment. The floodways were placed across the lowest ground sections to avoid reduction of the momentum of the sheet flow for the largest volume of water moving across the causeway. This configuration was considered the most practical option with the least potential for other secondary impacts and was carried forward into the next phase of the comparison.

The modelling illustrated that nearly exactly the same volume of water will continue to report into, and out of, the habitats to the north east of the proposed causeway alignment as the base case (Figure 59 and Figure 60). Flooding in the base and 22 test cases over all sites is calculated to occur faster than ebbing, which can be attributed to the larger effect of the offshore tidal head on pushing the flood waters. Drainage would occur through gravity acting on the held-up water and the model shows that some water may be left behind again for the base and 22 test cases.

The remainder of the causeway extent occurs within the intertidal flats, which become inundated on large high tides when the tidal creeks overflow. In those scenarios water would bank across the causeway, so intermediate culverts will be installed at existing low points if present, or at regular intervals on flat areas. The final location, spacing and sizing of these culverts will be determined after a detailed site investigation and will be informed by modelling.

There may be some water left in the floodway after ebb tides, the volume may be overstated by the model because the model bathymetry cannot represent very small drainage lines due to erosion.

With the installation of appropriately sized and spaced floodways and culverts, the causeway is not considered likely to significantly affect tidal inundation regimes. RPS (2020) concluded that the design of the causeway should support maintenance of natural inundation patterns and exchange of water between the mangrove, saltmarsh and crusting algal habitats at the northern end of the Proposal. Further modelling and monitoring will be undertaken prior to construction to ensure the above inundation outcomes for the base case are materially replicated following construction and during operations.



Mardie Project Proposed Causeway Alignment

BCI MINERALS LIMITED

Coordinate System:

Figure 58: Proposed causeway alignment

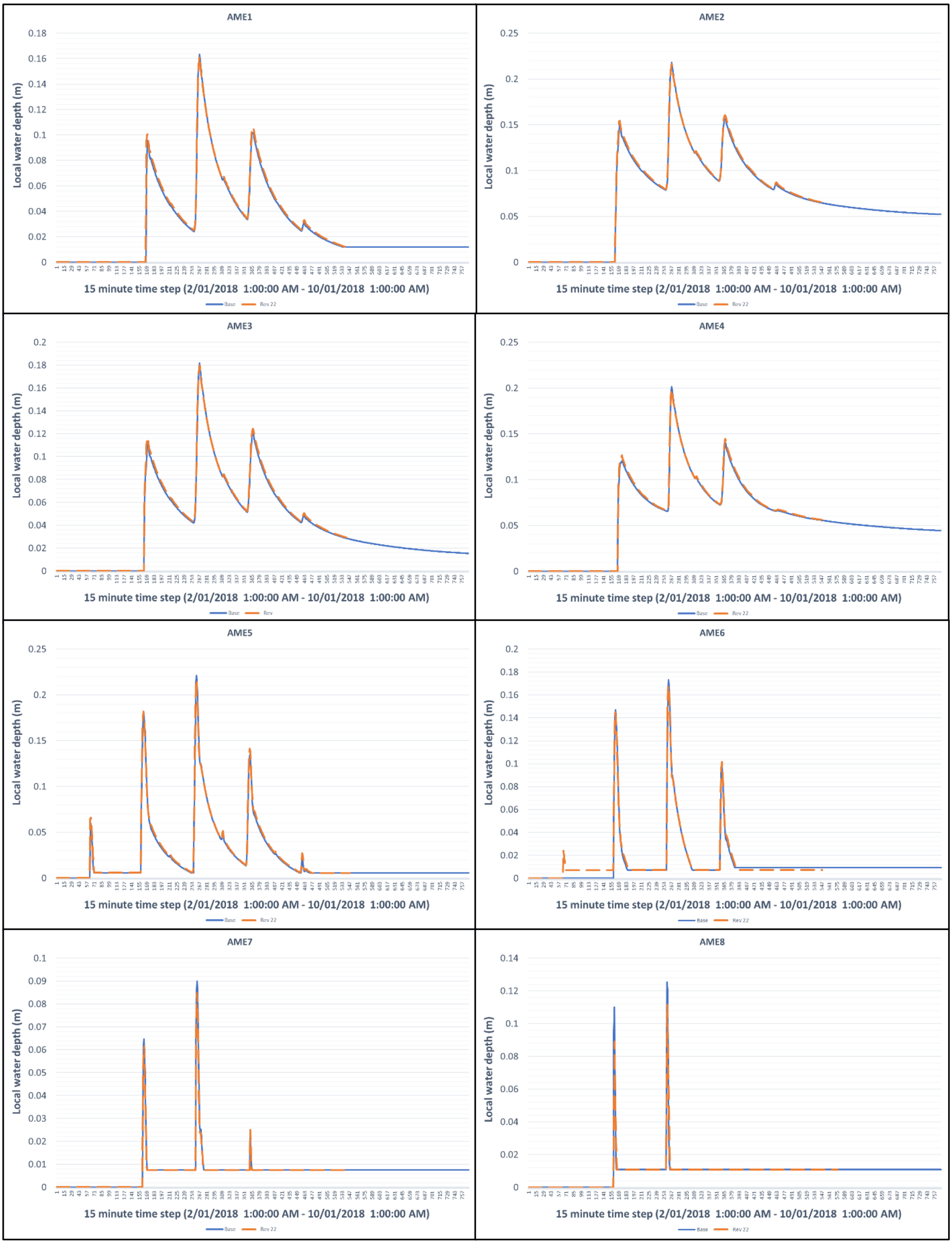


Figure 59: Local water depth at locations for the base case and the proposed causeway case (Rev 22)

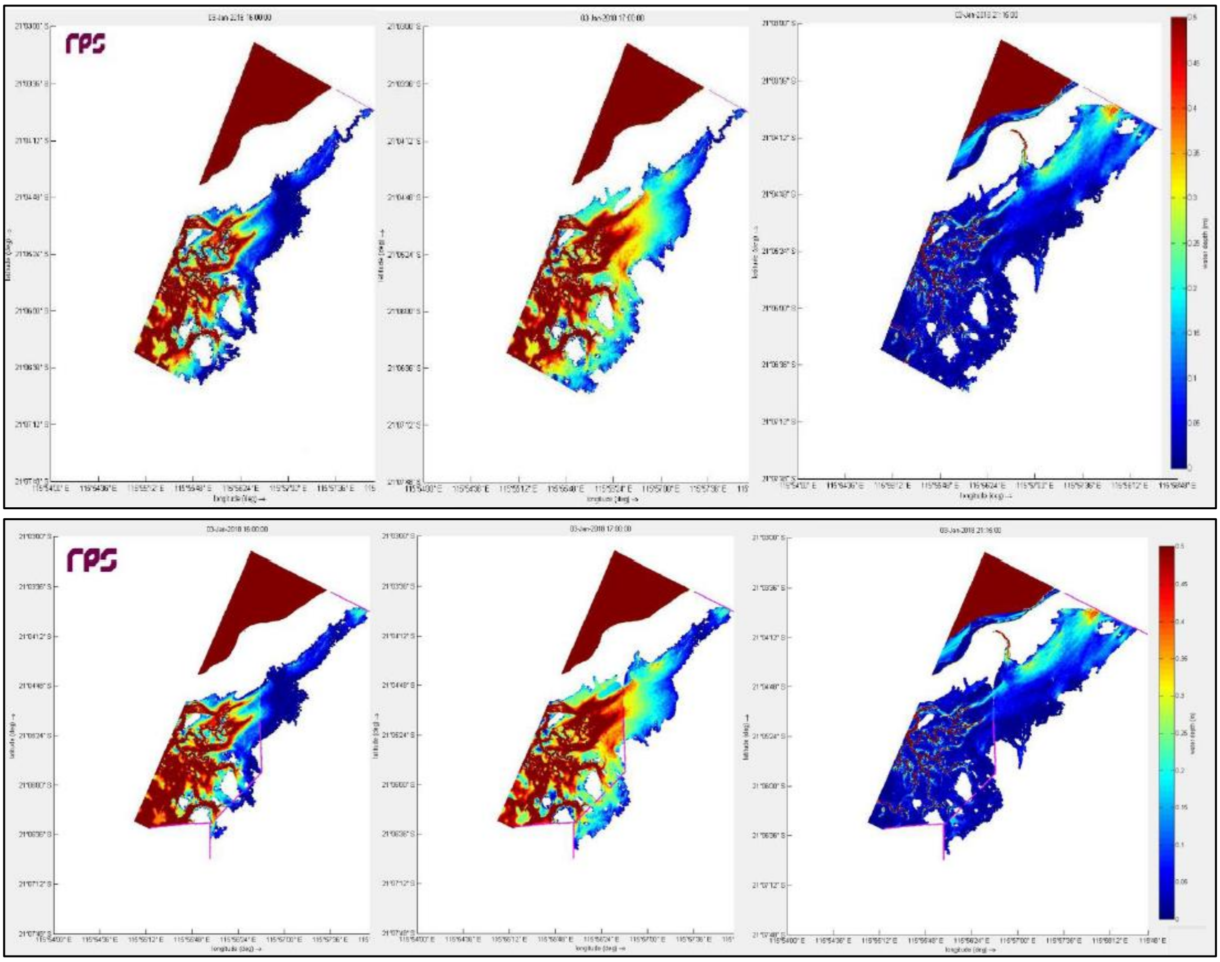


Figure 60: Comparison of water depth between the base case (top images) and the proposed floodway / causeway case (bottom images)

Intake Creek

Up to 150 GL of seawater per year is proposed to be abstracted from a designated tidal creek (Figure 4 and Figure 5). Abstraction will not be uniform across the year, with demand varying from month to month. As a precautionary approach, seawater will only be abstracted when the tide level is above MSL (~50% of the time).

In effect, the peak abstraction rate will be 20 m^3/s, and, while the tidal creek is fed from the ocean (almost infinite resource), the abstraction of large volumes of seawater has the potential to significantly alter tidal flows, possibly even preventing the upper reaches and surrounding samphire wetlands (approximately 75 ha) from receiving tidal inflows on some circumstances.

To determine if the abstraction will have a material effect on the water levels within the tidal creek, the intake creek was considered as an open, rectangular channel, and the Manning Formula was applied:

$$Q = VA \qquad V = \frac{k}{n}\left(\frac{A}{P}\right)^{2/3} S^{1/2}$$

At a given flow rate (Q), the slope of the channel (S) can be considered as the drop in the water level in the creek at the point of abstraction (RPS, 2019a). At the intake point, which is located approximately 2.2 km from open water, the creek is 80 m wide and 1.3 m deep at MSL, rising to

2.5 m deep when the tidal creek banks overtop. The full extent of the creek itself occupies close to 300 ha of channels and sand flats, with one of the channels being continuous with a channel from the next major tidal creek to the north – this represents another inflow to the tidal creek, meaning the use of the Manning's Equation is conservative in estimating the drop in water level at the abstraction point.

Using the derived values shown in Table 13, the equation resolves to give a value for S of 0.017 mm/m. Over a distance of 2.25 km, that value equates to an estimated drop in water levels at the abstraction point of 3.82 cm, or close to 3% of the depth of creek at MSL. As water levels rise above MSL, the percentage drop in water levels would decrease exponentially. At tide levels greater than +1.2 m, the tidal channel would overtop its banks and any drop in water level as a result of abstraction would be indeterminable.

Table 13: Derived values used to determine hydraulic gradient, S.

Parameter	Value & Derivation
Flow rate, Q	20.0 m^3/s
Cross-sectional area, A	104 m^2 (80 m wide x 1.3 m deep at MSL)
Wetted Perimeter, P	82.6 m
Surface roughness, n	0.025 (literature value for uneven sandy bed)
Constant, K	1.0 (literature value for SI units) (International System of Units)

Erosion and Sediment Loss

Erosion within the intertidal zone may occur, as parts of the western pond walls will intersect with tidal inundation, particularly during spring tides. The walls are designed to withstand tidal movements against the wall and armouring will be used in some areas to ensure that erosion of the walls (and associated sediment loss) is minimised and the integrity of the wall is maintained.

The majority of the disturbance for the Proposal is associated with the flooding of an existing landscape rather than vegetation clearing. Any sedimentation caused by flooding the ponds would be captured within the ponds themselves. Sediment may be released during construction of the pond walls, however these walls are generally low and as such contain relatively low volumes of fill material. The wall material is generally high in clay content and will be compacted in place, which means the walls will consolidate quickly and therefore sediment losses will be minimal. Mardie Minerals have committed to mitigation measures to reduce the risk of sedimentation (refer to Section 5.6.2).

The nearshore waters of the Proposal are generally quite turbid (O2 Marine, 2019a) and catchment runoff events transport significant volumes of suspended sediments into the marine environment). Any minor sediment losses are therefore not expected to significantly impact the intertidal zone.

Accidental Brine Leaks and Spills

A spill or leak of brine from the ponds or pipelines could result in impacts to the quality of the intertidal waters. 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 5.6). Ponds have been designed with adequate freeboard and overflow features to minimise the risk of unplanned overflows and wall breaches. 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.

If a spill was to occur, it would either be discharged into the intertidal zone, which has similar water quality conditions (due to evapoconcentration). The spill would then be flushed out over a timeframe of days to weeks and ongoing water quality within the intertidal zone would be unaffected after this time.

Acid Sulfate Soils

Potential impacts to the intertidal zone from the disturbance of ASS is not expected, based on the results that have been collected and analysed to date that all show the local soils and sediments to be alkaline and of low to no reactivity. Mardie Minerals will collect and assess additional samples regularly for ASS during construction of the pond walls and also during dredging, to ensure the ongoing reliability of the original assessments (refer to Section 5.6.2).

Restriction of Inland Movement of Zone due to Sea Level Rise

Sea level rise associated with climate change is predicted to result in water flooding further inland during more high tide events, until it meets higher ground (Figure 33). The concentrator and crystalliser ponds will create a barrier to this inland progression, which will mean that the flooding will reach a 'higher ground' barrier an estimated 20 years earlier than it would have if the ponds were not there (RPS, 2019a). The Proposal is therefore only expected to bring forward the natural sea level rise impacts in the area by an estimated 20 years, rather than increase the impacts.

5.6 Mitigation

Mardie Minerals has mitigated the potential impacts to this factor according to the mitigation hierarchy; avoid, minimise, rehabilitate, offset. Offsets are not expected to be required for this factor.

5.6.1 Avoid

The key avoidance mechanism implemented by Mardie Minerals was the iterative design of the development envelopes to avoid key environmental features. Mardie Minerals has conducted numerous ecological surveys and this information has been utilised to design the Proposal and its development envelope boundaries to avoid the following:

- The majority of the intertidal zone where environmental values are present, such as mangrove and algal mats;
- Crossing of Mardie Creek tributaries, by relocating the causeway alignment to the east
- 13 of the 15 tidal creeks;
- Peter Creek – the southern-most pond wall was relocated to avoid Peter Creek and retain flows into the intertidal zone; and
- Mardie Pool.

In addition to the above, the following avoidance mitigation measures have been incorporated:

- A trestle jetty has been proposed which avoids impacts to the water movement within the offshore intertidal zone, thereby preserving coastal processes; and
- Impacts associated with groundwater abstraction have been avoided by the use of seawater desalination and the use of a third-party water supply as an interim measure; and
- Impacts associated with the reverse osmosis waste have been avoided by utilising the waste brine in the salt production process (pumped to a concentrator pond or discharged through the bitterns stream).

5.6.2 Minimise

The following mitigation measures are proposed to ensure that direct and indirect impacts to inland waters are minimised:

1. **Obtain and comply with the following approvals**:
   a. Ministerial Statement to be issued under Part IV of the EP Act;
   b. Works Approval and Licence to be issued under Part V of the EP Act for solar salt manufacturing and bulk material loading;
   c. Mining Proposal to be approved under the *Mining Act 1978* (for activities on *Mining Act 1978* tenure);
   d. 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;
   e. Development and Construction Application under the *Port Authorities Act 1999* (PPA-managed lands);
2. **Monitor groundwater levels and quality down-gradient of the concentrator and crystalliser ponds**. One or more monitoring bore will be installed down-gradient of each bank of crystalliser ponds, and at a minimum three locations along the concentrator pond walls. Other bores will be installed between the crystalliser ponds and Mardie Pool. The monitoring information will be used to determine whether any impacts to groundwater are occurring. Suitable reference bores will also be monitored to allow an appropriate comparison;
3. **Install cut-off bores, sumps and / or trenches and pump the water to the appropriate salinity pond if the monitoring described above either**:
   a. Identifies sustained mounding that is encroaching on mangrove or algal mat habitat or is leaching water on the surface; or
   b. Identifies seepage of high salinity brine that is above the natural groundwater range and likely to significantly impact on environmental values;
4. **Prepare and implement a Mardie Pool Monitoring and Management Plan (MPMMP)**. The MPMMP will include the following details:
   a. Locations of the monitoring bore network down-gradient of the crystalliser ponds;
   b. Monitoring parameters and timing;
   c. Triggers for the installation and operation of cut-off bores;
   d. Ongoing monitoring and maintenance;
   e. Life of Mine performance indicators;
5. **Install a combination of engineered floodways and culverts along the causeway alignment to ensure intertidal flow regimes are maintained either side of the causeway**. The following works are to be completed:

   a. The inundation model will be re-run during the detailed design phase of the Proposal just prior to construction to ensure the outcomes presented in this ERD are able to be achieved;
   b. Once the above is confirmed, floodways and culverts are to be installed at appropriate locations in the landscape to maintain intertidal flow regimes;
   c. Visual monitoring will be conducted immediately after construction of the floodways and culverts to ensure that there is no ponding or other flow restrictions that do not align with the modelled predictions. If significant flow restrictions are noted that do not align with the modelled predictions then the following actions will be taken:
      i. Additional field monitoring will be conducted to define the quantitative extent of the flow restriction;
      ii. The model will be re-run with this updated site specific data to determine if the restriction will alter the targeted outcomes of the model (no significant change to baseline tidal movement);
      iii. If the target outcomes are unlikely to be achieved then the relevant floodway or culvert(s) will be revised, reinstalled or redesigned to ensure the target outcomes are achieved
   d. Ongoing monitoring is proposed after construction to ensure the results align with modelling predictions;
6. **All existing inland drainage lines are to be diverted around the ponds or through one of the drainage channels**
7. **The drainage system will include overflow structures to safely direct surface water flow from rainfall events greater than 1 in 50 ARI into the concentrator ponds;**
8. **Prepare and implement an Erosion and Sediment Control Plan (ESCP) for the construction phase, to ensure that erosion and sediment control strategies and measures are implemented consistent with industry best practice guidelines;**
9. **Verify inundation modelling results after construction to ensure potential indirect impacts to the tidal regimes of the intertidal zone are within predicted outcomes.** The verification monitoring will collect data from several points within the intertidal zone, including:
   a. Water levels;
   b. Inundation periods;
   c. Flow rates (if relevant to the monitoring location);
10. **Concentrator and crystalliser ponds will be designed and constructed to be safe and stable,** according to DMIRS requirements and in accordance with an approved Mining Proposal issued under the *Mining Act 1978*;
11. **Routinely inspect the condition and performance of pond walls, pipelines, containment systems and internal drainage structures,** to ensure they are in acceptable condition and / or operating appropriately;
12. **The following controls will be used to further reduce the risk of impact from unintentional brine pipeline spills**:
   a. Pipelines will be fitted with leak detection;
   b. Water flows will be shut off if leaks are detected;
   c. Pipelines will be inspected regularly, especially during extreme heat or fire events;
   d. Pipelines will be located off access road surfaces;
   e. If pipelines have to cross access roads then they will be buried;

   f. Investigations will be conducted into the cause of any spills, and remedial actions will be taken to minimise the chance of reoccurrence; and
   g. Spills response training to mitigate damage for site-based personnel.
13. **Monitor erosion at the outlets of the surface water corridors after each significant flow event.** If erosion is noted then install additional erosion controls to minimise further erosion**;**
14. **Comply with Water Quality Protection Guidelines and guidance notes,** particularly in relation to the storage and use of hydrocarbons and other harmful chemicals, the design and operation of vehicle maintenance areas and facilities, the siting and operation of wastewater treatment systems, and the handling and storage of other waste materials, including contaminated soils**;**
15. **Collect and assess additional soil samples regularly for ASS during construction of the pond walls and during dredging,** to ensure the ongoing reliability of the original assessments**;**
16. **Limit seawater abstraction to 150 GL/yr by including the limit in the Key Characteristics Table**; and
17. **Abstract seawater from the designated tidal creek only when tides are above MSL**. This will ensure that sufficient water volumes are available in the creek to minimise abstraction impacts.

5.6.3 Rehabilitate

At the completion of the Proposal the site will be rehabilitated to reinstate inland water regimes.

The port area will be located on a lease under the *Port Authorities Act 1999;* therefore a MCP will not be required under the *Mining Act 1978* for the port infrastructure. Mardie Minerals will liaise with PPA regarding the port infrastructure, as it may be of value for ongoing use by PPA. If not, the marine components of the Proposal are relatively easy to rehabilitate. All marine infrastructure including the jetty, wharf, seawater intakes, boat ramp and navigation infrastructure will be removed and the dredge channel will be left to gradually fill with sediment. The causeway material will be removed back to ground level to ensure tidal flows are maintained after closure.

The remaining infrastructure will be rehabilitated and closed in accordance with a MCP approved under the *Mining Act 1978*. An interim MCP has been developed and provided in Appendix 12.1 which contains detail about the proposed rehabilitation of the Proposal. The MCP will be submitted to DMIRS for assessment and approval prior to the construction of the Proposal, and will be reviewed and revised every three years.

The key rehabilitation measures that relate to inland waters are summarised below:
1. Salts will be harvested from each pond prior to closure;
2. Concentrator pond walls will be opened up to allow tidal flows to enter the ponds;
3. All infrastructure, including the causeway will be removed if not retained by Mardie Station or PPA; and
4. Key surface water drainage systems will be reinstated.

5.7 Predicted Outcome

The EPA's environmental objective for this factor is to maintain hydrological regimes and quality of groundwater and surface water so that environmental values are protected (EPA, 2018d).

5.7.1 Groundwater

A potential has been identified for hypersaline water within the concentrator and crystalliser ponds to impact on the quality of underlying shallow groundwater. Given that the existing groundwater is four times saltier than seawater in most areas (and the clay-lining of the eastern crystalliser ponds) and that the rate of movement through the aquifer is very slow, the proposed management approach of monitoring groundwater chemistry near risk areas and recovering adversely affected groundwater for disposal to the ponds is expected to be sufficient to prevent impacts to environmental values. This process is able to be appropriately managed through a works approval and licence under Part V of the EP Act.

With regards to other potential impacts to groundwater quality, there is negligible risk of ASS, and standard safeguards and responses for leaks and spills of hydrocarbons and other hazardous chemicals will be implemented across the Proposal.

5.7.2 Inland Surface Waters

There are several ephemeral creekline systems that drain to the intertidal claypans where they spread across the intertidal zone and drain to the ocean via tidal creeks. The Proposal will require the diversions of these drainage systems either around the ponds or through dedicated channels. These diversions will be designed, constructed and maintained appropriately to ensure the Proposal infrastructure is protected, and as a result there is a high level of confidence that surface water diversions will allow adequate flows through to the intertidal zone without significant erosion of the pond walls, thereby maintaining the overall volume and timing of freshwater flows from the catchment into the intertidal zone, where the important mangrove and samphire communities are located.

5.7.3 Mardie Pool

A potential has been identified for hypersaline seepage from the crystalliser ponds to impact on the quality of the water within Mardie Pool. Given that the rate of movement through the aquifer is very slow, the proposed management approach of monitoring groundwater chemistry down-gradient of the ponds and recovering adversely affected groundwater for disposal to the crystalliser ponds has been shown to be sufficient to prevent impacts to Mardie Pool. This process will be detailed in a MPMMP which will be developed prior to operation. The implementation of this plan is able to be appropriately managed through a works approval and licence under Part V of the EP Act.

With regards to other potential impacts to Mardie Pool, standard safeguards and responses for sediment loss, leaks and spills of hydrocarbons and other hazardous chemicals will be implemented and are expected to be sufficient to minimise any impacts to Mardie Pool Intertidal Zone

The Proposal will affect tidal exchange by:

- Reducing the extent of the intertidal zone due to the construction of pond walls and the causeway; and
- Abstracting seawater from a tidal creek, as feed for the concentrator and crystalliser ponds.

The Proposal has been specifically designed to minimise impacts to the intertidal zone, by locating the pond walls a significant distance from the coast and away from the mangal, samphire and algal mat communities.

Extensive surveys and modelling demonstrate with a high degree of confidence that, because of the low topography, interconnected flow systems, and a highly dynamic intertidal environment and tidal regime, the effect of the pond walls on tidal exchange will be minimal. Monitoring will be conducted to verify the modelling outcomes.

The installation of appropriately sized and spaced floodways and culverts as part of the causeway design is not predicted to significantly affect tidal inundation regimes. The impacts of the abstraction of up to 150 GL of seawater per year from a designated tidal creek is not expected to result in any discernible impact to environmental values of the creek, owing to the creek's size, interconnectivity with other creeks and the intertidal claypans, as well as the proximity of the draw point to the open water. As a precautionary measure, seawater will only be drawn when the tide is above MSL.

The Proposal has the potential to alter the quality of surface waters as a result of soil erosion and sediment resuspension, and leaks and spills, however the susceptibility of the receiving environment to water quality impacts of nature and scale associated with the Proposal are not expected to be significant, given the regular exposure to high turbidity events. The Proposal has incorporated industry-standard approaches to minimise the potential for surface water quality to be adversely affected, including erosion controls and contamination safeguards. These potential impacts are able to be appropriately managed through a works approval and licence under Part V of the EP Act, and a Mining Proposal under the *Mining Act 1978*.

5.7.4 SUMMARY

The presence of the causeway and concentrator and crystalliser ponds will result in changes to hydrological regimes, both tidal and overland. Mardie Minerals has incorporated floodways and culverts into the causeway design, significant drainage corridors (>200 m) into the pond design, and has relocated the development envelopes inland to minimise impacts to tidal regimes within the intertidal zone. As a result the Proposal is predicted to be able to be developed without significant impacts to hydrological regimes.

Potential impacts to inland water quality can be appropriately managed under Part V of the EP Act via a works approval and licence, as the Proposal will be considered under the 'solar salt manufacturing' category in Schedule 1 of the Environmental Protection Regulations 1987. A Mining Proposal issued under the *Mining Act 1978* will also provide additional regulation for activities that are considered under that Act, such as pond wall geotechnical design and erosion.

The seawater intake is considered to be adequately managed under Part V of the EP Act via a works approval and licence however an intake volume limit is expected to be required under Part IV of the EP Act to enforce the commitments made in Section 5.6.2.

Sea level rise is predicted to completely alter the intertidal zone west of the development envelopes and modelling predicts that the Proposal will not add to these alterations, however it will bring the timing of the changes forward by an estimated 20 years.

Based on the above, the Proposal is expected to be able to be implemented in a way that maintains hydrological regimes and quality of groundwater and surface water so that environmental values are protected. The EPA objective for this factor is therefore able to be met.

6 MARINE ENVIRONMENTAL QUALITY

The Marine Environmental Quality factor was noted as being linked to several other key environmental factors such as Benthic Communities and Habitats (BCH), and Marine Fauna. As such this section was moved ahead of these other factors to provide a logical flow to this ERD.

6.1 EPA OBJECTIVE

The EPA Objective for this key environmental factor is to maintain the quality of water, sediment and biota so that environmental values are protected.

6.2 POLICY AND GUIDANCE

Relevant guidance documents for marine environmental quality are listed below:

Western Australian Government

Key EPA Documents

- Statement of Environmental Principles, Factors and Objectives 2016 (EPA, 2016a);
- Guidelines for Preparing Mine Closure Plans (DMP and EPA, 2015);
- EIA (Part IV Divisions 1 and 2) Administrative Procedures 2016;
- EIA (Part IV Divisions 1 and 2) Procedures Manual 2016; and
- Instructions on how to prepare Environmental Protection Act Part IV Environmental Management Plans (EPA, 2018a).

Relevant EPA Factor Guidelines
Environmental Factor Guideline – Marine Environmental Quality (EPA, 2016f).

Relevant EPA Technical Guidance

- Technical Guidance – Protection of BCH (EPA, 2016c);
- Technical Guidance – Protecting the Quality of Western Australia's Marine Environment (EPA, 2016d); and
- Technical Guidance – Environmental Impact Assessment of Marine Dredging Proposals (EPA, 2016e).

Other Policy and Guidance

- Identification and investigation of acid sulphate soils and acidic landscapes (DoER, 2015a);
- Treatment and management of soil and water in acid sulphate soil landscapes (DoER, 2015b);
- Pilbara Coastal Water Quality Consultation Outcomes – Environmental Values and Environmental Quality Objectives, DoE, Government of Western Australia, Marine Series Report No. 1 (DoE, 2006);
- Australian and New Zealand Guidelines for Fresh and Marine Water Quality (ANZG, 2018);
- WA Environmental Offsets Policy (EPA, 2011);
- WA Environmental Offsets Guidelines (EPA, 2014); and
- WA Offsets Template.

Commonwealth Government

Key Documents

- Generic guidelines for the content of a draft EPBC Act PER/EIS (including the objects and principles of the EPBC Act 1999) (DotEE, 2016b);
- Other Minister of the Environment (Cth) approval decision making considerations;
- EPBC Act Environmental Offsets Policy (DSEWPaC, 2012) – including the Offset Assessment guide;
- Environmental Management Plan Guidelines (DotE, 2014a);
- Environmental Management Plan Guidelines, - template (DotEE, 2018a);
- EPBC Act Condition Setting Policy (DAWE, 2020);
- EPBC Act Outcomes-based conditions policy (DotE, 2016b);
- EPBC Act Environmental Offsets Policy (DSEWPaC, 2012);
- *Environment Protection (Sea Dumping) Act 1981;* and
- National Assessment Guidelines for Dredging (DEWHA, 2009b).

Relevant Technical Guidance

- Relevant EPBC listed species specific survey guidelines and protocols;
- Relevant EPBC listed species specific Recovery plans, Threat Abatement Plans, Approved Conservation Advices and other documents;
- Marine bioregional plan for the North-west Marine Region (DSEWPaC, 2012b); and
- Environmental best practice port development: an analysis of international approaches (GHD, 2013).

6.3 Receiving Environment

The Proposal occurs in a relatively undisturbed marine environment, with the only disturbance associated with two gas pipelines that run through the development envelopes (Figure 2). These pipelines have been fully installed and as such they are not expected to influence the surrounding water quality.

6.3.1 Levels of Ecological Protection - Background

The following text has been sourced from *Pilbara Coastal Water Quality Consultation Outcomes - Environmental Values and Environmental Quality Objectives* (Department of Environment, 2006).

The EPA has developed an Environmental Quality Management Framework (EQMF) for the marine waters of WA. The EQMF was first implemented for Perth's coastal waters and then in greater detail for Cockburn Sound (EPA, 2000; Government of WA, 2005). The State Government has endorsed the progressive implementation of the EQMF for all of the State's marine waters on a priority basis (Government of WA, 2003). The key elements of the EQMF are Environmental Values (EVs), Environmental Quality Objectives (EQOs) and Environmental Quality Criteria (EQC). EVs are defined as "particular values or uses of the environment that are important for a healthy ecosystem or for public benefit, welfare, safety or health, and which require protection from the effects of pollution, waste discharges and deposits." (ANZECC & ARMCANZ, 2000). The EVs reflect the importance that the community places on the marine environment for its intrinsic biodiversity and ecosystem functions, its recreational and cultural attributes, and its commercial and industrial uses.

Five EVs are relevant to marine waters:

- Ecosystem Health (ecological value);
- Recreation and Aesthetics (social use value);
- Cultural and Spiritual (social use value);
- Fishing and Aquaculture (social use value); and
- Industrial Water Supply (social use value).

The ecosystem health value is fundamental and of most relevance to the Proposal because healthy ecosystems support and sustain life. The other four environmental values represent specific human benefits or uses that rely on a clean, healthy environment; collectively, they are referred to as social-use values. Given the lack of social uses of the waters surrounding the Proposal, these EVs are not focussed on in this assessment.

For each EV, one or more EQOs may be defined. The EQOs are more specific than the EVs and represent management goals for maintaining environmental quality to protect particular aspects of the EVs from the effects of wastes. The EQO for maintenance of ecosystem integrity has four different levels of ecological protection (LEP), each representing a different environmental quality condition (described in Table 14). These LEPs are applied to each part of the ecosystem in such a way that the general integrity of the ecosystem is maintained. This allows for management of conservation values and multiple uses (some with localised effects) while still maintaining the broad structure and function of the ecosystem. Clearly, setting a Moderate or Low LEP over large areas would not protect ecosystem integrity overall. Conversely, it would be unreasonable to propose an area of Maximum LEP adjacent to major existing development or population nodes.

Table 14: Requirements of various levels of ecological protection

Level of Ecological Protection	Environmental Quality Condition (Limit of acceptable change)	
	Contaminant concentration indicators	Biological indicators
Maximum	no contaminants – pristine	no detectable change from natural variation
High	very low levels of contaminants	no detectable change from natural variation
Moderate	elevated levels of contaminants	moderate changes from natural variation
Low	high levels of contaminants	large changes from natural variation

6.3.2 Current Level of Ecological Protection within Mardie Marine Waters

The WA Government has assigned a 'Maximum' level of ecological protection for nearshore marine waters along the Mardie coastline, and the offshore marine waters have been assigned a 'High' level of ecological protection (Figure 61). These classifications infer that the "environmental condition for this area as essentially pristine, with no detectable change from natural background conditions and no effects on marine life as a result of waste inputs or contamination".

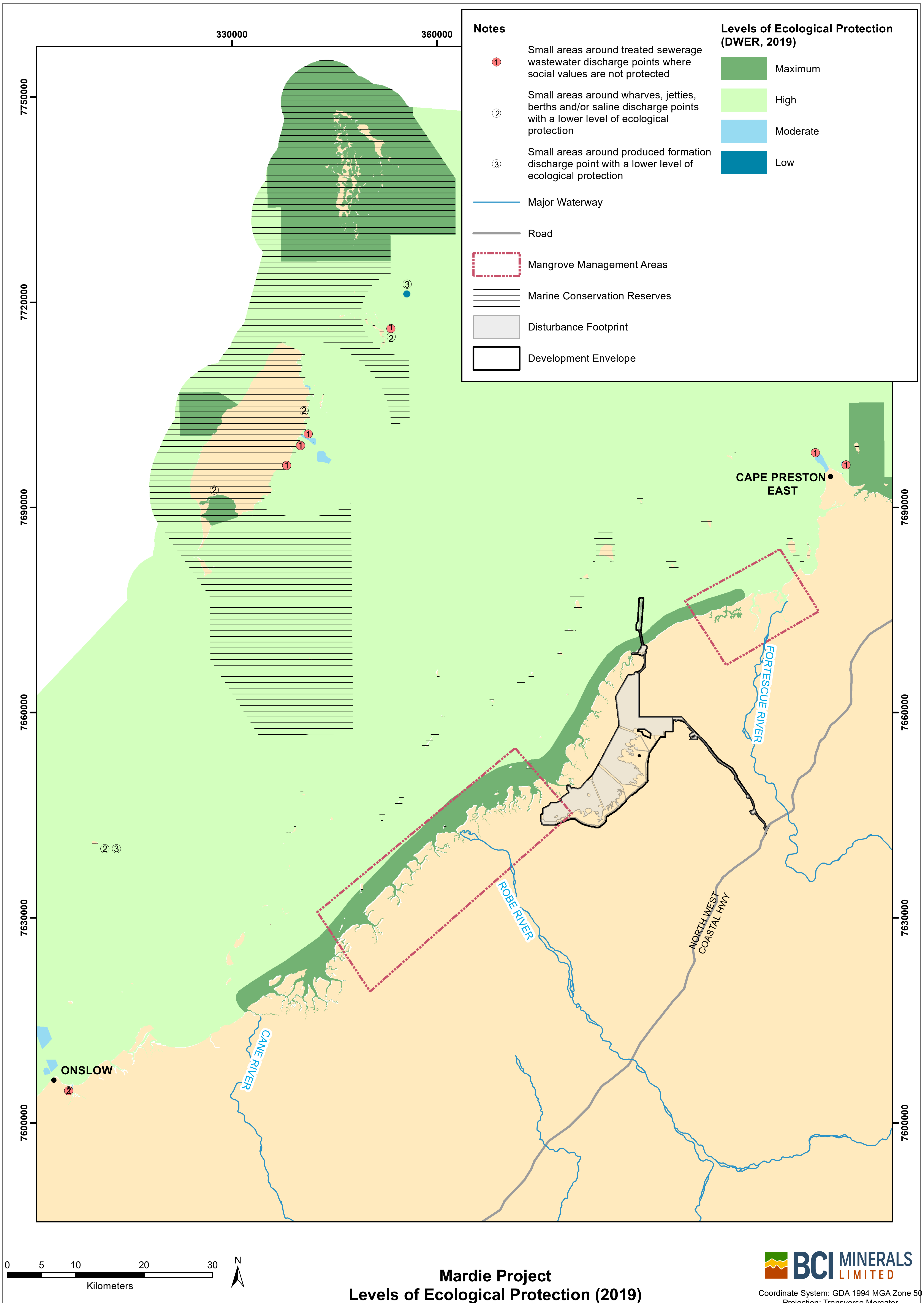


Figure 61: Current levels of ecological protection in the regional marine waters

6.3.3 Sediment Quality

O2 Marine (2019a; Appendix 5.1) undertook a Sediment Quality Investigation to determine the characteristics and quality of the material to be dredged and disposed of onshore (Appendix 4.1). The assessment included both preliminary and detailed site investigations in accordance with DWER (2014) guidelines for the Assessment and Management of Contaminated Sites.

Preliminary Site Investigation

The preliminary site investigation reviewed historical sediment investigations (i.e. DEC, 2006) and sources of contaminants and identified that there are no known contaminants of potential concern within the proposed dredging area. Therefore, all areas were classified as being "uncontaminated".

Outcomes of the preliminary site investigation provided a basis for determining the scope of the detailed site investigation, including defining the contaminants of potential concern (CoPC) and identifying the number, depth and location of required sampling (O2 Marine, 2019a).

Detailed Site Investigation

A detailed site investigation was undertaken by O2 Marine in December 2018, January 2019 and February 2019 (O2 Marine, 2019a). Sediment samples were collected using a combination of vibro-coring and surface grab methods from 32 sites with 34 samples collected in total (excluding QAQC samples). The vibro-corer used for this campaign was capable to collect sediment to a maximum depth of 4 m below the seabed. However, refusal was experienced at 0.5 m depth on hard substrate (i.e. gravel and/or limestone layers) at all but two locations. In these two locations samples were collected up to 1 m depth and subsamples were collected from two horizons respectively; 0 - 0.5 m and 0.5 – 1 m.

Collected sediment samples were sent to a NATA-accredited laboratory for testing of:

- Physical Sediment Characteristics: particle size analysis (PSA), total organic carbon (TOC), moisture content;
- Inorganic Compounds: Total metals and metalloids (Al, Ag, As, Cd, Co, Cr, Cu, Fe, Hg, Mn, Ni, Sb, V and Zn);
- Organic Compounds: Total petroleum hydrocarbons (TPH), benzene, toluene, ethylbenzene, xylenes and Naphthalene (BTEXN), polycyclic aromatic hydrocarbons (PAH) and tributyltin (TBT);
- Phenoxyacetic acid herbicides;
- Organochlorine (OCP) and organophosphate pesticides (OPP);
- Nutrients (total nitrogen, total kieldjahl nitrogen, ammonia, nitrate and nitrite, total phosphorous and filterable reactive phosphorous); and
- Acid sulfate soils (ASS) screening test.

Samples from seven locations were also analysed to provide an assessment of the benthic infauna communities present in the sampling area. The following key findings were noted:

- There was no significant difference in species richness or diversity indices across all the sites;
- All sites had high evenness suggesting that the abundances are distributed evenly among the different morphological species present;

- Composition of taxa varied at each site. However, there was no significant difference in community composition between sites;
- Surface feeding was the most common source of food for all sites and omnivores dominated across all sites; and
- *Quinqueloculina spp*. was present in high numbers across most sites. Previous studies suggest that the presence of this particular genus of Foraminifera in relatively high abundance may be an indication of low environmental stress and that this genus may be considered a good bioindicator of marine environmental quality.

The following key findings were made during the detailed site investigation (O2 Marine, 2019a):

- The 95% Upper confidence limit (UCL) of metal concentrations were below the ANZECC DGV-low level screening guidelines for all contaminants of concern with exception of Nickel and Arsenic. However, these were deemed to be lithographically occurring exceedances supported by previous marine sediment sampling in the Pilbara (DEC, 2006) and normalisation to Aluminium;
- Organics including organotins (TBT etc.), Total Recoverable Hydrocarbons (TRH), TPH, and BTEXN contaminant concentrations were all below ANZECC DGVs (if available) and the vast majority of organic analytes were non-detections below the laboratory Limit of Reporting;
- All analytes in OC/OP Pesticides and Phenoxyacetic Acid Herbicides suites were at non-detection levels below the Limits of Reporting. Herbicides were identified early as a CoPC due to their extensive use on Mardie Station. This investigation found no evidence of herbicides in the marine sediments sampled; and
- None of the samples failed the ASS screening test and, as such, the sediments within the dredging area are considered to pose a low ASS / PASS risk.

O2 Marine (2019a) concluded that the sediment within the dredge corridor is uncontaminated and is considered suitable for onshore disposal. Additionally, the background sediment quality in the vicinity of the proposed outfall is also uncontaminated and is similar to other unimpacted areas of the Pilbara, WA.

6.3.4 Marine Water Quality

O2 Marine (2020f; Appendix 5.2) undertook a Baseline Marine Water Quality Investigation to characterise the existing water quality conditions in the Mardie region.

Survey Effort

Marine water quality baseline monitoring was conducted from March 2018 - September 2019 at two locations (inshore and offshore). A range of multi-parameter instruments were deployed on site, each attached to purpose designed frames. The frames are designed to stand upright on the seabed, while maintaining the instruments at approximately 0.5 m above the seafloor where they are outside the influence of soft sediment or large rocks and rubble on the benthos. These instruments measured the following:

- Electrical Conductivity and salinity (inshore location only);
- Salinity;
- Temperature;
- Depth/Pressure;
- Photosynthetically Active Radiation (PAR) (offshore location only); and

- Turbidity (NTU).

Marine water samples were collected from the surface 0.5 m during two field campaigns; one on 16 January 2019, and one on the 3 March 2019. Samples were sent to a NATA-accredited laboratory and analysed for the following;

- Alkalinity and Hardness;
- Nutrients;
- TRH;
- TPH;
- BTEXN;
- Total Organic Carbon (TOC);
- Dissolved Major Cations and Anions;
- Dissolved Metals; and
- Fluoride.

The baseline data collected to date demonstrates that the marine waters of the Mardie Project area are pristine and not currently affected by anthropogenic impacts. Although further baseline data collection is recommended to develop site-specific Environmental Quality Criteria (EQC) and refine monitoring and management plans, the data collected to date is considered sufficient to inform the assessment of environmental impacts of the Proposal.

To derive site-specific EQC for monitoring and management, the EPA guidance (EPA 2016) recommends collection of two years of baseline data. Therefore, continued collection of baseline water quality data will be conducted to inform dredge management and as part of the operational Marine Environmental Quality Monitoring and Management Plan (MEQMMP).

The following additional baseline data will be collected and incorporated into the relevant management plans as discussed below.

MEQMMP:

- Continue collection of water samples for laboratory analysis of potential contaminants on a quarterly basis;
- Consider inclusion of suitable reference monitoring location (s) for comparison against data collected at the proposed inshore (outfall) location; and
- Compile all baseline data and derive site specific EQC using the methods outlined in ANZG (2018).

Dredge and Spoil Disposal Management Plan:

- Continue baseline data collection of light, turbidity, temperature and depth in the vicinity of the proposed dredging for a further 12 months prior to commencement of dredging; and
- Compare baseline data against the proposed (to be developed) WAMSI thresholds for turbid water coral communities to determine suitability for future dredge management; or
- Derive site specific dredge monitoring criteria for SSC based on 80^{th} and 95^{th} percentile.

Water temperature

Lowest temperatures at the inshore location were recorded during the dry season (18 - 26°C), with the highest recorded during the wet season (22 - 33°C). Temperature variability at the offshore location was lower than at the inshore location, however the sampling period for temperature at the offshore location was limited to approximately three months, compared to the inshore location which sampled a full annual cycle. Lower variability in temperature at the offshore location in comparison to the inshore location is likely explained by the greater influence of oceanic water at the offshore site and greater depth of the instrument. Deeper oceanic waters are generally less influenced by diurnal temperature variation than shallower inshore waters.

Salinity

Salinity was comparable between the dry season (36.9 – 38.0 ppt) and the wet season (–36.6 – 38.31 ppt). Median salinity remained at 37.5 ppt across both the wet and dry seasons, but was highest during March (38.3 ppt) and lowest during April (36.6 ppt).

The salinity conditions recorded at the inshore monitoring location for the dry and wet seasons is slightly higher than the median salinity range (35.1 - 37.1 ppt) previously reported by CALM (2005) for the nearshore Pilbara region. The values are lower than the nearshore salinity range reported by Oceanica (2004) for the eastern side of Exmouth Gulf (35.9 - 42.7 ppt). Therefore, the metahaline salinity conditions reported at Mardie appear to be more characteristic of a sheltered bay or estuary, which has limited vertical mixing and limited exchange with lower salinity oceanic currents.

Hydrodynamic modelling undertaken by Baird (2020a; Appendix 6.1) found that due to the alignment of the island and reef features of the Passage Islands, the majority of incoming tidal flow on the flood tide is directed through the gap between Scholl Island and Mardie Island, approximately 10 km to the north of the inshore monitoring location. Seawater exchange from the open ocean to the inshore region in the vicinity of the Proposal export facilities is therefore influenced by this constraint of flows around the Passage Islands, which is likely to affect the rate of mixing with the open ocean (Baird, 2020a). It is therefore possible that restricted mixing with lower salinity oceanic currents, combined with high evaporation rates and very little freshwater runoff to the nearshore waters has contributed to creation of a higher salinity environment in the vicinity of the inshore monitoring location (O2 Marine, 2020f).

Light

Light data was collected between 19 December 2018 and 3 August 2019 at an offshore and inshore location. Variable levels of underwater light were recorded reaching the substrate throughout the sampling period. Data recorded for Daily Light Integral (DLI) typically identified highest DLI recordings during neap tides and lowest during spring tides when compared with the results from the pressure / depth data.

Light levels are significantly affected by water depth due to absorption, refraction and diffraction through the water column (Jones *et al.,* 2019). Despite the greater depth of the offshore site (11 m) than the inshore site (6 m), higher light levels were recorded on the seabed offshore for most of the monitoring period. This is supported by general field observations of higher water clarity offshore than inshore.

The offshore DLI recorded ranges between 0 – 16.5 (mol/m^2)/day, with the maximum recorded on 16 January 2019 and the minimums recorded on 28 January, 21 March, 11 April, 17 May, 3 June and 28 July 2019. The maximum DLI for the inshore sites was recorded on 9 July 2019 and the timing of several of the extended light minimum events corresponded with those listed for the offshore site. One period of low light coincided with Tropical Cyclone Veronica approaching the coast on 21 March and the other coincided with the low pressure system on the 3 June 2019.

Light levels are influenced by the amount of suspended sediment / turbidity present through the water column, as well as the depth of the water column. The lowest light levels at the end of January corresponded with turbidity maximums. It is noted that, thus far, light data for Mardie is only available for the wet season, which also corresponds with strong seasonal onshore winds, both of which may have contributed to lower levels of light through increased suspended sediment concentrations (SSC).

Turbidity / Suspended Sediment Concentration

Turbidity data was recorded between 7 November 2018 and 9 September 2019. A notable difference in turbidity was observed between the inshore and offshore monitoring locations. In general turbidity was found to be much higher at the inshore location [mean of 14.03 Nephelometric Turbidity Units (NTU)] than at the offshore location (mean of 1.45 NTU), which is consistent with regional surveys which also found turbidity and SSC declined with distance from shore (O2 Marine, 2020f).

At the inshore location the 14-day rolling mean of natural baseline NTU and SSC frequently exceeded the Jones *et al*. (2019) thresholds for possible and probable effects on corals. Conversely, the 14-day rolling mean for NTU and SSC at the offshore location did not exceed either of the Jones *et al.* (2019) coral thresholds. Therefore, whilst these thresholds may be appropriate criteria for dredge monitoring in the offshore areas, they are unlikely to be suitable for dredge monitoring in the inshore areas.

Laboratory Results

All results were below the Australian and New Zealand Guidelines for Fresh and Marine Water Quality (ANZG, 2018) 99% species protection guidelines for all analytes with stated guideline values. These results indicate that the current allocation of maximum and high LEPs are appropriate for Mardie marine waters.

Thresholds

The recently published WA Marine Science Institute (WAMSI) (Jones *et al*., 2019) SSC and DLI thresholds for possible and probable effects on coral were found to be suitable as criteria for monitoring dredging effects in the offshore portion of the development envelopes. However, frequent natural exceedances of SSC thresholds in the inshore areas indicates that these thresholds are not appropriate for use as dredge monitoring criteria in the inshore portion of development envelopes. Jones *et al.* (2019) recognises these potential threshold limitations and advises that WAMSI is in the process of developing thresholds for turbid water coral communities. O2 Marine therefore recommended that these new turbid water thresholds (once available) be evaluated following collection of sufficient (i.e. two years) baseline data.

6.4 Potential Impacts

Table 15 defines the potential impacts (direct, indirect and cumulative) on the environmental values for this factor in a local and regional context. No cumulative impacts are expected as no other proposals are likely to impact marine environmental quality within and surrounding the development envelopes.

Table 15: Potential impacts on Marine Environmental Quality

Environmental value and current extent	Potential direct impact	Potential indirect impact
Marine waters surrounding port infrastructure. These waters are currently listed as having a 'high' LEP.	Discharge of up to 3.6 GL/yr of bitterns.	• Increased turbidity caused by dredging activities (construction) or vessel movements (propeller churn) • Spills of salt products during transfer to port vessels • Hydrocarbon spills from vessels
Tidal creeks. Numerous tidal creeks occur along the coastline west of the Proposal. These waters are currently listed as having a 'maximum' LEP.	No direct impacts proposed.	• Hydrocarbon spills associated with seawater intake or boat launching facility • Increase in salinity due to leaks or spills of brine from ponds or pipelines • Sedimentation due to runoff during construction or during construction of seawater intake or boat launching facility

6.5 Assessment of Impacts

6.5.1 Marine Waters Surrounding Port Infrastructure

Proposed Levels of Ecological Protection

Consistent with EPA guidance for managing impacts to marine environmental quality (EPA, 2016d) three new ecological protection areas are proposed to be developed for the Proposal. Ecological protection area boundaries have been previously described for the Mardie area in the *Pilbara Coastal Water Quality Consultation Outcomes* (DoE, 2006). These existing boundaries were reviewed and updated in the context of the proposed waste bitterns outfall and port operations, to spatially define proposed ecological protection areas around the Proposal infrastructure.

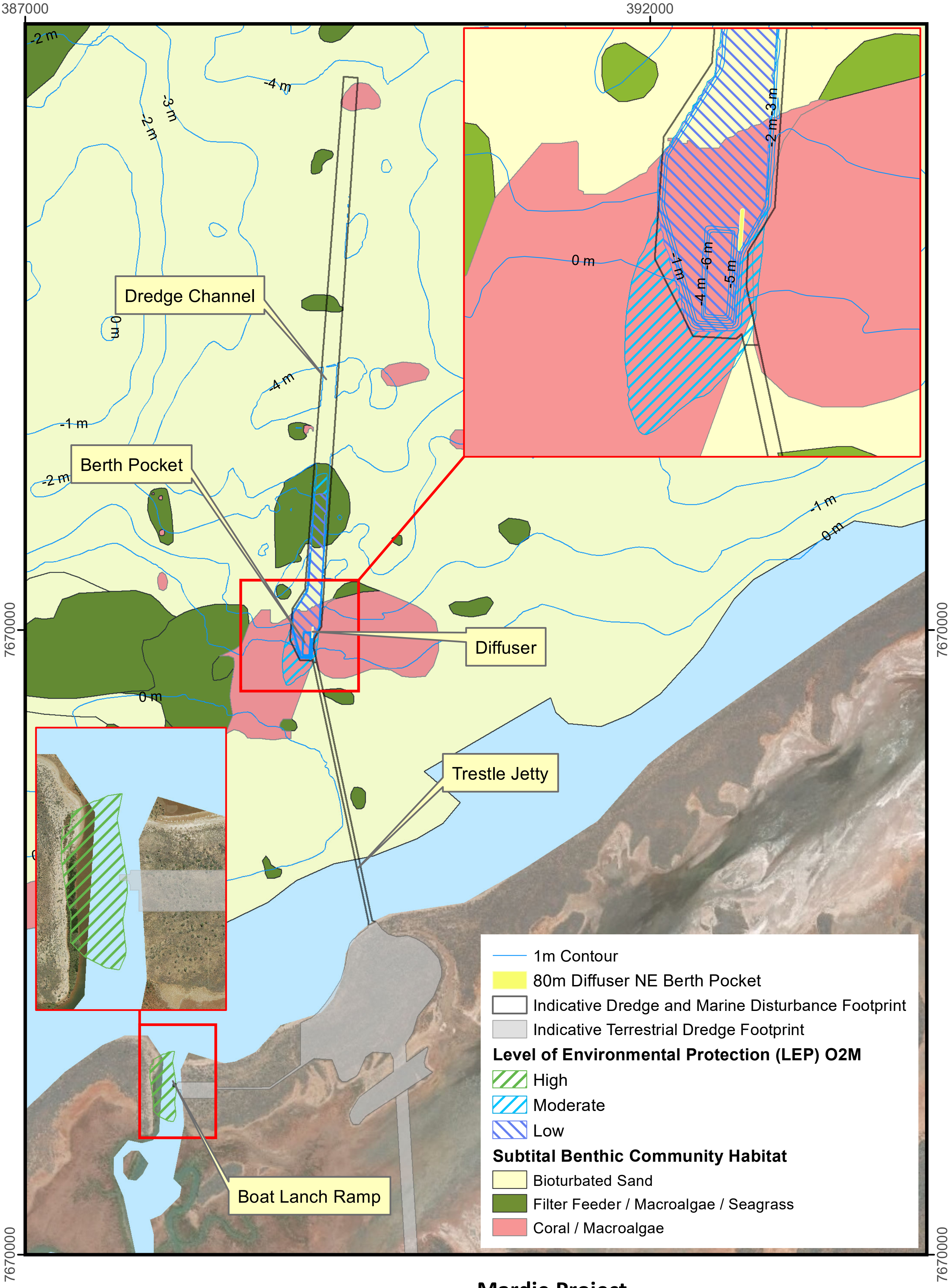
The ecological protection area boundaries were defined and mapped in consideration of the following key elements:

- A Low Ecological Protection Area (LEPA) was designated based on modelled predictions of the bitterns plume to determine where a 90% SPL (i.e. moderate level of ecological protection) would be achieved (Baird, 2020c; Appendix 5.2). WET testing results presented in O2 Marine (2019b;) were used to inform the number of dilutions required to meet the 90% SPL used by Baird (2020c);
- A Moderate Ecological Protection Area (MEPA) was designated based on modelled predictions of the bitterns plume to determine where a 99% SPL (i.e. high level of ecological protection) would be achieved (Baird 2020c). WET testing results presented in O2 Marine (2019b; Appendix 5.2) were also used to inform the number of dilutions

required to meet the 99% SPL used by Baird (2020c). No alterations to this MEPA boundary were required to account for potential port operational impacts;

- Two small High Ecological Protection Areas (HEPAs) were designated adjacent to the proposed boat launching facility and the seawater intake in the northern and southern tidal creeks respectively. The size of these HEPAs were both based upon a 250 m buffer around proposed infrastructure; and
- Existing ecological protection areas as presented in the DoE (2006) were retained for all other areas.

The proposed spatial designation of ecological protection areas for the Proposal is presented in Figure 62.



Mardie Project
Bitterns disposal mixing zone and dredging boundaries

BCI MINERALS LIMITED

Figure 62: Proposed Levels of Ecological Protection

Bitterns Disposal

The production process will produce a high-salinity bittern that will be discharged through a diffuser at the end of the trestle jetty. A seawater intake will be installed along the trestle jetty (outside the area influenced by the bitterns disposal) to allow the mixing of bitterns at a ratio of at least one-part bitterns to five parts seawater to reduce the salinity concentration of the bitterns. The diluted bitterns will be discharged to marine waters via a 200 m 8-port diffuser, with 10.5 m spacing between the ports.

The following key points are relevant to this assessment:

- The Key Characteristics Table restricts the bitterns disposal to within the Dredge Channel Development Envelope;
- The Key Characteristics Table will restrict the total volume of undiluted bitterns discharge; and
- New Low and Moderate LEPs will be required for the mixing zone and port operations.

Effluent Testing

Whole of Effluent Testing (WET testing) was conducted by EcoTox Services Australia to determine and describe the toxic effects of the bitterns' discharge and predict the number of dilutions required to meet the different LEPs surrounding the outfall (O2 Marine, 2019b). A representative bitterns sample was tested using tropical species from a range of trophic levels (primary producer, herbivore and carnivore) and development stages, using both acute and chronic tests for toxicity.

The WET testing determined that the number of dilutions required for the whole effluent is greater than would be required to dilute discrete parameters such as pH, zinc and arsenic. Therefore, WET testing results indicate that potential toxic effects on local marine indicator species are derived predominantly from changes in salinity. The analysis from the ecotoxicity testing reported the raw bitterns product had a salinity of 325 ppt.

O2 Marine (2019b) determined that the following dilutions of the waste bitterns would need to be achieved in order to meet the required species protection levels (SPLs) for each of the designated LEPs:

- Moderate (90% SPL) requires 263 dilutions; and
- High (99% SPL) requires 417 dilutions.

Dispersion Modelling

Baird Australia Pty Ltd (Baird, 2020c) was engaged to undertake bitterns outfall modelling for the Proposal, using the required dilutions detailed above. The objectives of the modelling were to:

- Conduct an outfall options assessment to determine the optimum location, means and duration of the bitterns discharge;
- Full process (3D) modelling of bitterns discharge, examining plume dispersion under four seasonal environmental conditions; and
- Assess the plume stability.

The bitterns outfall modelling was completed using a near-field and far-field modelling approach. The near-field model modelled the bitterns plume dispersion in the immediate vicinity of the outfall. The system used provides mixing zone analysis for a range of discharges into bodies of water, with particular emphasis on the geometry and dilution characteristics of plumes defining the near-field mixing zone.

The far-field model simulates two-dimensional (in either the horizontal or a vertical plane) and three-dimensional flow, sediment transport and morphology, waves, water quality, and ecology and can handle the interactions between these processes. To determine an appropriate discharge regime at the site, the current velocity and direction were analysed based on a reporting location at the outfall location in the validated hydrodynamic model developed for the Proposal (Baird, 2020c) with the developed case bathymetry included.

Results

The analysis of the far-field model results for the four representative seasonal scenarios indicates the minimum dilution target for the 90% species protection level at the proposed LEPA / MEPA boundary is achieved and the minimum dilution target for the 99% species protection level at the proposed MEPA / HEPA boundary is achieved (Figure 62).

Assessment of Impact

Mardie Minerals have investigated numerous discharge options for bitterns disposal in order to reduce the size of the impacted areas (LEPA and MEPA). Given the relatively shallow water in the areas surrounding the jetty, and the presence of the dredge channel, there is limited opportunity for mixing. An option of extending the discharge pipeline and diffuser out to deeper water was considered, as this would encourage mixing and be likely to reduce the size of the mixing zone. This option was however discounted as it would present additional direct BCH impacts and would require the discharge of bitterns into a previously unimpacted area. The preferred discharge method was therefore targeted on encouraging mixing as much as practicable to ensure the LEPA is contained within the confines of the dredge channel, which will be free of BCH.

Bitterns disposal will therefore result in localised impacts on water quality within the base of the dredge channel. While the entire dredge channel will be flushed several times a month, outside of these times the bitterns will sink to the bottom of the channel, resulting in stratification within the water column that can remain for up to eight days (Figure 63). Stratification can lead to a reduction in dissolved oxygen, creating anoxic conditions at the base of the channel during these periods.

These impacts will be limited to the boundary of the dredge channel in order to minimise impacts to BCH and marine fauna (refer to Sections 7 and 8 respectively for an assessment of bitterns disposal impacts on these environmental factors). With the exception of the MEPA that surrounds the dredge channel and loading areas, a High LEP can be met outside this range (Figure 62). Water quality impacts can therefore be contained to defined impact areas if managed appropriately. Management of the bitterns discharge will therefore be required to ensure these impacts are limited to these areas as described (Section 6.6).

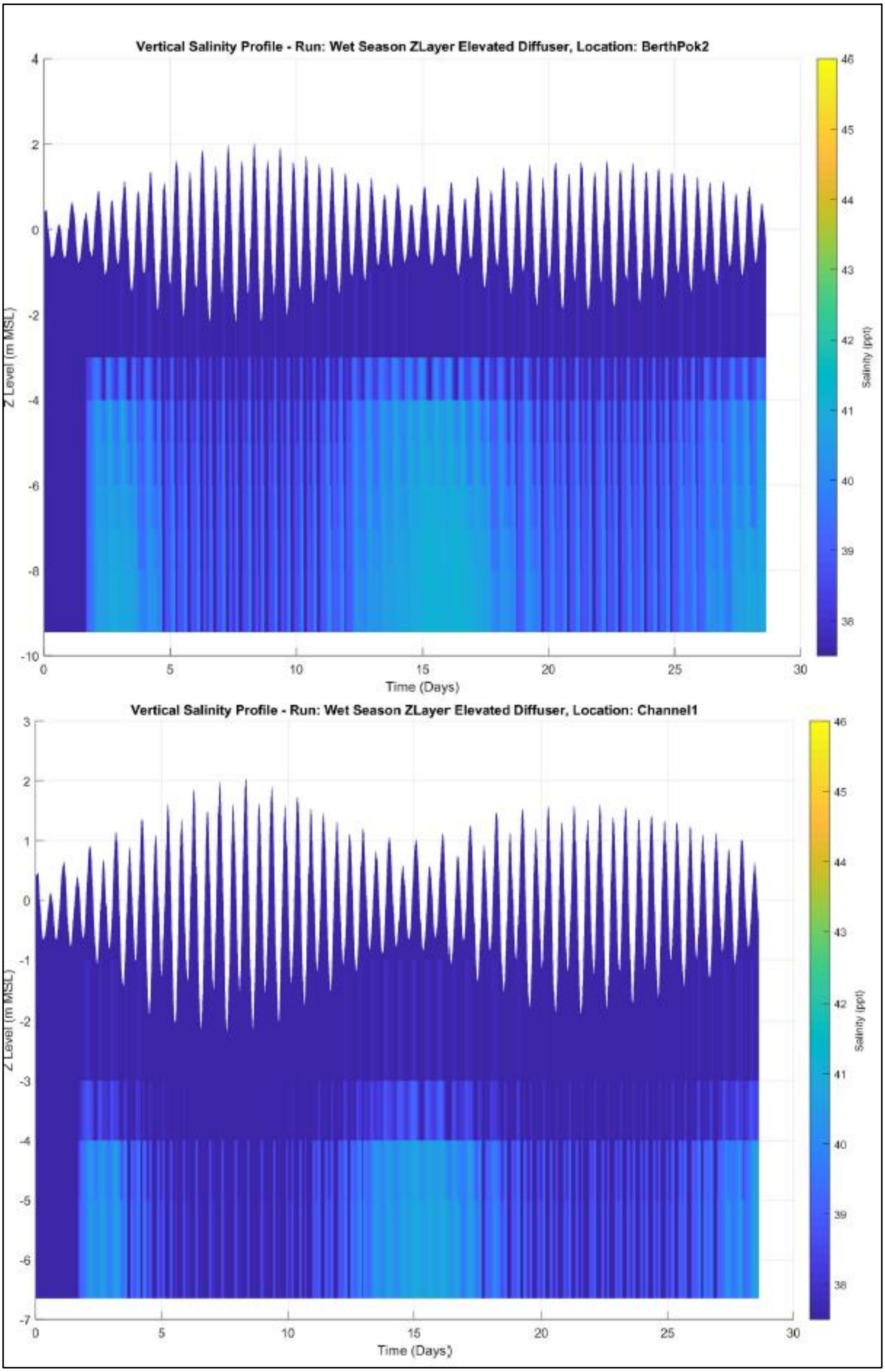


Figure 63: Vertical salinity profiles from within the berth pocket (top) and along the channel (bottom) with a 200 m diffuser outputting at a level elevated within the column

Dredging Activities

Dredging activities will be minimised by using a transhipment export method (which can operate in shallow water), and following existing low points on the seabed. Up to 800,000 m^3 of material will need to be dredged to ensure sufficient depth for the transhipment barge berth pocket at the end of the trestle jetty, as well as along a defined channel out to deeper water. The average dredging depth is shallow, only approximately 2 m below the current sea floor. The following key points are relevant to this assessment:

- The location of dredging is restricted to only within the Dredge Channel Development Envelope;
- The Key Characteristics Table restricts the total volume of dredging;
- Dredging will be conducted using a barge-mounted long-reach excavator instead of a cutter-suction vessel. Material will be dug up and placed into a container on a hopper barge. The barge will then transport the container to the trestle jetty where it will be lifted by crane onto a truck and taken to a bunded containment cell (Figure 3). Any decant water from the cell will be pumped into the adjacent evaporation pond;
- Dredging rate is expected to be a maximum of 2,500 m^3 a day on two 10-hourr shift; and
- The dredging schedule aims to complete the dredging requirements over dry season months in two successive years.

Modelling

Baird Australia Pty Ltd (Baird, 2020b; Appendix 6.3) was engaged to undertake modelling to assess the extent of dredge plumes from the Proposal. The objectives of the modelling were to:

- Determine the location, extent and duration of a potential dredge plumes;
- Model realistic sediment plume outputs (over multiple seasons) relevant to the scale of the dredging (including potential worst-case impact scenarios) to guide appropriate management (discussed in Section 6.6); and
- Assess the likely dredge plume impact in relation to marine environmental quality.

The model consisted of a number of modules capable of simulating the complex hydrodynamic processes in the nearshore environment and assessment of sediment plumes. The modules were applied to recreate the environmental forces acting through the water column at the proposed dredging locations, directly influenced by tides, wind and waves. The model utilised a combination of regional scale hydrodynamic and wave models for the north-west shelf, and site-specific baseline data collected by O2 Marine (metocean, water quality and sediment quality data).

Sediment plumes from dredging will be generated from two principal sources; mobilisation of fine sediments at the excavator bucket with each load, and overflow water from the hopper barges.

There were seven dredge sequences along the dredging footprint in which the sediment composition and volume was assessed and inputted into the model to determine the dredge plume extents. Within each of the sequence areas the volume of sediment removed varied between 112,000 m^3 and 116,000 m^3.

The dredge sequences commenced at the most inshore location and progressed offshore. Sequence 1 (SEQ1) was the first section that is dredged in the model simulations and the region covers the berth pocket area. When the SEQ1 section was completed in the model (approximately 8 weeks of dredging), the next section of the channel in SEQ2 commenced. At the start of SEQ2, the bathymetry was updated in the model to represent the completed SEQ1 section and hydrodynamics in the model run were based on interaction with the partially completed dredged channel and footprint.

Within each of the dredge sequences (SEQ1 through to SEQ7 offshore), the particle size distribution of the dredged material for application in the model was calculated based on the measured geotechnical data. This process is described in detail in Baird (2020b), outlining the samples that have been considered for each of the sections and the calculation of the respective sediment fractions (clay, silt, sand). It is noted that for the sand fraction, only fine sands (62 µm – 0.25 mm) were included in the dredge plume modelling. It is assumed that medium and coarse sand particles (0.25 mm – 2 mm) would fall to the seabed close to the source. The PSD were examined in each sample to define the representative proportion of fine sand to include in the model, which is generally about one third of the total sand.

Dredging volumes were calculated through the transhipment channel and berth pocket dredge footprint based on the target design depth (-3.9 m LAT) and the natural seabed levels with an allowance for over-dredging of 0.5m. The calculation was completed through a GIS-based analysis utilising the high resolution multibeam bathymetry dataset collected through the transhipment corridor in 2019 (Surrich and EGS, 2019).

A transect along the channel centreline is shown in Figure 64.

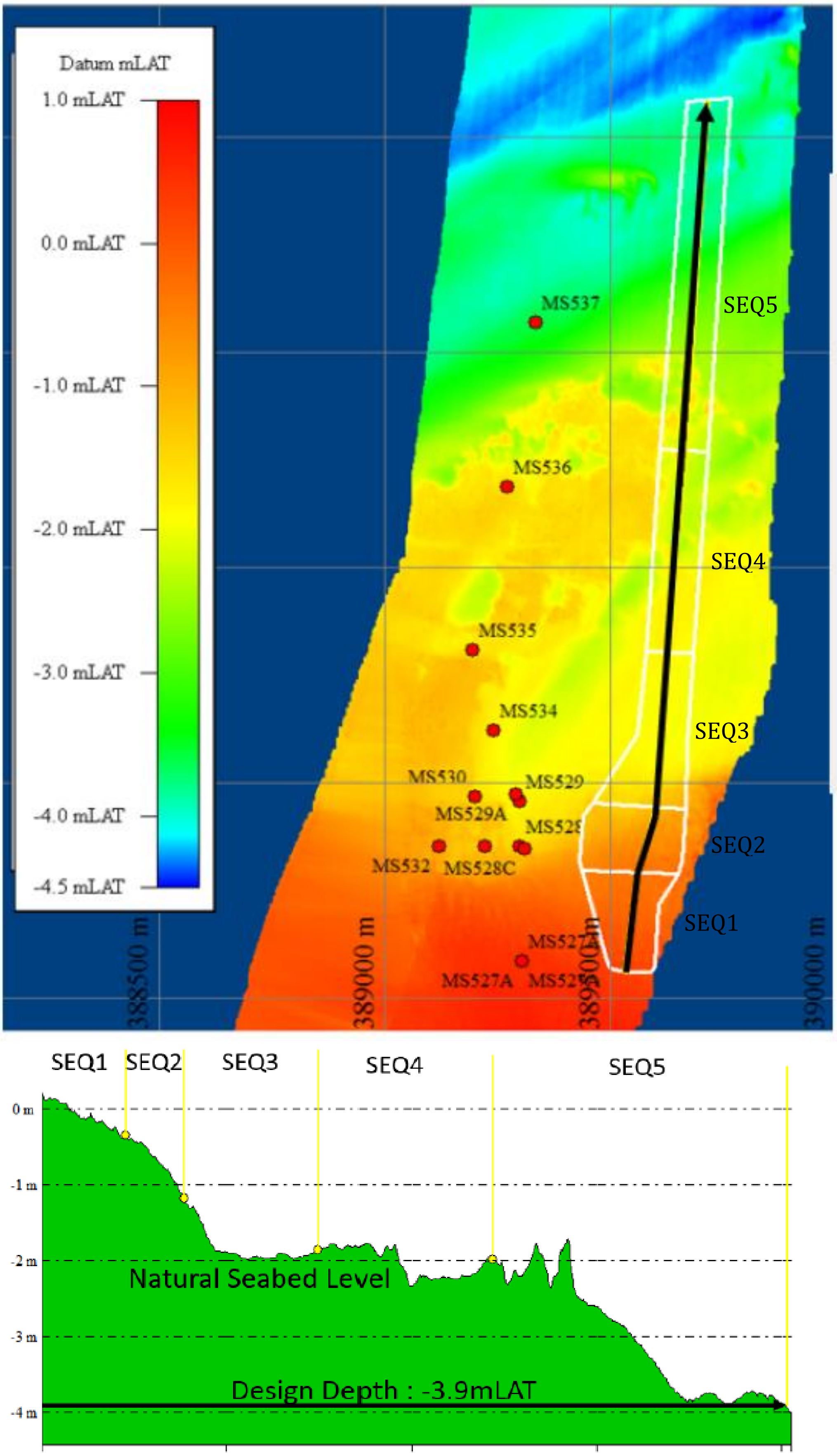


Figure 64: Current seabed level within the proposed dredge footprint

Model Results

For the nearshore region of the dredging footprint (marine precinct, berth pocket), the general tidal currents are aligned along a north-east to south-west axis for the ebb and flood tides (Baird, 2020b). As a result, the dredge plumes are directed along this axis, with dredge plume impacts elongated to the southwest driven by the stronger flood tides in comparison to ebb tide.

The dredge plume impacts are most pronounced from dredging of the inshore sections (Figure 22). This is due to the large volume of material being dredged at the seabed over a comparatively small spatial area. For the offshore sections of the channel, the dredging requirements are spread out over a much larger area and the dredge plume extents are significantly less. Additionally, the fines content is much higher inshore than offshore (up to 75% inshore compared with 38% through the offshore sections of the channel).

The EPA 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 their dredging proposals (EPA, 2016e). The scheme consists of three zones that represent different levels of impact:

1. 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;
2. 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 ZoHI. The outer boundary of the ZoMI is coincident with the inner boundary of the next zone, the Zone of Influence (ZoI);
3. 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.

In accordance with EPA (2016e) guidance, the dredge plume impact assessment was undertaken to develop predictions of the ZoHI, ZoMI and ZoI under both best-case and worst-case scenarios in the vicinity of the dredging. The 'best case' scenario for dredge plume impacts is defined as the case where expected dredge production rate is achieved throughout the duration of the dredge program. The assumption is based on two ten-hour shifts per 24-hour period where 2,000m^3 / day is dredged, and the dredge operates seven days a week. The 'worst-case' scenario for dredge plume impacts is defined as the case where an upper limit dredge production rate is achieved throughout the duration of the dredge program. The assumption is based on two ten-hour shifts per 24-hour period where 2,500 m^3 / day is dredged, and the dredge operates seven days a week).

The calculated zones of impact (ZoMI and ZoHI) were compiled from the full two years of modelled dredging. The dredge plume model outputs for likely best and worst case ZoMI / ZoHI are shown in Figure 65.

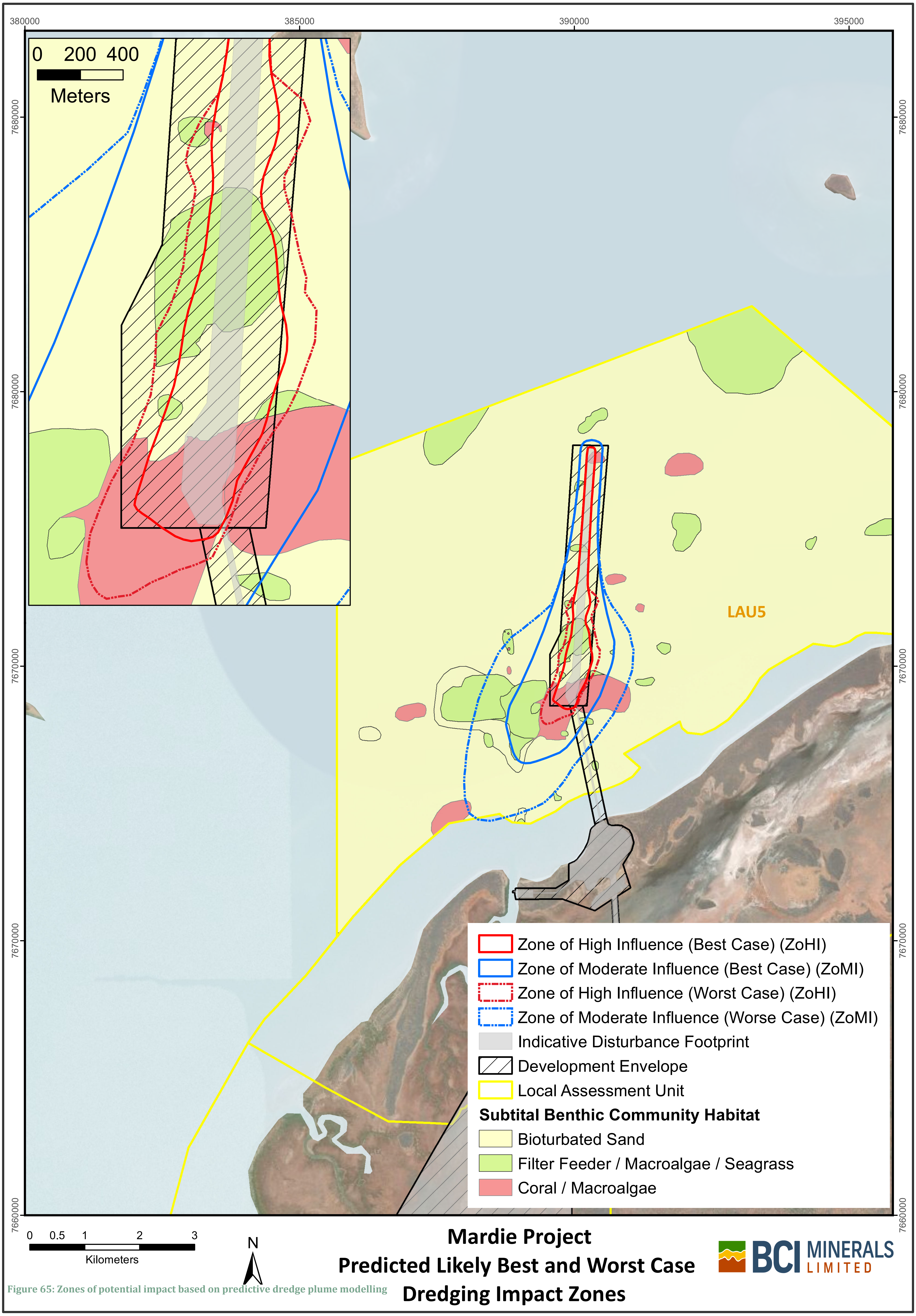


Figure 65: Zones of potential impact based on predictive dredge plume modelling

Assessment of Impact

Mardie Minerals have investigated numerous options for the berth pocket location, based on a cost analysis between dredging and additional jetty lengths. The proposed location was deemed to be the most cost-effective as extending the jetty further offshore would be cost-prohibitive for the Proposal.

Dredging will result in impacts on water quality in the vicinity of the dredging activities during dredging and for a short period afterwards. These impacts may result in moderate to high short term impacts to water quality over several kilometres on a modelled worst-case scenario (Figure 65; Baird, 2020b).

The dredging will be carefully managed to ensure these impacts are limited to the areas predicted (Section 7.6).

The transfer of the dredge material from the hopper barge to trucks on the trestle jetty may result in some dredge material falling into the water. The entire container will be lifted off the barge onto the truck by a crane, rather than transferring the material using loaders. The barge will be located underneath the container as it is lifted therefore the majority of material spills will be captured by the barge itself. Spills will therefore be limited to material that has been spilt onto the sides or base of the container and falls into the water column (rather than the barge) during the transfer of the container.

Spills of dredge material are therefore expected to be uncommon and of low volume when they occur. Associated potential impacts to water quality will occur within the jetty head area, which will already have been (or will be) affected by dredging activities (refer above). Spills of dredge material are therefore unlikely to result in water quality impacts greater than those caused by the dredging activities.

These water quality impacts will also have subsequent impacts to BCH and Marine Fauna. These impacts are discussed in Sections 7 and 8 respectively.

Incidental Product Spills

The Proposal includes the export of bulk salt and SoP. SoP and other potential by-products may also be transported to other ports in bulk bags or shipping containers. The salt and SoP will be loaded onto a transhipment vessel using typical conveyors and ship loading infrastructure which are designed to eliminate product spills. The vessel will then travel offshore and re-load the salt onto an ocean-going vessel anchored offshore.

Some product spills may occur during the loading of vessels, however these events are expected to be rare and volumes will be small. As the receiving environment is already saline these discharges are not expected to significantly impact marine environment quality.

Leaks or spills of hydrocarbons or chemicals

Refuelling of vessels is proposed to occur at the Mardie Export Facility, and therefore there is a risk of hydrocarbon spill from vessels during construction and operation as a result of vessel collisions or hydraulic hose leaks. With the exception of vessels used in jetty construction, the majority of these vessels would be located several kilometres offshore as refuelling will occur at the end of the trestle jetty. Construction vessels are also small in size and therefore would not contain significant volumes of hydrocarbons. All ocean-going vessels will be located offshore in deeper water. With the implementation of standard industry safeguards and operating procedures (Section 7.6) any offshore spills are expected to be able to be contained and cleaned up before reaching the shore.

Refuelling of the transhipment barge and support vessels is likely to be undertaken alongside the trestle jetty, within the berth pocket and the proposed Low/Moderate LEP zone. Hydrocarbon spills to the marine environment are possible in this area, however with the implementation of standard industry operating procedures (Section 7.6) this is predicted to represent a relatively low risk.

6.5.2 Tidal Creeks

Hydrocarbon Spills

The pond seawater intake is located within a tidal creek and will contain high-volume pumps that run on diesel fuel. These pumps will be located within a bunded area on the shore. Any spills from these pumps will be captured by the bund which is designed to contain spills and prevent them reaching the tidal creek waters.

A small boat launching facility will be located within the main northern tidal creek (adjacent to the jetty). The boat launching facility will be used to launch small vessels used in the construction and operation of the export facility. Refuelling of vessels will occur on land, away from the water's edge. Refuelling will be conducted in accordance with refuelling procedures developed in consultation with PPA, and spill equipment will be maintained to ensure any spills are contained and cleaned up. Section 7.7 contains more detail about the mitigation measures proposed.

Based on the above, the risk of hydrocarbon spills impacting the marine environmental quality within tidal creeks is not expected to be significant.

Brine Spills

A significantly large spill or leak of brine from the ponds or pipelines, or product infrastructure washdown water could result in impacts to the marine environmental quality within adjacent tidal creeks. 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 7.6). 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 is most likely to spread across the mudflat area given the current flow regimes (refer to Section 5) and the brine would be expected to dilute and wash away over a period of several weeks, depending on the tidal regime at the time and rainfall events. In the unlikely circumstance that the spill reaches an adjacent tidal creek the brine would be gradually diluted by the sea water in the tidal creek.

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.

Sedimentation

Sediment loss during the construction of the ponds and other infrastructure could result in increased turbidity within adjacent tidal creeks. The risk of sedimentation impacts within tidal creeks is expected to be low given the following:

- Construction of the ponds involves the construction of embankments only (i.e. the base of the evaporation ponds will not be disturbed) and therefore there will not be large areas of disturbed ground that could release sediment. In addition the construction of the pond walls will result in shallow depressions in some areas (due to the cut-and-fill construction method), which will capture some of the sediment before it flows offsite;
- Construction areas remain dry almost all of the time, therefore there is very little potential for flow paths between these areas and tidal creeks; and
- During significant flooding events marine waters are likely to be already turbid.

Mardie Minerals has committed to mitigation measures to reduce the risk of sedimentation (refer to Section 7.6.2).

Some minor excavations into the tidal creek bed will be required during the construction of the seawater intake and boat launching facility. These excavations may lead to sediment being stirred up and released into the water column. Given the high tidal movements within both of these creeks the sediment is likely to be rapidly mixed and diluted. As these impacts are short-term (only during construction) this potential impact is considered unlikely to have a significant impact on the water quality within the creeks. Nevertheless Mardie Minerals has committed to mitigation measures to reduce the risk of sedimentation (refer to Section 7.6.2).

6.6 Mitigation

Mardie Minerals has mitigated the potential impacts to this factor according to the mitigation hierarchy; avoid, minimise, rehabilitate, offset. Offsets are not expected to be required for this factor.

6.6.1 Avoid

The primary avoidance mechanism implemented by Mardie Minerals was to design the development envelopes to restrict the location of marine environmental quality impacts. Mardie Minerals has designed the Proposal and its development envelope boundaries to avoid the following:

- Discharge of bitterns within the intertidal zone by requiring the outfall to be located offshore within the Dredge Channel Development Envelope; and
- Dredging within the intertidal zone by proposing dredging only within the Dredge Channel Development Envelope.

In addition to the above, the following mechanisms were implemented to avoid impacts to marine environmental quality:

- The disposal of dredge material offshore has been avoided by bringing the material to shore for use in construction.

6.6.2 Minimise

The following mitigation measures are proposed to ensure that direct and indirect impacts to marine environmental quality are minimised:

1. **Obtain and comply with the following approvals:**
    a. Ministerial Statement to be issued under Part IV of the EP Act;
    b. 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;
    c. Mining Proposal to be approved under the *Mining Act 1978* for activities on *Mining Act 1978* tenure;
    d. 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;
    e. Development Application to be approved under the *Port Authorities Act 1999* for activities within Pilbara Ports Authority managed lands and waters;
2. **The Key Proposal Characteristics (Section 2.3.2) provide several limits that were included to minimise impacts to marine environmental quality.** These include:
    a. A limit of 3.6 GL/yr of bitterns discharge (prior to dilution); and
    b. A dredging limit of 800,000 m^3;
3. **Implement the MEQMMP (Appendix 3.1).** The MEQMMP contains detailed information about the discharges, proposed management and monitoring, and contingency actions, including:
    a. Baseline monitoring requirements;
    b. Implementation of a Marine Environmental Quality Monitoring Program;
    c. WET testing of initial bitterns and comparison against initial modelling input and outputs. Conduct remodelling if required to verify LEP boundaries;
    d. Model verification monitoring;
    e. Detailed design of the outfall diffuser;
    f. Ongoing bitterns quality monitoring;
    g. Develop and implement procedures and plans, including a Chemical Storage and Handling Procedure, Bunkering Procedure, Port Facility Oil Spill Response Plan, Shipboard Oil Pollution Emergency Plan;
    h. Reporting requirements; and
    i. Contingency actions;
4. **Implement the Dredge and Spoil Disposal Management Plan (DSDMP; Appendix 4.1).** The DSDMP includes key management actions to minimise impacts to marine environmental quality including:
    a. Dredged material is not to be dumped offshore. Dredged material will be brought onshore to be used in pond construction;
    b. Dredging will be conducted using a barge-mounted long-reach excavator instead of a cutter-suction vessel;
    c. Measures proposed to ensure the ZoMI remains within modelling predictions;
    d. No detectable impact on subtidal BCH within the ZoI;
    e. Plume modelling and monitoring; and
    f. Contingency measures;
5. **Dredge material is to be placed into a container to allow a crane to transfer the container to trucks via the trestle jetty**. The container is to be lifted above the barge to ensure any spills are captured within the barge

6. **Ensure fuel is stored within self-bunded tanks or within a bunded area;**
7. **Concentrator and crystalliser ponds will be designed and constructed to be safe and stable according to DMIRS requirements;**
8. **The following controls will be used to minimise the risk of impact from unintentional brine pipeline spills**:
    a. Pipelines will be fitted with leak detection;
    b. Water flows will be shut off if leaks are detected;
    c. Pipelines will be inspected regularly, especially during extreme heat or fire events;
    d. Pipelines will be located off access road surfaces;
    e. If pipelines have to cross access roads then they will be buried;
    f. Investigations will be conducted into the cause of any spills, and remedial actions will be taken to minimise the chance of reoccurrence;
    g. Spill response training to mitigate damage for site-based personnel; and
9. **Monitor erosion at the outlets of the drainage corridors after significant flow events and install erosion protection (i.e. rock baffles etc.) if required** (refer to Section 5);
10. **Visually monitor sediment plumes during the construction of the seawater intake and boat launching facility.** If plumes are evident that are not dissipating quickly then install silt curtains if suitable.

6.6.3 Rehabilitate

The port area is expected to be located on a lease under the *Port Authorities Act 1999* and if this occurs a MCP will not be required under the *Mining Act 1978* for the marine infrastructure. Mardie Minerals will liaise with PPA regarding the port infrastructure, as it may be of value for ongoing use by PPA. If not, the closure objective for this factor will be to remove all infrastructure and stabilise all altered lands such that there are no ongoing impacts to marine environmental quality. The marine components of the Proposal are relatively easy to rehabilitate, and the following measures will be taken:

- All marine infrastructure including the jetty, wharf, seawater intakes, boat launching facility and navigation infrastructure will be removed and taken offsite; and
- The dredge channel will be left to gradually fill with sediment.

The remaining infrastructure will be rehabilitated and closed in accordance with a MCP approved under the *Mining Act 1978*. An interim MCP has been developed and provided in Appendix 12.1 which contains detail about the proposed rehabilitation of the Proposal, including closure outcomes and objectives.

6.7 Predicted Outcome

The EPA's environmental objective for this factor is to maintain the quality of water, sediment and biota so that environmental values are protected (EPA, 2016f).

The Proposal will require dredging to develop the transhipment corridor, which will result in impacts on water quality in the vicinity of the dredging activities during dredging and for a short period afterwards. These impacts may result in moderate to high short-term impacts to water quality over several kilometres on a modelled worst-case scenario (Figure 65; Baird, 2020b). The dredging will be carefully managed via a DSDMP to ensure these impacts are limited to the areas predicted (Section 7.6). A DSDMP has been prepared and provided in Appendix 4.1. The DSDMP was finalised in consultation with DWER to ensure that all potential impacts to marine environmental quality associated with dredging will be within the impact predictions presented in this ERD. The Proposal includes the discharge of bitterns into the marine environment on outgoing tides. The bitterns will be diluted prior to discharge by mixing with seawater taken from a seawater intake located within the port boundaries (but outside the area influenced by the bitterns disposal to avoid drawing in bitterns), and discharged through a multi-port diffuser to promote mixing. This discharge will result in unavoidable water quality impacts in the vicinity of the diffuser. Given the pre-dilution method proposed, the use of a diffuser and the siting of the diffuser within the port area will limit the LEPA within the dredge channel and MEPA to within 250 m of the dredge channel the impacts to marine environmental quality from bitterns disposal are not considered to be significant if managed appropriately. Bitterns disposal will be regulated by a Licence issued under Part V of the EP Act and managed by DWER. A Bitterns Outfall Management Plan is proposed to be developed as part of the Part V approval process, which will detail the monitoring and management measures proposed to ensure the bitterns discharges meet appropriate criteria.

The development of an export facility and export operations will increase the risk of water quality impacts (i.e. from oil spills, product loss). The proposed export activities at the Proposal are however small in scale (4 Mtpa) in comparison to other bulk export ports in the Pilbara. The potential risks associated with export operations are mitigated using a number of well-established measures, in this case it will be managed under a Works Approval and the *Port Authorities Act 1999*. A Moderate LEP is requested to be applied around the port operating areas as per other ports in the Pilbara.

The MEQMMP has been prepared and provided in Appendix 3.1. The MEQMMP was developed in consultation with EPA Services at DWER to verify and ensure that all potential impacts to marine environmental quality associated with the operation of the Proposal will be within the predicted levels.

In summary, the resultant potential impacts to marine environmental quality are not expected to be significant given that:

- The development envelope boundaries restrict the location of dredging and bitterns disposal;
- The Key Characteristics Table will restrict the total volume of dredging and bitterns discharge;
- Dredging activities have been minimised by using a transhipment method and following existing low points on the seabed;
- Dredging will be conducted using a front-end loader instead of a dredging vessel;
- Additional products (SoP and others) will be abstracted from the bitterns which reduces the total volume;
- Bitterns will be diluted with seawater prior to discharge;
- Bitterns will be discharged within a LEPA and the LEPA will be limited to within the already disturbed dredge channel;
- Port operations will be located within a MEPA; and
- Operations within tidal creeks are limited to low impact items, i.e. a seawater intake and a launching facility.

It is expected that the Ministerial Statement will include the limits described above in the Key Characteristics Table. The MEQMMP and DSDMP are expected to be requirements under the Ministerial Statement. Solar salt manufacturing (including bitterns disposal) and bulk material loading are prescribed activities and therefore all emissions and discharges associated with those activities will be managed under Part V of the EP Act including bitterns, oil spills and brine spills.

With the implementation of controls, the Proposal is able to be implemented while maintaining the quality of water, sediment and biota so that environmental values are protected. The Proposal is therefore able to meet the EPA's objective for this factor.

7 BENTHIC COMMUNITIES AND HABITATS

7.1 EPA Objective

The EPA Objective for this key environmental factor is to protect BCH so that biological diversity and ecological integrity are maintained.

7.2 Policy and Guidance

Relevant EPA and Commonwealth Government guidance documents for BCH are listed below:

Western Australian Government

Key EPA Documents

- Statement of Environmental Principles, Factors and Objectives 2016 (EPA, 2016a);
- Statutory Guideline for Mine Closure Plans (DMIRS, 2020);
- EIA (Part IV Divisions 1 and 2) Administrative Procedures 2016;
- EIA (Part IV Divisions 1 and 2) Procedures Manual 2016; and
- Instructions on how to prepare *Environmental Protection Act* Part IV Environmental Management Plans (EPA, 2018a).

Relevant EPA Factor Guidelines

Environmental Factor Guideline – BCH (EPA, 2016b).

Relevant EPA Technical Guidance

- Technical Guidance – Protection of BCH (EPA, 2016c);
- Technical Guidance – Protecting the Quality of WA's Marine Environment (EPA, 2016d);
- Technical Guidance – Environmental Impact Assessment of Marine Dredging Proposals (EPA, 2016e); and
- Guidance Statement No. 1 – Protection of Tropical Arid Zone Mangroves along the Pilbara Coastline (EPA, 2001).

Other Policy and Guidance

- Pilbara Coastal Water Quality Consultation Outcomes – Environmental Values and Environmental Quality Objectives, Department of Environment (DoE), Government of Western Australia, Marine Series Report No. 1 (DoE, 2006);
- Australian and New Zealand Guidelines for Fresh and Marine Water Quality (ANZG 2018);
- WA Environmental Offsets Policy (EPA, 2011);
- WA Environmental Offsets Guidelines (EPA, 2014); and
- WA Offsets Template.

Commonwealth Government

Key Documents

- Generic guidelines for the content of a draft EPBC Act PER/EIS (including the objects and principles of the EPBC Act) (DotEE, 2016b);
- Other Minister of the Environment (Cth) approval decision making considerations;
- EPBC Act Environmental Offsets Policy (DSEWPaC, 2012a);
- Environmental Management Plan Guidelines (DotE, 2014a);
- Environmental Management Plan Guidelines, - template (DotEE, 2018a);
- EPBC Act Condition Setting Policy (DAWE, 2020);
- EPBC Act Outcomes-based conditions policy (DotE, 2016c); and
- EPBC Act Environmental Offsets Policy (DSEWPaC, 2012) – including the Offset Assessment guide.

Relevant Technical Guidance

- Relevant EPBC listed species specific survey guidelines and protocols;
- Relevant EPBC listed species-specific Recovery plans, Threat Abatement Plans, Approved Conservation Advices and other documents;
- Marine bioregional plan for the North-west Marine Region (DSEWPaC, 2012b);
- National Assessment Guidelines for Dredging (DEWHA, 2009b); and
- Environmental best practice port development: an analysis of international approaches (GHD, 2013).

7.3 Receiving Environment

The information provided in this section has been sourced from the following reports:

- Stantec (2018; Appendix 2.2) Assessment of Mangal and Algal Communities for the Mardie Solar Salt Project;
- O2 Marine (2018) BCI Minerals – Mardie Salt Project. Snapshot Survey of the Benthic Habitats and Communities at the Proposed Bitterns Pipeline and Outfall Infrastructure Options, March 2018;
- O2 Marine (2020a; Appendix 2.3) Mardie Project – Intertidal Benthic Communities and Habitat. Report prepared for Mardie Minerals Ltd;
- O2 Marine (2020b; Appendix 2.4) Mardie Project – Subtidal Benthic Communities and Habitat. Report prepared for Mardie Minerals Ltd;
- O2 Marine (2020c; Appendix 2.5) Mardie Project – Benthic Communities and Habitat Cumulative Loss Assessment. Report prepared for Mardie Minerals Ltd; and
- O2 Marine (2020d; Appendix 2.6) Mardie Project – Expert Advice on the Significance of the BCH Impacted by the Proposal from a Local and Regional Perspective.

7.3.1 Study Area Boundaries

This ERD refers to a number of different study areas, depending on the scope of the study. Figure 66 shows the boundaries of the different study areas for reference through this section and the remainder of this ERD.

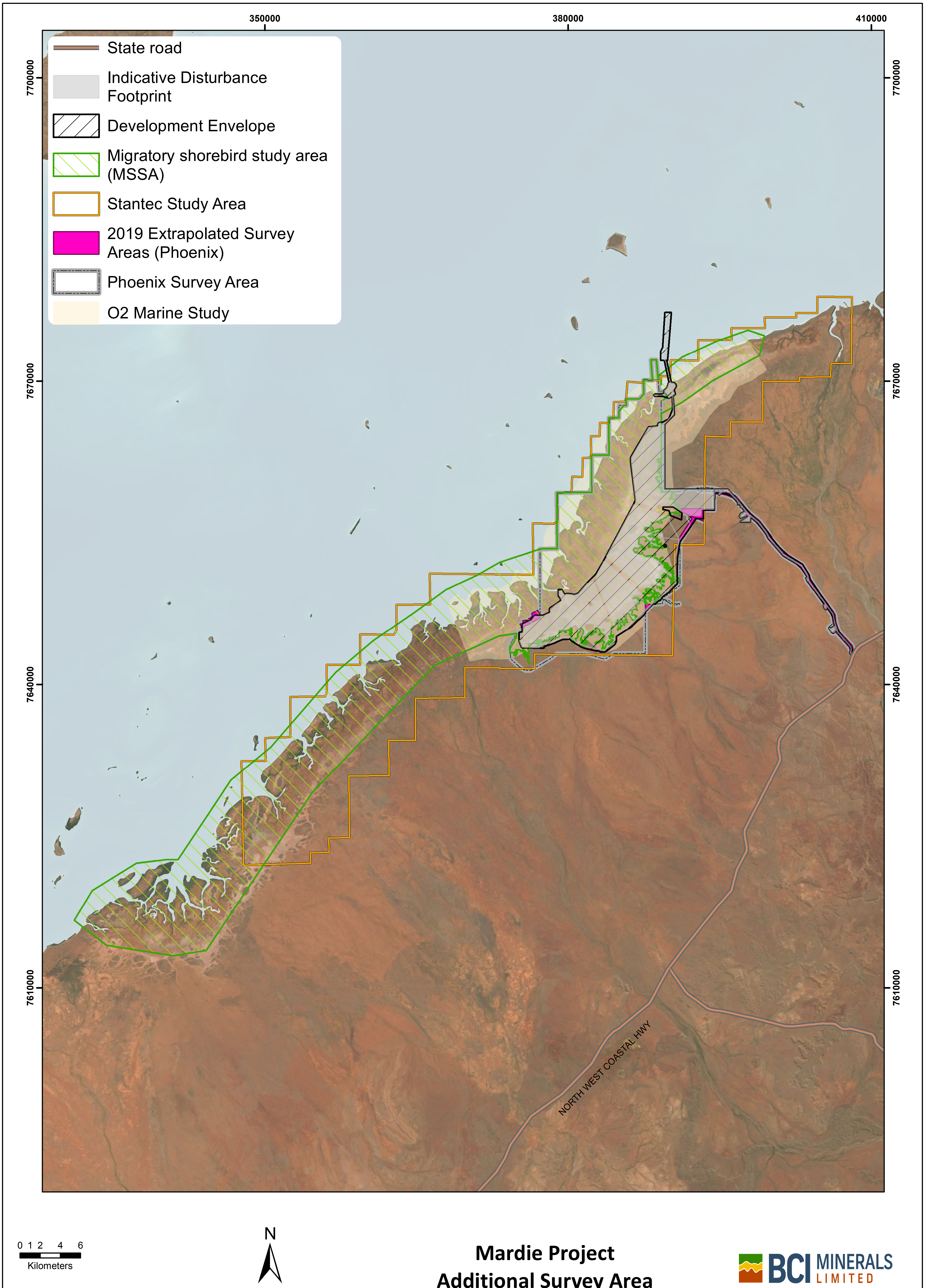


Figure 66: Boundaries of different Study Areas

7.3.2 Survey Effort - Intertidal Benthic Communities and Habitat

Intertidal BCH surveys were conducted at a regional scale by Stantec and a local scale by O2 Marine. The Stantec assessment was undertaken in 2017 – 18 to gain a preliminary understanding of mangrove and algal mat communities in the region. The area was 82,833 ha in size, extended along approximately 75 km of coastline and included broad habitat zonation with mapping and analysis of mangroves, algal mats and samphires. Figure 66 shows the extent of each study completed for the Proposal including the Stantec Study Area.

The Stantec assessment comprised a desktop review of available and relevant literature and was supported by preliminary hydrological modelling and reconnaissance and targeted field surveys. The results of the assessment, along with the literature review, were used to redefine the engineering design of the Proposal.

Further detailed BCH assessments were undertaken by O2 Marine in 2018 and 2019. These assessments primarily focussed on the coastal zone extending from the southern boundary of the EPA-designated regionally significant mangrove management Area 8: Fortescue River Delta in the north to the Robe River Delta in the south, however assessment of the intertidal habitats also included sites within Area 8 (Figure 67). The study area includes the foreshore mudflats of the LAT level to the intertidal habitats of the HAT level. The intertidal zone extends approximately 5 km inland in the northern and southern sections, and out to a maximum of 12 km through the central area (Figure 22).

Part of O2 Marine's work included a comprehensive desktop review of the intertidal BCH in vicinity to the Proposal. The review focussed on surveys undertaken for previous coastal development projects in the Pilbara and relevant scientific journal literature on intertidal BCH in the Pilbara region.

O2 Marine undertook two field surveys during March and December 2018 with the specific objectives of collecting detailed information to allow any data gaps identified in the desktop review to be sufficiently addressed. The surveys involved four primary tasks:

1. Collect information on mangrove tree health measurements to enable an investigation into the functional ecological value and regional significance of mangrove communities throughout the Study Area, including areas where mangroves intersect with the Proposal;
2. Collect information on mangrove fauna abundance and biodiversity to enable an investigation into the functional ecological value and regional significance of mangrove communities throughout the Study Area;
3. Collect low-altitude geo-referenced video of the mangrove communities to validate mapping of mangrove vegetation associations using satellite imagery (March survey only); and
4. Conduct helicopter transects combined with site walk observations to validate existing mapping of intertidal BCH classes prepared by Stantec (2018).

In total 51 sites were surveyed across the defined 36,195 ha Study Area. During the initial March 2018 survey, five monitoring sites were selected for assessment of the health and community dynamics of seaward mangrove communities, including sites within mangrove areas identified as regionally significant: the Robe and Fortescue River Deltas. Concurrent mapping undertaken prior to and after this survey identified that the development envelopes intersected some areas of mangrove BCH. Hence, a subsequent survey of 46 sites was undertaken in December 2018 to provide additional health and community dynamics for these typically landward mangrove associations. Survey sites, the Study Area and 'Regionally Significant' mangrove areas are presented in Figure 67. Note that helicopter transects were also conducted but are not shown on Figure 67 (refer to O2 Marine, 2020a; Appendix 2.3).

7.3.3 Survey Effort - Subtidal Benthic Communities and Habitat

Consistent with the commitments provided in the ESD, O2 Marine was commissioned to characterise and map the subtidal BCH within a proposed Local Assessment Unit (LAU 7). Limited information existed regarding the extent and distribution of subtidal BCH within LAU 7 and the surrounding area generally, therefore extensive field surveys were undertaken to characterise, map and describe the functional ecological value and regional significance of the subtidal BCH. All surveys were conducted by qualified and experience marine scientists from O2 Marine. The field survey effort is summarised in Table 16 and presented in Figure 68.

Table 16: Subtidal BCH field survey effort

BCH Survey	Survey Date	Sampling Locations	Survey Objective
Initial Survey	8 – 14 March 2018	50	• Undertake 'snapshot' survey to broadly characterise the subtidal BCH at 3 potential outfall locations • Identify the discharge location which poses the lowest risk of significant impact on subtidal BCH.
Second Survey	12 – 15 December 2018	64	Undertake targeted survey at the proposed port location and broader regional area
Third Survey	14 – 18 January 2019	18	Undertake targeted survey at the proposed port location, focussing on dredging footprint
Fourth Survey	6 – 8 February 2019	8	Undertake opportunistic survey of dredging footprint (conducted during sediment sampling survey)
Final Survey	16 – 18 March 2019	66	Undertake targeted survey of modelled worst-case dredging Zone of Influence (ZoI) and any other areas not surveyed within LAU 7

Surveys were conducted at a total of 206 locations using a combination of drop camera/towed video at all locations and diving/snorkelling for habitat verification at eight suspected seagrass BCH locations and six suspected coral BCH locations. To ensure accurate BCH characterisation within potential impact areas, the majority of survey locations were selected within the proposed dredge channel, jetty and outfall locations. Additional target survey locations were identified based on review of the available multibeam bathymetry data (i.e. acoustic backscatter) and aerial imagery to achieve broad spatial coverage across LAU 7.

Survey locations also extended beyond the LAU 7 boundary to include the Passage Islands group, Angle Island in the south and Mardie Island in the North.

During each video survey, the observed BCH was assigned a preliminary classification based on the Collaborative and Automated Tools for Analysis of Marine Imagery (CATAMI) classification scheme for scoring marine biota and physical characteristics from underwater imagery. Post-hoc review of the videos was undertaken and nine subtidal BCH classes were identified and mapped. These ground-truth locations were then used in conjunction with multibeam bathymetry data (i.e. acoustic backscatter) and aerial imagery to delineate the boundaries of the nine BCH classes.

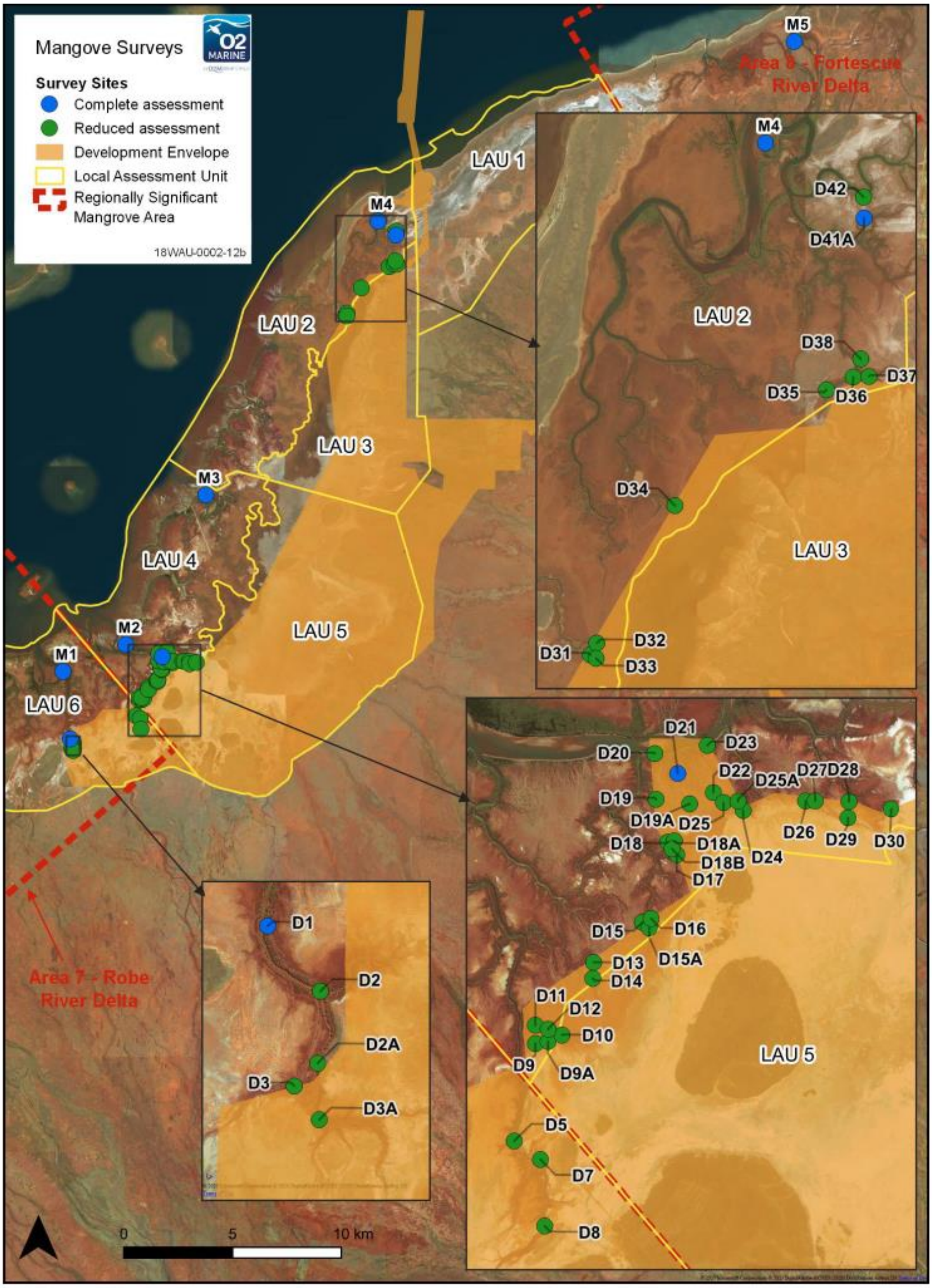


Figure 67: Intertidal BCH Study Area (boundary of Local Assessment Units) and survey effort

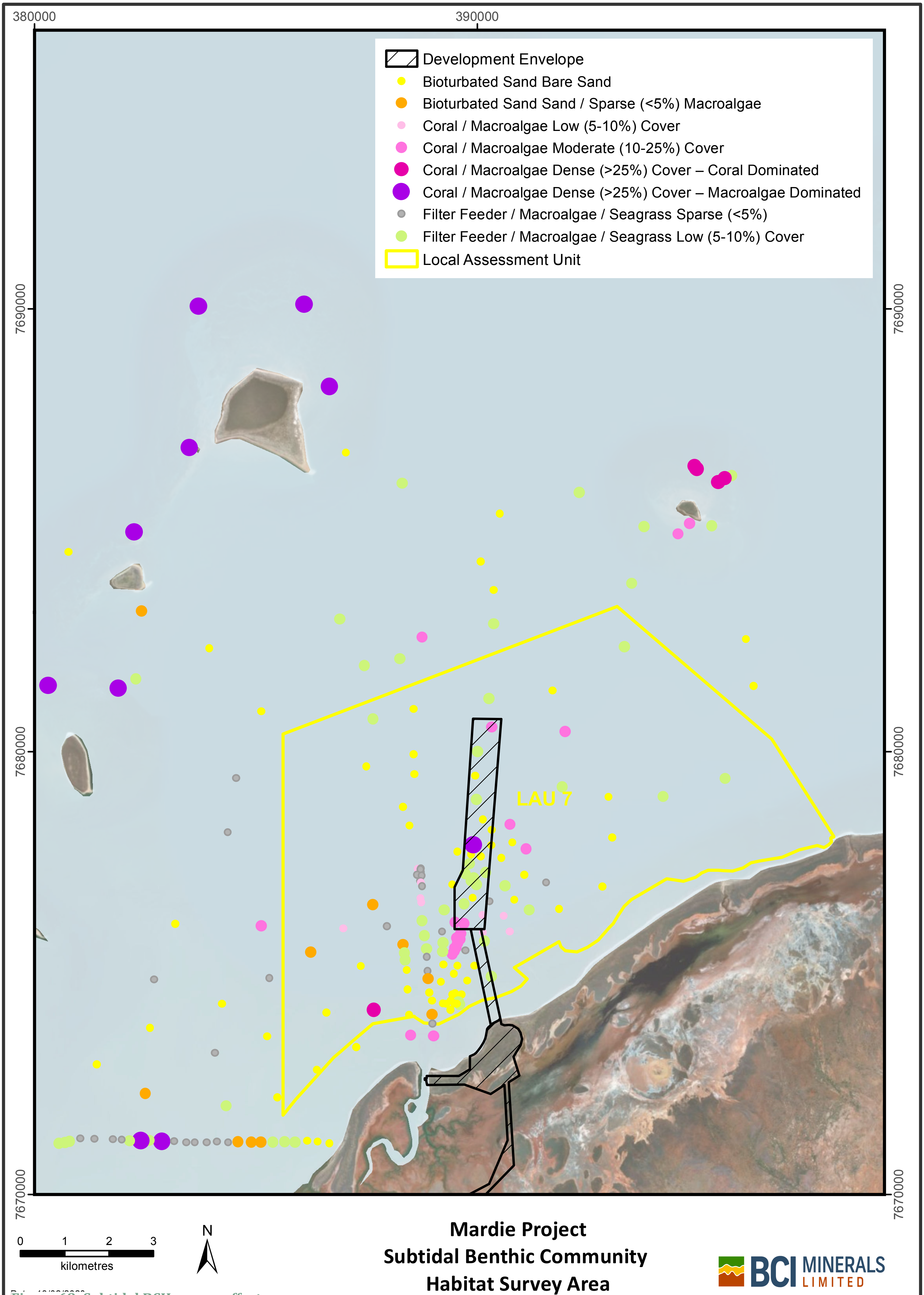


Figure 68: Subtidal BCH survey effort

7.3.4 Regional Intertidal Survey

Stantec completed an assessment of mangal (mangroves) and algal mat communities for the Proposal. The aim of the assessment was to identify the potential impacts and risks from the Proposal to inform the pre-feasibility team. Specific objectives were to:

- Gain a preliminary understanding of mangrove and algal mat communities;
- Provide environmental criteria for engineering design;
- Identify Proposal constraints for mangrove and algal mat communities; and
- Recommend future studies to support the Proposal.

The assessment comprised two field surveys (reconnaissance and targeted surveys), and a desktop review of available and relevant literature, supported by preliminary hydrological modelling. In the Study Area, broad habitat zonation, including mapping and analysis of mangroves, algal mats and samphires was undertaken, to provide regional context. The Study Area was extensive, and covered approximately 75 km of coastline, extending 20 km south of Robe River, and north to the Fortescue River (Figure 69).

Three mangrove species were identified within the Study Area, comprising *Avicennia marina*, *Ceriops australis* and *Rhizophora stylosa*. These are distributed in other tropical regions globally, and are widespread along the Pilbara coastline. Mangal communities were sparse near the Fortescue River, becoming more prevalent in the southern parts of the Study Area.

Algal mats were dominated by filamentous cyanobacteria including *Microcoleus* and *Lyngbya*, while *Calothrix* and *Schizothrix* were also common. Diversity was comparable with global communities and the Pilbara coast. Algal mats occurred within a relatively nominal elevation of between 1.1 - 1.3 m Australian Height Datum (mAHD). They were classified as either contiguous (thick and extensive) or fragmented (thin and patchy).

Regional BCH mapping is shown on Figure 69.

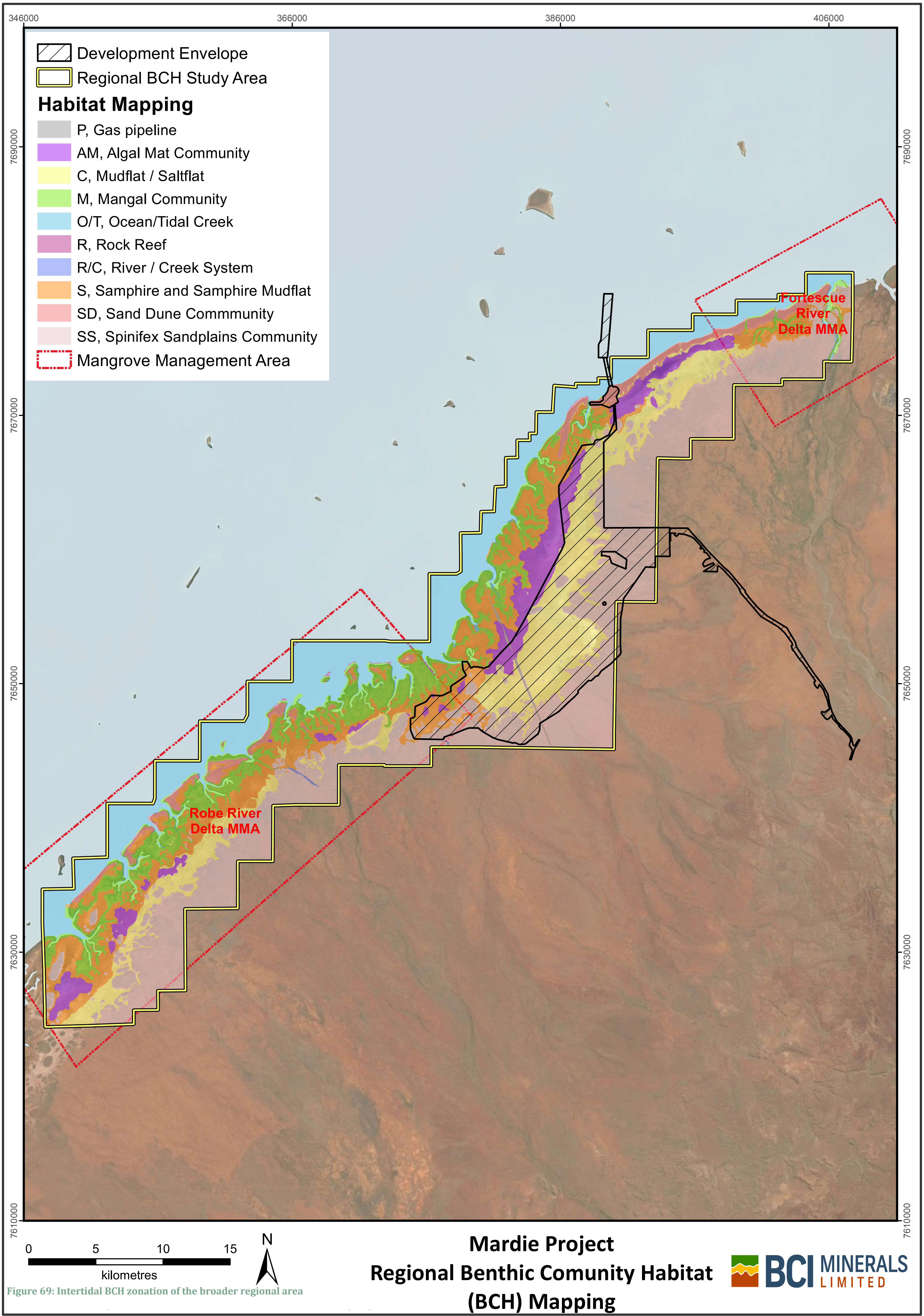


Figure 69: Intertidal BCH zonation of the broader regional area

Mardie Project
Regional Benthic Comunity Habitat (BCH) Mapping

BCI MINERALS LIMITED

7.3.5 Local Assessment Units

Seven LAUs were established across the Study Area to provide a regional context for characterisation, mapping and assessment of impacts to BCH. The location and extent of the five LAUs are shown on Figure 70. LAU 1 - 6 are focussed on the intertidal BCH areas, whilst LAU 7 focusses on subtidal BCH areas.

Consistent with the guidance provided in EPA (2016c) and the requirements of the ESD, the seven LAUs were established in consideration of the following key factors:

- BCH type, condition, extent and distribution;
- Management boundaries (i.e. Regionally significant mangrove areas);
- Bathymetry; and
- Coastal geomorphology.

The rationale for determination of LAU boundaries is summarised below:

- LAU1:
    - Intertidal BCH area (5,392 ha/53.92 km^2);
    - North-eastern boundary is determined by the by the southern boundary of the Fortescue River Regionally Significant Mangrove Area;
    - Eastern and western boundaries are determined by the extent of intertidal BCH
    - LAU is characterised by a large dunal complex with associated terrestrial vegetation extending along the coastal fringe of the algal mat from the south west to north-east;
    - BCH consists primarily of intertidal mudflats and an algal mat community extending from the southern boundary and continuing into the Fortescue River Delta. Some samphires occur surrounding the algal mat in the south of the LAU; and
    - No mangrove BCH are present.
- LAU2:
    - Intertidal BCH area (5,784 ha/57.84 km^2);
    - North-eastern boundary is determined by the northern extent of mangrove BCH and runs adjacent to the project footprint prior to where algal mat BCH occurs to the north;
    - Eastern boundary typically follows the western extent of samphire communities prior to the low lying supratidal algal mat community occurs;
    - BCH consists of mangrove and samphire BCH surrounding an unknown, considerably sized creek system behind primary foredune in the north which makes way for a series of smaller creeks lined with fringing mangroves interspersed by samphire communities; and
    - Mangrove BCH typically declines with distance south.
- LAU3:
    - Intertidal BCH area (4,450 ha/44.50 km^2);
    - Western border aligns with the western extent of the large algal mat community from the north to the southern border;
    - Eastern border runs adjacent to the project (northern half) and the western extent of intertidal BCH (southern half); and
    - LAU characterised by a low-lying area of contiguous algal mat which extends along the western boundary and increases in width with distance south. This is flanked

by supratidal mudflats along the eastern extent which make way for samphire BCH communities mixed with terrestrial communities in the central east and terrestrial vegetation in the south.

- LAU4:
  - Intertidal BCH area (4,724 ha/47.24 km^2);
  - Coastline forms a shallow embayment and intertidal delta;
  - Southern boundary is aligned to the Robe River Regionally Significant Mangrove Area and (approximately) with the Peter Creek East / Robe River Secondary Coastal Compartment boundary;
  - BCH is similar to LAU 1, however tidal creek systems become increasingly complex in the south and support more extensive mangrove communities which are interspersed by samphire communities;
  - Mangrove BCH of generally of better quality in the south associated with the delta formation; and
  - Small portion of LAU area historically affected by DomGas Pipeline.
- LAU5:
  - Intertidal BCH area (9,171 ha/91.71 km^2);
  - Western boundary follows extent of contiguous algal mat from northern border and supratidal BCH to the southern border;
  - Eastern boundary follows the Project envelope;
  - Similar characteristics as LAU2 however, the intertidal zone extends further from coast, the proportional extent of mudflats is greater and algal mats lower and samphire communities occur only at the southern border;
  - Eastern boundary is flanked by terrestrial vegetation along the entire boundary; and
  - Small portion of LAU historically affected by DomGas Pipeline.
- LAU6:
  - Intertidal BCH area (6,181 ha/61.81 km^2);
  - Located entirely within the Robe River Regionally Significant Mangrove Area;
  - Borders the northern extent of a coastal dune system in the west and the Robe River Regionally Significant Mangrove Area boundary in the east;
  - Eastern boundary also aligns with the Peter Creek East / Robe River Secondary Coastal Compartment boundary;
  - LAU excludes all tributaries and mangrove areas of the Robe River; and
  - Mangrove BCH represents the best quality across the LAU.
- LAU7
  - Subtidal BCH area (7,574 ha/75.74 km^2);
  - Extends from the foreshore mudflat at the Lowest Astronomical Tide Line (southern boundary) to approximately the 8 m Isobath (northern boundary);
  - Eastern boundary of the LAU is aligned to the western boundary of the Fortescue River Regionally Significant Mangrove Area;
  - Western boundary of the LAU is aligned to the change in aspect of the coastline from NNW to NW;
  - LAU is characterised by gently sloping, bare silt / sand substrate with areas of low relief, sand veneer over limestone pavement, which typically support sparse to moderate cover of filter feeders, macroalgae, seagrass and coral species; and

- LAU specifically excludes BCH associated with the nearshore islands, which tend to support more diverse and better-quality coral and macroalgal BCH communities than is present within the LAU.

Additional information is provided in the BCH Cumulative Loss Assessment Report (O2 Marine, 2020c), which is included Appendix 2.1.

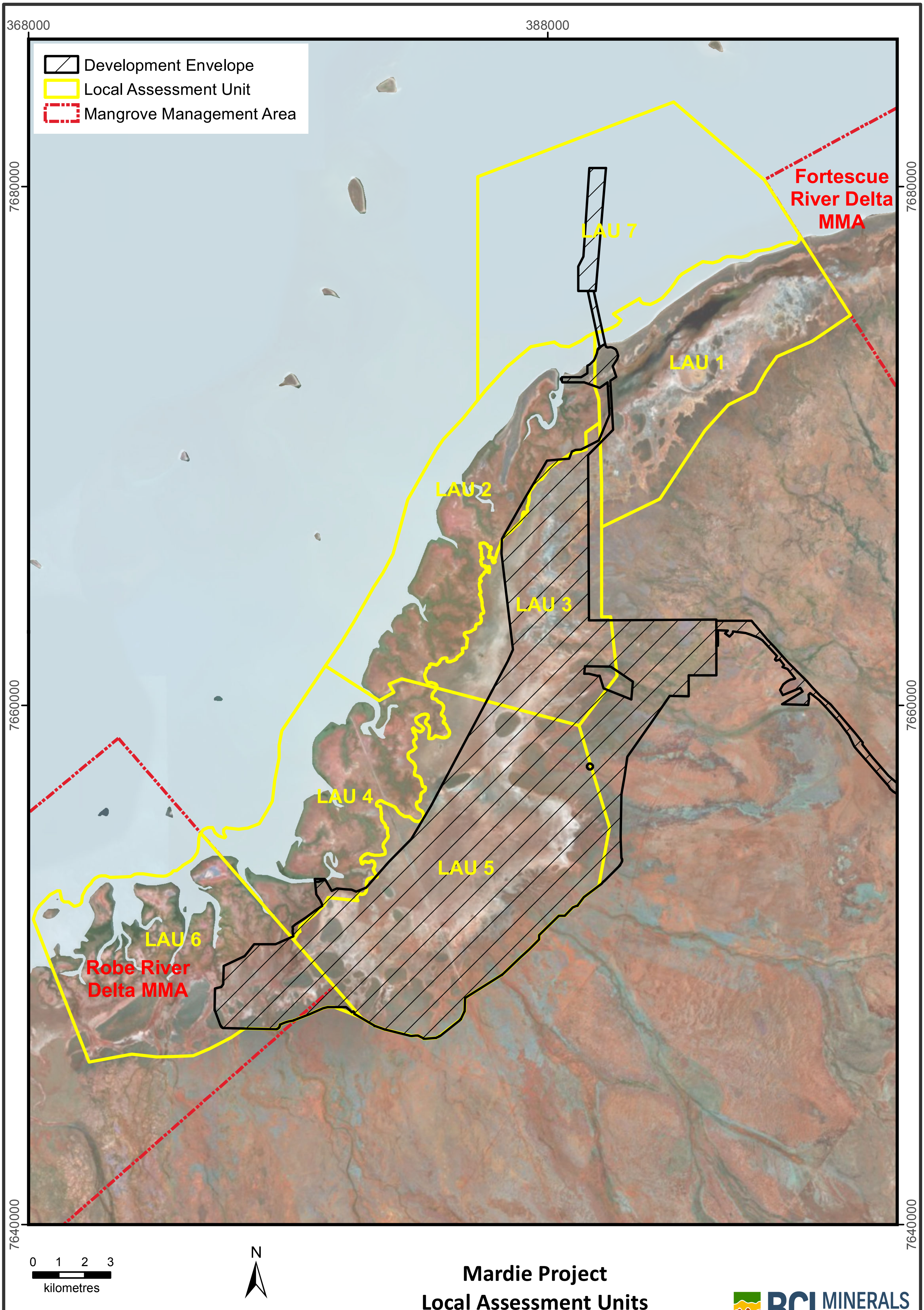


Figure 70: Boundaries of Local Assessment Units

7.3.6 Intertidal Benthic Communities and Habitat Summary

The term 'Study Area' in this section refers to the combined boundary of LAU 1 – 7.

The intertidal BCH surveys identified seven broad habitat classes within the Study Area. The distribution of each intertidal BCH habitat type within the Study Area and each proposed LAU are presented in Table 17 and shown on Figure 71.

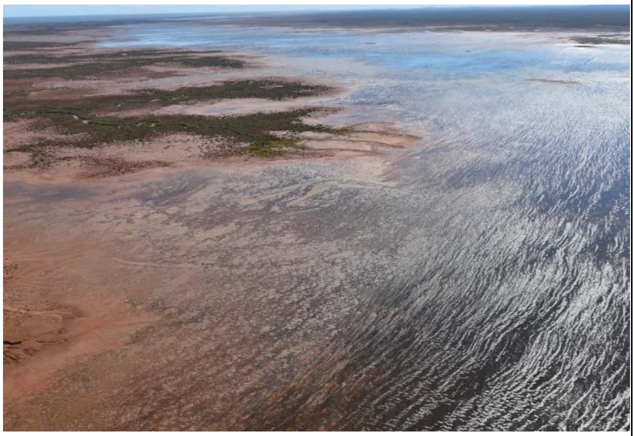
Table 18 provides a description of each BCH category within the Study Area.

Table 17: Area of the intertidal benthic communities and habitat within each LAU

BCH Class		LAU 1	LAU 2	LAU 3	LAU 4	LAU 5	LAU 6	LAU 7	TOTAL
		ha (%)	ha (%)	ha (%)	ha (%)	ha (%)	ha (%)	ha (%)	ha (%)
Total area of LAU		5392 (12%)	5,784 (13%)	4,450 (10%)	4,724 (11%)	9,171 (21%)	6,181 (14%)	7,574 (18%)	**43,277 (100%)**
Algal mat		857 (16%)	0 (0%)	1,300 (29%)	0 (0%)	1,259 (14%)	43 (1%)	-	**3,459 (10%)**
Foreshore mudflat / tidal creeks		401 (7%)	2,133 (37%)	0 (0%)	1,596 (34%)	0 (0%)	833 (14%)	-	**5,014 (14%)**
Mangroves (Closed Canopy)	*A. marina* (Seaward edge)	0 (0%)	95 (2%)	0 (0%)	113 (2%)	0 (0%)	116 (2%)	-	**325 (1%)**
	R. stylosa (Behind Am)	0 (0%)	2 (0%)	0 (0%)	28 (1%)	0 (0%)	135 (2%)	-	**164 (<1%)**
	R. stylosa / A. marina (Closed canopy mixed)	0 (0%)	37 (1%)	0 (0%)	77 (2%)	0 (0%)	177 (3%)	-	**291 (1%)**
	A. marina (Landward edge)	0 (0%)	79 (1%)	0 (0%)	151 (3%)	0 (0%)	273 (4%)	-	**503 (2%)**
Mangroves (Scattered)	*A. marina* (Scattered)	0 (0%)	750 (13%)	0 (0%)	751 (16%)	0 (0%)	827 (13%)	-	**2,327 (7%)**
Rocky Shores		0 (0%)	6 (0%)	0 (0%)	0 (0%)	0 (0%)	53 (1%)	-	**59 (<1%)**
Samphire / samphire mudflats		149 (3%)	2,030 (35%)	264 (6%)	1,533 (33%)	471 (5%)	1,546 (25%)	-	**5,993 (17%)**
Sandy beaches		22 (<1%)	10 (0%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)	-	**32 (<1%)**
Mudflat / saltflat		2,260 (42%)	339 (6%)	2,069 (46%)	429 (9%)	4,775 (53%)	636 (10%)	-	**10,509 (29%)**
Previously cleared areas		0 (0%)	0 (0%)	0 (0%)	46 (1%)	164 (2%)	0 (0%)	-	**210 (<1%)**

BCH Class	LAU 1	LAU 2	LAU 3	LAU 4	LAU 5	LAU 6	LAU 7	TOTAL
	ha (%)	ha (%)	ha (%)	ha (%)	ha (%)	ha (%)	ha (%)	ha (%)
Other terrestrial habitats (included for information purposes)	1,702 (32%)	304 (5%)	817 (18%)	0 (0%)	2,502 (28%)	1,496 (24%)	-	**6,820 (19%)**

Table 18: Description of broad intertidal BCH classes mapped within the Study Area

Habitat Class	Example Image
Algal Mat Algal mats are typically green to grey or black, and either contiguous or fragmented. 11 species were identified with filamentous cyanobacteria *Microcoleus* sp. and *Lyngbya* sp. the dominant species. Algal mat communities extend over 3,400 ha and comprise 10% of the total mapped intertidal BCH area. They predominantly occur in two major communities within the central and northern sections of the Study Area. They occur within a relatively nominal elevation of 1.1 – 1.3 m AHD which is lower than the adjacent seaward BCH where they form vast shallow lakes at high tides (>1.2m).	
Foreshore Mudflat/Tidal Creek A variety of benthic habitat types from flat fine to coarse sands, flat mud, sparse to high macroalgae, and low to moderate seagrasses were identified occurring within Foreshore Mudflats/Tidal Creeks. Foreshore Mudflats/Tidal Creeks occur over 5,000 ha and comprise 14% of the total mapped intertidal BCH area. Tidal creeks are typically well established within the southern LAUs (Robe River Delta) and become sparser in the northern LAUs. Foreshore mudflats extend over a wider area through the central LAUs with subtidal area much closer to the coastline in the northern and southern LAUs.	
CC Mangroves CC mangroves comprise the greater structural complexity, typically higher seaward mangrove associations. *Avicennia marina* dominate the species with *Rhizophora stylosa* the sub dominant species. CC mangrove communities extend over 1,280 ha and comprise 4% of the total mapped intertidal BCH area. They are very well established within LAU 6, with over 46% of their total area represented. CC mangroves occur as ribbons along the coastline and fringing tidal creeks, with more vast forest occurring within the southern LAU, particularly LAU 6 within the boundary of the Robe River Delta.	

Habitat Class	Example Image
SC Mangroves SC mangroves comprise the least structural complexity, typically lower landward mangrove associations. *Avicennia marina* dominate the species with *Ceriops australis* also observed. SC mangrove communities occur over 2,300 ha and comprise 7% of the total mapped BCH area. SC mangroves are the most extensive mangrove functional groups representing over 64%. They are typically located on the landward extents extending over wide intertidal mudflat areas with the largest areas occurring in LAU 2, LAU 4 and LAU 6.	
Rocky Shoreline Rocky shorelines within the Study Area were typically low relief rock platforms generally with little to low associated flora and fauna. Macroalgae were identified as the dominant communities with minimal juvenile hard corals, oyster stacks and some soft corals also present. Rocky shorelines occur over 59 ha comprising <1% of the total mapped BCH area. They are only located within LAU 2 and LAU 6.	Not available.
Samphire/Samphire Mudflat Samphire/Samphire Mudflats are distributed over more than 5,900 ha, comprising approximately 17% of the mapped intertidal BCH. They are typically located on the landward extent of mangroves, whilst through the centre of the Study Area are on the seaward extent of algal mats, with a smaller communities in LAU 1 and LAU 3 seaward of terrestrial vegetation. By area they are the greatest in LAU 2 and lowest in LAU 1.	
Mudflat/Saltflat Mudflat/Saltflats are extremely low in biodiversity and support little to no associated fauna or flora due to their characteristic high salinities. Mudflat/Saltflats are the dominant intertidal BCH extending over 10,500 ha and comprising 29% of the total mapped BCH area. They are most dominant through the supratidal LAUs (3 & 5) representing over 83% of their total distribution. They typically occur on the higher intertidal gradients on the landward extent of Samphire's or Algal Mats.	

Habitat Class	Example Image
Sandy Beach Sandy beaches are typically flat, low energy, low profile beaches backed by gently rising dunes. Sandy beaches are only located within LAU1 and LAU 2 representing 32 ha in total and comprising <1% of mapped BCH. They are found extending from the northern extent of LAU 1 into the northern LAU 2 they continue along the coast for approximately 2.5 km west of the northernmost creek mouth.	

Mudflats / saltflats constitute the largest BCH habitat type by area within the Study Area, followed by samphire / samphire mudflats, with sandy beaches comprising the smallest.

A decreasing trend was identified in the relative composition of algal mat and mudflats / saltflats habitats corresponding with increasing mangrove and samphire / samphire mudflats habitats from the north (LAU 1) to the south (LAU 6). Comparably, the proportional area of foreshore mudflat / tidal creek habitat remains relatively consistent across the western LAUs ranging from approximately 14% in LAU 6 to 37% at LAU 2. Rocky Shore communities only occur in LAU 2 and LAU 6, and Sandy Beaches were mapped in LAU 1 only. All other BCH types are present across the six intertidal LAUs.

For the purposes of this ERD, sand dune, spinifex sandplains, samphire / samphire mudflats and mudflats / salt flats were also considered in the context of terrestrial flora and vegetation where applicable to that factor (Section 9).

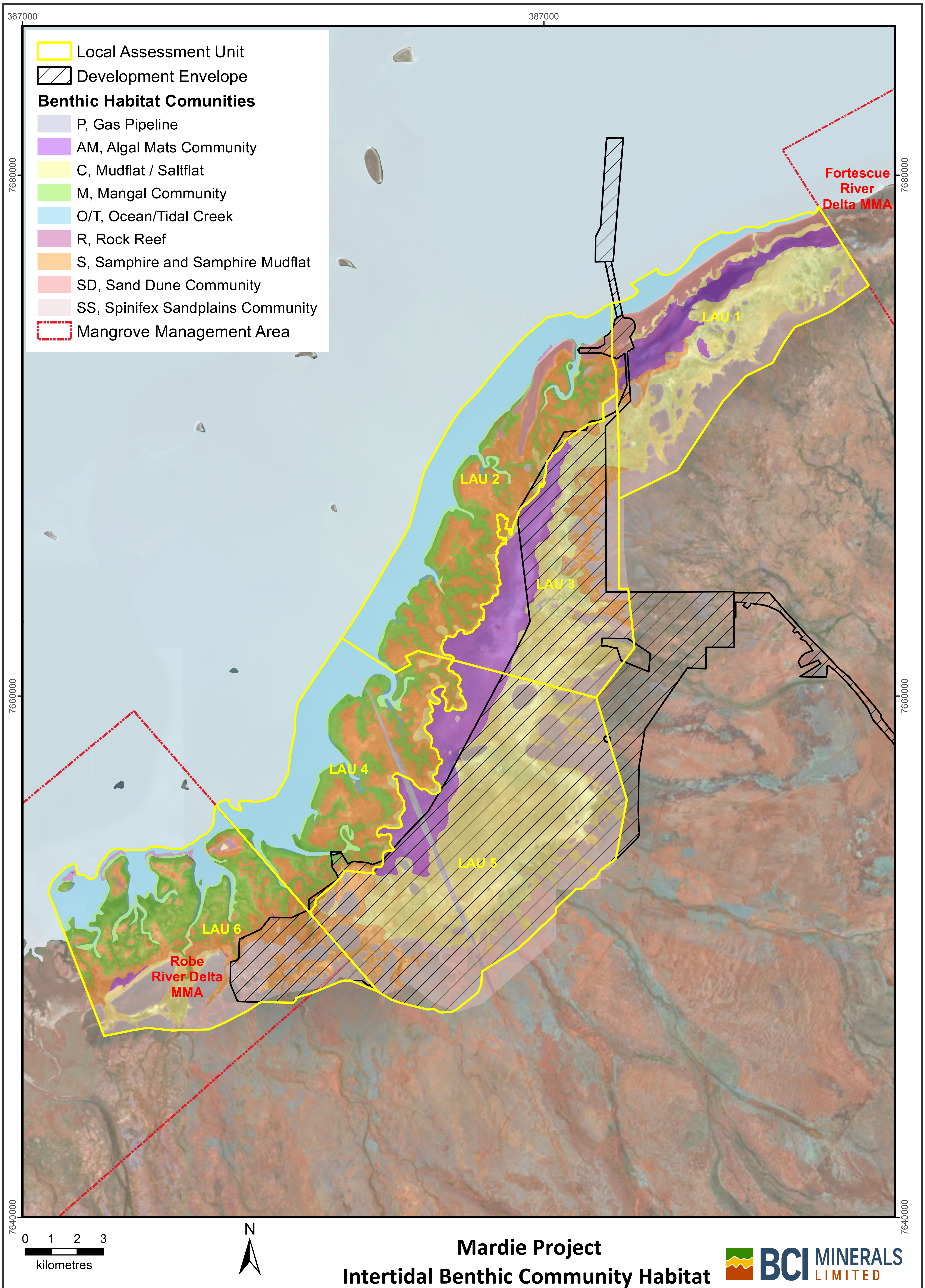


Figure 71: Intertidal benthic communities and habitat within the LAUs

7.3.7 Mangroves

Distribution

Seven species of Mangroves are known to occur within the Pilbara region (EPA, 2001). Of these, three species representing two families were identified during surveys undertaken by Stantec and O2 Marine. These included:

- *Avicennia marina* (Avicenniaceae);
- *Ceriops australis* (Rhizophoraceae); and
- *Rhizophora stylosa* (Rhizophoraceae).

Mangrove habitat was further mapped into five dominant vegetation associations in accordance with Paling *et al.* (2003) (Table 19). Mangrove distributions and associations are presented in Figure 72 and the calculated areas for each association type occurring within the Study Area and as a percentage of the total mapped area is presented in Table 20.

Table 19: Mangrove classifications and the description used to prepare mangrove association maps

Code	Classification	Description
Am1	*A. marina* (Seaward edge)	Typically closed canopy cover and usually big, spreading trees and often with limbs that bend down onto the substrate - this is usually only a few 10's meters wide and backed by *Rhizophora* (Rs either in a monospecific stand or mixed association with Am).
Rs	*R. stylosa* (behind Am)	Typically closed canopy and dense, often just tens of metres wide and may extend as fingers into the landward Am where there are narrow shallow tidal channels.
Rs/Am	*R. stylosa / A. marina* closed canopy mixed	This is usually a transition zone between the Rs monospecific stands and the monospecific stands of the landward edge Am closed canopy. *R. stylosa / A. marina* (closed canopy, mixed) was allocated where either species contributed approximately between 20 - 80% of the mangrove stand.
Am2	*A. marina* closed canopy (Landward edge)	Typically the largest area of mangrove association and comprises trees that show a decline in height moving from seaward to landward.
Am3	*A. marina* scattered	The point where Am landward edge displays canopy gaps and these gaps eventually become larger in total area than the surrounding Am. Individual scattered mangroves were excluded if tree density was approximately less than 5 trees per 100 m^2.

Table 20: Total area of mapped mangrove associations within proposed LAUs

Mangrove Association	LAU 1 (ha)	LAU 2 (ha)	LAU 3 (ha)	LAU 4 (ha)	LAU 5 (ha)	LAU 6 (ha)	LAU 7 (ha)	Total Area (ha)
Am1 (Seaward Edge)	0	95	0	113	**0**	116	-	**325**
Am2 (Landward)	0	2	0	28	**0**	135	-	**164**
Rs (Behind Am)	0	37	0	77	**0**	177	-	**291**
Mixed Rs/Am	0	79	0	151	**0**	273	-	**503**
Am3 (Scattered)	0	750	0	751	**0**	827	-	**2,327**
Total	**0**	**963**	**0**	**1120**	**0**	1528	-	**3,610**

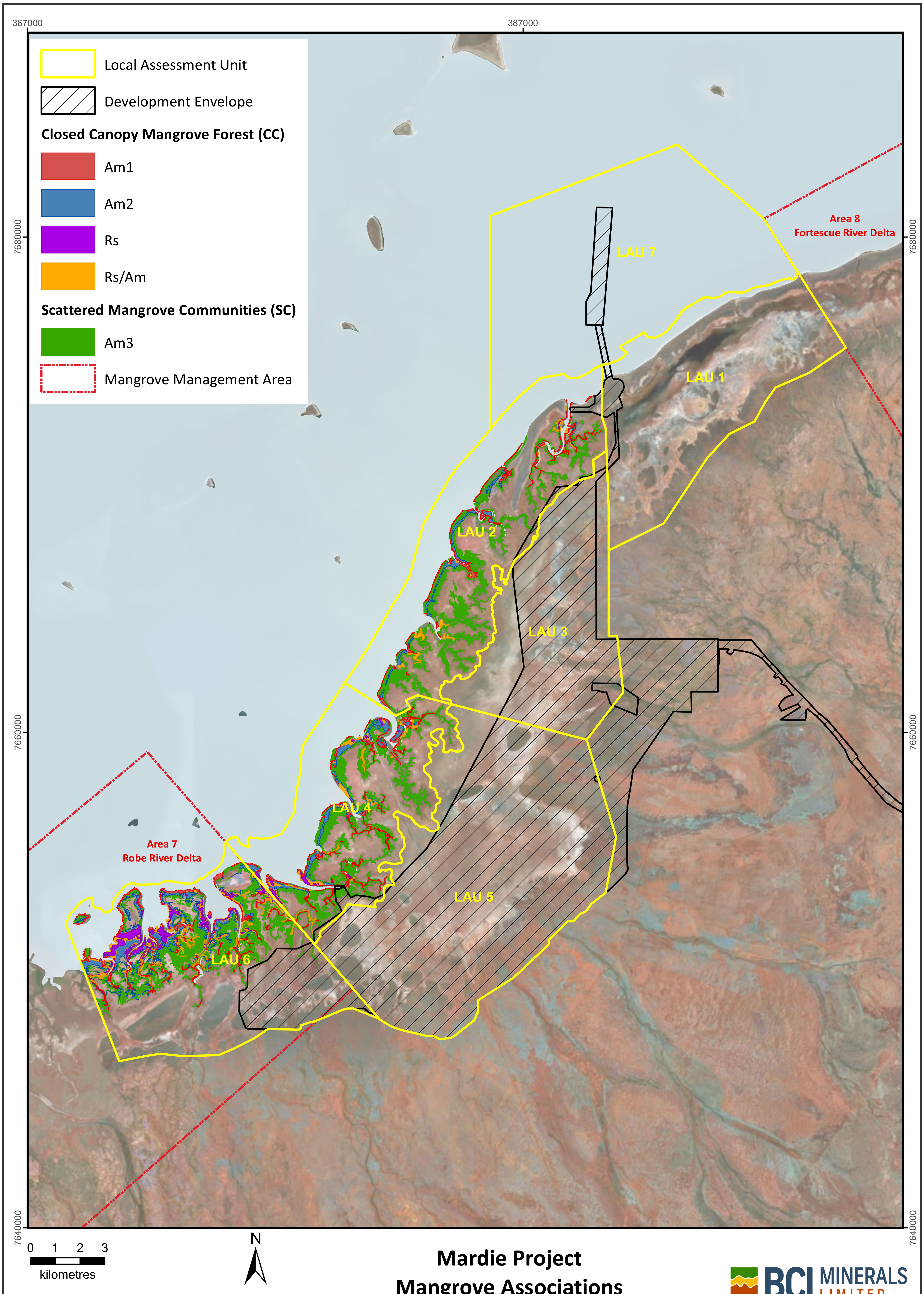


Figure 72: Mangrove associations within the Study Area

Mangrove assemblages are present within all coastal LAUs except LAU 1. A. *marina* dominated associations (Am1, Am2 and Am3) by far comprising the greatest spatial extent covering over 3,150 ha or 87% of the mapped mangrove BCH area. The Am3 (Scattered) association dominates the landward fringe comprising 64% of the total area of mangroves, followed by 14% for Am2 (Landward) and 9% for Am1 (Seaward Edge). The mixed association comprising Rs/Am occupies 8% of the total area of mangroves and the Rs (Seaward) association occupies 5% of the total Study Area.

Approximately 42% of the total mapped mangrove habitat occurs within LAU6, which is located within the Robe River Delta significant mangrove area. Comparably, 27% and 31% of mangrove habitats occur within LAU2 and LAU4, respectively. Key characteristics across the regional area from north to south identifies decreasing trends in the relative composition of Am1 (Seaward) and Am3 (Scattered) corresponding with increasing Am2 (landward), Rs (behind Am) and Mixed (Rs/Am).

Each mangrove association is present within each of the three LAUs, with Am3 (Scattered) the dominant association by area within each. Am2 (Landward) extends over the second largest land area in LAU 4 and LAU 6, while Am1 (Seaward) is the second largest within LAU 2. Association Rs (Behind Am) and Mixed Rs/Am extend over their largest mapped area within LAU 6 and the least within LAU 2.

Am1 (Seaward Edge) distribution

Am1 mangrove associations occur throughout the Study Area comprising 9% of the total mapped mangrove area. The distribution of Am1 within the Study Area is typically associated with major tidal creeks where they occur in narrow ribbons generally limited to the lower or middle reaches. They are also found along certain areas of the coastal shoreline between tidal creek systems, particularly in the southern and central sections of the Study Area. These locations directly adjacent to permanent tidal creek or oceanic waters provide greater soil salinity regulation, thus supporting larger and denser *A. marina* communities than Am2 or Am3 assemblages (Paling *et al* 2003, URS 2010a).

Am2 Closed Canopy (Landward Edge) distribution

Am2 mangrove associations are most widely distributed in the southern section of the Study Area, forming 18% (273.2 ha) of mangrove BCH in LAU 6, and become more limited in their extent further north forming only 8% (79 ha) in LAU 2. Am2 comprise approximately 14% of the total mapped mangrove area regionally. Am2 communities are predominately located extending landward behind the taller and larger associations (Am1 and mixed Rs/Am) across tidal flats, often forming quite widespread forest, particularly within LAU 4 and LAU 6. Am2 associations also occur in smaller, scattered pockets, fringing the mid to upper reaches of tidal creeks. On the landward edge Am2 associations were strongly associated with Am3 communities, often becoming integrated where they meet.

Am3 (Scattered) distribution

Am3 are the dominant mangrove community type occurring over the greatest mapped mangrove BCH area and dominant within every LAU. Am3 comprise 64% of the total mangrove area with the highest relative composition found in LAU2 (78%) and the lowest in LAU6 (54%). This mangrove association generally occurs in widespread areas associated with the higher reaches of drainage systems and the landward edge of the mapped mangrove extent. They are often integrated with Am2 communities on the seaward edge and samphire communities towards the landward edge where they often share an overlap between distinctly defined habitats. The qualitative canopy condition analysis was observed as 'healthy' among all sites with a general condition of 'juvenile trees' noted many sites, particularly where proposed saltwater intake and export facilities are located. Being located at the landward edge of mapped mangrove habitat Am3 are exposed to reduced tidal inundation frequencies which regulate soil salinities and these communities are existing at the extreme end of their salinity range (Paling *et al.,* 2003).

Mixed Rs/Am distribution

Mixed Rs/Am are mostly found occurring in the southern section of the Study Area with over 60% of their total area located within LAU 6. The mixed Rs/Am associations extend over 8% of the total mapped mangrove area, forming the greatest area (12%) within LAU 6 and the lowest area (4%) in LAU 2. Mixed Rs/Am are regularly located adjacent to Rs and Am1 assemblages across the site, particularly in the southern locations whereby a diverse range of BCH occurs with frequent tidal inundation and soil and groundwater salinities required for *R. stylosa* to occur.

Rs (Behind Am) distribution

Rs mangrove associations are the lowest represented association within the Study Area comprising less than 5% of the total mapped mangrove area. Rs is mostly located within LAU 6, with over 82% of their distribution occurring here. Rs forms <1% of mangrove BCH within LAU 2. Similarly to Am2, Rs communities are typically located extending landward over tidal flats forming dense and widespread forest or fringing tidal creeks in the mid to upper reaches. Rs communities are also often associated with Am1 and Mixed Rs/Am communities, occurring directly behind on the landward edges of their extent. As with the Mixed Rs/Am these communities typically occur in the southern locations where suitable habitats are available to support their establishment.

Mangrove Biomass

Sites within 'regionally significant' mangrove areas (Robe River and Fortescue River Deltas) were typically identified to support less dense, but taller and thicker trees which comprise a higher or comparable canopy cover to that recorded within mangrove sites in the Study Area. The reduced tree density within the Robe River Delta is likely associated with a higher proportional composition of multi-stemmed *R. stylosa* trees than found within other sites, whereas the Fortescue River Delta site is dominated by tall, thick *A. marina* trees which are broadly spatially dispersed. *A. marina* trees were typically thicker than *R. stylosa* resulting in higher above-ground biomass recorded for *A. marina* trees within quadrats. Therefore, less variation was associated with the above-ground biomass recorded for *R. stylosa* trees throughout sites and the highest above-ground biomass was calculated for quadrats containing tall/thick diameter *A. marina* trees within 'regionally significant' mangrove areas.

A. marina trees surveyed during the December survey were typically associated with Am3 associations and were generally characterised by low canopy heights, few trees and low AGB. Average DBH measurements for each proposed LAU were typically small indicating either juvenile trees or restricted, stunted growth. Only a single mangrove species (*A. marina)* was identified within quadrat locations during the December survey, however, general observations noted the presence of *Cyriops australis* at sites D11 and D42. *C. australis* was observed at these sites occurring in association with *A. marina* to form an open scrub along the landward extent of the mapped and surveyed mangrove habitat, as was observed and reported by LeProvost Environmental Consulting (1991) and URS (2010a) in surveys undertaken between Tubridgi Point and Four Mile Creek, south of Onslow.

Comparison of the functional groups identified in Table 19 identifies a distinct and significant dissimilarity between total calculated AGB between CC and SC mangrove communities as well as regionally across the Study Area. The regionally significant Robe River Delta (LAU 6) was identified to support the highest calculated tonnage of above ground biomass (AGB), comprising over 62% of the total biomass, with LAU 2 containing a significantly lower AGB (11%). AGB calculated for both CC and SC presented an increasing trend in AGB with respect to distance south.

Table 21 presents the total calculated AGB for CC and SC within each LAU and the Study Area. CC mangrove assemblages account for approximately 66% of the total biomass within the Study Area, whilst only accounting for 36% of the total mapped mangrove areas. LAU 1 represents the lowest total AGB within the Study Area.

Table 21: Mean Above Ground Biomass estimates (tonnes) and percentage for Closed Canopy and Scattered Mangrove functional groups.

Mangrove functional group	LAU 2 (t)	LAU 4 (t)	LAU 6 (t)	Total biomass (t)
Closed Canopy	10,876 (43%)	31,587 (52%)	106,087 (76%)	**148,551 (66%)**
Scattered	14,347 (57%)	29,705 (48%)	34,099 (24%)	**78,151 (34%)**
Total	**25,223 (11%)**	**61,293 (27%)**	**140,187 (62%)**	**226,703 (100%)**

Factors Affecting Mangrove Distribution

Salinity Gradient

The major contributing factor for mangrove distribution is the salinity gradient (Paling *et. al.* 1993, URS, 2010). These salinity gradients are responsible for altering mangrove species distribution (through altered salt tolerances between species) and mangrove community structure (URS, 2010). Of all the Mangrove species within the Pilbara *A. marina* has the widest salt tolerance range and can occur anywhere in the salinity gradient from normal seawater (~45 ppt) to around 90 ppt (Gordon, 1988). Whilst this may be true, *A. marina* requires salinities at the lower end of their range to thrive. *R. Stylosa* typically requires salinities around 40-55 ppt, hence they are commonly located within the Study Area at the seaward margins, extending across mudflats (as found within LAU 4) with regular tidal inundation or occurring with the larger structural forms of *A. marina.* Within the Study Area the range of habitats that are conducive to regular tidal inundation occur within LAU 6 and to some extent into LAU 4, where the delta formation provides an extensive area of mudflats that can support the more structurally complex and ecologically valuable Am1, Rs and Mixed Rs/Am associations.

Hydrology

Fresh groundwater or surface water flows can be important pathways for the removal of salt extruded through mangrove roots and the removal of wastes, such as sulphides, methane etc. During extended drought periods, freshwater flows drastically subside resulting in increased salinities, particularly at the higher tidal elevations (Alonghi, 2009). The reliance of freshwater input in maintaining mangrove systems typically decreases with increasing aridity (Semeniuk, 1983; Gordon, 1988). This is particularly relevant in the Pilbara as rainfall is highly sporadic and often extended periods of drought are experienced. The Pilbara region is known to support the most arid mangrove assemblages within Australia (EPA, 2001).

Freshwater flows may also provide nutrient inputs, however this is highly dependent upon local climatology and season (Alonghi, 2009). A recent study within Exmouth Gulf concluded that freshwater inputs had a negligible influence on the regulation of salinity, nutrient flows and removal of wastes, due to the high evaporation rate, limited catchment area, low rainfall and lack of perennial rainfall (Biota, 2005). Due to the similarity of mangrove associations, climate and catchment characteristics between the Study Area and Exmouth Gulf, the same reduced reliance on freshwater inputs for maintenance on mangroves is expected, as opposed to highly seasonal tropical mangrove assemblages, existing in northern Australia.

Ecological Significance

Intertidal BCH, primarily mangroves, are well understood to play key roles in primary and secondary productivity, and nutrient and carbon cycling in coastal environments. Due to their restricted distributions worldwide, arid zone mangroves have been less extensively researched than their larger, more structurally complex and widespread tropical variants, however the importance of arid zone mangroves are still known to be high in their respective ecosystems. Mangroves provide high levels of organic matter in the form of leaf litter and are active sinks for dissolved nitrogen, phosphorous, carbon and silicon. Detritus serves as an important nutrient source and forms the basis of an extensive coastal food web. In addition, mangrove ecosystems serve as shelter, feeding, nursery and breeding zones for crustaceans, molluscs, fish, and resident and migratory birds. In a review conducted on various studies Holgium (2001) surmised that mangroves have more juvenile fish than the adjacent coastal waters, and that most of the fish in coastal waters spend some of their juvenile stage in mangroves.

The species richness of primary and secondary producers associated with arid zone algal mat and mangrove communities are low compared with tropical communities, and the variety of habitats is also more limited. This net result is a comparably low level of biodiversity, although abundance of associated fauna can be very high. Many studies have identified higher rates of catches for many commercial species of fishes and prawns in areas adjacent to mangroves, as opposed to those in other coastal areas due to the high primary and secondary productivity (Holgium *et. al*., 2001). Mangroves are also an important source of primary production for many species which only temporarily (juvenile fish and crustaceans) or seasonally (migratory birds) utilise mangrove communities.

The Pilbara has a lower mangrove species richness occupying a reduced variation of assemblages than those in the Kimberley region, and accordingly associations are far less complex (URS, 2010). The Pilbara has tropical arid climate, with lower tidal variations and whilst there are some major creeks, typically they are much smaller, and estuaries are poorly developed. Additionally, the intertidal characteristics are remarkably different between the Kimberley and Pilbara regions, with the Pilbara region being characterised by large expanses of mudflats/saltflats and algal mats along the landward margins of intertidal zones. Similar areas in the Kimberly are typically associated with several species of mangrove, which due to hypersaline conditions are absent in the Pilbara.

The O2 Marine survey identified three of the seven known mangrove species within the Pilbara coastline, with previous surveys identifying an additional two species. None of the observed species are identified as being of national or international significance and are typically widely distributed.

7.3.8 ALGAL MATS

Species Diversity

Preliminary mapping surveys undertaken by Stantec (2018) identified algal mat communities as either contiguous or fragmented. Contiguous algal mats were described as extensive, thicker (1 - 5 mm) and more cohesive, characterised by a smooth appearance (Stantec 2018). Fragmented algal mats were thinner (1 – 3 mm) and patchier, often appearing pustular (Stantec 2018). Stantec (2018) identified 11 taxa recorded within algal mat samples collected, dominated by filamentous cyanobacteria. Comparable composition of taxa was identified between contiguous and fragmented communities, and little variation among assemblages was evident across the entire Stantec Study Area.

Stantec (2018) considered that the algal mats surveyed within the intertidal zone are representative of algal mat habitats assessed through studies occurring in similar sites within the Pilbara region, including Exmouth Gulf and south of Onslow.

Distribution

Algal mat communities occur over 3,400 ha and comprise 12% of the total coverage of BCH within the intertidal LAUs. They were identified to occur within a relatively nominal elevation of 1.1 - 1.3 m AHD (Stantec, 2018). Algal mats typically occur adjacent to samphire/samphire mudflats on the seaward edge and mudflat/saltflats on the landward edge. There are two primary communities of algal mat extending through the centre of the study area (Figure 71). Algal mats are most abundant within LAU 1 and LAU 3 comprising slightly over 2,150ha or 62% of their total area, whereas within LAU 2 and LAU 4 the coverage of algal mat is less than ha (1%).

The contiguous algal mats were identified as the larger of the two communities described above, existing in the central and northern sections of the Study Area (Figure 71). The smaller communities occurring within the southern extent of the Study Area were considered fragmented.

<u>Factors Affecting Algal Mat Distribution</u>

Microbial mats proliferate in shallow aquatic ecosystems, including tidal flats and coastal and hypersaline lagoons because of their ability to tolerate extremes in salinity, desiccation, temperature and ultraviolet radiation (Lee and Joyce, 2006). Biota (2005) and URS (2010a) observed high salinity and dehydration as the controlling factors at the higher elevations of algal mat communities in studies along the Exmouth Gulf and Onslow Coast, respectively. These observations are considered applicable to the Proposal given the similar conditions. Mudflats/saltflats typically occur on the landward edge of algal mat communities throughout the Study Area, likely indicating the point at which maximum salinity levels are reached or exceeded. Mudflats/saltflats are characterised by very high salinity, little to no tidal inundation and are extremely dry (Biota, 2005 and URS, 2010). Grazing by invertebrates, molluscs and fish at high tides was also noted by Paling (1990) as a controlling factor in the distribution of algal mats at the lower gradient. This occurs at Mardie with grazing invertebrates associated with samphire/samphire mudflats, typically occurring on the seaward edge, contributing to algal mat extent (Stantec, 2018).

Whilst salinity and predation mechanisms are thought to impact distributions, uniquely, the two large algal mat communities occurring within the Study Area are located in lower lying areas than the seaward BCH communities. This has created a unique environment whereby tidal creeks essentially drain into the algal mat communities, and when tides recede water remains over the algal mats for some time. This typically results in a shallow water level remaining during spring tidal cycles which are then exposed to periods of around 7 - 10 days whereby no tidal inundation would occur. This cycle results in a continuous saline water source entering the algal mat communities, whereby exposure to intense evaporation results in the algal mats experiencing frequently changing and extremely high salinity levels.

Assessment of the extent of cyanobacteria mats is challenging due to a lack of knowledge about the factors that control their distribution. What is known suggests substantial variability in the extent of mats on an interannual basis, driven primarily by rainfall, which makes mapping difficult and introduces doubt over long terms estimations of areal coverage (O2 Marine, 2020a).

7.3.9 Mangrove and Algal Mat Ecological Relationship

Mangrove Communities

Mangrove communities are recognised as highly productive ecosystems that provide large quantities of organic matter to adjacent coastal waters. Recent research has identified primary productivity of tropical Mangroves as rivalling those of tropical terrestrial forests, however Alongi (2009) concluded that not all mangrove habitats are highly productive, particularly arid zone or those stunted, sparse association types typical of landward associations (i.e. SC communities). Mangrove leaves and wood consist mainly of lignocellulose components that are degradable by microorganisms. Degradation of fallen mangrove vegetation starts immediately after its colonization by fungi and bacteria, and may last for 2 – 6 months, or more for degradation of the wood. The degradation of mangrove vegetative material produces detritus, which is rich in energy and contains a large active microbial population (Holgium *et. al.*, 2001). As well as being an important food source, Boto and Bunt (1981, 1982) estimated that up to 46% of the primary productivity of an Australian mangrove ecosystem was exported to coastal waters through tidal movement as particulate organic matter.

The main source of primary productivity in the Study Area are the seaward CC mangrove associations as these were calculated to have the greatest biomass of all habitat types, and therefore represent the highest ecologically valuable habitat within the Study Area.

Primary productivity within mangrove habitats is not just limited to the mangrove trees themselves, many studies have also investigated the microbial activity of associated soils. Soils in which mangroves grow are typically composed of thick organic matter mixed with sediment, are anaerobic except for the sediment surface, and supports highly productive microphytobenthos which fix significant amounts of nitrogen. The higher the above-ground biomass (AGB) associated with the mangrove community, the higher the associated microbial activity. Therefore, as with AGB related to nutrient export, the CC mangroves also support a far greater net primary productivity of associated microbial activity.

Other primary producer sources occurring within mangrove communities are epiflora and bacteria residing on vegetation or detritus and tidal phytoplankton imported from coastal waters. The magnitude of organic matter exported from mangrove areas depends on the biomass and extent of the mangrove ecosystem, the frequency and duration of tides, the size of the draining channel(s), the frequency and magnitude of rains, and the inflow of fresh water. In the Pilbara the main export mechanisms is essentially tidal movements due to low rainfall.

Nitrogen-fixing Cyanobacteria

Many studies have inferred the importance of algal mats as an important nutrient source in Pilbara intertidal BCH through their nitrogen-fixing properties in an otherwise nitrogen deficient system (Paling et al., 1989, Paling and McComb, 1994, Biota, 2005, URS, 2010, Stantec, 2018). However, there have been limited studies quantifying the indirect impacts on BCH and coastal environments due to loss, removal or degradation of these communities, particularly in tropical arid zones of the Pilbara region.

Primary productivity that occurs within algal mats is directly related to the nitrogen-fixing characteristics of the cyanobacteria that dominate the species composition within the Study Area. Whilst there are specific areas located within the Study Area assigned with the BCH type of algal mat, it is widely understood that nitrogen-fixing cyanobacteria are present within most intertidal BCH, particularly mangroves, though there is little in the literature by way of comparison of respective nutrient input loading (Pearl *et al*., 1993, Alongi, 1994, Holgium *et. al*., 2001 and Alongi, 2009). Whilst the predominately cyanobacterial algal mat communities form a higher standing biomass, the cyanobacterial communities associated with CC mangroves are likely to be higher in primary productivity (non-seasonal) and due to lower associated soil salinities also support significant secondary productivity (grazing by primary heterotrophs) and therefore play a more valuable ecological function within the system.

These algal mats, unlike mangroves or samphires, do not directly support additional sources of primary productivity within their habitats and export minimal nutrients in the form of detritus due to their physiology and associated inundation regimes. Cyanobacteria are limited in their ability to export dissolved organic nitrates and ammonia through tidal, surface or ground water exchange, and depending upon associated hydrology may be limited in their ability to support other BCH (O2 Marine, 2020a).

A soil chemistry study undertaken by Soilwater Group (2019b; Appendix 10.2) investigated the chemical properties of soils across the study site providing a comparison between Algal Mats, Mudflats/Saltflats and 'crusts' present within the study area. The results concluded the following:

- Elevated Colwell Potassium, Extractable Sulphur and Total Organic Carbon associated with the Algal Mat material, compared to the typical surface crust that forms on the mud flats, suggesting a more 'biological' component to Algal Mats;
- Algal Mat material contains appreciably higher salinity than the normal surface crust and the surrounding soils; and
- No difference in mineralised nitrogen between the Algal Mat material and the typical surface crust, and these are similar to the surrounding soils, although the mud flat soils contain appreciably higher Colwell Phosphorous.

Based on these results and the spatial distribution it would be difficult to establish a firm nutrient sharing connection between Algal Mats and Mangroves. Mangroves are likely to be able to get all relevant nutrients from the surrounding soils on the mud flat, tidal migration of nutrients from surrounding Samphires or through nitrogen fixing processes occurring within localised soils. Algal Mats may therefore represent a surface accumulation or concentration of potassium, sulphur and organic matter, and it is likely they do not influence the surrounding area (02 Marine, 2020a).

Algal mats support a limited number of grazing heterotrophs that are associated with adjacent BCH along seaward edges. During certain tides or seasons these heterotrophs migrate from their associated BCH to the edges of algal mats whereby they graze directly on the 'crust'. In terms of supported heterotroph biomass, algal mats provide these opportunistic grazers with supplementary primary productivity source and do not solely support them as opposed to mangroves or samphire BCH. Penrose (2011) undertook a study in Exmouth Gulf to investigate the potential role of nekton as transport pathways for the export of cyanobacterial mat primary production and nutrients from supratidal flats to adjacent habitats and thereby into coastal food webs. The results show a clear link between several fish species and cyanobacterial primary productivity using carbon and nitrogen isotope tracing. Evidence is presented that several species are dependent on cyanobacterial sources of carbon (Penrose, 2011). Attribution of the cyanobacterial 'mats' as the likely source of the cyanobacterial carbon (Penrose, 2011) is however, problematic because there is substantial cyanobacterial primary productivity in the adjacent habitats, where grazing prevents the formation of mats. The majority of the mats form at levels on the shore where soil salinities exclude virtually all of the grazers such as molluscs, crustaceans and especially polychaetes (osmoconformers) which have limited tolerances of high salinities. It appears that Penrose (2011) employs a much broader definition of cyanobacterial mats and includes areas much lower in the tidal zone which are classified in this report as other habitat types.

Nutrient Pathways

Whilst primary productivity within mangroves are widely understood and investigated, there is limited understanding of the direct pathways between BCH and the primary productivity associated with algal mats. Within the Study Area, the identified pathways for algal mat communities to export organic nitrogen are tidal, surface or groundwater flows or direct grazing. In comparison with samphire and mangrove BCH, the contribution from grazing would be negligible and warrants no further discussion (O2 Marine, 2020a).

Inundations studies undertaken for the Proposal have identified that algal mats occur within depressions, or at lower elevations than their seaward and landward habitats. During incoming tides (>1.2 m), oceanic water flows up through tidal creeks emptying into these depressions, however during receding tides (and dependent upon tidal height), this water becomes trapped within the depression. This remaining water either evaporates, and repeated cycles result in the high salinities which characterise this BCH or migrates down into groundwater. Tidal exchange occurring between the depression and coastal water has not been quantified, but the net flow of water back from the depression is thought to be minor, and realistically occur as a steady decant, rather than mixed flow or flush.

During large low-pressure weather systems with heavy rainfall, the surrounding catchments may fill and begin to flow through drainage channels into the Study Area. Depending upon which catchment, these flows are either directed straight through natural drainage channels and tidal creeks into coastal waters (in the southern LAUs) or into the vast depressions where algal mats occur whereby, as with tidal inflows, water becomes trapped and subject to either evaporation, or migration into groundwater.

Once water is trapped within the depressions it is only able to exit via groundwater or evaporation. Hydrogeological studies undertaken for the Proposal (Soilwater Group, 2019a; Appendix 10.1) suggest that groundwater flows are minimal to static within these depressions and the surrounding claypan type geology. It must therefore be assumed that the greatest proportion of water entering these depressions exits via evaporation, with any dissolved nutrients remaining.

Burford *et al.* (2012) concluded that supratidal algal mat production on the Norman River system potentially contributed to higher trophic levels in years when the period of inundation was sufficiently long. Periods of inundation were related to episodic floods and there were many years where there was no flooding of the supratidal flats with freshwater and consequently negligible export of carbon or fixed nitrogen to coastal waters.

As there are limited pathways available for nutrients that accumulate due to nitrogen-fixing properties within algal mat depressions, export loads are therefore considered to be extremely low, particularly when compared with the combined export associated with the more frequently inundated, expansive and connected, mangrove and samphire BCH.

Biomass and Primary Productivity

Across the Study Area there is a particular seaward to landward trend whereby BCH with the highest AGB occurs along the seaward edge and typically decreases until the BCH becomes saltflats whereby no organisms are supported. This AGB is directly related to productivity and where there is higher AGB net productivity is also at its highest, along with all the ancillary benefits these BCH provide such as erosion protection, shelter and refuge, food, nursery and breeding habitats.

Along the seaward edge CC mangrove communities represent the highest biomass across all BCH types. These communities support complex communities and regulate nutrient and carbon cycles which support wider coastal food webs. These communities are also the most structurally complex and robust, resulting and their delivery of a wide range of ecological functions that the remaining BCH types do not provide. CC mangroves support and provide shelter for a range of marine invertebrate and vertebrate communities which utilise the mangroves during high tides for breeding, feeding, shelter, as nursery areas for juvenile stages. Mangrove communities are also known to support a wide range of terrestrial vertebrates, particularly shoreline birds, whereas lower biomass BCH types do not.

As the seaward communities become more scattered, less structurally complex and support lower AGB, the level of ecological functions they provide also reduces. The ecological functionality of SC mangroves is reduced from CC mangroves; samphires represent a further reduction in functional ecology which continues through mudflats, algal mats and finally the saltflats which support no organisms or provide no productivity to surrounding BCH.

Whilst algal mats are identified to contribute, albeit vastly reduced, nutrients to support primary productivity of adjacent BCH, they do not support, nor provide any additional associated ecological functionality.

7.3.10 SAMPHIRE / SAMPHIRE MUDFLATS

Samphire/Samphire Mudflats are distributed over ~6,000 ha, comprising ~17% of the mapped intertidal BCH making them the sub-dominant intertidal BCH within the study area by extent. Samphire/Samphire Mudflats are associated with a wide range of both intertidal and terrestrial habitats types, commonly found adjacent to or in association with Algal Mats, Mudflats/Saltflats, Mangroves and terrestrial flora associations. Regionally, they are typically located on the landward extent of Mangroves, whilst through the centre of the study site are on the seaward extent of Algal Mats, with a smaller community in LAU 3 landward of the Algal Mats. Pockets in LAU 1 and LAU 5 also occur seaward of Mudflat/Saltflats. In LAU 6 and southern LAU 4/5 the width of the intertidal zone is reduced and instead of mudflats/saltflats being the dominant BCH, a vast area of samphire occurs extending from the mangroves to the terrestrial boundary which is interspersed with many terrestrial islands occurring within the intertidal zone. They are particularly dominant in LAU 2 and LAU 4 where they respectively occupy ~35 and ~33% of mapped area.

This BCH type varies greatly in ecological value across the mapped extent, with higher values identified with the higher cover samphires closest to the coast. Figure 73 provides an example of the higher density coastal samphire vegetation in comparison to the samphire vegetation types found further inland (Figure 74).

Figure 73: Photographs taken within coastal samphire habitats (Phoenix, 2020a; Appendix 8.1)

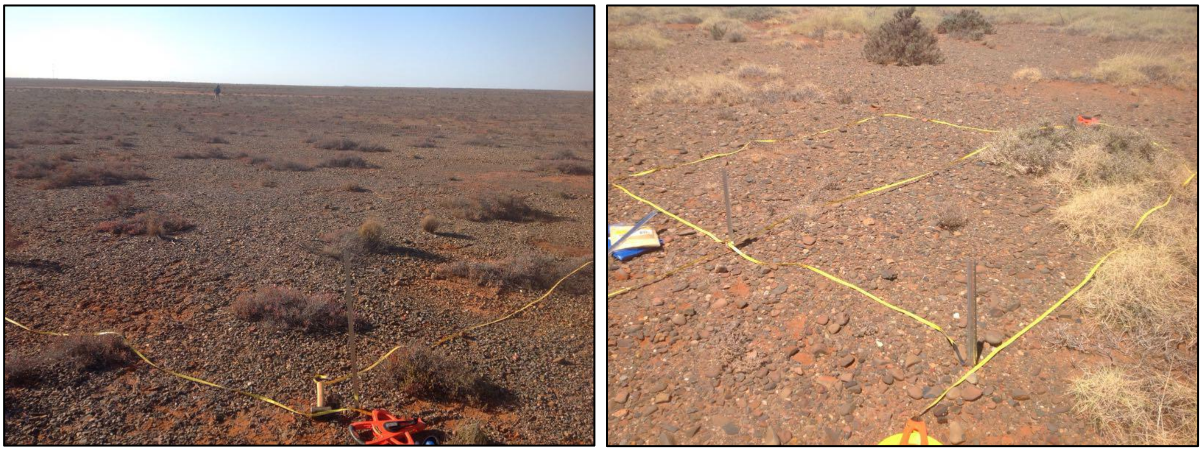


Figure 74: Photographs taken within samphire habitats further inland (Phoenix, 2020a)

Salinity is predicted to be the primary driver of this zonation (O2 Marine, 2020a). Soil salinity in the Study Area is generally predicted to increase with distance from the coast, with a clear linkage to tidal inundation frequency. In the intertidal zone tidal inundation flushes the soils of evapoconcentrated salts and maintains a consistent range of soil salinities. Soils in the upper reaches of the intertidal zone are rarely inundated and as a result the evapoconcentration of tidal waters results in hypersaline conditions. This is evident within the Study Area, where the denser coastal samphire vegetation types are inundated regularly whereas the sparser samphire vegetation types found further inland are only inundated in extreme events (refer to Section

5.3.5). Lower salinity soils also provides more suitable habitat for invertebrates, with higher numbers recorded closer to the coast where salinity is lowest (O2 Marine, 2020a).

The samphire vegetation types found further inland (SdThstEf, TaEfLv, TiTIEf, TtSvTc) also contain flora known to be terrestrial, such as *Eragrostis falcata* grasses, which range across WA and are found frequently on salt lakes and saline flats (Grant Wells pers. comm. 5 June 2019). The inland samphire communities are therefore likely to be aligned at the transition between BCH and terrestrial vegetation, and in some cases may not be considered BCH.

This separation aligns with migratory shorebird records for the Proposal (refer to Section 7), where almost all of the records are from the coastal samphire vegetation types (Figure 75 to Figure 78). It also aligns with expert advice sought from Dr Russell Hanley (O2 Marine, 2020d) which states:

> "While tidal samphires and mudflats were designated as important to migratory shorebirds and other birds by the Phoenix surveys they also report the great majority of the birds observations were in the tidal samphires to the west of the development envelope. The tidal samphires lower on the shore, closer to the mangroves and tidal creek margins had high numbers of birds relative to the areas of this habitat higher on the shore. This likely to be a consequence of lower soil salinities closer to the mangroves and tidal creeks due to more regular and longer inundation of the substrate with a corresponding increase in invertebrate infauna".

Based on the above, the inland samphire vegetation types are considered to have lower ecological value in the context of BCH and associated usage by significant fauna. Further discussion on the functional ecology, regional significance and species diversity of these vegetation types is provided within Phoenix (2020a; Appendix 8.1) and Section 9.

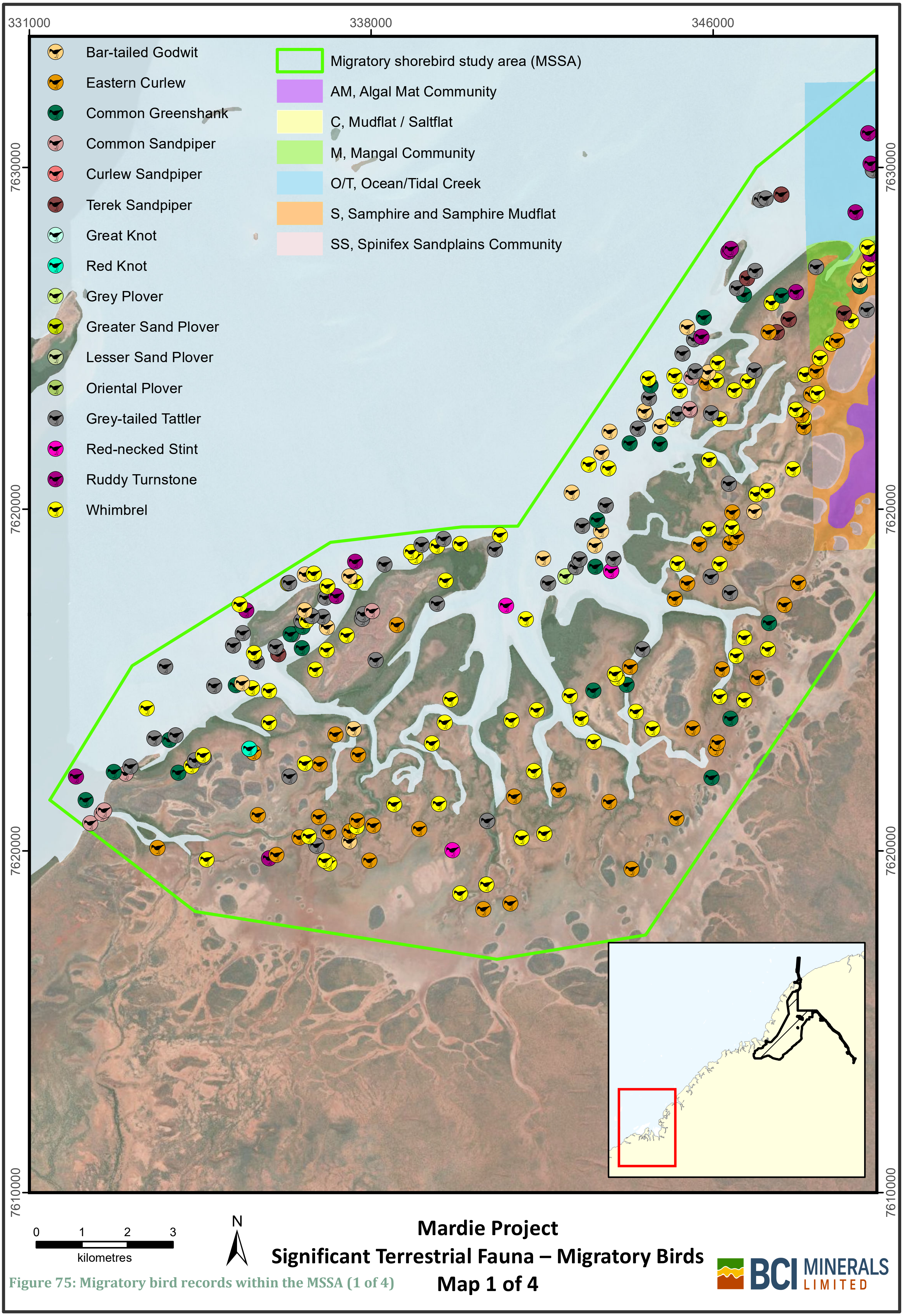


Figure 75: Migratory bird records within the MSSA (1 of 4)

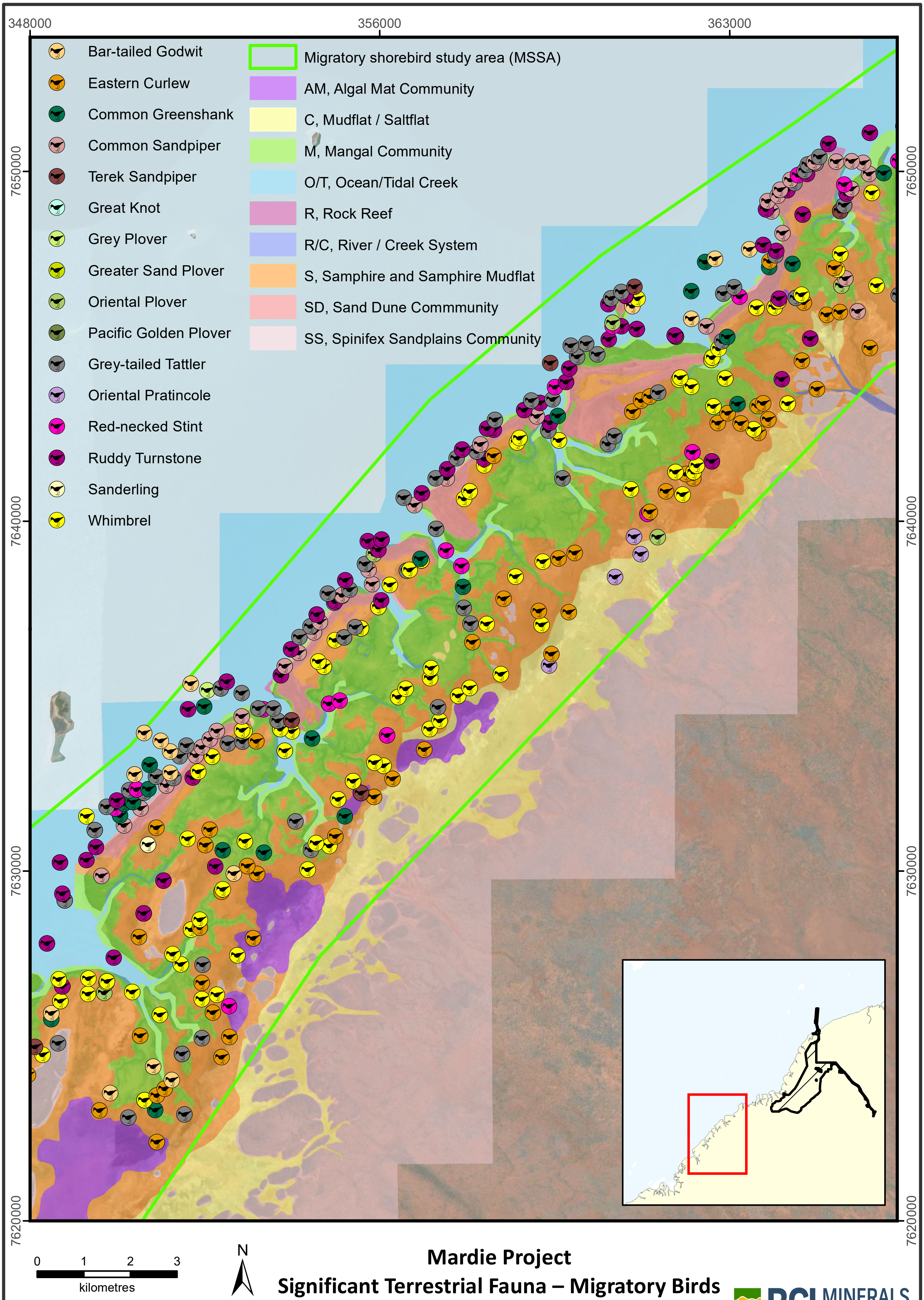


Figure 76: Migratory bird records within the MSSA (2 of 4)

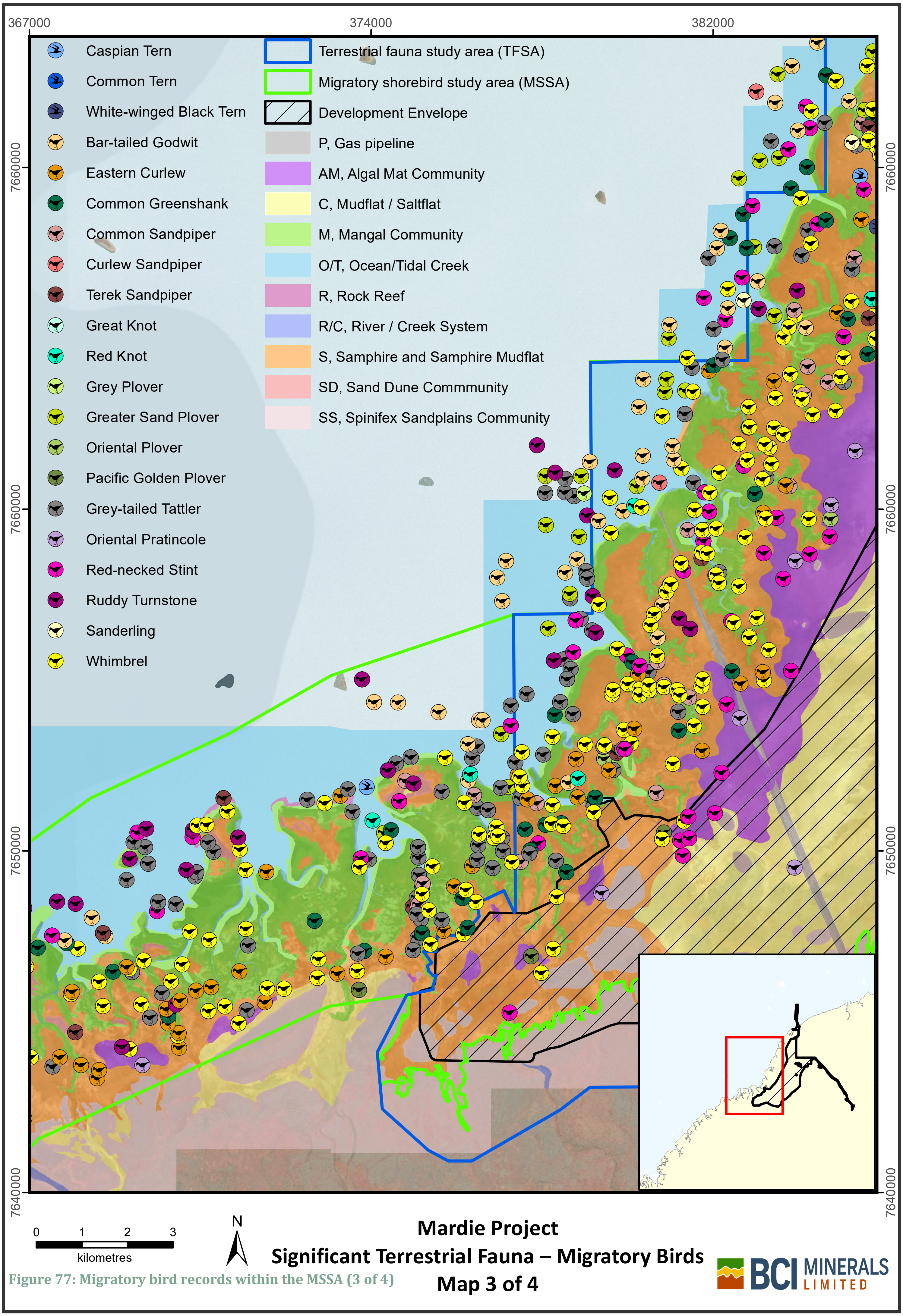
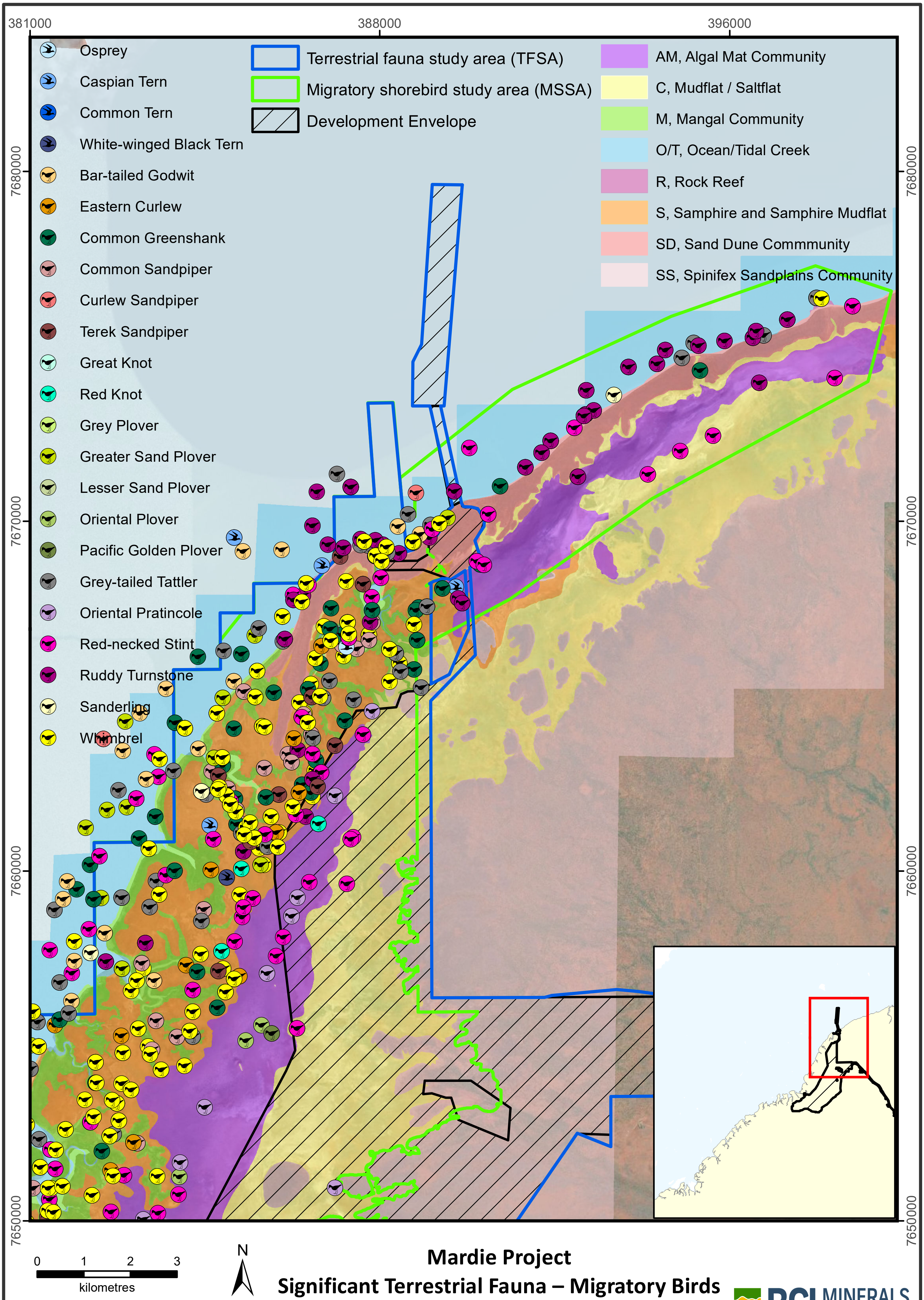


Figure 77: Migratory bird records within the MSSA (3 of 4)



Mardie Project
Significant Terrestrial Fauna – Migratory Birds
Map 4 of 4

BCI MINERALS LIMITED

Figure 78: Migratory bird records within the MSSA (4 of 4)

7.3.11 Rocky Shores and Sandy Beaches

Rocky shores and sandy beaches comprise approximately 60 ha, or less than 1%, of the total mapped intertidal BCH habitats in the Study Area (Figure 71). Small sections of Rocky Shores can be found within LAU 1 and LAU 6. Sandy beaches are found extending from the lower third of LAU 1 along the coast, past the creek mouth in northern LAU 2 and then continuing along the coast for approximately 2.5 km west of the creek mouth.

Rocky shores within the Pilbara intertidal zone are typically exposed to quite extreme conditions due to the tidal environment and climate during exposed periods. Rocky shores are not very well-developed BCH within the Study Area occurring only over a small area (0.2% of BCH) within two LAUs (LAU 2 and LAU 6).

Investigations by O2 Marine along the easternmost intertidal rocky shoreline in LAU 6 categorised this BCH as a low relief rock platform typically dominated by macroalgae with minimal juvenile hard corals, oyster stacks and some soft corals. This rocky shoreline is considered representative of others within the LAU 6, however no surveys were undertaken on the rocky shoreline in LAU 2. The location of the rocky shoreline within LAU 1 adjacent to an extensive foreshore mudflat and sandy beach would likely result in higher levels of abrasive and erosive forces, likely resulting in little or negligible associated flora or fauna communities.

Sandy beaches are found extending from the northern extent of LAU 2 to the mouth of the large creek located towards the southern extent and then continuing along the coast for approximately 2.5 km west of the creek mouth (Figure 71). East of the creek is characterised by a low dune system with a narrow (1 m long) supratidal zone (dunes to high-water line of spring high-tide) whilst the supratidal zone was wider (5 m) to the west (Pendoley, 2019a). Beaches were typically flat, low energy, low-profile beaches backed by gently rising dunes.

7.3.12 Mudflat / Saltflats

Mudflats and Saltflats have been grouped for the purposes of this assessment as the change from mudflat to saltflat is often imperceptible due the gradual alteration between habitats (O2 Marine, 2020a). Productive mudflats that support samphires have been grouped separately and for the purpose of this assessment saline mudflats and super saline saltflats that are highly unproductive have been grouped.

Mudflat/Saltflats cover the largest area of intertidal BCH and are the dominant intertidal BCH occurring within the Study Area. They cover over 10,000 ha and represent approximately 29% of the intertidal BCH within the Study Area. Mudflat/Saltflats comprise the highest proportion of the intertidal coverage of BCH in the eastern supratidal LAUs with 46% and 53% occurring within LAU 3 and LAU 5, respectively(O2 Marine, 2020a).

Mudflats/Saltflats are typically widespread across the supratidal zone between the landward edge of Algal Mats or Samphire/Samphire Mudflats and the terrestrial boundary, which increase in lateral distribution between LAU 1 through LAU 3 and into LAU 5. The width of the intertidal zone decreases in LAU 6 and the expanse is dominated by Samphire/Samphire Mudflats rather than Mudflat/Saltflats. In LAU 6, and to a lesser extent LAU 1, Mudflats/Saltflats surround pockets of terrestrial islands within the intertidal zone, where Mudflats/Saltflats comprise 10% of intertidal BCH within LAU 6.

Data collected by Soilwater Group, (SWG, 2019; Appendix 10.2) indicated soil salinities collected from mudflats range from 52.7 - 4,420 mS/m whilst sulphur, organic carbon and potassium

(Colwell) were typically lower than algal mats suggesting a low biological component (Soil Science Unpublished data). This is typical of intertidal BCH studies undertaken within the Pilbara.

Associated Faunal Diversity

Mudflats/Saltflats are typically hypersaline and support little to no flora or fauna communities as was observed during site observations during the March survey from the saltflats observation point. Phoenix (2020b; Appendix 9.1) surveys identified very few associated faunal observations, noting 'Aerial transects in this habitat, which was extensively surveyed, often went minutes without observing a single bird; where they were observed they were typically individuals or small groups (e.g. Red-capped Plover).' SKM (2011) also identified very few benthic invertebrate species from a study area within Port Hedland, also noting the absence of molluscs and insects. SKM (2011) noted that within these systems tidal inundation is highly infrequent and short in duration, and the soil and porewater salinities typically exclude organisms.

7.3.13 Subtidal Benthic Communities and Habitat Summary

Subtidal BCH surveys identified three broad habitat classes present within LAU 7 (Bare sand, filter feeder/macroalgae/seagrasses and coral/macroalgae) with eight BCH subclasses distinguished based on varying levels of benthic cover and dominant taxa. These classes are described in Table 22 and mapped in Figure 79.

LAU 7 is a shallow, naturally turbid environment that is characterised by bare sand / silt with patchy distribution of predominantly macroalgal (Phaeophyceae: *Sporochnus*, *Hormophysa, Sargassum* & *Dictyota*; Rhodophyceae: *Asparagopsis*; Chlorophyceae: *Caulerpa*, *Halimeda*) and filter feeder communities (e.g. sponges, octocorals, hydroids, ascidians). These inshore sand, macroalgal and filter feeder habitats are known to be widespread throughout turbid nearshore environments of the Pilbara region and, as such, are not considered to be of any regional significance (O2 Marine, 2020b).

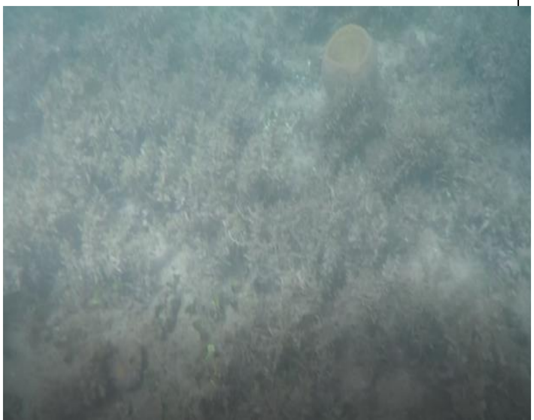
Halophila seagrass species are also present in LAU 7, however, targeted multi-season surveys failed to identify any locations within LAU 7 that recorded benthic cover of seagrass that was more than 1%. It is well documented that seagrass habitats in the Pilbara vary greatly between seasons and years. However, unrelated surveys by O2 Marine at nearby Cape Preston (50 km north of Mardie) in March 2018 identified extensive *Halophila sp*. seagrass meadows, indicating that seasonal local conditions were appropriate to support meadow formation at Mardie at the time of surveys undertaken. Therefore, it is unlikely that LAU 7 constitutes ideal habitat to support the quality of the regionally significant seagrass meadows that are regularly observed at Cape Preston to the north and Coolgra Point to the South.

Coral species are also present in low to moderate densities within LAU 7. However, the majority of corals in the vicinity of LAU 7 are confined to biogenic reefs and rocks fringing the nearby islands. The diversity and abundance of corals in LAU 7 was relatively low and confined to sediment tolerant species (e.g. *Faviidae, Dendrophyllidae, Mussidae* and *Poritidae).* However, a marked increase in diversity and abundance of coral species was observed at the fringing reefs surrounding the nearby islands, indicating that these areas represent the most regionally significant coral habitats.

Although LAU 7 supports complex BCH, including coral and seagrass species, extensive surveys did not identify any subtidal BCH areas that are considered to be locally or regionally significant.

Table 22: Description of broad subtidal BCH classes mapped within LAU 7

BCH Class	Description	Example Image
Bare / bioturbated sand	**Bare Silt / Sand** Typically comprises of silt or sand with no or occasional very sparse macroalgae. Silt areas often comprised of bioturbation (burrows formed by living organisms). Sand areas often contain traces of shell grit. This habitat comprises 89% of the subtidal BCH within LAU 7 and is also widely dispersed across the region.	
	Sand / Sparse (<5%) Macroalgae Fine silt/sand and bioturbated bedform with a very patchy distribution of macroalgae and invertebrates. Macroalgae (*Phaeophyta*) was the dominant cover, but was very sparse, generally comprising <1% of the overall cover. Class was differentiated from the other macroalgal classes due to the very sparse nature of the cover and the much finer grained, and often bioturbated sediments. This habitat comprises 1% of the subtidal BCH within LAU 7. Outside LAU 7, it was also observed on the eastern fringing waters of Round Island, whilst the largest contiguous area was observed closer to the mainland in the shallow waters between Angle Island and the mainland.	
Filter feeder/ macroalgae / seagrass	**Sand / Sparse (<5%) Filter Feeders** Sparse filter feeder habitat occurs where the relief is flat and is associated with fine to coarse sands. Although only present in sparse densities (<5% cover), hydroids are most common where there is no bedform, whilst sponges occur where there is some bioturbation. This habitat comprises 2% of the subtidal BCH within LAU 7 and is widely dispersed throughout the region.	
Filter feeder/ macroalgae / seagrass	**Low (5-10%) Cover Macroalgae / Filter Feeders** Flat to low relief constituting either fine to coarse sands, including shell grit on occasions. Macroalgae, hydrozoan and sponge species are equally dispersed throughout this habitat although benthic cover is low (3-10%). Occasional very sparse (<1%) cover of *Halophila* sp. seagrass was also observed at some locations. This habitat comprises 6% of the subtidal BCH within LAU 7 and follows a patchy distribution throughout the region. Outside of LAU 7, this habitat was also observed in small patches fringing the shallow	

BCH Class	Description	Example Image
	waters of Long Island, Mardie Island and close to the mainland.	
Coral/ macroalgae	**Low (5-10%) Cover Coral** Flat to low relief rock and rubble with coarse sand. Low (3 - 10%) cover of soft and hard corals, including *Faviidae, Dendrophyllidae, Mussidae and Octocroals*. Sparse macroalgae was also present. This habitat comprises 1% of the subtidal BCH within LAU 5. Outside of LAU 7 this habitat was also found fringing Mardie Island and in small isolated patches between Angle Island and the mainland. It was generally recorded in waters between 1-3 m depth.	
	Moderate (10-25%) Cover Coral / Macroalgae Low to moderate relief rock and rubble/coarse sand. Low to moderate cover (3 – 25%) of soft and hard corals with macroalgae. Corals largely consisted of *Faviidae, Poritidae, and Octocorals,* while *Phaeophyceae* dominated the macroalgae communities. This habitat class comprises only 1% of the subtidal BCH within LAU 7. However, outside of LAU 7, it was recorded in larger areas in fringing shallow waters south of Mardie Island and adjacent to the mainland coast.	
Coral/ macroalgae	**Dense (>25%) Cover Macroalgae / Coral / Filter Feeders** This habitat class occurs on low relief substrate with fine to coarse sands and areas of exposed limestone reef. Dense assemblages (>75%) of macroalgae and hydrozoan species predominately in waters at depths of 2.2 - 4.0 m. This habitat also supported sparse juvenile corals (*Faviidae, Dendrophyllidae, Mussidae)* with occasional larger coral (*Poritidae*) bommies (1 – 2 m diameter). This habitat class comprised <1% of the subtidal BCH in LAU 7. It was also identified outside of LAU 7 in the waters fringing the eastern outer edge of Long Island, Round Island and Sholl Island.	
	Dense (>25%) Cover Coral Dominated Low relief limestone reef and rubble substrate which supports high coral cover (25%-75%) of diverse coral species, including *Faviidae, Dendrophyllidae, Mussidae, Portitidae*, and *Octocoral* species. This habitat class was only recorded at one location in LAU 7 and, as such, comprises only <1% of the subtidal BCH within LAU 7. However, it was also recorded outside LAU 7, in a much larger area, fringing the northern edge of Mardie Island.	

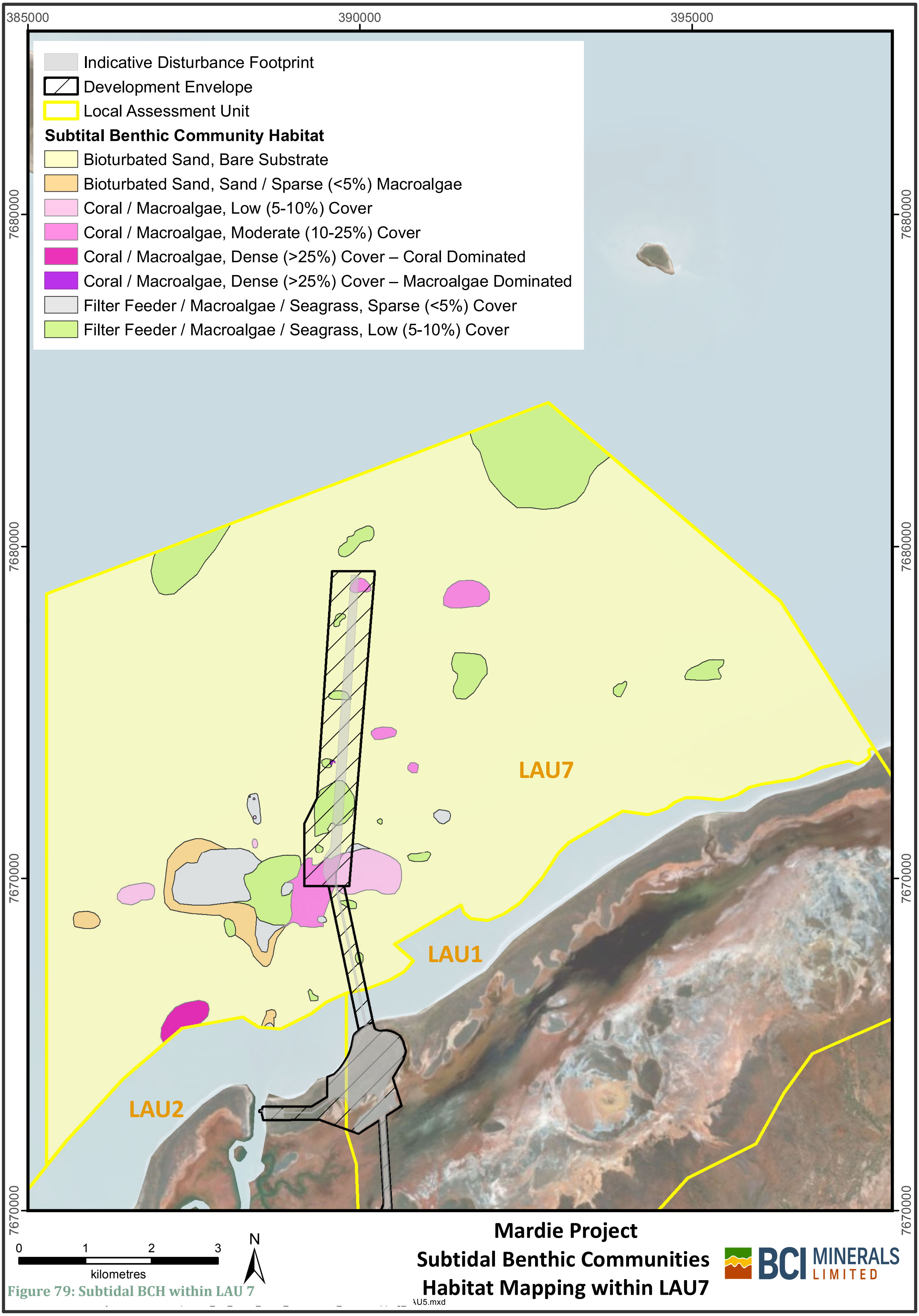


Figure 79: Subtidal BCH within LAU 7

7.3.14 BARE SUBSTRATE / SOFT SEDIMENTS

Distribution

The dominant BCH that occurs extensively in the nearshore subtidal zone of the Pilbara is bare sand substrate comprising of fine silty to coarse sands (Figure 79). This habitat has been identified as the most dominant habitat type found throughout the Study Area which is similar to studies completed at Cape Preston (~70% sand) and for the DomGas Pipeline, 10 km south-west of LAU 7 (O2 Marine, 2020b)

In O2 Marine's study, bare, fine, coarse and bioturbated sands have been classed as Bare Sand and sub-classed as either completely bare substrate or sand substrate that supports very sparse (1 - 3%) macroalgae cover. There is a general gradation of silty sands from inshore to the 10 m isobath to sandy gravels seaward of the 10 m isobath. Silty sands closer to shore were generally found to support a lower density of sessile invertebrates compared to the coarse sands offshore, which is consistent with the nearshore sediments around Onslow (URS, 2010a). The silty sands however, showed greater bioturbated activity compared to the coarser sands further from shore. This seems to be common throughout the Pilbara, as species of infauna are likely to dominate softer sediments, whereas epifaunal species are likely to inhabit harder substrates (Chevron, 2015).

Functional Ecological Value

Bare or unvegetated substrate is afforded the lowest level of protection given the limited contribution to primary production and low relative value as marine fauna habitat. However, this BCH class does support microphytobenthic algal communities and benthic infauna.

7.3.15 MACROALGAE

Macroalgae are locally and regionally widespread within the Pilbara region with as many as 187 different algal species found in the region by the Pilbara Marine Conservation Partnership (Kendrick and Olsen, 2017). Macroalgae are generally restricted to hard substratum in subtidal and lower intertidal areas and appear to be most dominant on shallow hard pavement, platforms and flats that surround islands (Chevron, 2015b).

Species Diversity

Macroalgal assemblages surveyed within LAU 7 were dominated by Phaeophytes (e.g. *Padina sp.*, *Glossophora* sp. and *Spatoglossum* sp.), with a smaller component of chlorophytes (e.g. *Halimeda* sp. and *Caulerpa* sp.) and a low abundance of rhodophytes (e.g. *Laurencia* sp., *Amphiroa* sp. and, *Asparagopsis* sp.*).* The greatest diversity was typically related to the limestone reef and limestone pavement whilst sand and limestone veneer substrates supported much lower diversity and abundance macroalgae. The species observed in LAU 7 are typical of the turbid nearshore Pilbara environment and have been observed in similar areas including Cape Preston, Onslow and Dampier (O2 Marine, 2020b).

Distribution and Condition

Macroalgal assemblages represent the most extensive ecological element in the study area. Percentage cover of macroalgae assemblages within mapped areas within LAU 7 were spatially variable, both between and within sites. Percentage cover was generally highest on the areas of low to medium relief, such as limestone reefs and platforms, whilst sparse cover (<5%) was present on areas of mainly coarse sands to fine sands either attached to small rocks or shell fragments which permitted colonisation in a typically soft substratum habitat. Similar fine sand bioturbated habitat at Onslow have also been found to support benthic macroalgae (0.05 - 0.4 m) and other benthic species.

Low cover (5 - 10%) of macroalgae found on low relief limestone pavement covered with coarse sand was generally found in association with filter feeders and corals. Macroalgae that are classed under the filter feeder/macroalgae/seagrass BCH are found interspersed in the community. Similar associations have also been found at Onslow and south of Mardie (Chevron, 2015b and OMSB, 2017). Denser (>25%) assemblages of macroalgae found in the Study Area occurred in association with coral species on limestone reef and pavement and macroalgae were either dominant or intermixed with low cover (5 - 10%) or moderate (10 - 25%) cover in mainly dominant coral communities. This association is consistent with results found at Onslow, where coral, filter feeders (sponges) and macroalgae associations (phaeophytes) were found to commonly occur on larger low-profile rocky outcrops (1 m wide).

In Onslow, nearshore surveys opposite creek systems, recorded predominately rippled sand with low density of sponges, bryzoans and macroalgae to approximately 800 m, whilst at Cape Preston the habitat class dense/sparse macroalgae were the second most dominant (~29%). Macroalgal assemblages were dense (>70%) at Mardie associated with fringing reefs surrounding the islands, consistent with observations from the Onslow Coastline (URS, 2011).

Tropical macroalgae such as that found at Mardie are typically less dense and rarely form obvious beds when compared to temperate areas in WA, except for ephemeral species which are known to increase in abundance during summer in the southwest Pilbara such as *sporochnus* and *sargassum* (Kendrick and Olsen, 2017). Seasonal trends in macroalgae percent cover and biomass are generally minor and comparable between seasons (Chevron, 2015a). Seasonal trends in macroalgal abundance are commonly observed on tropical shallow reef systems and have been recorded elsewhere in northern WA.

Functional Ecological Value

Macroalgae are an important component of tropical reef ecosystems as they contribute to the productivity of a system as a food source, provide habitat for a range of economically and ecologically important species, contribute to local sediments and play an important role in the nutrient cycle from decomposition (Kendrick and Olsen, 2017). Some algae such as crustose coralline algae are also crucial in terms of their contribution to the formation and maintenance of coral reefs, as they lay down calcium carbonate as calcite, cementing and binding reef materials which in turn affect the settlement and establishment of corals (Kenrick and Olsen 2017).

7.3.16 SEAGRASSES

Species Diversity

Two species of seagrass were identified from in LAU 7, *Halophila ovalis* and *Halodule uninervis*. These species are consistently recorded from across Pilbara region, particularly in shallow nearshore environments, and are known to be the most widespread seagrass species in the Pilbara (O2 Marine, 2020b).

Whilst seagrass species diversity at Mardie is low, there are only seven species of seagrass, known to occur in the Pilbara region, and the highest species diversity (i.e. five) recorded in recent years was at Exmouth Gulf. The low diversity recorded at the Proposal is also consistent with other locations in the Pilbara (i.e. South Murion Island, Bundegi and Thevenard which were also found to support only two seagrass species (O2 Marine, 2020b).

Distribution and Condition

Seagrass were identified in the shallow (<5 m LAT) nearshore waters within LAU 7, generally in areas dominated by filter feeder and macroalgal BCH. However, targeted multi-season surveys failed to identify any locations that recorded benthic cover of seagrass that was more than 1%. No obvious seagrass meadows were identified within LAU 7, however, seagrass (*Halophila sp.*) was identified in densities up to 25% approximately 5 km south.

The seagrass species (i.e. *Halophila sp*. and *Halodule sp*.) that were observed in the Study Area are common and widely distributed across the Pilbara. They are known to be rapid colonisers of bare substrates, which reflect life-history traits of short individual turnover times (less than two months), fluctuating total biomass, a high level of reproductive effort producing seeds and an ability to build up a seed bank (O2 Marine, 2020b). In WA, the genus *Halophila sp*. is the most widespread of the tropical seagrass species, can colonise the widest range of habitat types and appears to be genetically diverse.

For both seagrass species, spatial and temporal fluctuations are likely to be influenced by naturally limiting processes in the area, such as the resuspension of sediments in nearshore waters, elevated warm temperatures and cyclones during summer months. Biomass or cover is likely to be highest late in the year when water temperatures are within the optimal growth range. However, the seasonal growth and reproductive pattern for these seagrasses is spatially and temporally variable and no clear and generally applicable environmental window can be specified. Seagrass biomass is likely to be lower in winter (O2 Marine, 2020b).

Whilst *Halophila* sp. have previously been observed in turbid nearshore environments to the south and north of LAU 7 (i.e. near Onslow and Cape Preston respectively) (O2 Marine, 2020f; Appendix 5.2; Chevron, 2015a and GHD, 2013), McMahon *et al.* (2017) identified that the silty substrates which dominate LAU 7 are the least preferred habitat for seagrasses. Additionally, a study by Bertolino (2006) indicated that most seagrass species typically prefer coarser, more compact sediments, where resuspension is less likely to occur; the water column is less likely to be turbid, and where sufficient light can reach the seabed. In LAU 7, seagrass assemblages were recorded in or adjacent to soft sediment substrates, with veneers of sand overlying limestone pavement, generally as small sparse (<5% cover) patches rather than distinct, dense (i.e. meadow-forming) beds.

Functional Ecological Value

Seagrasses are known to provide valuable ecosystem services such as carbon storage, filtering nutrients and particles from the water column, stabilising sediments and providing high primary productivity (McKenzie *et al.,* 2006). However, their limited distribution and low cover in LAU 7 suggests that their contribution to ecosystem services is limited.

The nearest known seagrass ‘meadows’ to LAU 7 are located in the north, near Cape Preston (GHD, 2013) and in the south, near Coolgra Point (Chevron, 2014), with densities up to 50% recorded at both locations. Seagrass meadows provide an important source of foraging habitat for Dugong, marine turtles and commercially important fisheries species, such as prawns. Whilst it is well documented that seagrass habitats in the Pilbara vary greatly between seasons and years, unrelated surveys by O2 Marine at nearby Cape Preston (50 km north of Mardie) in March 2018 identified extensive *Halophila* sp. seagrass meadows, indicating that local (i.e. <50 km from LAU 7) seasonal conditions were appropriate to support meadow formation at the time of surveys undertaken for the Proposal. Therefore, it is unlikely that LAU 7 constitutes ideal habitat to support the quality of the regionally significant seagrass meadows that are regularly observed at Cape Preston and Coolgra Point.

Similarly, BCH surveys of the Cape Preston region in March 2018, indicated obvious Dugong activity in the vicinity of dense seagrass meadows, with four individual observations recorded over two days. However, no Dugong were observed in over 700 hours of vessel-based observations around the Mardie coast. This suggests that the very low, patchy cover of seagrass in LAU 7 is unlikely to represent regionally significant habitat for Dugong. Similarly, observations by Pendoley (2019a) found that the majority of turtle activity was recorded on the offshore islands for nesting, in comparison to the mainland around Mardie Creek suggesting this area is not a regionally important rookery for turtles. This is turn suggests turtles are likely to utilise areas around offshore islands as feeding grounds, although sightings of Juveniles were also recorded in creeks and inlets associated with coastal mangrove habitat (Stantec, 2018). Overall, the use of subtidal BCH within LAU 7 for foraging is unlikely in lieu of higher quality habitats surrounding the islands.

7.3.17 Filter Feeders

Species Diversity

Filter feeder communities include bivalves, hard and soft corals, sea squirts and sponges. Filter feeder communities found in the Pilbara dominate the seafloor where waters are turbid or deep and sunlight penetration is low. Sponges comprise the highest abundance and diversity of filter feeders in the Pilbara and at Mardie with 1233 species identified in the Pilbara (Abdul *et al.,* 2019). At the Proposal, sessile filter feeder communities included hydroids, bryozoans, ascidians, gorgonians and soft corals, which is typical of the filter feeder communities found in the nearshore Pilbara environments (Abdul *et al.,* 2019).

Distribution and Condition

Most areas identified to support filter feeders within LAU 7 were found in association with either algae, coral, seagrass or sponge in habitats with low to dense cover. These species were therefore classified in the subtidal BCH class Filter Feeder / Macroalgae / Seagrass. These associations were also found in Onslow, common on the sand veneered pavement and dominated the inner shelf. At Mardie this BCH was identified as one of the largest BCH units present throughout LAU 7.

At some sites, filter feeders such as hydroids were found in isolation with sparse (<5%) to low (5 - 10%) cover occurring in soft substratum such as fine bioturbated sands. This same level of cover was identified at Cape Preston for sponges but not for hydroids (~1%) (GHD, 2013). Similarly, at Onslow and south of Mardie filter feeder communities were rarely described as homogenous and were characterised by patches of different community types with sponges forming a significant component of this community like at Mardie (O2 Marine, 2020b; Chevron, 2014).

Functional Ecological Value

Filter feeders are considered keystone species with a major influence on the dynamics of aquatic ecosystems. They are key elements in food webs, controlling primary production, phytoplankton community structure and nutrient cycle (Sanchez *et al.*, 2016 & Abdul *et al.*, 2019). At Mardie benthic filter feeders (secondary production) can be important both in terms of ecological connectivity and in terms of providing food for pelagic, demersal and even for commercially important species.

7.3.18 CORALS

Species Diversity

Coral diversity in WA is high, with 361 species from 17 families and 83 genera of hard corals recorded. The species richness of coral taxa in at the Proposal is considerably lower, however, it is characteristic of inshore Pilbara environments which are generally low in diversity and abundance and often dominated by sediment-tolerant Faviid, Dendrophylliid and Poritid species (O2 Marine, 2020b).

In the vicinity of the Project area, the highest diversity of coral taxa was observed on the fringing reef and limestone platform surrounding the nearby islands with species observed from the families Faviidae, Acroporidae, Merulinidae, Poritidae and Dendrophyliidae. However, these islands were located outside of the mapped LAUs. Within LAU 7, diversity and abundance of coral was much lower, and the communities were generally dominated by octocoral species, *Turbinaria* sp. and corals from the Faviidae family (*Favites, Favia, Cyphastrea* spp.) with occasional larger >1 m diameter Poritid bommies.

Distribution and Condition

For most coral species that are found at Mardie and in the Pilbara, their composition and spatial distribution are likely due to natural disturbance events that have found to be associated with anomalous water temperatures and cyclones (O2 Marine, 2020b). As well as natural disturbance events, natural physiochemical parameters such as depth and turbidity (light availability) affect where corals are likely to be found and the extent of their cover.

The corals that inhabit Mardie coastal waters experience turbid waters for most of the year, particularly in the summer months, due to stronger winds and the generation of wind swell resulting in the uplift of fine sediment in the water column (O2 Marine, 2020b). These environmental conditions are also experienced at Onslow and Cape Preston. Low coral cover (<10%) was found in shallow nearshore waters up to 10 m at Onslow in an area characterised by a ridge of scattered shoals. Low to sparse cover (~8%) of corals have been found at Cape Preston. Higher abundance and diversity of corals at Mardie, Onslow and Cape Preston were found around on the protected edge of the nearshore islands, where protection from prevailing winds, wave action and cyclonic activity provided relief from physical environmental stressors that are likely to cause damage to the fragile corals communities.

Coral families were identified in higher densities (>25%) on low profile limestone platforms (shoals) in the shallow nearshore waters (<5 m LAT) of LAU 7 and found fringing the nearshore islands, generally in areas associated with macroalgae. Low (5 - 10%) to moderate (10 - 25%) coral cover was found to occur in association with macroalgae and bordering sparse to low filter feeder / macroalgae / seagrass BCH. The fringing reefs and shoals lacked evidence of true coral reef formation (a reef formed on layers of dead coral), rather the reefs found were formed by a thin layer of live coral on a veneered limestone pavement or rock substratum (O2 Marine, 2020b).

The coral families found at Mardie (and Onslow and Cape Preston), supported dominant coral species that are resistant to bleaching, storm damage and wave damage. Species of *Acroporid* which are fast growing were not as prevalent as the other coral species found due to their susceptibility to stress. In comparison large coral groups such as those found on the Great Barrier Reef support *Acroporid* which accounts for 50 - 90% of all coral species. These observations suggest that over time the composition of corals around Mardie, Onslow and Cape Preston have developed to be represented by species that have a high tolerance to the natural stressors (i.e. cyclones, waves, sedimentation, etc.) that are commonly experienced in the region (Ayling & Ayling, 2005; Chevron, 2014). Turbidity conditions are expected to prevail all year round within Mardie nearshore areas. A study conducted just south of LAU 7 (Chevron, 2014) identified turbid conditions during each of their baseline surveys.

On a larger regional scale Barrow and Montebello islands to the north of Mardie consist of fringing mid-shelf reefs which support a greater species diversity and abundance of corals, mainly due to the difference in gradients found between the low latitude inshore areas at Mardie and the oceanic shelf edge of which the islands are located. The islands also experience typically lower turbidity due to their offshore location as opposed to the nearshore sites of LAU 7 which are subjected to high tidal velocities, finer sediments and seasonal riverine discharges of freshwater sediments (Jones *et al.*, 2019).

Functional Ecological Value

Corals are important in terms of their role in contributing to primary production, nutrient recycling, and providing habitat and a food source for a myriad of marine species. In addition to ecosystem services associated with fishing and recreational use including tourism, corals are very significant because of their ability to form habitats with high levels of associated biodiversity (O2 Marine, 2020b).

The coral communities found on the limestone platforms and fringing reefs surrounding the nearshore Islands on the Mardie Coast appeared to support high levels of biodiversity and showed some similarities (i.e. species composition and distribution patterns) to the regionally important coral communities found north of Mardie on the barrier islands located in the Proposed Regnard Marine Management Area (O2 Marine, 2020b). The coral communities were therefore considered to be some regional importance and impacts to these areas should be avoided. In contrast, the coral communities found within LAU 7, are generally low in terms of diversity and abundance and represent less than 2% of the total area of BCH within LAU 7, therefore the likely contribution of these coral communities to local and regional ecosystem services is considered to be limited.

7.3.19 NATURE RESERVES AND MARINE PARKS

In WA the conservation of ecologically significant marine, estuarine or terrestrial ecosystems may be managed through reserves established under the *Conservation and Land Management Act 1984*. The coastal or subtidal habitats within the Study Area have not been identified as containing significant ecological communities warranting protection through the introduction of marine or terrestrial reserves. The nearest Marine Park is the Montebello Islands Marine Park, which is located over 60 km northwest of the Proposal.

All inshore islands of the West Pilbara are listed as Class C Nature Reserves and although no inshore islands are located within the Study Area, several inshore islands including the Passage Islands group, Sholl Island, Angle Island and Mardie Island are located approximately 8 – 10 km offshore. These islands are known to be important areas for migratory seabirds, turtles and dugong and support large areas of macroalgal beds and both biogenic coral reef and coral communities on pavement. However, the subtidal areas surrounding the inshore islands are not afforded the same conservation status as the islands themselves.

There are no implications for any of the proposed Commonwealth Marine Reserves as the Proposal and associated activities are to be contained completely within State Waters. Export vessels will not enter the Montebello Marine Park (Figure 17).

7.3.20 INTRODUCED MARINE PESTS

This section has been sourced from O2 Marine (2020h; Appendix 2.6) unless stated otherwise.

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)).

Six IMP alerts for WA were current at the time of the O2 Marine (2020h) report , including observations of Asian Green Mussel *Perna viridis* on a vessel at Barrow Island, Asian Paddle Crab *Charybdis japonica* in the Swan Estuary, Perth, Black Striped Mussel *Mytilopsis sallei*, European green crab *Carcinus maenas*, Japanese Kelp *Undaria pinnatifida* and Northern Pacific seastar *Asterias amurensis*. None of these species are known to have established self-sustaining populations in WA waters but all represent a serious threat.

Wells (2018) conducted a review of IMS in the Pilbara (based on results of publicly available studies) and found that 15 IMS are present, however only one species listed on the Australian National IMS list, the ascidian *Didemnum perlucidum,* has established a self-sustaining population.

The Mardie area has not been surveyed for IMPs in the past. However, nearby at Cape Preston, URS conducted an IMP survey in 2009 and found no IMP species listed by the National IMP Coordination Group (URS, 2009). The IMP species *Didemnum perlucidum* is found at Barrow Island, approximately 50 km to the north-west of the Proposal (O2 Marine, 2020h).

7.3.21 ENVIRONMENTAL VALUES

Based on the information provided in this section, the following environmental values were determined to require assessment for this factor:

- General intertidal BCH;
- Mangrove communities;
- Algal mat habitat;
- Samphire / samphire mudflat habitat; and

- Sub-tidal BCH.

7.4 POTENTIAL IMPACTS

Table 23 defines the potential impacts (direct, indirect and cumulative) on the environmental values for this factor in a local and regional context. These impacts are informed by the results of detailed BCH studies described in Section 6.3 and provided in Appendix 2.1.

Table 23: Potential impacts on BCH

Environmental value and current extent	Potential direct impact	Potential indirect impact	Impacts associated with other proposals	Total cumulative impact

General intertidal BCH
7 broad BCH classes recorded within LAU 1 - 6
	Up to 8,282 ha of intertidal BCH to be disturbed, of which 6,412 ha is bare mudflat / salt flat BCH	• Introduction of marine pests
		• Indirect impacts associated with changes to water quality, including:
		  ○ Increased sedimentation resulting in settlement and smothering of habitat
		  ○ Alteration to surface water regimes
		  ○ Changes to the dynamics of nutrient flows and budgets
		  ○ Leaks or spills of hydrocarbons or chemicals
		  ○ Leaks or spillages of hypersaline brine
		  ○ Potential movement of hypersaline groundwater as a result of hydrostatic pressure of the brine in the salt ponds
			Up to 210 ha of intertidal BCH was disturbed for the development of two gas pipelines	8,378 ha of cumulative direct disturbance
				Potential indirect impacts associated with changes to water quality and the risk of introducing marine pests

Mangrove habitat 3,608 ha recorded across the LAUs, including: • 962 ha in LAU 2 • 1,120 ha in LAU 4 • 1,526 ha in LAU 6	Up to 17 ha of disturbance, consisting of: • 1 ha in LAU 2 • 12 ha in LAU 4 • 4 ha in LAU 6	As above.	1 ha disturbance associated with two gas pipelines running through LAU 4 No other proposals occur within the remaining LAUs	Up to 18 ha of total cumulative disturbance, including up to: • 1 ha in LAU 2 • 13 ha in LAU 4 • 4 ha in LAU 6 Some potential indirect impacts
Algal mat habitat 3,459 ha recorded across the LAUs, including: • 857 ha in LAU 1	Up to 880 ha of disturbance, consisting of: • 10 ha in LAU 1 • 452 ha in LAU 3 • 416 ha in LAU 5	Indirect impacts associated with changes to water quality, including: • Increased sedimentation resulting in settlement and smothering of habitat	63 ha disturbance in LAU 5 associated with two gas pipelines running through the Study Area	Up to 880 ha of total cumulative disturbance, including up to: • 10 ha in LAU 1 • 452 ha in LAU 3 • 479 ha in LAU 5 • 1 ha in LAU 6

Environmental value and current extent	Potential direct impact	Potential indirect impact	Impacts associated with other proposals	Total cumulative impact
• 1,300 ha in LAU 3 • 2,259 ha in LAU 5 • 43 ha in LAU 6	• 1 ha in LAU 6	• Alteration to surface water regimes • Changes to the dynamics of nutrient flows and budgets • Leaks or spills of hydrocarbons or chemicals • Leaks or spillages of hypersaline brine • Potential movement of hypersaline groundwater as a result of hydrostatic pressure of the brine in the salt ponds		Some potential indirect impacts
Samphire mudflat habitat 6,743 ha recorded across the LAUs, including: • 149 ha in LAU 1 • 2,030 ha in LAU 2 • 264 ha in LAU 3 • 1,533 ha in LAU 4 • 471 ha in LAU 5 • 1,546 in LAU 6	Up to 954 ha of disturbance, consisting of: • 8 ha in LAU 1 • 15 ha in LAU 2 • 216 ha in LAU 3 • 57 ha in LAU 4 • 322 ha in LAU 5 • 335 ha in LAU 6	As above.	40 ha disturbance in LAU 4 associated with two gas pipelines running through the Study Area	Up to 994 ha of total cumulative disturbance, including up to: • 8 ha in LAU 1 • 15 ha in LAU 2 • 216 ha in LAU 3 • 97 ha in LAU 4. • 322 ha in LAU 5 • 335 ha in LAU 6 Some potential indirect impacts

Sub-tidal BCH
9 broad BCH classes present within LAU 7
	Up to 19 ha of vegetated sub-tidal BCH to be disturbed (dredged) within LAU 7 to develop the dredge channel
	Up to 36 ha of bare unvegetated substrate will also be disturbed
		• Introduction of marine pests
		• Indirect impacts associated with changes to water quality, including:
		  o Increased sedimentation resulting in settlement and smothering of habitat
		  o Leaks or spills of hydrocarbons or chemicals
		  o Bitterns disposal (salinity) at discharge location
			No other proposals occur within LAU 7.	Up to 183 ha of sub-tidal BCH to be lost to develop the dredge channel with some potential indirect impacts.

7.5 Assessment of Impacts

7.5.1 General Intertidal Communities and Habitat

Direct Disturbance

The Proposal will result in the direct disturbance of up to 8,282 ha of intertidal BCH, in addition to the 210 ha that has previously been disturbed to install two gas pipelines. There are several items of note during this assessment:

- The disturbance is to occur within a largely uncleared landscape as all intertidal BCH mapped during this assessment currently have at least 92% of their pre-European extent remaining (O2 Marine, 2020c);
- The BCH generally represents widespread communities and is well represented with many having distributions either within the Australian tropics or internationally (O2 Marine, 2020c);
- There has been minimal clearing in the local area, limited to that required for pastoral purposes and clearing associated with the gas pipeline running through the development envelopes.

Table 24 shows the amount of each intertidal BCH that is expected to be disturbed to implement the Proposal, and the percentage of the total mapped within each LAU.

Table 24: Intertidal BCH direct disturbance

BCH Class	LAU 1 (ha)	LAU 2 (ha)	LAU 3 (ha)	LAU 4 (ha)	LAU 5 (ha)	LAU 6 (ha)	Direct Impact (ha)	Indirect Impacts (ha)
Algal Mat	10 (1%)	0 (0%)	452 (35%)	0 (0%)	416 (31%)	1 (3%)	880	0
Foreshore Mudflat/Tidal Creeks	2 (0%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)	2	0
CC Mangrove	0 (0%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)	0	0
SC Mangrove	0 (0%)	1 (0%)	0 (0%)	12 (2%)	0 (0%)	4 (1%)	17	100.1
Rocky Shores	0 (0%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)	0	0
Samphire Mudflat	8 (5%)	15 (1%)	216 (82%)	57 (4%)	322 (68%)	335 (22%)	954	508.5
Sandy Beaches	0 (0%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)	0	0
Mudflat/Saltflat	5 (1%)	45 (13%)	1,775 (86%)	24 (6%)	4,355 (89%)	208 (33%)	6,415	18.5
Total	**25**	**61**	**2,443**	**93**	**5,093**	**548**	**8,282**	**627.1**

The largely barren Mudflat/Saltflats BCH was targeted by Mardie Minerals when designing the Proposal to minimise disturbance to more productive and important BCH, and as a result the disturbance within this BCH represents the greatest BCH direct loss (77% of total extent within the Study Area). Algal Mats represent the second greatest direct loss with 25% of the total mapped within the Study Area to be disturbed. The third greatest loss is Samphire / Samphire Mudflats with a loss of 16%. Zero to negligible losses are proposed to occur to Rocky Shores, Sandy Beaches, CC and SC Mangroves, and Foreshore mudflats/Tidal Creeks BCH.

The direct loss of BCH has been assessed in context with the cumulative indirect impacts described in the sections below. This cumulative assessment is provided at the end of this section.

Introduced Marine Pests

Technical information in this section has been sourced from O2 Marine (2019b; Appendix 2.6) unless stated otherwise.

The Proposal will utilise vessels during construction and operation that will be brought to Mardie marine waters from other ports within Australia and overseas. These vessels have the potential to transport IMPs which can potentially impact intertidal BCH through (O2 Marine, 2019b):

- Out-competition with native species for resources;
- Predation on native species; and
- Alteration of trophic interactions and food-webs.

The most common forms of transport vector for an IMP being biofouling on vessels, debris and submersible equipment, or in ballast water / sediment and seacocks / sea strainers (CSIRO, 1998). The individual IMP(s) must attach to - or be taken in by - the vessel at the location of origin and then survive the journey as a 'passenger'. The survival and translocation risk of the IMP depends on several factors, including:

- Frequency and duration of vessel visits;
- Vessel operating speeds (e.g. stationary or slow- moving vessels in port areas allow fouling pests to attach, while transit times between ports will affect survivorship in ballast water);
- Type of vessel operations (direct contact with seabed brings higher risk);
- Origin location;
- Level of hull biofouling and prevention (anti-fouling coatings);
- Capacity and use of ballast water throughout journey;
- Voyage duration, the length of time species can survive in ballast water;
- Presence and size of internal vessel areas such as sea chests, anchor cable lockers, propeller shafts;
- Inspection of internal areas and treatment systems used; and
- Dry docking - duration since the last dry-docking or removal from the water.

Risk nodes are the areas to which potential IMP translocation may occur. The conditions at the receiving environment are risk factors which can influence the likelihood of IMP's becoming established. These factors include:

- Similarity of the receiving environment to the IMPs location of origin (habitat / substrate type, bioregional matching, physico-chemical conditions, temperature and salinity regimes);
- Availability of substrate / habitat;
- Availability of prey / food / nutrients;
- Presence of predators;
- Competition with local / native biota;
- Water quality (temperature and salinity regimes); and
- Distance to high risk areas (ports, harbours, aquaculture facilities).

The risk factors described above are incorporated into several private sector and government-supplied risk assessments. Mardie Minerals engaged O2 Marine (2019b) to conduct an IMP risk assessment. There are two key inputs to the risk assessment; the risk of a vessel or equipment introducing a marine pest, and the risk of the IMP becoming established.

The vessel types proposed for use in construction and operation of the Proposal were assessed using rating methods utilised by McDonald *et al.* (2015) and allocated relative risk ratings:

- Bulk carriers and crew transfer vessels were given a risk rating of 1 (low risk);
- The transhipment vessel, barges, tugs and long-reach excavator were given a risk rating of 2 (medium risk); and
- The jack-up barge and dredging barge were given a risk rating of 3 (high risk).

The vessels listed above have not yet been contracted and as such, the origin locations of these vessels are unknown. However, it is likely that at least some of the construction vessels and the bulk carriers will be sourced from China and south-east Asian ports, which share similar environmental conditions with Pilbara marine waters. Many IMP species on the National Introduced Marine Pests Coordination Group (NIMPCG) list either originate from or are established in large south-east Asian ports such as Singapore. There is a greater likelihood for introduction of such species to Mardie due to the similarity of habitat and climate.

O2 Marine (2019b) assessed the Australian National priority trigger list for marine pests that are considered to be at risk of introduction and causing harm in Australian waters (NIMPCG, 2009a; 2009b) and identified 27 species as having a risk of becoming an IMP at Mardie.

Increased sedimentation resulting in settlement and smothering of habitat

The majority of the Proposal disturbance is associated with the flooding of an existing landscape. Any sediment would be captured within the ponds during this activity. Sediment may be released during construction of the pond walls; however, the method and sequencing of construction of these walls will involve isolating working areas from interaction with water movements (including tidal flows) to ensure mobile sediments are not allowed to escape to the surrounding environment. The wall material is generally high in clay content and will be compacted in place, which means the walls will consolidate quickly and therefore sediment losses will be minimal. The seaward toes of the walls will be rock armoured to further protect against erosion. Mardie Minerals have committed to mitigation measures to reduce the risk of sedimentation (refer to Section 7.6.2).

Alteration to overland surface water regimes

Table 24 provides estimates of the area of each BCH that may be impacted by changes to surface water regimes. Section 5 describes that the overland flows will be largely diverted through two drainage channels that pass between the ponds. This drainage system will be developed to deliver through these channels or around the ponds and to their current destination; spreading across the intertidal zone and draining out through the tidal creek network.

Flow events larger than 1 in 50 ARI will overflow the drainage diversion channels and flow into the concentrator and crystalliser ponds, where sufficient freeboard will be maintained to completely capture these inflow volumes

As described in Section5, there will be negligible net change in the volumes of freshwater from the catchment entering the intertidal area each year, and given that arid-zone BCH is not reliant on freshwater inputs (in comparison to tropical mangroves for example), the changes to overland flows described above are not expected to result in significant impacts to the composition or health of mangrove, algal mats or mudflat / saltflat BCH. Samphire / Samphire Mudflats BCH however is predicted to be more likely to be affected by changes to fresh water inflows and as such the potential impact of fresh water inundation changes on Samphire / Samphire Mudflats BCH has been discussed separately in Section 7.5.4.

Alteration to intertidal flow regime – pond walls

As described in Section 5, an extensive tidal inundation study conducted by RPS (2019a) confirms that, during highest tides, the pond walls would affect the landward movement of seawater at the northern and southern ends of the Pond and Terrestrial Infrastructure Development Envelope, where the walls are closest to the ocean. The modelled period coincided with the annual king tide, so inundation depths and predicted changes would be substantially lower if modelled over an annual period.

Larger high tides gradually fill the multiple tidal creeks until they overflow their banks, discharging water into a large intertidal catchment. The presence of the pond walls closest to the coast will reduce the size of this catchment in those areas and is predicted to result in increases in water depth compared to current conditions (up to 20 cm deeper closest to the wall on an annual king tide; RPS, 2019). This water then drains back out on the outgoing tide, at a faster rate than currently experienced, again due to the reduced catchment.

BCH in these areas will therefore experience some changes in intertidal flows:

- Tidal flows will reach the area of BCH at the same time, however water depths will rise at a faster rate, up to a maximum of 20 cm (on an annual king high tide); and
- Outgoing tides will drain faster, draining the area of BCH earlier than it would currently experience.

The RPS (2019; Appendix 1.1) study also confirmed that, due to the multiple flow paths available to the tidal waters, no areas currently flooded would be left dry as a result of the Proposal.

These changes to the intertidal flow regime are not expected to have a significant impact on BCH as:

- No new areas of BCH will be flooded (or not flooded) due to the presence of the ponds;
- The increased water depths will only occur on large high tides;
- The increased water depths will only occur within areas that would already be flooded; and
- The duration of the increased flooding depth and the quicker drainage would only be a few hours on each large high tide.

None of the BCH types recorded within the impacted areas (i.e. mangroves, samphires and algal mats) are expected to be impacted by the changes described above. These BCH are adapted to infrequent inundation for several hours and the depth of the inundation is not a defining factor for any species.

Monitoring of BCH health and the verification of model predictions is proposed to verify this position (refer to Section 6.6).

Section 5 (Inland Waters) provides more detail about the modelling and predicted results.

The potential impacts on mangrove communities and algal mats are discussed in more detail in Section 7.5.2 and 7.5.3 respectively.

Changes to the dynamics of nutrient flows and budgets – causeway

As described in Section 5, an extensive tidal inundation study of the proposed causeway crossing (RPS, 2020; Appendix 1.2) confirmed that tidal flows to BCH either side of the causeway would not be impeded by the presence of the causeway structure, given the presence of floodways and culverts. Indirect impacts to BCH in these areas are therefore considered unlikely, and the mitigation measures proposed in Section 5.6.2 will ensure that modelling predictions are verified and mitigated if required.

Key points regarding nutrient budgets are outlined below:

- CC Mangroves and their related ecosystems (especially cyanobacterial communities) are the single most important contributor to the nutrient budget within the intertidal LAUs;
- A significant trend is identified with respect to decreasing biomass and productivity with respect to tidal elevation. Seaward mangrove communities with the highest associated biomass are the most productive, with biomass reducing with each BCH type until the Mudflats/Saltflats BCH, which are represented by no biomass (the least productive intertidal BCH); and
- Nutrient productivity from Algal Mat BCH, whilst potentially high, has not been identified as a significant source within the system due to limited connectivity with adjacent BCH.
- The key points regarding nutrient flows are outlined below:
    - Tidal inundation is the single most important mechanism with regards to connectivity for nutrient transportation between BCH and coastal waters;
    - Freshwater inputs are highly sporadic and therefore associated nutrient inputs are considered supplementary and not essential to ecosystem nutrient flows; and
    - Groundwater flows are considerably static and therefore considered negligible in contribution to nutrient flows within the system.

The Proposal has purposefully been designed to minimise any direct or indirect losses of the structurally complex, higher biomass and primary productivity BCH. By avoiding direct loss of these BCH, the impacts upon primary productivity and nutrient budgets within the intertidal LAUs has been minimised. A minor alteration to the tidal cycle is predicted (i.e. a time delay from current regime), with no predicted alteration to tidal inundation frequency or significant change in tidal heights. This maintains the single most important aspect related to nutrient flows between BCH and coastal waters.

Alterations to surface water flows have also been minimised and engineered to ensure surface water continues to flow to the intertidal zone and in similar volumes, albeit through altered pathways. As surface water flows are considered unessential to the function of arid zone BCH, and every attempt has been made to ensure the ultimate source (tidal creek and coastal waters) still receive any supplementary nutrients, minimal indirect impacts are predicted from alterations to surface water flows from the development of the Proposal.

Leaks or spills of hydrocarbons or chemicals

There will be limited storage of hydrocarbons or chemical in the vicinity of intertidal BCH. The pond seawater intake is located within a tidal creek and will contain high-volume pumps that run on diesel fuel. These pumps will be located either within a bunded area on an intake barge, or within a bunded area on the shore. Any spills from these pumps will be captured by the bund and will not reach the surrounding intertidal BCH.

A small boat launching facility will be located within the main northern tidal creek (adjacent to the jetty). The boat ramp will be used to launch small vessels used in the construction and operation of the export facility. Refuelling of vessels will not occur while the vessels are moored at the boat ramp. Refuelling will be conducted onshore in accordance with refuelling procedures developed in consultation with PPA, and spill equipment will be maintained to ensure any spills are contained and cleaned up. Section 7.7 contains more detail about the mitigation measures proposed.

Based on the above, the risk of oil spills impacting the intertidal BCH is not expected to be significant.

Leaks or spillages of hypersaline brine

A sufficiently large spill or leak of brine from the ponds or pipelines could result in impacts to the intertidal BCH within adjacent tidal creeks. 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 have been designed to minimise the chance of leaks, and mitigation will be implemented to reduce this risk further (refer to Section 7.6). Ponds have been designed with adequate freeboard and overflow features to minimise the risk of unplanned overflows and wall breaches.

If a brine spill or leak was to occur, depending on the volume it may reach an adjacent tidal creek, however it is most likely to spread across the mudflat area given the current flow regimes (refer to Section 5). Nevertheless, the tidal creek is adapted to saline conditions and is regularly inundated with seawater. Brine would be expected to move rapidly to the coast and mix with seawater and be diluted over a period of days to weeks, depending on the size of the spill and the tidal regime at the time.

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.

Potential movement of hypersaline groundwater as a result of hydrostatic pressure of the brine in the salt ponds

Modelling of the hydraulic influence of the proposed ponds on the underlying groundwater was conducted by Soilwater Group (2019a; 10.1), incorporating the results of laboratory testing of natural as well as screened and compacted soils from the proposed pond areas. The modelling indicated that, over varying periods, brine within the ponds would seep downwards into the shallow water table underlying the claypans and create a groundwater mound beneath the ponds.

The modelling results show that surface evaporation of the supratidal mudflats surrounding the concentrator and crystalliser ponds will play a significant role in determining the extent to which groundwater mounding is likely to impact on the downstream soils. It is important to recognise that although the pan evaporation rate for the Pilbara region is around 3,100 mm per year, the actual evaporation from the surface of the mudflats will be appreciably lower as the dry soil conditions at the surface will effectively impede the upward movement of water from the soil; hence the permeability of the dry soils at the surface become rate-limiting.

If an evaporation rate of 1,000 mm per year is considered, then the spread of the groundwater mound is reduced such that after two years of continuous operation the surface soils downstream of the embankment wall remain unsaturated. Under this evaporation scenario, the surface soils at distances greater than 10 m from the embankment wall, only become saturated after 10 years of continuous operation. If an actual surface evaporation rate of 2,000 mm per year is used, then the surface soil profile will remain unsaturated, likely over the life of the operation (Soilwater Group, 2019b).

Based on the above, there is some uncertainty about the extent of the downstream mounding resulting from the presence of the concentrator and crystalliser ponds. Monitoring and contingency actions are however proposed in Section 5.6 which adequately address this uncertainty.

Any surface expressions and subsurface seepage within down-gradient areas will occur within BCH that is already subject to hypersaline conditions. The predicted salinity levels for the process solution within the concentrator ponds, which occupy the largest land area, are within the measured range of salinity for the isolated groundwater within the supratidal flats. Similarly, the predicted major cation (Ca, Mg, Na, and K) and anion (Cl and SO_4) concentration of the process water in the concentrator ponds are within the measured range for the groundwater in the supratidal flats (Soilwater Group, 2019b). Tidal waters that flow into these areas regularly saturate the upper soil profile and concentrate in the surface layers, therefore the environmental consequence of any brine surface expressions is expected to be non-existent to negligible. Therefore potential impacts to intertidal BCH are not considered significant.

Prevention of Inland Movement of Habitats Due to Sea Level Rise

Inundation studies conducted by RPS (2019a) have been included in Appendix 1.1 and described in Section 5. A high-level summary of the predicted inundation effects from sea level rise is presented below:

- The Study Area would still wet and dry, exposing current mangroves at lower tides and increasing inundation frequencies of algal mats;
- Current King Tides (2.2 m MSL - the current minimum tide required for algal mat inundation) would occur at the same frequency of the current 1.2 m MSL tides), approximately >15 times per month;
- The pond walls will limit the eastern extent of 'King Tides plus 0.9 m' (EPA 100yr sea level rise for coastal hazard assessment) resulting in higher water levels over seaward BCH during high tides; and
- Current mangrove areas will still be exposed at lower tides, a scenario that is consistent between modelling results with or without project infrastructure (i.e. Proposal infrastructure will not cause different tidal cycles that would not occur naturally over this period).

Sea level rise associated with climate change is predicted to result in water flooding further inland during more high tide events, until it meets higher ground (Figure 28). The concentrator and crystalliser ponds will create a barrier to this inland progression, which will mean that the flooding will reach a 'higher ground' barrier an estimated 20 years earlier than it would have if the ponds were not there (RPS, 2019a). The Proposal is therefore only expected to bring forward the natural sea level rise impacts in the area by an estimated 20 years, rather than increase the impacts.

As discussed within O2 Marine (2020a), there are several physical and chemical factors that affect the localised spatial distribution of key BCH within the Study Area. BCH distributions are principally controlled by the effects of tidal inundation on soil salinity regulation. The particular physical and chemical properties typical of BCH is highly dependent upon the current interrelationships that occur between tidal inundation and geomorphological structures. Understanding exactly how these interrelationships may alter over time due to rising sea levels is surrounded by a high degree of uncertainty. Therefore, it cannot be assumed that BCH will definitely migrate east (i.e. mangroves colonising saltflats or samphire mudflats) as sea levels rise. Rather, BCH will remain wherever conditions allow and colonise newly created environs, whereby chemical and physical properties offered are suitable for their respective tolerances (inundation, soil salinity, nutrient budgets, connectivity etc.). For example, mangrove communities typically occur as thin ribbons associated with tidal creeks, as these habitats provide the exact physical and chemical conditions required for colonisation. As sea levels rise, tidal creek systems are likely to also alter and with this mangrove habitat may remain, be lost or be created. However, if tidal creek systems do not retreat landwards, and the tidal plains currently comprising landward BCH do not offer the required chemical and physical condition that mangroves require, then their eastward retreat will be controlled by physico-chemical properties, not the presence of Proposal infrastructure.

Thus, the mechanisms driving altered BCH through sea level rise will occur irrespective of the Proposal. Whilst the Proposal infrastructure may reduce available area for new BCH to occur, it cannot be predicted whether the chemical and physical properties characteristic of the current mudflats (i.e. where the ponds and associated infrastructure is proposed) would remain or alter to become new BCH.

Whilst sea level rise is predicted to temporarily (estimated 20 years) impact the current spatial extents of mapped BCH, the inclusion of Proposal infrastructure is not predicted to significantly impact the predicted results.

Cumulative Loss Assessment

Table 25 lists the predicted cumulative loss across each BCH type within each LAU (from O2 Marine, 2020c).

Table 25 identifies that:

- The Proposal will have no or negligible impacts to Foreshore Mudflat/Tidal Creek, CC Mangroves, Rocky Shores and Sandy Beaches BCH;
- 25% of the total mapped Algal Mat BCH will be disturbed, with the disturbance primarily occurring within LAU 3 and 5;
- Less than 1% of SC Mangroves BCH will be disturbed, with the disturbance primarily to occur within LAU 4 and LAU 6; and
- BCH disturbance is greater in the higher elevation BCH (Samphire Mudflats and Mudflat/Saltflat).

Samphire Mudflats and Mudflat / Saltflat BCH are rarely inundated as they occur in areas that are higher in elevation. These BCH contain very little biomass and as such are expected to contribute very little to the intertidal ecosystem. These BCH and their particular ecological significance to BCH processes as a whole have been considered in this section, however they are also relevant to the EPA's objective for 'Flora and Vegetation' and 'Terrestrial Fauna' and as such an assessment of impacts on these BCH types has been provided in more detail in Section 9 and 10 respectively.

Mangrove Communities and Algal Mat BCH were determined to be of particular significance within the Study Area. These BCH are assessed separately in Section 7.5.2 and 7.5.3 respectively.

Intertidal habitats assessed within the Study Area were found to be commonly distributed throughout the wider Pilbara region, with many having distributions either within the Australian tropics or internationally. Many species identified during the assessment are also typically found within a broader geographical distribution.

The coastal habitats within the Study Area have not been identified as containing significant ecological communities warranting protection through the introduction of marine or terrestrial reserves. There are no implications from any of the proposed Commonwealth Marine Reserves for the Proposal due to the coastal location contained completely within State Waters. Whilst no formal reserves have been established, two areas relevant to the Proposal have been identified by EPA (2001) as regionally significant areas: Robe River (Area 7) and Fortescue River (Area 8) deltas. These areas are considered mangrove management areas and direct impacts within these have been minimised with cumulative losses of only 1% for SC mangroves and 0% for CC mangroves within LAU 6 which intersects the Robe River Delta (discussed further in Section 7.5.2).

Numerous Proposal design iterations were developed to minimise impacts to significant BCH, and as a result the current Proposal has significantly lower impacts to Algal Mat and Mangrove (SC and CC) BCH than previous design iterations (refer to Section 2.2.2). This has ensured that there are no significant cumulative losses to structurally complex BCH, which are required for ongoing support and maintenance of the biodiversity and ecological integrity and functionality of the intertidal zone. Where cumulative losses have been calculated, the impact upon biodiversity and ecological integrity has been minimised through locating the development envelopes primarily within BCH which will not irreversibly impact upon ecosystem function, integrity or biodiversity of not only this area, but also the wider region (O2 Marine, 2020c).

Overall, the Cumulative Loss Assessment determined that the direct impacts to each intertidal BCH were negligible and were unlikely to result in any risks of impacting biological diversity and ecosystem integrity.

Table 25: Intertidal cumulative BCH loss within each intertidal LAU

LAU	Loss Assessment	Algal Mat		Foreshore Mudflat/Tidal Creek		CC Mangroves		SC Mangroves		Rocky Shores		Samphire Mudflat		Sandy Beaches		Mudflat/Saltflat	
		ha	%	ha	%	ha	%	ha	%	ha	%	ha	%	ha	%	ha	%
LAU 1	Pre-European Extent	857	-	401	-	0	-	0	-	0	-	149	-	22	-	401	-
	Current Extent	857	100%	401	100%	0	-	0	-	0	-	149	100%	22	100%	401	100%
	Irreversible Loss	10	1%	2	0%	0	-	0	-	0	-	8	5%	0	-	5	1%
	Recoverable Impact	0	-	0	-	0	-	0	-	0	-	0	-	0	-	0	-
	Cumulative Loss	**10**	**1%**	**2**	**<1%**	**0**	**-**	**0**	**-**	**0**	-	**8**	**5%**	**0**	**0%**	**5**	1%
LAU 2	Pre-European Extent	0	-	2,133	-	212	-	750	-	6	0%	2,030	-	10	0%	339	-
	Current Extent	0	-	2,133	100%	212	100%	750	100%	6	100 %	2,030	100%	10	100%	339	100%
	Irreversible Loss	0	-	0	0%	0	0%	1	0%	0	-	15	1%	0	0%	45	13%
	Recoverable Impact	0	-	0	-	0	-	0	-	0	-	0	-	0	-	0	-
	Cumulative Loss	**0**	**-**	**0**	**0%**	**0**	**0%**	**1**	**<1%**	**0**	**0%**	**15**	**1%**	**0**	**0%**	**45**	**13%**
LAU 3	Pre-European Extent	1,300	-	0	-	0	-	0	-	0	-	264	-	0	-	2,069	-
	Current Extent	1,300	100%	0	-	0	-	0	-	0	-	264	100%	0	-	2,069	100%

LAU	Loss Assessment	Algal Mat		Foreshore Mudflat/Tidal Creek		CC Mangroves		SC Mangroves		Rocky Shores		Samphire Mudflat		Sandy Beaches		Mudflat/Saltflat	
		ha	%	ha	%	ha	%	ha	%	ha	%	ha	%	ha	%	ha	%
	Irreversible Loss	452	35%	0	-	0	-	0	-	0	-	216	82%	0	-	1,775	86%
	Recoverable Impact	0	-	0	-	0	-	0	-	0	-	0	-	0	-	0	-
	Cumulative Loss	**452**	**35%**	**0**	**-**	**0**	**-**	**0**	**-**	**0**	**-**	**216**	**82%**	**0**	**-**	**1,775**	**86%**
LAU 4	Pre-European Extent	0	-	1,600	-	369	-	752	-	0	-	1,572	-	0	-	431	-
	Current Extent	0	-	1,596	100%	369	100%	751	100%	0	-	1,533	97%	0	-	429	100%
	Irreversible Loss	0	-	0	-	0	-	12	2%	0	-	57	4%	0	-	24	6%
	Recoverable Impact	0	-	0	-	0	-	0	-	0	-	0	-	0	-	0	-
	Cumulative Loss	**0**	**-**	**3**	**<1%**	**0**	**0%**	**13**	**2%**	**0**	**-**	**97**	**6%**	**0**	**-**	**26**	**6%**
LAU 5	Pre-European Extent	1,323	-	0	-	0	-	0	-	0	-	471	-	0	-	4,866	-
	Current Extent	1,259	95%	0	-	0	-	0	-	0	-	471	100%	0	-	4,775	98%
	Irreversible Loss	416	31%	0	-	0	-	0	-	0	-	322	68%	0	-	4355	89%
	Recoverable Impact	0	-	0	-	0	-	0	-	0	-	0	-	0	-	0	-

LAU	Loss Assessment	Algal Mat		Foreshore Mudflat/Tidal Creek		CC Mangroves		SC Mangroves		Rocky Shores		Samphire Mudflat		Sandy Beaches		Mudflat/Saltflat	
		ha	%	ha	%	ha	%	ha	%	ha	%	ha	%	ha	%	ha	%
	Cumulative Loss	**479**	**36%**	**0**	**-**	**0**	**-**	**0**	**-**	**0**	**-**	**322**	**68%**	**0**	**-**	**4,446**	**91%**
LAU 6	Pre-European Extent	43	-	883	-	700	-	826	-	53	-	1,546	-	0	-	636	-
	Current Extent	43	100%	883	100%	700	100%	826	100%	53	100 %	1,546	100%	0	-	636	100%
	Irreversible Loss	1	3%	0	-	0	-	4	1%	0	-	335	22%	0	-	208	33%
	Recoverable Impact	0	-	0	-	0	-	0	-	0	-	0	-	0	-	0	-
	Cumulative Loss	**1**	**3%**	**0**	**0%**	**0**	**0%**	**4**	**1%**	**0**	**0%**	**335**	**22%**	**0**	**-**	**208**	**33%**
TOTAL (All LAUs)	***Pre-European Extent within LAUs***	**3,523**	**-**	**5,014**	**-**	**1,282**	**-**	**2,327**	**-**	**59**	**-**	**6,032**	**-**	**32**	**-**	**10,602**	**-**
	Current Extent within LAUs	**3,459**	**98%**	**5,014**	**100%**	**1,282**	**100%**	**2,326**	**100%**	**59**	**100 %**	**5,993**	**99%**	**32**	**100%**	**10,509**	**99%**
	Current Regional Extent (Stantec, 2018)	**-**	**-**	**-**	**-**	**7,849 (includes SC Mangroves)**	**-**	**7,849 (includes CC Mangroves)**	**-**	**-**	**-**	**13,111**	**-**	**-**	**-**	**17,424**	**-**
	Irreversible Loss	**880**	**25%**	**2**	**0%**	**0**	**0%**	**17**	**1%**	**0**	**0%**	**954**	**16%**	**0**	**0%**	**6,412**	**77%**

LAU	Loss Assessment	Algal Mat		Foreshore Mudflat/Tidal Creek		CC Mangroves		SC Mangroves		Rocky Shores		Samphire Mudflat		Sandy Beaches		Mudflat/Saltflat	
		ha	%	ha	%	ha	%	ha	%	ha	%	ha	%	ha	%	ha	%
	Recoverable Impact	**0**	**0%**	**0**	**0%**	**0**	**0%**	**0**	**0%**	**0**	**0%**	**0**	**0%**	**0**	**0%**	**0**	**0%**
	Cumulative Loss	**880**	**25%**	***5***	**<1%**	**0**	**0%**	**17**	**1% (<0.1% of regional extent)**	**0**	**0%**	**954**	**16% (<0.1% of regional extent)**	**0**	**0%**	**6,505**	**77% (0.37% of regional extent)**

7.5.2 Mangrove Communities

The assessment conducted in Section 7.5.1 contains information relevant to mangrove communities as they form part of the intertidal BCH within the LAUs. This section provides additional information specific to mangrove communities to ensure potential impacts on this BCH type were assessed in detail.

Advice was sought from Dr Russell Hanley to inform this assessment. Dr Hanley is a marine biologist who has over 38 years of experience, with strong expertise in the ecology of intertidal and subtidal flora and fauna, especially in macrotidal settings such as in the Pilbara. The content of this section has been sourced from Dr Hanley's Technical Memorandum as appropriate (O2 Marine, 2020d; Appendix 2.5).

Direct Loss

For the assessment of the impacts of mangrove losses in the LAUs the CC assemblages have been combined into a single CC group reflecting the high level of heterogeneity within each of the assemblages. The SC mangrove assemblage has been treated separately as it is substantially different in terms of canopy height, AGB, primary productivity and associated fauna.

Direct loss calculations from the Proposal are presented in Table 24. Irreversible loss of 17 ha (1%) of SC Mangroves is predicted to occur as a result of the Proposal (Figure 80). CC Mangroves are not predicted to be impacted by the Proposal.

CC Mangrove communities extend over 1,283 ha and comprise 3% of the total mapped intertidal BCH area. CC Mangroves occur as ribbons along the coastline and fringing tidal creeks, with more vast forest occurring within the southern LAUs, particularly LAU 6 within the boundary of the Robe River Delta.

The SC Mangrove assemblage covers an area of 2,326 ha and is well represented in three of the four coastal LAUs (LAU 2, LAU 4 and LAU 6). Losses of SC Mangroves will occur across all three LAU comprising 1 ha in LAU 2 (<1% of the assemblage present), 12 ha in LAU 4 (2% of the assemblage present), and 4 ha in LAU 6 (1% of the assemblage present).This is in addition to the 1 ha of loss associated with the gas pipeline within LAU 4.

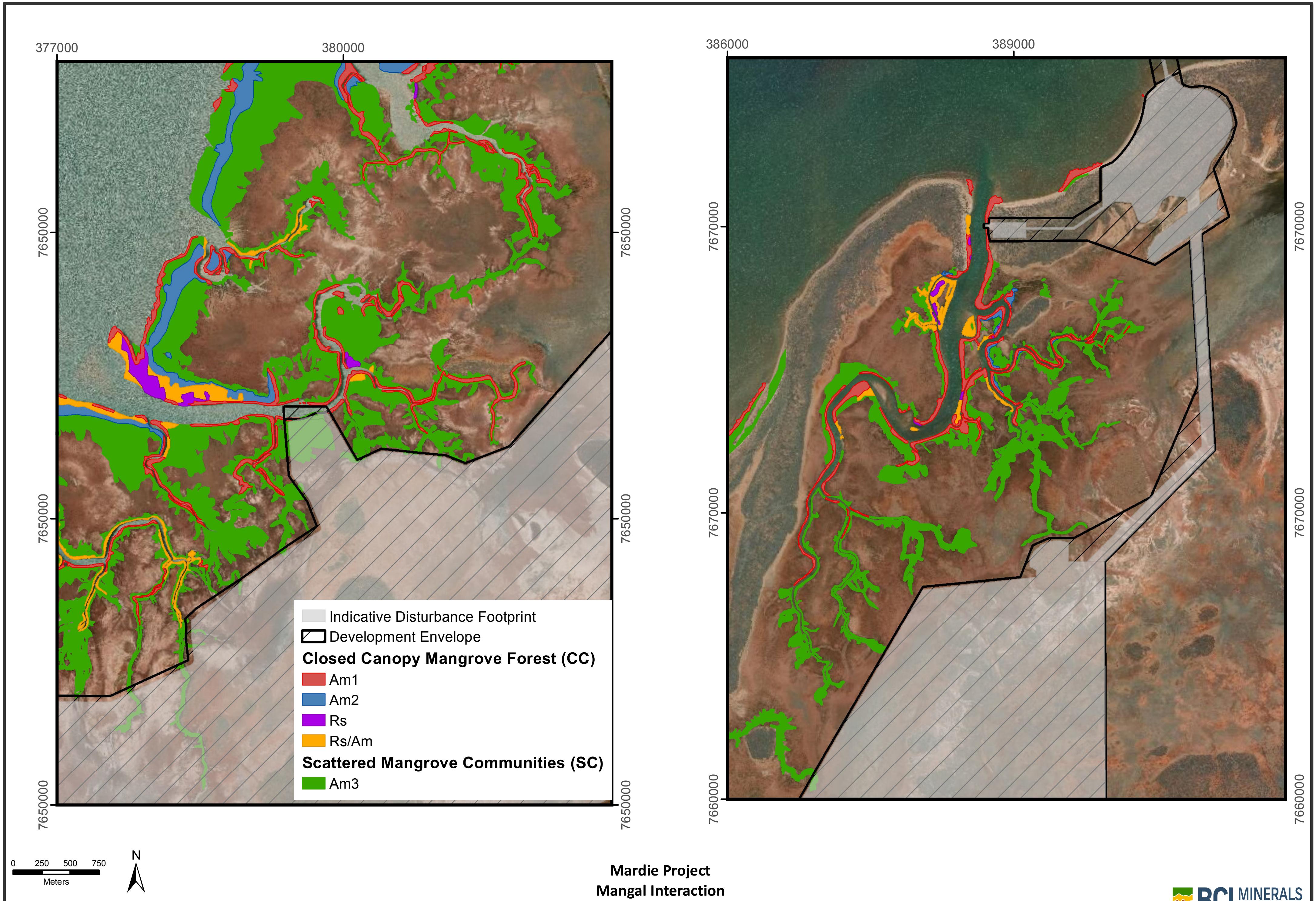


Figure 80: Mangrove habitat and indicative disturbance

Alteration to Intertidal Flow Regime

This section adds to the assessment provided in Section 7.5.1 to provide more information regarding the potential impacts to mangrove communities. The assessment in Section 7.5.1 determined that:

- No new areas of BCH will be flooded (or not flooded) due to the presence of the ponds;
- The increased water depths will only occur on large high tides;
- The increased water depths will only occur within areas that would already be flooded; and
- The duration of the increased flooding depth and the quicker drainage would only be a few hours on each large high tide.

To investigate the inundation frequencies that are currently tolerated by the mangrove communities, RPS (2019a) generated inundation frequency plots for multiple locations within current mangrove BCH areas (see inset on Figure 81).

Plots for those sites (Figure 81) show that many of them experienced little to no inundation for more than half of the King Tide cycle. Over that cycle, peak inundation depth varied from 100 - 330 cm (x-axis).

RPS then modelled the inundation frequency curves for the same ten sites, but with the pond walls present (Figure 82), and the differences in the two sets of curves were calculated. The difference to most sites was negligible, and no site's inundation frequency curve changed by more than +/- 10 cm. A modelled site in the south showed water levels within the mangroves during King Tides would increase faster, but not higher overall, due to the reduced overflow area surrounding the tidal creek as a result of the pond walls. This also caused some of the water levels in the creeks to drop faster, as there was less tidal water in the catchment to drain because of the presence of the ponds.

The change of inundation by +/- 10 cm is not expected to have a notable impact on mangrove species, given that all sites currently experienced up to 1 m of flooding depth (some sites up to 3.5 m).

Mangrove BCH is not expected to be impacted by the changes described above. Mangroves are adapted to infrequent inundation for several hours and the depth of the inundation is not a defining factor.

Monitoring of BCH health and the verification of model predictions is proposed to verify this position (refer to Section 6.6).

Section 5 (Inland Waters) provides more detail about the modelling and predicted results.

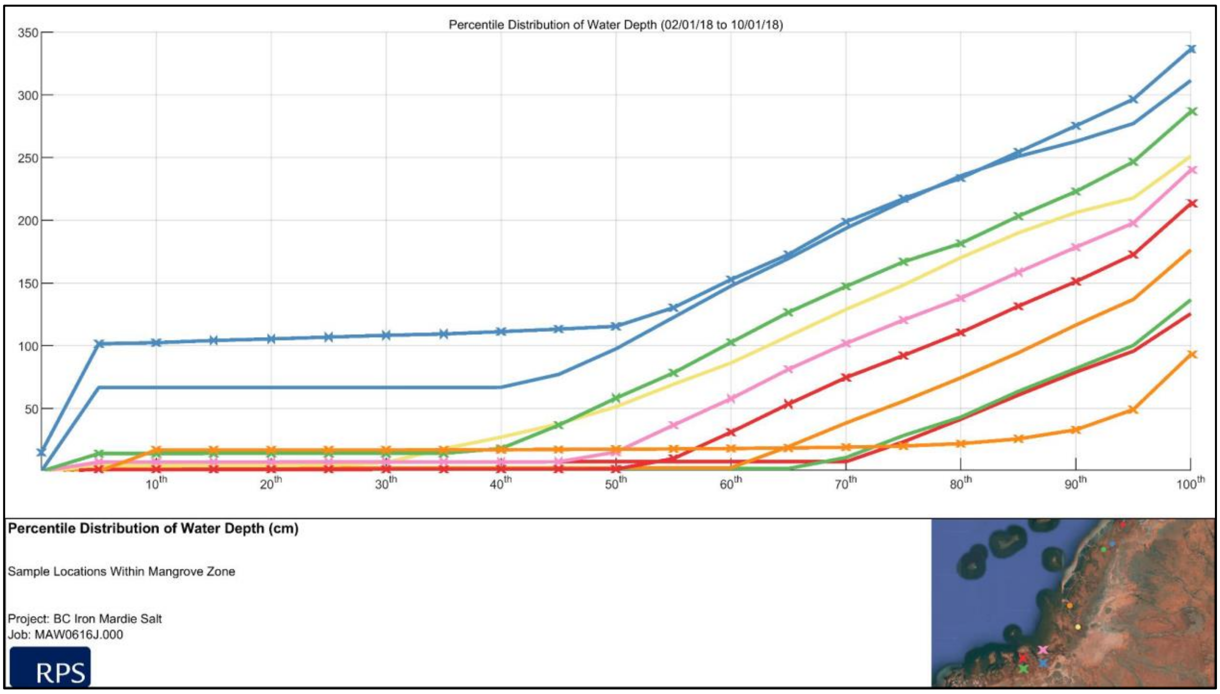


Figure 81: Current percentile distribution of water depth in mangrove areas during a king tide (RPS, 2019a)

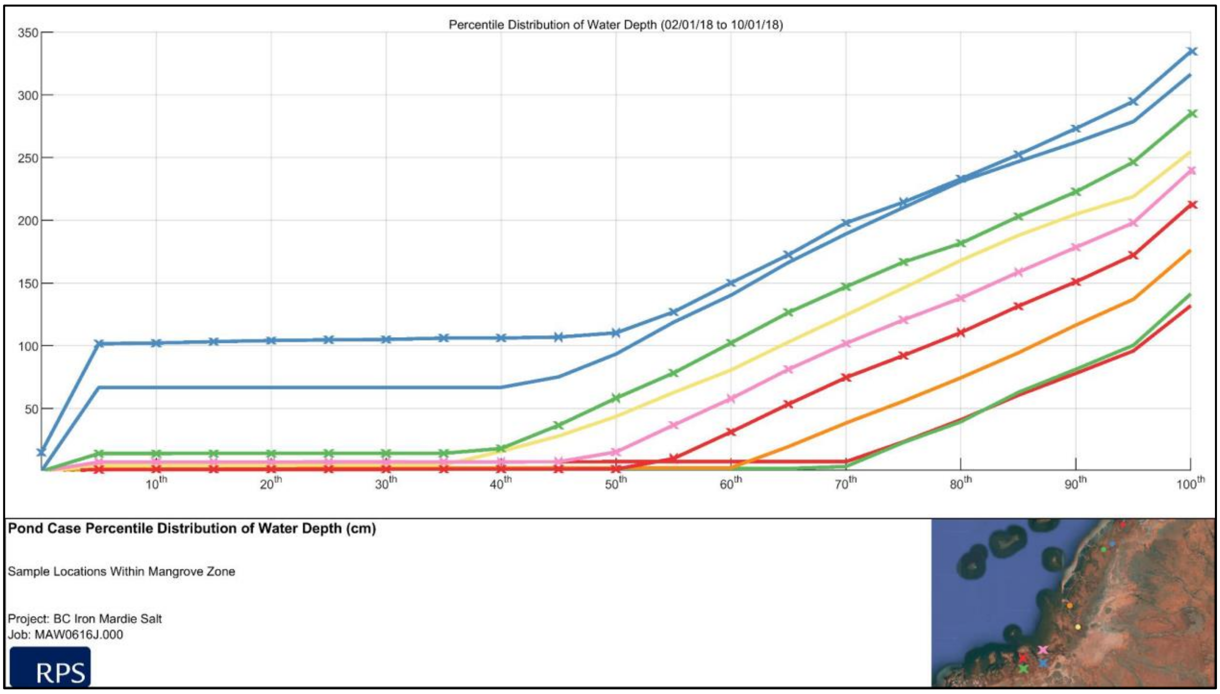


Figure 82: Predicted percentile distribution of water depth in mangrove areas with ponds in place, during a king tide (RPS, 2019a)

RPS (2019a) modelled the effects of the ponds with a higher sea level scenario. There was minimal difference in inundation frequency and effects of the sea level rise on the mangrove communities between the base case and pond case (Figure 83 and Figure 84).

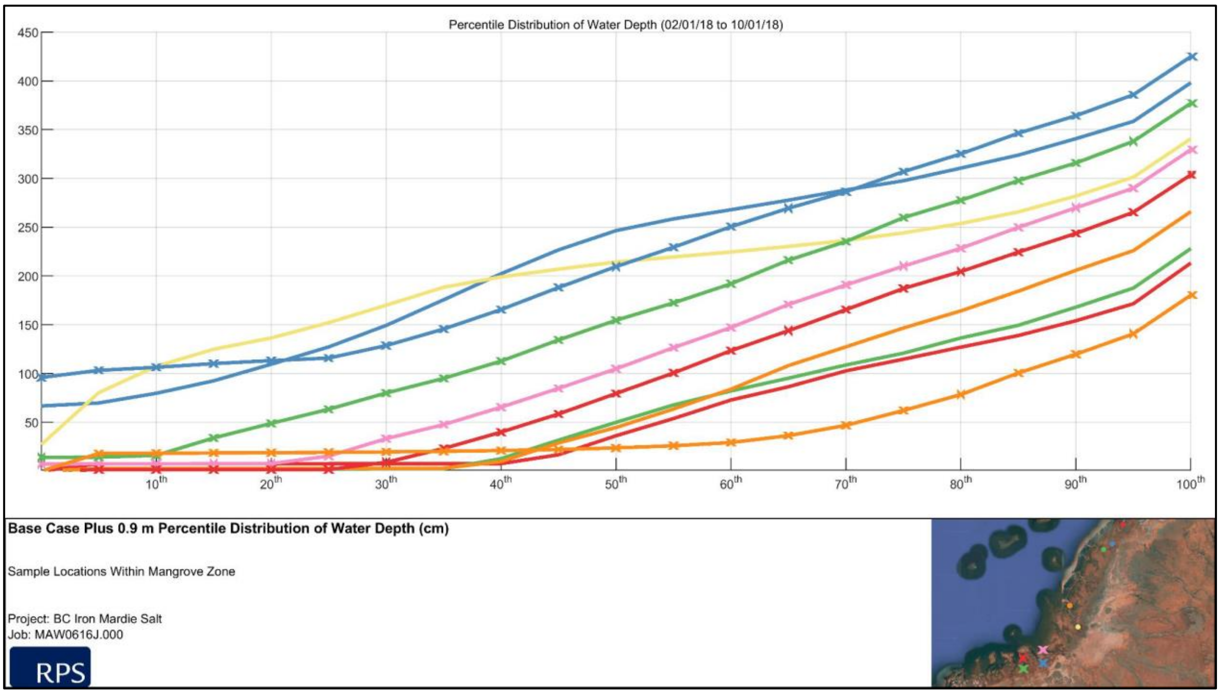


Figure 83: Inundation frequencies calculated over the simulation period for locations in the mangrove zone, derived from the Base Case simulation with an additional 0.9 m of sea level rise. Line styles and colours refer to locations shown in the inset

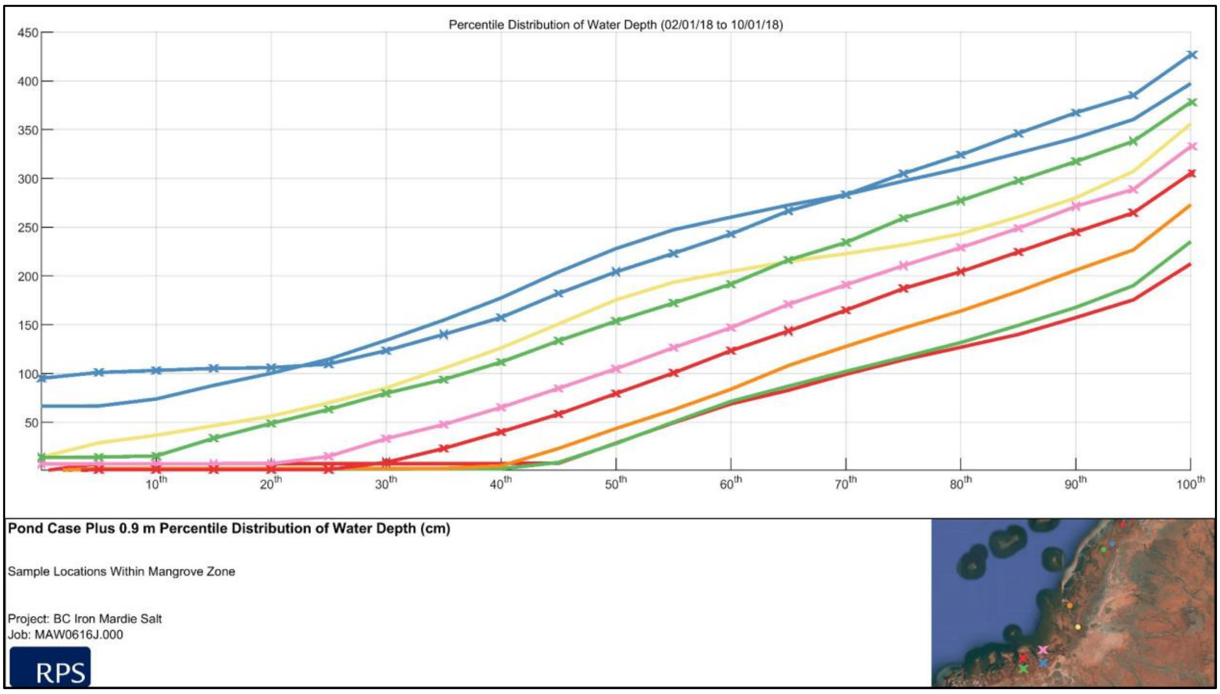


Figure 84: Inundation frequencies calculated over the simulation period for locations in the mangrove zone, derived from the Pond Case simulation with an additional 0.9 m of sea level rise. Line styles and colours refer to locations shown in the inset

Significance of Impacts

None of the observed mangrove species were identified as having national or international significance and are typically widely distributed. The dominant mangrove species, *A. marina* is extremely common along the WA coast occurs across a large range.

O2 Marine (2020b) identified mangroves as being the highest ecologically important BCH within the LAUs, particularly CC mangroves, due to the range of ecological services in which they provide to adjacent BCH and coastal waters. All efforts have been made during the Proposal design phase to maintain maximum mangrove biomass, with CC Mangroves being completely avoided and no net predicted indirect effects. There are no cumulative losses of CC mangroves within LAU 6, which intersects the Robe River Delta regionally significant mangrove area. It is therefore anticipated that any risk or impact to biological diversity and ecological integrity of mangrove communities is not considered to pose a significant risk to ecological integrity and biological diversity of this BCH.

While a larger area of SC Mangroves will be lost, 17 ha still represents less than 1% of this assemblage that is present across all four LAUs and will not impact on the integrity of this assemblage in terms of contributions to local and regional ecological function and connectivity.

The Proposal is not predicted to impact either of the two regionally significant mangrove areas that lie either side of the Proposal.

7.5.3 Algal Mats

The assessment conducted in Section 6.5.1 contains information relevant to Algal Mats as they form part of the intertidal BCH within the LAUs. This section provides additional information specific to Algal Mat BCH to ensure potential impacts on this BCH type were assessed in detail.

Advice was sought from Dr Russell Hanley to inform this assessment. The content of this section has been sourced from Dr Hanley's Technical Memorandum as appropriate (O2 Marine, 2020d).

Direct Loss

A total of 3,459 ha of algal mats was identified in the Study Area during the survey, comprising 8% of the total area of the six intertidal LAUs, although the bulk of the mats are in LAU 1, LAU 3 and LAU 5.

The estimate of direct loss of algal mats is 880 ha or 25% of the total of this BCH type distributed across the six intertidal LAUs. Most of the losses would be within LAU 1 (10 ha or 1% of the total extent of algal mat recorded in that LAU), LAU 3 (452 ha or 35% of the total recorded in that LAU) and LAU 5 (479 ha or 36% of the total recorded in that LAU) with negligible losses in LAU 1 and LAU 4.

The report on the distribution and composition of mats undertaken by Stantec (2018) concluded that algal mats were either contiguous or fragmented communities but there was little variation among assemblages across the entire 82,833 ha Stantec Study Area. Stantec (2018) also considered that the algal mats surveyed within the LAUs are representative of algal mat habitats assessed through studies occurring in similar sites within the Pilbara region, including Exmouth Gulf (Biota 2005) and south of Onslow (Paling 1990, URS 2010a). Accordingly the algal mats that will be directly impacted are not considered to be regionally significant, in terms of representation and diversity.

Studies from the Pilbara region have concluded that algal mats do not support any particular species solely reliant upon them, although opportunistic grazing on the seaward boundary by crabs and some fish species during high tides is likely to occur within the LAUs (Paling 1990, Biota 2005, URS 2010a). Live algal mat communities were observed by SKM (2011) within Port

Hedland to have no evidence of grazing and live samples analysed under microscope provided no evidence of micro-invertebrates. The absence of invertebrates is consistent with findings made elsewhere by Stahl (2000) that as soil salinities increase, invertebrate species diversity decreases. Algal mats therefore do not provide essential ecological services such as supporting abundant or diverse fauna assemblages. Refer also to Phoenix (2020b).

Alteration to surface water regimes

This section adds to the assessment provided in Section 7.5.1 to provide more information regarding the potential impacts to algal mat BCH. The assessment in Section 7.5.1 determined that:

- No new areas of BCH will be flooded (or not flooded) due to the presence of the ponds;
- The increased water depths will only occur on large high tides;
- The increased water depths will only occur within areas that would already be flooded; and
- The duration of the increased flooding depth and the quicker drainage would only be a few hours on each large high tide.

To gain an understanding of the inundation frequencies that are currently tolerated by the algal mats, inundation frequency plots were generated for multiple locations within the areas that are currently colonised by algal mats. Output points were selected along a transect running north-south along the algal mat zone. Further locations were selected along transects running from the seaward margin to the landward margin of these zones. These plots revealed that the algal mats tolerate a relatively wide range of inundation frequencies under the Base Case (Figure 85). The locations of the output points are indicated in the figure insets. Locations towards the seaward edge of the algal mat zone are wetted at substantially higher frequencies than locations towards the landward edge. The median (50th percentile) depth over the simulation period varied between a few cm to ~20 cm among locations within the algal mat zone. Peak water depths were calculated to exceed 30 cm only rarely at all locations. Bearing in mind that these frequencies have been calculated for a period that spanned the annual King Tide period, such extremes would occur at lower frequencies (higher percentile values) if calculated over an annual period.

Plotting of inundation frequencies for the same locations under the Pond case (Figure 86) revealed no obvious changes in the inundation frequency and only very small (1-2 cm) differences in the depths at the extreme, low frequency cases (i.e. high percentile end) for those locations closest to the wall. This result suggests that the effect of the walls on holding up the peak rising tides and speeding the drainage of water near the wall locations would be dissipated before reaching the algal mats. Because the simulation period covered the King Tide period, when effect of the walls would be largest, this result suggests that there would be no secondary effect of the pond walls on the area currently colonised by algal mats, in terms of inundation of water from the coast.

A similar inundation frequency analysis was performed for an area that is currently colonised by mangroves. The mangrove locations selected for the analysis are significantly closer to the seaward margin than the algal mat zone. The inundation frequencies for the Base Case and Pond Case scenarios are indicated in Figure 81 and Figure 82, respectively. The locations of the output points are indicated in the figure insets. The results indicate that the inundation frequencies at the selected locations range from inundation 35% of the time to 100% inundation. The median inundation level at most locations was non-zero, indicating that these sites are more often wet than dry. The results for the Pond Case scenario are very similar to the Base Case scenario results, indicating little, if any, influence from the pond walls on the mangrove areas in terms of inundation frequencies.

Algal mat BCH is not expected to be impacted by the changes described above. Monitoring of BCH health and the verification of model predictions is proposed to verify this position (refer to Section 7.6).

Section 5 (Inland Waters) provides more detail about the modelling and predicted results.

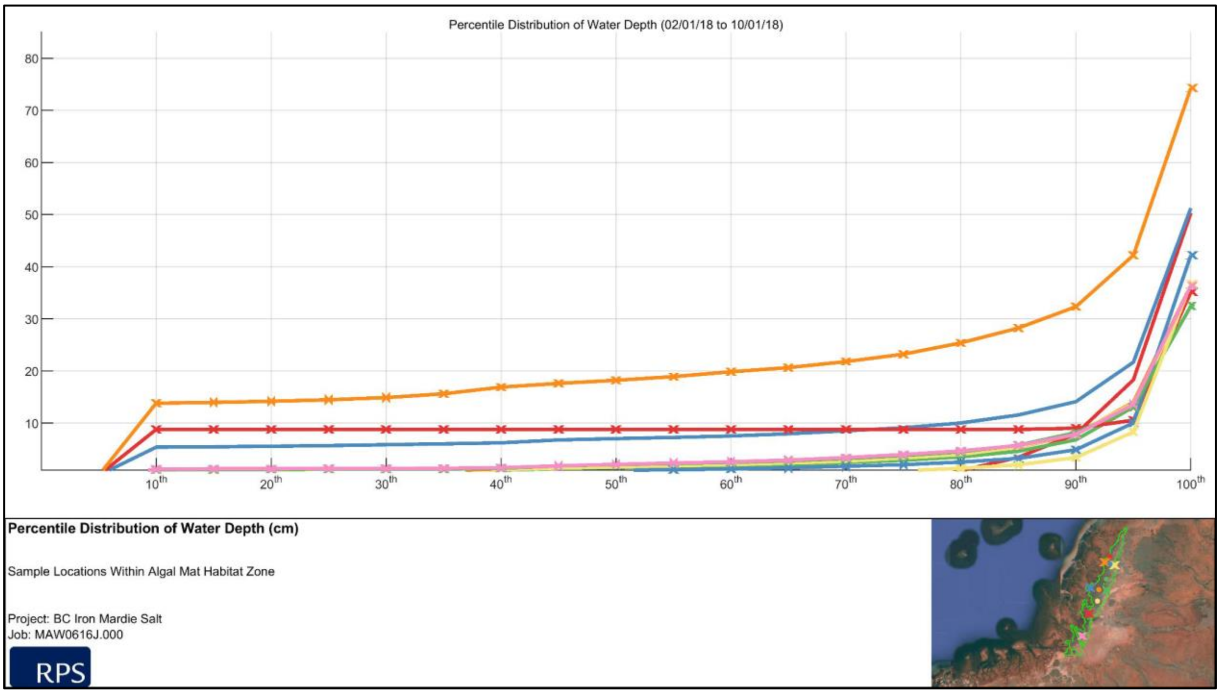


Figure 85: Percentile distribution of water depth over algal mat areas during a king tide (RPS, 2019a)

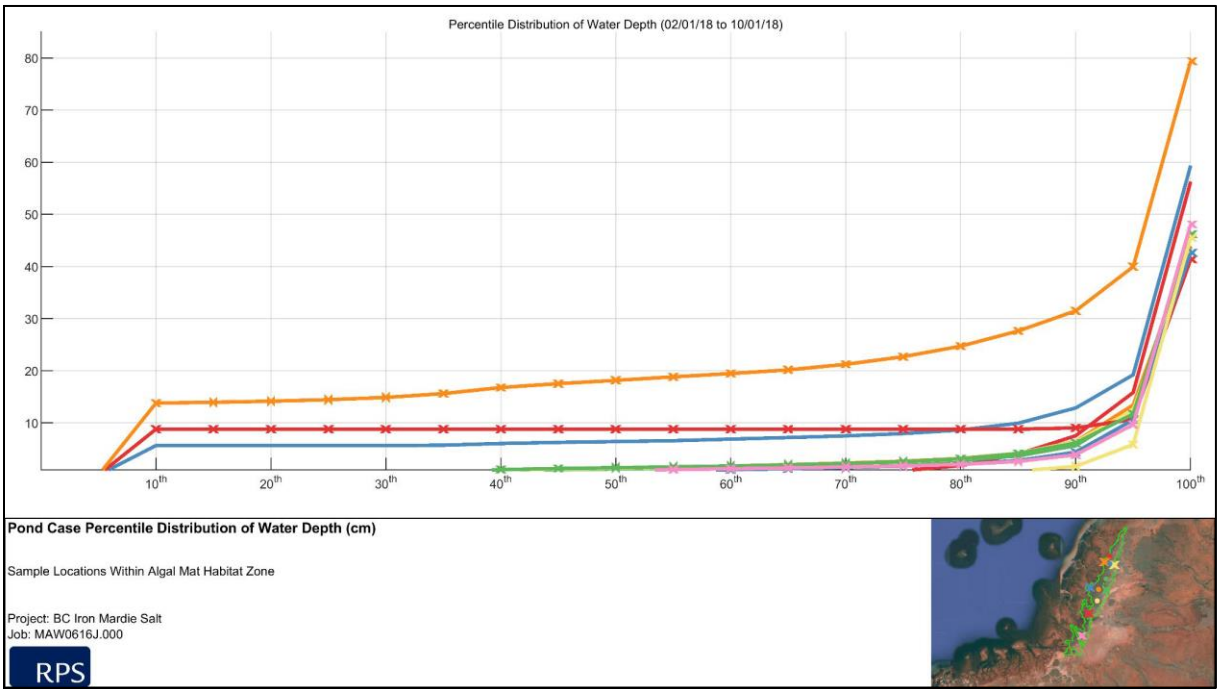


Figure 86: Percentile distribution of water depth over algal mat areas during a king tide, derived from the pond case simulation (RPS, 2019a)

RPS (2019a) modelled the affects of the ponds with a higher sea level scenario. There was minimal difference in inundation frequency and effects of the sea level rise on the algal mats beween the base case and pond case (Figure 87 and Figure 88).

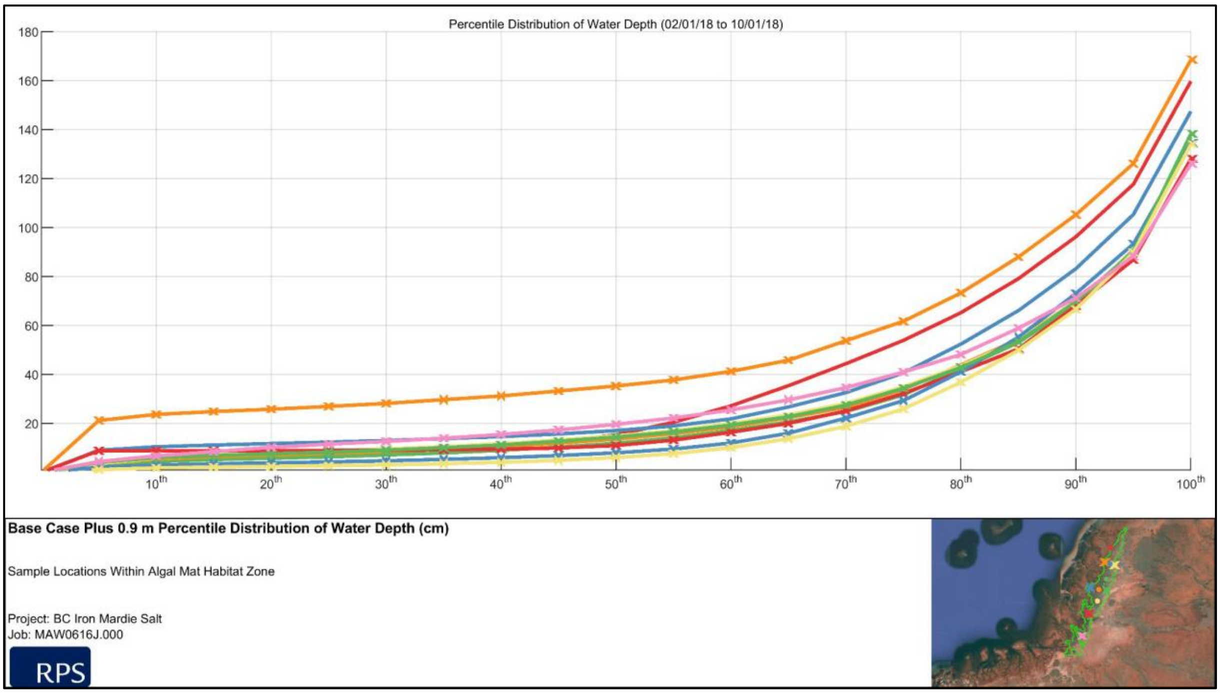


Figure 87: Inundation frequencies calculated over the simulation period for locations in the algal mat zone, derived from the Base Case simulation with an additional 0.9 m of sea level rise. Line styles and colours refer to locations shown in the inset

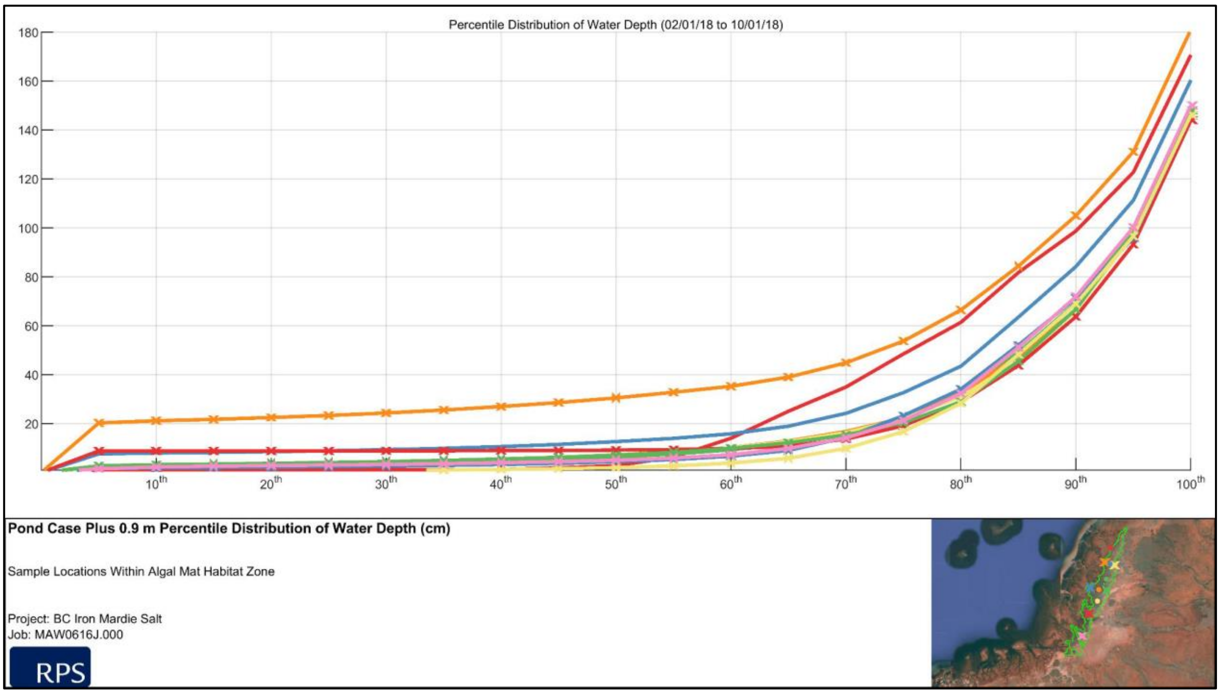


Figure 88: Inundation frequencies calculated over the simulation period for locations in the algal mat zone, derived from the Pond Case simulation with an additional 0.9 m of sea level rise. Line styles and colours refer to locations shown in the inset

Significance of Impact

Substantial percentages of the total area of algal mat BCHs present within LAU 3 (35%) and LAU 5 (36%) will be lost, with the overall loss across all six LAU being 25% of the total present. While these loss percentages are high, the ecological impact of the losses are best assessed in the context of the ecological value of this habitat type. Taking this into consideration, the loss of algal mats is not considered to be a significant impact at either local or regional scales because:

- Assemblages comprising the algal mats are widespread across the LAUs and more broadly throughout the Pilbara region;
- Remaining algal mats will maintain connectivity and a large contiguous area;
- Algal mats are unlikely to be significant in the context of local or regional contributions to primary productivity and nutrient export due to periods of dormancy, low primary productivity, low level of use by secondary producers and absence of physical pathways for transport of nutrients; and
- Algal mats do not appear to provide significant habitat for other flora or fauna primarily because the mats are typically associated with very high soil salinities.

7.5.4 Samphire / Samphire Mudflat Habitat

The assessment conducted in Section 7.5.1 contains information relevant to samphire / samphire mudflat habitat as it forms part of the intertidal BCH within the LAUs. In addition the Flora and Vegetation factor assesses impacts to *Tecticornia* spp. shrubland vegetation (which generally aligns with the boundaries of samphire / samphire mudflat BCH) from a terrestrial perspective. This section provides additional information specific to samphire/ samphire mudflat BCH to ensure potential impacts on this BCH type were assessed in detail.

Advice was sought from Dr Russell Hanley to inform this assessment. The content of this section has been sourced from Dr Hanley's Technical Memorandum (O2 Marine, 2020d).

Direct Loss

Up to 954 ha of samphire / samphire mudflat will be lost and this represents 16% of this habitat type which is present across all six LAU. More than 5% losses (of the habitat extent within each LAU) are predicted within LAU 3 (216ha, 82%), LA U 5 (322ha, 68%) and in LAU 6 (335ha, 22%). These are the largest areas of habitat supporting intertidal benthic primary producers that will be lost due to the Proposal footprint.

As discussed in Section 7.3.8, this BCH type is separated into higher value habitat located along the coast, and lower value habitat located further inland. The majority of the proposed disturbance of samphire / samphire mudflat habitat will occur within the lower value inland habitat. Section 9.5.6 and 10.5.2 provide an assessment of these impacts in further detail, demonstrating that almost all of the higher ecological value samphire / samphire mudflat habitat will not be impacted by the Proposal.

Alteration to surface water regimes

Samphire species are salt-tolerant, however they are susceptible to prolonged inundation and some species rely on a freshwater input for germination (Purvis *et al.* 2009). There are therefore two ways that changes to surface water regimes caused by the Proposal could potentially indirectly impact samphire / samphire mudflat habitat:

1. Less fresh water reaches the vegetation downstream of the ponds if fresh water flows are significantly restricted; or
2. Less fresh water reaches the vegetation upstream of the ponds if fresh water flows are diverted around the area.

As detailed in Section 5.5.2, the concentrator ponds have been designed to include two large drainage channels to allow overland flow through the development envelopes. In addition, the size of the southern-most pond has been reduced significantly to allow the main channel of Peters Creek to continue to flow to the ocean, which is the main drainage channel in the vicinity of the *Tecticornia* spp. shrubland vegetation. RPS (2019a) modelled the potential changes to the overland freshwater flows due to the presence of the ponds and determined that there would be some changes to the flow regime within downstream areas as a result of the Proposal. Section 5 (Inland Waters) provides more detail about this modelling and predicted results.

An estimated 452.5 ha of samphire / samphire mudflat habitat is predicted to experience more freshwater inflows than it currently experiences during run-off events (based on a 20 year ARI flow event). These additional flows are not expected to impact *Tecticornia* species as any flooding will be short in duration given that water will drain to the ocean on low tides. The habitat characteristics would be expected to return to current conditions relatively quickly after each flow event.

An estimated 54.0 ha of samphire / samphire mudflat habitat is predicted to experience less freshwater inflows than it currently experiences during run-off events (based on a 20 year ARI flow event). This reduction in flows may influence the germination of some samphire species if they rely on a freshwater pulse to germinate. Mardie Minerals has committed to monitoring of samphire health within this area and will investigate and implement mitigation measures if impacts are identified (refer to Section 7.6.2 and 9.6.2).

Significance of Impact

When viewing this BCH type as a uniform habitat the losses of this habitat type are substantial in both LAU 3 and LAU 5 comprising around two thirds of this habitat type present in those LAU. Lesser amounts of this habitat type will be lost in LAU 1 and LAU 2 (<5%), whilst LAU 6 (22%) still represents a substantial loss in a local context.

Losses of this BCH type will have significant impacts in a local context (within each LAU) as removal of these areas will substantially diminish the biomass of this BCH type present within each LAU. However as the majority of the losses are within the sparse inland habitats this loss of biomass is likely to low in the context of the overall LAUs. In addition, relative to adjoining mangrove habitats lower on the shore for example, samphire / samphire mudflat BCH in the LAUs (including the coastal habitats) are likely to comprise much lower AGB per hectare.

There will also be total loss of the component of in situ invertebrates such as crabs and molluscs that require regular tidal inundation and exposure. However, the biodiversity and abundance of these invertebrate fauna in the samphire / samphire mudflat BCH is likely to be low - a consequence of the higher position on the shore with correspondingly higher soil salinities (SKM, 2011).

While tidal samphires and mudflats were designated as important to migratory shorebirds and other birds by the Phoenix surveys they also report the great majority of the birds observations were in the tidal samphires to the west of the development envelope. The tidal samphires lower on the shore, closer to the mangroves and tidal creek margins had high numbers of birds relative to the areas of this habitat higher on the shore. This likely to be a consequence of lower soil salinities closer to the mangroves and tidal creeks due to more regular and longer inundation of the substrate with a corresponding increase in invertebrate infauna (refer to Section 10 for shorebird assessment).

In terms of likely impact on ecological functions, while the removal of a large area of this BCH type will have a significant impact on the BCH itself, it is unlikely to make a significant difference to the maintenance of ecological functions and diversity across the shoreline, outside the areas where the samphire / samphire mudflat habitat is present.

Also, while there will be removal of substantial areas of this habitat class the connectivity between the remaining areas of this habitat will be maintained both within and between adjoining LAU.

7.5.5 Sub-tidal Benthic Communities and Habitat

A detailed assessment of the potential impacts on subtidal BCH from the Proposal is provided in O2 Marine (2020c; Appendix 2.1).

Direct Disturbance

The Proposal will result in the direct disturbance of up to 55 ha of subtidal BCH within LAU 7 comprising:

- 9 ha (6% of mapped habitat) of filter feeder/macroalgae/seagrass BCH;
- 10 ha (6% of mapped habitat) of coral/macroalgae BCH; and
- 36 ha (16% of mapped habitat) of bare 'unvegetated' substrate.

Direct loss of sub-tidal BCH has been assessed in context with the cumulative indirect impacts described in the sections below. This cumulative assessment is provided at the end of this section.

Table 26: Sub-tidal BCH impacts

BCH Class	Direct Impact	Indirect Impacts	Cumulative
Bioturbated Sand	36 ha	68 ha (595 ha recoverable)	104 ha
Filter Feeder / Macroalgae / Seagrass	9 ha	26 ha (133 ha recoverable)	35 ha
Coral / Macroalgae	10 ha	34 ha (69 ha recoverable)	44 ha
Total	**55 ha**	**128 ha (797 ha recoverable)**	**183 ha**

Introduced Marine Pests

Technical information in this section has been sourced from O2 Marine (2020h; Appendix 2.6) unless stated otherwise. In addition, a detailed assessment for IMPs has been provided for 'General Inter-tidal BCH' above, and this section summarises that assessment where relevant to the sub-tidal environment.

During construction and operation the Proposal will utilise vessels that will be brought to Mardie marine waters from other ports within Australia and overseas. These vessels have the potential to transport IMPs which can potentially impact subtidal BCH through (O2 Marine, 2019e):

- Competition with native species for resources;
- Predation on native species; and

- Alteration of trophic interactions and food-webs.

Mardie Minerals engaged O2 Marine (2020h) to conduct an IMP risk assessment. There are two key inputs to the risk assessment; the risk of a vessel or equipment introducing a marine pest, and the risk of the IMP becoming established.

The IMP risk assessment concluded that the construction phase represented the highest risk as it will create new areas of hard sub-tidal substrate which could be colonised by IMPs such as Asian Green Mussel (*Perna viridis*) or Black Striped Mussel (*Mytilopsis sallei*). Two construction vessels - the jack-up barge (pile driving) and the dredging barge are both slow moving and will have direct contact with the substrate, presenting the greatest likelihood of IMP translocation if these vessels are sourced from high risk international ports in south-east Asia. Additionally, the dredged channel and turning basin have higher potential for successful IMP settlement than the surrounding undisturbed substrate. During the operational phase, the bulk carrier anchorages (primary node) are at greatest risk of marine pest introduction where soft substrates are to be the dominant habitat type. Seven high risk species for these soft substrates have potential of being introduced and surviving. All potential hard substrates are secondary nodes and have a lower risk of IMP translocation.

Increased Sedimentation Resulting in Settlement and Smothering of Habitat

Indirect impacts to subtidal BCH can be caused due to increased suspended sediment concentration (SSC), resulting in increased turbidity, a reduction in available benthic light and localised increase in sedimentation.

In accordance with guidance provided in EPA (2016e), a dredge plume impact assessment was undertaken to develop predictions of the ZoHI, ZoMI and ZoI for BCH in the vicinity of the dredging (See Section 6 and Baird, 2020b).

Within LAU 7, the BCH at most risk from indirect dredging related impacts include coral, macroalgae and seagrass, whereas filter feeder communities have been shown to be tolerant to dredging related impacts (O2 Marine, 2020c). Although seagrass was present within LAU 7, it was only present in very low densities (i.e. typically <1% cover) as a subdominant taxa within the filter feeder/macroalgae/seagrass BCH. Benthic light conditions at Mardie were shown in O2 Marine (2020d) to naturally exceed the tolerance limits for corals published in Jones *et al.* (2019). Therefore, coral threshold values were not considered to be suitable for impact assessment. However, given the high volume of fines (i.e. up to 80%) present in the dredge material it was considered that sedimentation, rather than benthic light reduction, posed the greatest risk to coral BCH. Therefore, the SSC and sedimentation tolerance limits for coral as published in Jones *et al.* (2019) were selected as the most appropriate thresholds to derive the separate zones of impact (i.e. ZoMI & ZoHI). Indirect impacts to bare substrate were not predicted as a result of dredging.

Indirect Irreversible Loss Baird (2020b; Appendix 6.3) identified that the sedimentation thresholds were exceeded beyond the dredge footprint for both best and worst-case model scenarios, typically in the southern half of the dredge corridor and adjacent to the berth pocket. For the purpose of this assessment, the worst case ZoHI for SSC was used to determine the extent of predicted indirect irreversible loss of subtidal BCH as a result of dredging. The area of irreversible loss (i.e. ZoHI) for each BCH type are displayed in Figure 89 and are quantified below:

- 27 ha (5% of extent within LAU 7) of Filter Feeder / Macroalgae / Seagrass BCH; and
- 35 ha (18% of extent within LAU 7) of Coral / Macroalgae BCH.

These predicted indirect losses are considered to be relatively conservative, as the threshold values used by Baird (2020a) were derived from a clear water coral reef environment (i.e. Barrow Island). As stated in Jones *et al.* (2019), these absolute threshold values may not be applicable to more marginal reef sites, such as the turbid reef zones in LAU 7. Nevertheless, the Jones *et al.* (2019) threshold values are based on the latest scientific understanding of coral pressure response pathways and as such are considered the most appropriate values for impact assessment purposes at this point in time. However, Jones *et al.* (2019) notes that studies are currently underway to derive thresholds for turbid water coral communities, which may be able to be used to inform monitoring and management to ensure that recoverable impacts to the Mardie nearshore reef systems are minimised.

Although the subtidal BCH present in the Mardie area are tolerant to turbid conditions (i.e. Mean 14.2 NTU and 90th percentile 29.5 NTU) (O2 Marine, 2020d), O2 Marine (2020c) identified a considerably high proportion of fines (i.e. up to 80%) present within nearshore sediments likely to be mobilised and released during dredging activities. These fine sediments pose the greatest risk to vulnerable life history stages for corals, such as fertilisation and settlement (Negri *et al,* 2019). In particular, the resulting film of fine sediment that will be present on substrate considered suitable for settlement may result in delayed recovery of the affected coral BCH areas, such that the coral BCH within the ZoHI may not recover within five years and so should be considered as an irreversible loss.

<u>Indirect Recoverable Impacts</u>

For the purpose of this assessment, the worst case ZoMI for SSC was used to determine the extent of predicted indirect recoverable impacts to subtidal BCH as a result of dredging. The area of recoverable impacts (i.e. ZoMI) for each BCH type are shown on Figure 90.

The following estimated recoverable impacts are predicted to subtidal BCH as a result of indirect dredging impacts:

- 133 ha (24%) of Filter Feeder / Macroalgae / Seagrass BCH; and
- 69 ha (36%) of Coral / Macroalgae BCH.

As with the indirect irreversible loss, the estimated recoverable impacts to subtidal BCH are considered to be relatively conservative due to the threshold values used in the modelled predictions. .

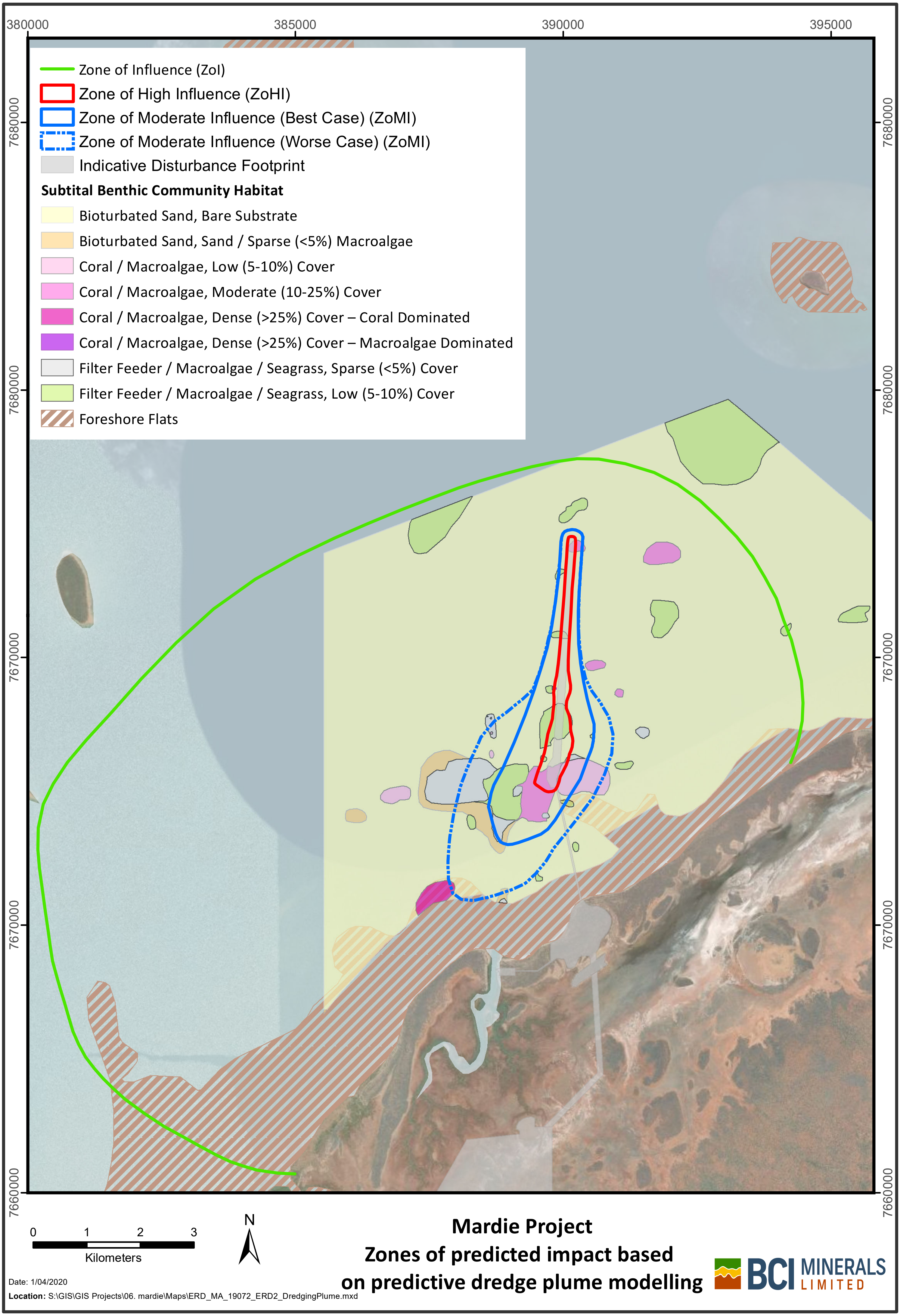


Figure 89: Predicted likely best- and worst-case dredging impact zones (i.e. ZoI, ZoMI & ZoHI) overlaid on Subtidal BCH

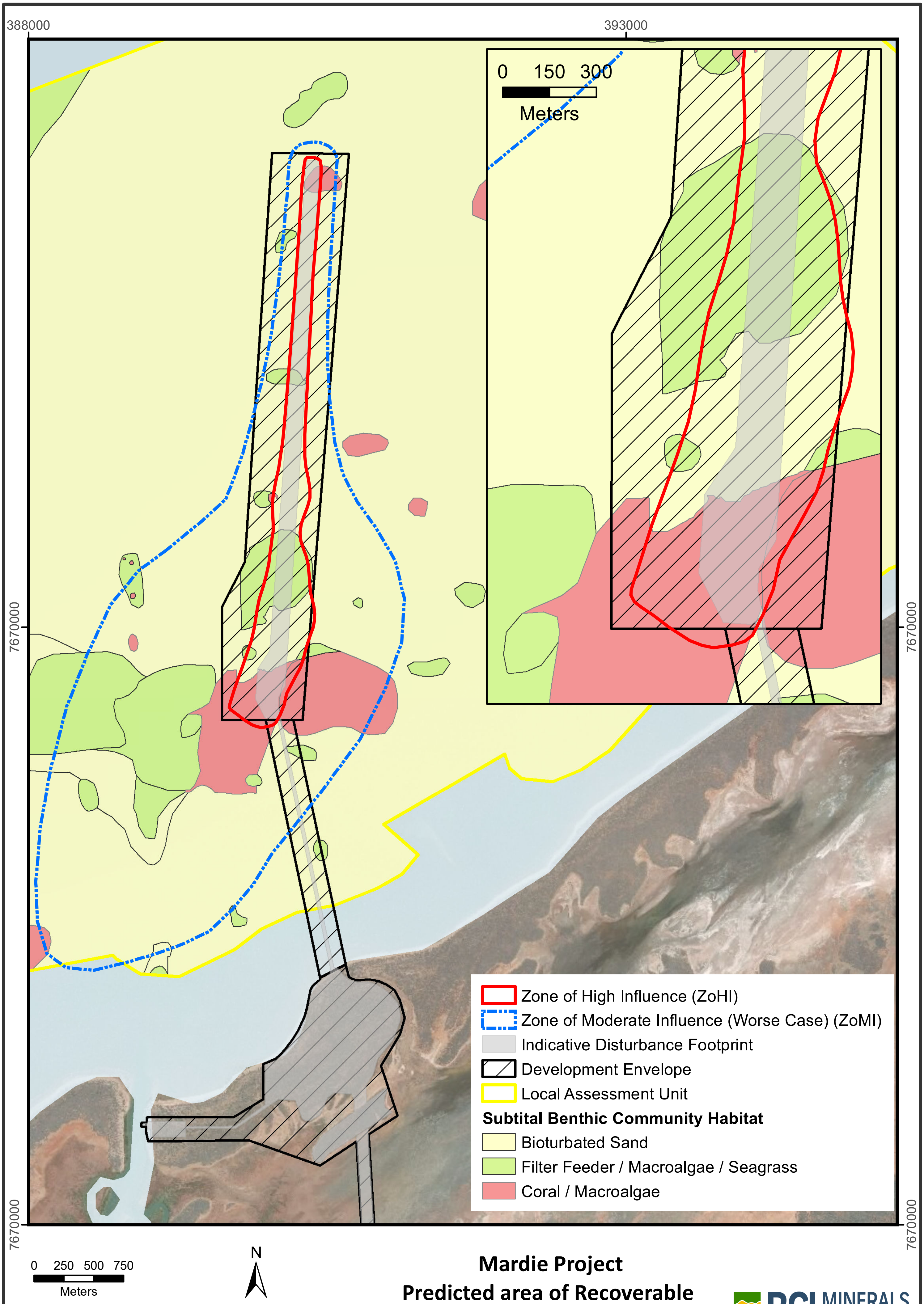


Figure 90: Predicted area of Recoverable Impacts to subtidal BCH

Mardie Project
Predicted area of Recoverable Impacts to subtidal BCH

BCI MINERALS LIMITED

Bitterns Disposal

The discharge of hypersaline waste bitterns is predicted to result in indirect impacts to subtidal BCH, as the discharge will result in a plume with increased toxicity and salinity characteristics, along with alterations to natural physico-chemical parameters (i.e. lower dissolved oxygen) (Baird 2020c; Appendix 6.2).

In accordance with guidance provided in EPA (2016d), bitterns outfall modelling was undertaken (Baird, 2020) based upon WET testing (O2 Marine 2019b) to predict the spatial boundaries of the LEPA and MEPA based upon achieving a 90% and 99% SPL, respectively, resulting from altered water quality due to bitterns discharge (refer to Section 6 for more information). The LEPA and MEPA boundaries are presented within Figure 91.

Within LAU 7, the BCH at most risk from indirect bitterns plume related impacts include coral, macroalgae, filter feeders and seagrass BCH. The impacts upon these BCH types will vary in the indirect impact, being either plume toxicity impacts upon vulnerable life stages of certain species (in accordance with the specified SPL), or through alterations to the water quality through increased salinity or other physicochemical alterations (i.e. dissolved oxygen, pH etc.).

Discharge of hypersaline waste bitterns would be predicted to result in an indirect impacts to the subtidal BCH within the LEPA and MEPA (to a lesser extent). However, the LEPA and MEPA are entirely contained within the predicted dredge ZoHI; an area already predicted to be lost due to dredge sedimentation impacts (refer to previous section) and as such no additional BCH is predicted to be impacted as a result of the bitterns discharge.

Leaks or Spills of Hydrocarbons or Chemicals

Refuelling of vessels is proposed to occur at the Mardie Export Facility, and therefore there is a risk of hydrocarbon spill from vessels during construction and operation as a result of vessel collisions or hydraulic hose leaks. With the exception of vessels used in jetty construction, the majority of these vessels would be located several kilometres offshore as refuelling will occur at the end of the trestle jetty. Construction vessels are also small in size and therefore would not contain significant volumes of hydrocarbons. All ocean-going vessels will be located offshore in deeper water.

With the implementation of standard industry safeguards and operating procedures (Section 6.6) any offshore spills are expected to be able to be contained and cleaned up before reaching the shore.

Refuelling of the transhipment barge and support vessels is likely to be undertaken alongside the trestle jetty, within the berth pocket and the proposed Low/Moderate LEP zone. Hydrocarbon spills to the marine environment are possible in this area, however with the implementation of standard industry operating procedures (Section 6.6) this is predicted to represent a relatively low risk.

Based on the above, the risk of oil spills impacting sub-tidal BCH is not expected to be significant.

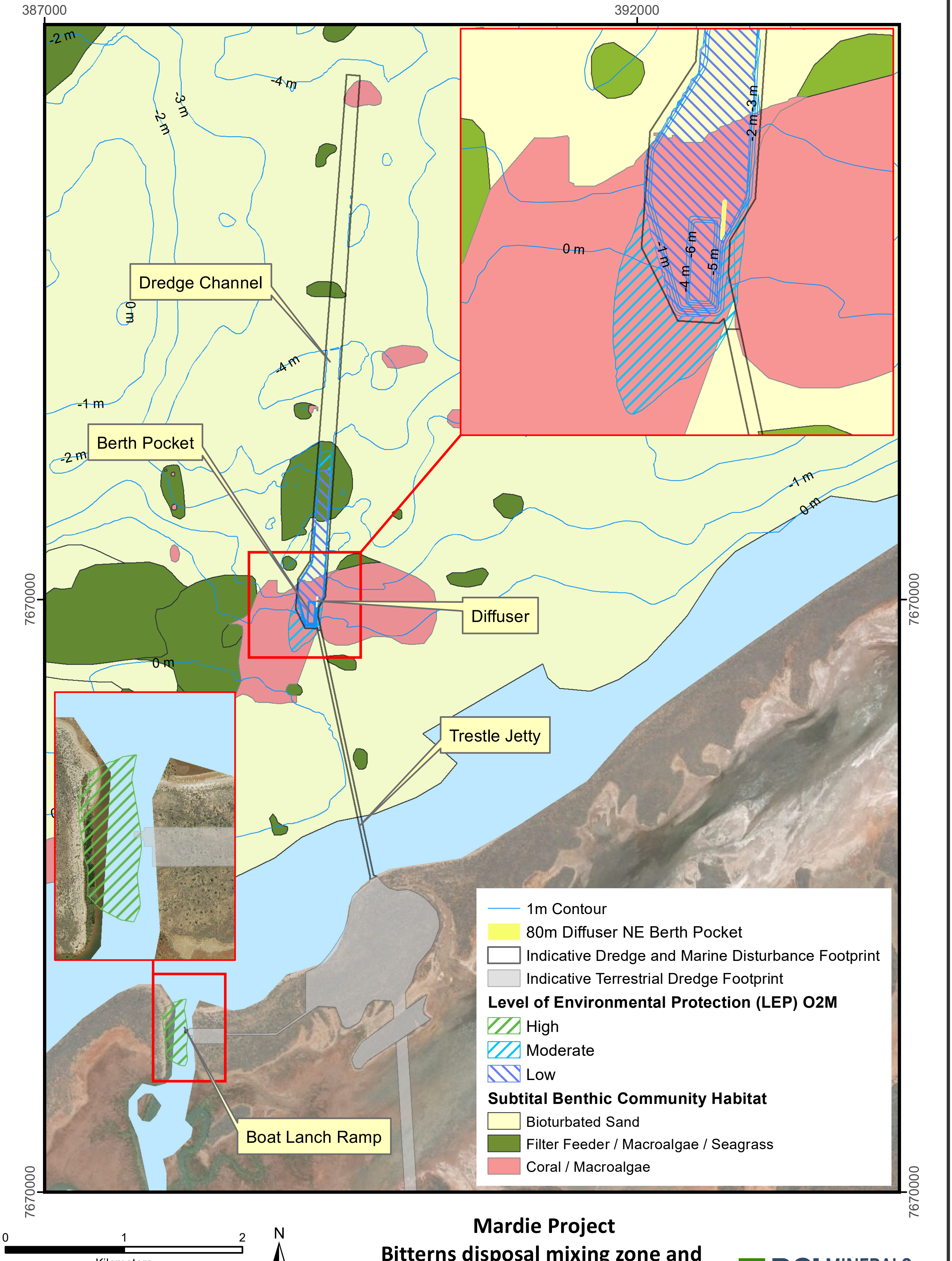


Figure 91: BCH within proposed LEPA and MEPA – note the LEPA will be contained within the ZoHI

Mardie Project
Bitterns disposal mixing zone and dredging boundaries

.mxd

BCI MINERALS LIMITED

Cumulative Loss Assessment – Coral / Macroalgae

An irreversible loss of 44 ha (23% of the extent within LAU 7) and recoverable impact of 69 ha (36% of the extent within LAU 7) of Coral / Macroalgae BCH is predicted to occur as a result of the Proposal. Of the irreversible loss <1 ha (<1%) is classified as Dense (>25%) cover and is dominated by macroalgae, with the remainder classified as Low (5 - 10%) and Moderate (10 - 20%) cover with 5 ha and 39 ha of irreversible loss, respectively.

O2 Marine (2020b) determined that similar Coral / Macroalgae BCH is well represented throughout LAU 7 and more broadly, whilst the offshore islands are surrounded by much denser macroalgal and coral communities than within LAU 7. Coral / Macroalgae BCH was also previously mapped as occurring with the Filter Feeder / Macroalgae / Seagrass BCH from the Fortescue River mouth in the north to the southern end of the Exmouth Gulf (Scott *et al.,* (2006) and is extensively well represented throughout the region. Additionally, of the 44 ha of the Coral / Macroalgae BCH predicted to be lost, <1 ha consists of 'dense' coral or macroalgae therefore the highest value of this BCH type within the LAU is still retained.

The area of coral BCH within LAU 7 represents marginal habitat and is unlikely to be a significant contributor to coral recruitment within the region. Rather, the high value, biologically diverse reefs with far denser colonisation surround the offshore islands. These reefs are the primary driver of long-term ecosystem health and sustainability of nearshore Pilbara coral communities in this area. Therefore, whilst the impacted area of coral BCH provides suitable habitat for a variety of marine fauna species, the loss of 44 ha is not considered a significant risk to the ecological integrity and biological diversity of this BCH (O2 Marine, 2020c).

Cumulative Loss Assessment – Filter Feeder / Macroalgae / Seagrass

An irreversible loss of 35 ha (6% of the extent within LAU 7) and recoverable impact of 133 ha (24% of the extent within LAU 7) of Filter Feeder / Macroalgae / Seagrass BCH is predicted to occur as a result of the Proposal.

O2 Marine (2020b) determined that the Filter Feeder / Macroalgae / Seagrass BCH is well represented throughout LAU 7 and more broadly. This BCH was previously also mapped as occurring with the Coral / Macroalgae BCH from the Fortescue River mouth in the north to the southern end of the Exmouth Gulf (Scott *et al.* (2006), and is extensively well represented throughout the region. None of the Filter Feeder / Macroalgae / Seagrass BCH to be lost within LAU 7 was identified as medium density or above, with all mapped densities being less than 10% benthic cover. Although this BCH is also known to provide suitable habitat for a variety of marine fauna species, the loss of 35 ha is not considered a significant risk to the ecological integrity and biological diversity of this BCH (O2 Marine, 2020c).

7.6 Mitigation

Mardie Minerals has mitigated the potential impacts to this factor according to the mitigation hierarchy; avoid, minimise, rehabilitate, offset. Offsets are not expected to be required for this factor.

7.6.1 Avoid

The key avoidance mechanism implemented by Mardie Minerals was the design of the development envelopes to avoid key environmental features. Mardie Minerals has conducted numerous ecological surveys and this information has been utilised to design the Proposal and its development envelope boundaries to avoid impacts to CC Mangrove BCH and the majority of SC Mangrove, algal mat and high value samphire BCH as they were identified as having a higher ecological value.

7.6.2 Minimise

The following mitigation measures are proposed to ensure that direct and indirect impacts to BCH are minimised:

1. **Obtain and comply with the following approvals:**
    a. Ministerial Statement to be issued under Part IV of the EP Act;
    b. 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;
    c. Mining Proposal to be approved under the *Mining Act 1978* for activities on *Mining Act 1978* tenure;
    d. Mine Closure Plan (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; and
    e. Development Application to be approved under the *Port Authorities Act 1999* for activities within PPA-managed lands and waters;
2. **The Key Proposal Characteristics (Section 2.3.2) provide several limits that were included to minimise impacts to BCH.** These include:
    a. A limit of 17 ha of mangrove community disturbance; and
    b. A dredging limit of 800,000 m^3;
3. **Minimise disturbance within mangrove and algal mat communities**;
4. **Construct the jetty using a top-down approach where appropriate**. This minimises the requirement for a cleared corridor through intertidal BCH and therefore minimises BCH disturbance;
5. **Install engineered floodways and culverts along the causeway alignment to ensure intertidal flow regimes are maintained either side of the causeway (refer to Section 5)**;
6. **Implement the MEQMMP (refer to Section 6 and Appendix 3.1)**;
7. **Implement the DSDMP (Appendix 4.1; refer to Section 6);**
8. **Develop and implement an Oil Spill Response Plan**. This Plan will be developed in consultation with PPA and will include:
    a. Refuelling procedures;
    b. Response equipment requirements;

   c. Response procedures and action plans for various spill scenarios;
   d. Reporting and responsibilities;
9. **The following controls will be used to minimise the risk of impact from unintentional brine pipeline spills**:
   a. Pipelines will be fitted with leak detection;
   b. Water flows will be shut off if leaks are detected;
   c. Pipelines will be inspected regularly, especially during extreme heat or fire events;
   d. Pipelines will be located off access road surfaces;
   e. If pipelines have to cross access roads then they will be buried;
   f. Investigations will be conducted into the cause of any spills, and remedial actions will be taken to minimise the chance of reoccurrence; and
   g. Spill response training to mitigate damage for site-based personnel.
10. **Ensure product infrastructure wash down water is captured and not released to the surrounding environment**;
11. **Minimise the risk of introducing marine pests by implementing the following measures**:
    a. All vessels should comply with Commonwealth Department of Agriculture and Water Resources – Biosecurity Requirements as well as all State legislation relating to management of introduced marine organisms;
    b. Any vessels visiting the Port of Mardie from international or interstate waters are required to complete the WA DoF 'Vessel Check' risk assessment (https://www.vessel-check.com/);
12. **Include 200 m wide drainage corridors through the ponds at a minimum two locations** (refer to Section 5);
13. **Monitor erosion at the outlets of the drainage corridors after significant flow events and install erosion protection (i.e. rock baffles etc.) if required** (refer to Section 5);
14. **Verify inundation model within twelve months of the completion of the western pond walls to confirm indirect impact predictions associated with changes to tidal regimes** (refer to Section 5);
15. **Monitor groundwater levels west of the ponds to verify that the ponds will not result in the movement of hypersaline groundwater toward areas inhabited by mangrove communities** (refer to Section 5);
16. **Develop and implement a BCH Monitoring Plan**. This Plan will be designed to monitor the health and distribution of mangrove, algal mat, samphire mudflat and subtidal BCH and will include:
    a. Annual health assessment and comparison with baseline surveys;
    b. Annual BCH boundary mapping; and
    c. Long-term sea level monitoring to determine if the intertidal communities are migrating inland as the sea level rises.

7.6.3 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 (provided in Appendix 12.1), and the key rehabilitation measures that relate to BCH are summarised below:

1. Salts will be harvested from each pond prior to closure;
2. Concentrator pond walls will be opened up to allow tidal flows to enter the ponds;
3. All infrastructure will be removed if not retained by Mardie Station or PPA; and

4. All crystalliser ponds will be rehabilitated to an acceptable landform.

The MCP has been submitted to DMIRS for assessment and approval and will be reviewed and revised every three years.

The port area is expected to be located on a lease under the *Port Authorities Act 1999* and if this occurs a MCP will not be required under the *Mining Act 1978* for the marine infrastructure. Mardie Minerals will liaise with PPA regarding the port infrastructure, as it may be of value for ongoing use by PPA. If not, the closure objective for this factor will be to remove all infrastructure and stabilise all altered lands such that there are no ongoing impacts to marine environmental quality. The marine components of the Proposal are relatively easy to rehabilitate, and the following measures will be taken:

- The causeway will be removed;
- All marine infrastructure including the jetty, wharf, seawater intakes, boat launching facility and navigation infrastructure will be removed and taken offsite; and
- The dredge channel will be left to gradually fill with sediment.

7.7 Predicted Outcome

The EPA's environmental objective for this factor is "to protect BCH 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).

BCH was identified by Mardie Minerals as being a key constraint during the planning process for the Proposal. As a result extensive design changes were made to minimise impacts to significant BCH, including:

- Relocating the ponds further inland, to minimise impacts to the significant BCH that occurs along the coastline (mangroves, algal mats and the denser samphire habitats);
- Bitterns disposal will occur within the area of the dredge footprint; and
- A transhipment export method was proposed which reduces dredging requirements by an order of magnitude.

Given the scale of the Proposal impacts to BCH are unavoidable. The Proposal will result in the loss of approximately 8,282 ha of intertidal BCH and 183 ha of sub-tidal BCH. Bare substrate has been targeted in both zones, 6,412 ha (77%) of the intertidal BCH to be disturbed is bare mudflat / salt flat BCH, and 104 ha (57%) of the sub-tidal BCH to be lost is bare unvegetated substrate.

More substantial losses of high intertidal zone BCH are required in order to construct the ponds. The BCH that will be lost in these areas is dominated by mudflat / saltflat habitat which is largely devoid of either primary producers or associated faunal communities. There will also be losses of areas of samphire and associated mudflats. These losses, while substantial in terms of total area, and as a percentage of the mapped total, are not considered to be significant in the context of the maintenance of local ecological functions such as primary productivity, biodiversity and nutrient transport.

There will also be losses of areas of algal mats comprising some 25% of the total of this habitat class across all intertidal LAUs. This loss is not considered to be significant as there is unlikely to be substantial impairment of the range of ecological functions provided by algal mats either locally or regionally (O2 Marine, 2020c).

Across the shoreline gradient the higher value habitat classes are lower on the shoreline where primary productivity, biodiversity and biomass are much higher, primarily because of frequent tidal inundation which maintains lower soil salinities. The primary productivity, biodiversity and biomass of the SC mangroves, samphires and algal mats is much lower due to higher salinities that increase with increasing elevation in the tidal zone. Any contribution of nutrients and organic carbon from these higher elevation habitat classes to habitats lower on the shoreline is considered to be negligible.

All types of BCH where losses will occur are found elsewhere nearby and are also widespread throughout the region (O2 Marine, 2020a, 2020b).

With the implementation of controls other indirect impacts are not predicted to be significant. Emissions from the construction and operation of the concentrator and crystalliser ponds and export facilities will be regulated under Part V of the EP Act (works approval and licence). Vessel hygiene (to prevent IMPs) is regulated by DPIRD.

Indirect impacts to BCH from dredging will be managed by a Dredge and Soil Disposal Management Plan. This plan is provided in Appendix 4.1. It is anticipated that the requirement for a Dredge and Soil Disposal Management Plan will be a condition applied to the Proposal and the plan will be updated through that process.

Mardie Minerals has committed to model verification monitoring and ongoing BCH monitoring to ensure the findings of the assessments in Section 7.5 are accurate.

In summary, the resultant potential impacts to BCH are not expected to be significant given that:

- The Proposal is located in an area with very little existing disturbance;
- The development envelopes exclude majority of significant BCH;
- The Proposal has been able to avoid all CC Mangroves CC mangroves;
- The sub-tidal BCH to be impacted is of a significantly lower ecological value than other similar BCH in the region;
- The direct disturbance of intertidal BCH occurs higher in the landscape where the intertidal BCH is of lower ecological significance and has a negligible contribution to the lower high productivity BCH (such as CC Mangroves);
- Discharges associated with the production and export of salt will be regulated under Part V of the EP Act;
- Other indirect impacts are not expected to be significant and the majority are easily mitigated;
- Rehabilitation will occur as described in the MCP to be assessed under the *Mining Act 1978* or as required under the *Port Authorities Act 1999*; and
- Hydrological processes will gradually return to existing conditions post-closure.

The EPA's environmental objective for this factor is "to protect BCH so that biological diversity and ecological integrity are maintained". While portions of several BCH types will be disturbed to implement the Proposal, the siting of the ponds within areas of lower value BCH and the implementation of mitigations measures is predicted to ensure that biological diversity and ecological integrity of the local and regional system are maintained.

The implementation of the proposed mitigation is expected to ensure that there are no significant residual impacts to BCH. Based on the above the Proposal is expected to be able to meet the EPA's objective for this factor.

8 MARINE FAUNA

8.1 EPA Objective

The EPA Objective for this key environmental factor is to protect marine fauna so that biological diversity and ecological integrity are maintained.

8.2 Policy and Guidance

Relevant EPA and Commonwealth Government guidance documents for marine fauna are listed below:

Western Australian Government

Key EPA Documents:

- Statement of Environmental Principles, Factors and Objectives 2016 (EPA, 2016a);
- EIA (Part IV Divisions 1 and 2) Administrative Procedures 2016;
- EIA (Part IV Divisions 1 and 2) Procedures Manual 2016; and
- Instructions on how to prepare *EP Act* Part IV Environmental Management Plans (EPA, 2018a).

Relevant EPA Factor Guidelines:

Environmental Factor Guideline - Marine Fauna (EPA, 2016g).

Relevant EPA Technical Guidance:

- Technical Guidance – Protection of BCH (EPA, 2016c);
- Technical Guidance – Protecting the Quality of WA's Marine Environment (EPA, 2016d);
- Technical Guidance – Environmental Impact Assessment of Marine Dredging Proposals (EPA, 2016e);
- National Light Pollution Guidelines for Wildlife Including Marine Turtles, Seabirds and Migratory Shorebirds (DAWE, 2020); and
- Environmental Assessment Guideline No 5 – Protecting Marine Turtles from Light Impacts (EPA, 2010).

Other Policy and Guidance:

- Status reports of the fisheries and aquatic resources of Western Australia 2015/16: State of the Fisheries (Department of Fisheries, 2017);
- WA Environmental Offsets Policy (EPA, 2011);
- WA Environmental Offsets Guidelines (EPA, 2014); and
- WA Offsets Template.

Commonwealth Government:

Key Documents:

- Generic guidelines for the content of a draft EPBC Act PER/EIS (including the objects and principles of the EPBC Act) (DotEE, 2016b);
- Other Minister of the Environment (Cth) approval decision making considerations;
- EPBC Act Environmental Offsets Policy (DSEWPaC, 2012) – including the Offset Assessment guide;
- Environmental Management Plan Guidelines (DotE, 2014a);
- Environmental Management Plan Guidelines, - template (DotEE, 2018a);
- EPBC Act Condition Setting Policy (DAWE, 2020);
- EPBC Act Outcomes-based conditions policy (DotE, 2016c);
- EPBC Act Environmental Offsets Policy (DSEWPaC, 2012); and
- National Assessment Guidelines for Dredging (DEWHA, 2009b).

Relevant Technical Guidance:

- Relevant EPBC listed species specific survey guidelines and protocols;
- Relevant EPBC listed species specific Recovery plans, Threat Abatement Plans, Approved Conservation Advices and other documents;
- Marine bioregional plan for the North-west Marine Region (DSEWPaC, 2012b);
- Environmental best practice port development: an analysis of international approaches (GHD, 2013); and
- National Strategy for Reducing Vessel Strike on Cetaceans and other Marine Megafauna (DotEE, 2017d).

8.3 Receiving Environment

The information in this section has been sourced from the following reports:

- Mardie Salt Project: Level 2 Targeted Terrestrial Fauna Survey 2019 (Phoenix 2020b; Appendix 9.1);
- Mardie Salt Project: Marine Turtle Monitoring Program 2018 / 2019 (Pendoley 2019a; Appendix 7.1); and
- Mardie Project Marine Fauna Assessment (O2 Marine, 2020d; Appendix 7.2).

8.3.1 Survey Effort

The marine fauna survey effort undertaken for the Proposal commenced in 2017 and concluded in 2019. A summary of the survey work undertaken is provided below.

Marine Turtles

Mardie Minerals commissioned Phoenix to complete initial marine turtle reconnaissance surveys in 2017 (Phoenix, 2017a). As a result of the presence of marine turtles being confirmed in the area, Pendoley Environmental (Pendoley) was then engaged to conduct field surveys of known and potential marine turtle habitat in proximity to the Proposal (Pendoley, 2019a). The surveys were conducted on suitable sections of sandy coastline in the vicinity of the Proposal as well as nearby offshore islands (Figure 92).

Two discrete field surveys were scheduled to capture the peak nesting and hatching periods for green and flatback turtles in this region. Each survey was conducted over 14 days to encompass one complete inter-nesting cycle. This duration was based on observations of the inter-nesting cycle at Mundabullangana (13 ± 3.3 days), Barrow Island (14.1 ± 2.2 days), and Cemetery Beach (12.2 ± 1.2 days) (Pendoley *et al.*, 2014). This duration was also consistent with DBCA recommendations for providing the most reliable abundance estimates from the peak of the flatback and green turtle nesting season.

The survey dates were:

- Field Survey 1 (nesting): 1 - 15 December 2018 ('December survey'); and
- Field Survey 2 (hatching): 30 January - 12 February 2019 ('February survey').

Both surveys were scheduled during the new moon phase of the lunar cycle. The new moon fell on 6 December 2018 and 4 February 2019.

Data captured during the survey included (refer to Figure 93 for locations):

- **Nesting habitat assessment – track census**. This included marking a line on the beach at each survey location and conducting an aerial survey each morning to determine if there were any crossings overnight (i.e. fresh tracks). Marine turtle species and the resulting nesting activity category (false crawl, attempt or nest) were determined using track and nest characteristics, including track width, shape and orientation of flipper marks, tail drag marks, movement of sand, morphology and depth of nest pit and associated mound (Eckert et al., 1999). All identified tracks were marked to avoid being recounted on subsequent days. Predator activity was identified by tracks left in the vicinity of the turtle nesting activity. Categories of predation included digging at and around the nest site, or egg shells scattered at the sand surface;
- **Nesting habitat assessment – incubation success**. Firstly, the field personnel found new clutches by digging into a fresh nest and locating the eggs at the top of the nest. A temperature logger was placed amongst the eggs at the top of the nest to record the temperature profile during incubation (every 30 minutes). Temperature loggers were also buried on each beach at 500 mm depth to collect control temperature data from the survey beaches. At the end of the survey period, previously identified clutches were excavated to determine hatchling success. Excavations of marked clutches were conducted with caution to avoid disturbance to live hatchlings within the clutch or to developing embryos that may not yet have hatched. The contents of the egg chamber were counted and sorted into live hatchlings, dead hatchlings, egg shells, undeveloped embryos or no discernible embryos (as per Shigenaka, 2003; Pendoley *et al.,* 2014);
- **Artificial light monitoring**. Light monitoring cameras were deployed on each monitored beach section during the December and February surveys. Images of night-time light emissions on a 360° horizon were captured automatically by the deployed camera at 15-minute intervals between sunset and sunrise; and
- **Hatchling orientation**. A nest fan was recorded if five or more hatchling tracks were sighted from a hatched clutch (defined by a depression in the sand from which the hatchling tracks were seen to emerge). A sighting compass was used to measure the bearing along the outside arms of emergent hatchling tracks. Bearings were taken at either the point where the track crossed the high tide line, or 5 m from the clutch emergence point (whichever distance was shortest).

Other Marine Fauna

A comprehensive desktop review was undertaken by O2 Marine (2020g) to identify significant marine fauna species known or likely to occur in the Study Area. The desktop review included database searches as well as a comprehensive literature review. The literature review focussed on marine fauna surveys undertaken for previous coastal development projects in the Pilbara and relevant scientific journal literature on marine fauna in the Pilbara region and globally; on some matters, recognised scientific researchers and academics were interviewed by O2 Marine. Particular emphasis was placed on species of conservation significance.

The following studies comprised the majority of the review:

- Onslow Salt ERMP Volume 2 Technical Appendix C Report on the Biological Environments near Onslow, Western Australia (Paling, 1990);
- The draft EIS for Chevron Australia's Wheatstone project (Chevron Australia, 2010a);
- Intertidal Habitats of the Onslow Coastline (URS, 2010b);
- Biota of subtidal habitats in the Pilbara Mangroves, with reference to the Ashburton Delta and Hooley Creek (URS, 2010c);
- Sea Noise Logger Deployment: Wheatstone and Onslow – April to July 2009 Preliminary Analysis (McCauley & Kent, 2010);
- A Description of Mega Fauna Distribution and Abundance in the SW Pilbara Using Aerial and Acoustic Surveys –Final Report 2010 (CWR, 2010);
- Draft Protected Marine Fauna Management Plan (Chevron, 2010a);
- Wheatstone Project Literature Review of Listed Marine Fauna (URS, 2010d);
- Possible Effects of Underwater Noise on Marine Fauna and Fish in the Wheatstone Project Area (URS, 2010e);
- Potential Interactions with the Onslow Prawn Managed Fishery (URS, 2011);
- Marine Mammals Technical Report (RPS 2010a);
- Dugong Aerial Survey Report (RPS 2010b);
- Identification and Risk Assessment of Marine Matters of National Environmental Significance (RPS 2010c); and
- Seagrass Dynamics and the Consequence of Seagrass Loss on Marine Megafauna: A Briefing Note (Chevron 2010b).

The results of the database searches and comprehensive literature review were used to conduct a likelihood of occurrence assessment (Section 8.3.3). This assessment identified that, based on its scale, location and marine habitat types, the Proposal posed a relatively low risk to marine fauna species other than Turtles. Therefore, specific surveys targeting other marine fauna species were not deemed to be warranted for this assessment. However, to supplement the desktop assessment, incidental observations of marine fauna were recorded by experienced marine scientists during extensive field surveys undertaken by O2 Marine and Stantec while delivering other work scopes, which added up to 738 observer hours (Table 27 and Figure 94).

Table 27: Marine field surveys that included incidental observations of marine fauna

Field survey	Company	No. of surveys	Timeframe	Observer hours
Water Quality Maintenance	O2 Marine	11	March 2018 – March 2019	264 Hours (Vessel-based)
Bathymetry Surveys	O2 Marine	2	August – October 2018	60 Hours (Vessel-based)
Benthic Habitat Surveys	O2 Marine	5	March 2018 - March 2019	264 Hours (Vessel-based)
Sediment Sampling Surveys	O2 Marine	3	December 2018 – March 2019	108 Hours (Vessel-based)
Mangrove & Intertidal Surveys	Stantec	2	August & October 2017	24 Hours (Aerial)
	O2 Marine	2	March – December 2018	18 Hours (Vessel-based)

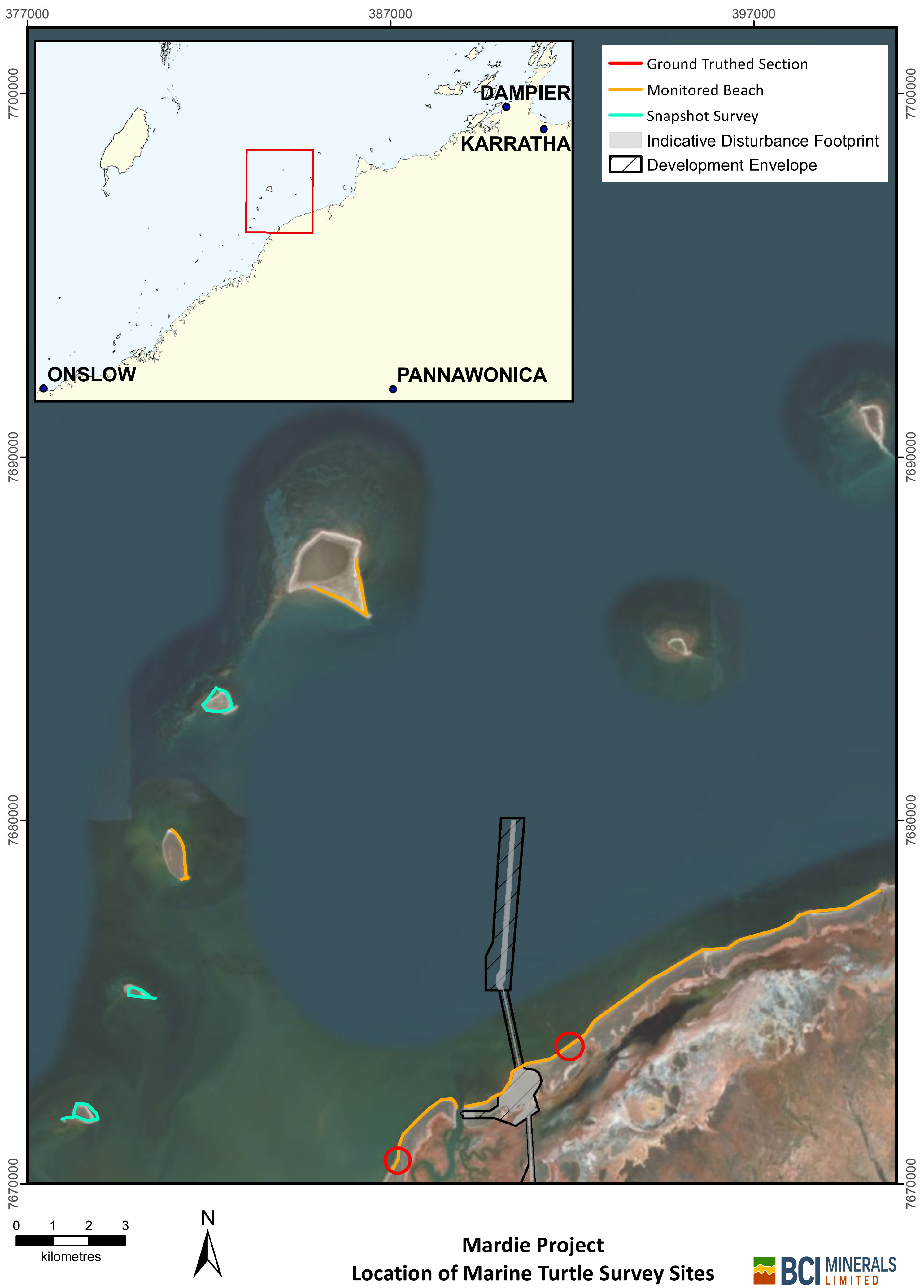


Figure 92: Location of marine turtle monitoring sites (from Pendoley, 2019a)

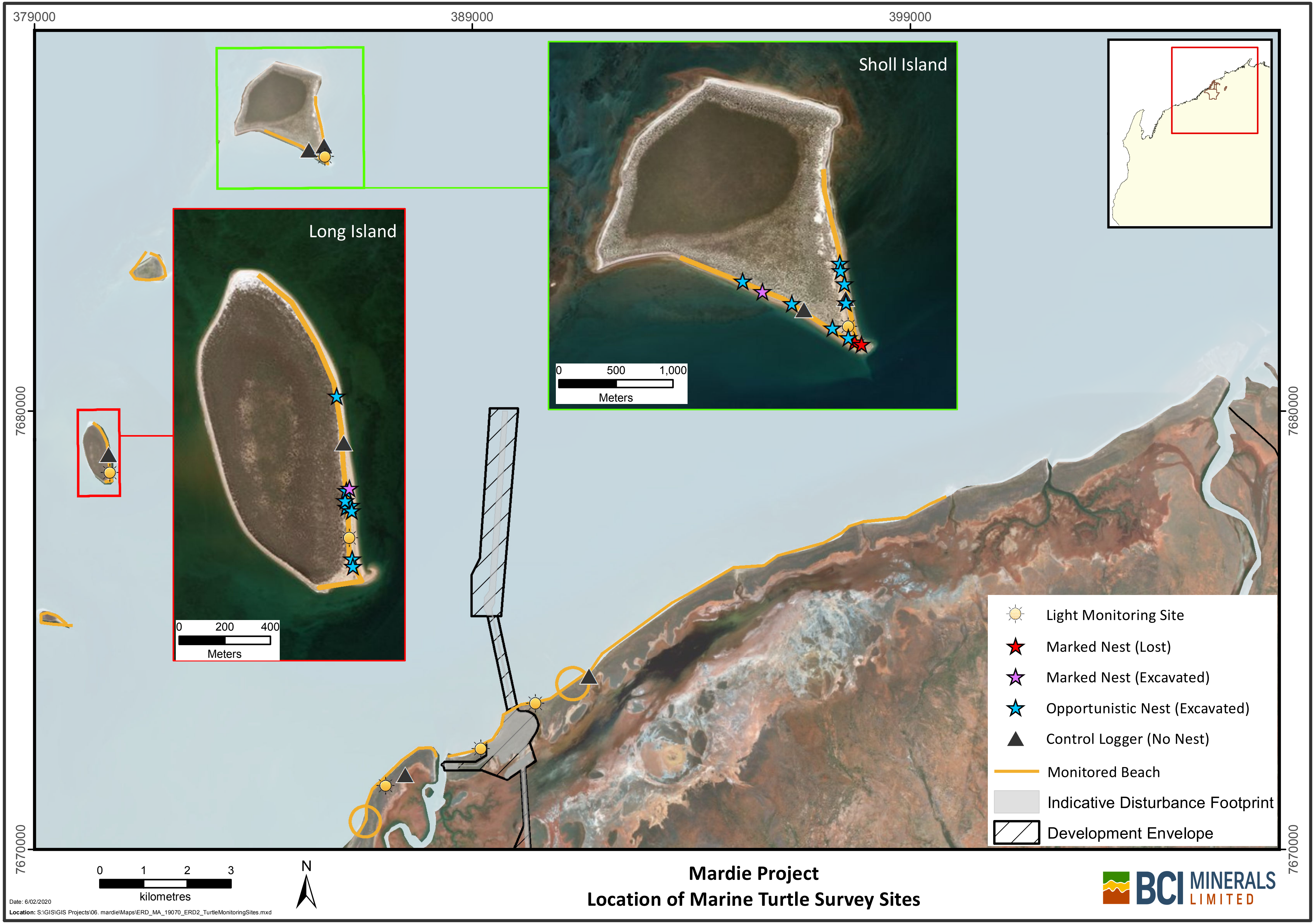


Figure 93: Location of marked clutches, excavated clutches, control loggers, and light monitoring sites

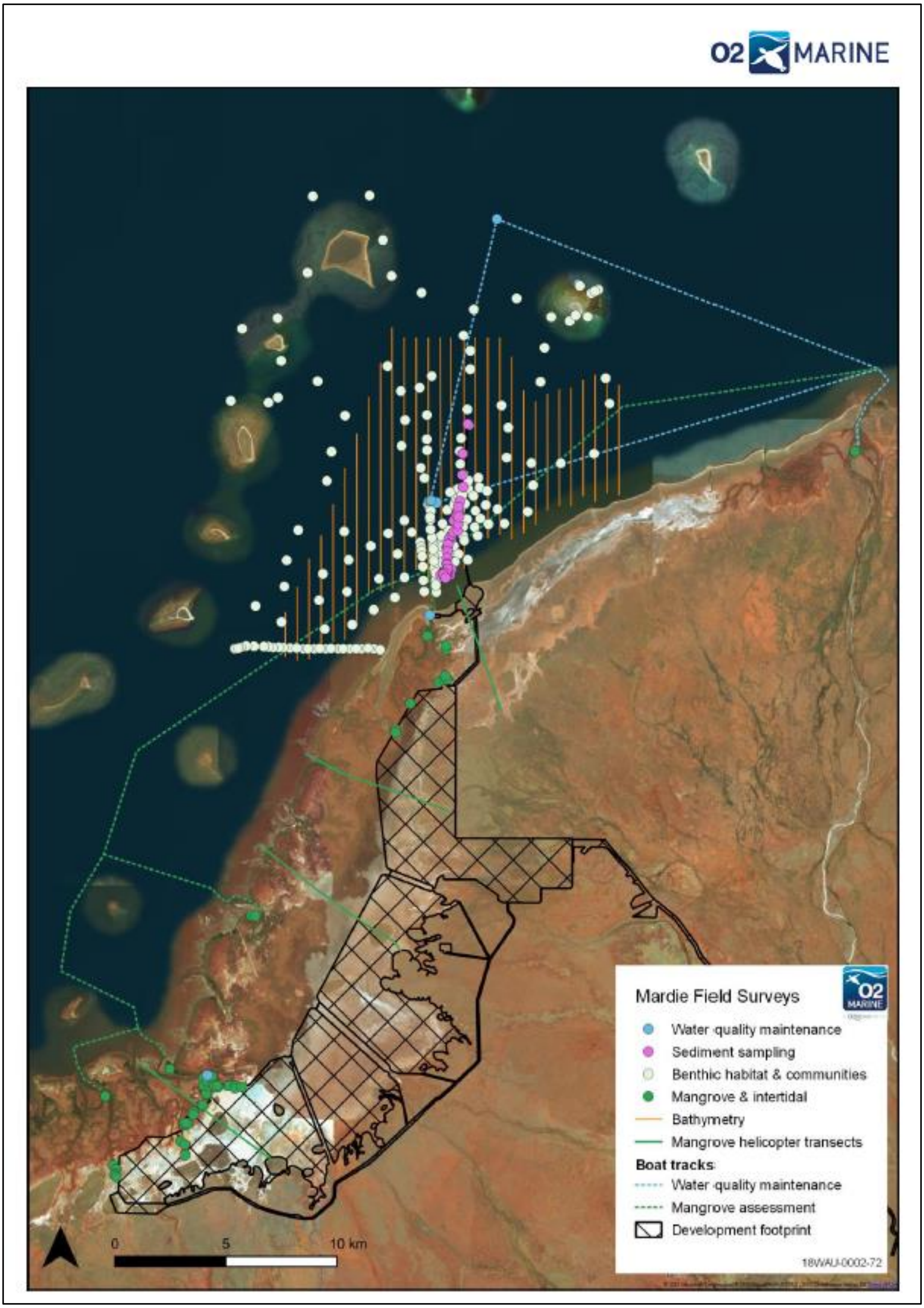


Figure 94: Mardie marine field surveys which included incidental observations of marine fauna

8.3.2 Habitat

A detailed description of the BCH present in proximity to the Proposal has been provided in Section 7.3.

8.3.3 Marine Mammals

An assessment was undertaken of the likelihood of occurrence for threatened marine mammal species identified through the desktop review, based on the list of species provided in the ESD (Preston, 2018). Threatened marine species are those listed under the EPBC Act, the *Biodiversity Conservation Act 2016* (BC Act) and the International Union for Conservation of Nature (IUCN) Red List of Threatened Species. The results for the likelihood of occurrence assessment is presented in Table 28. Listed threatened marine mammals with high potential to occur off the Mardie coast (on occasion) include the Humpback whale (*Megaptera novaeangliae*), Dugong (*Dugong dugong*) and Australian humpback dolphin (*Sousa sahulensis*).

Table 28: Likelihood of occurrence for marine mammals (from O2 Marine, 2020g)

Species	Range / habitat preference	Likelihood of occurrence
Dugong (*Dugong dugon*) Marine, Migratory EPBC Act, Specially Protected BC Act, Vulnerable IUCN	Dugongs undertake long-distance movements, which means Australia shares populations with other neighbouring countries. In Australia, dugongs occur in the shallow coastal waters of northern Australia from the Queensland / NSW border in the east to Shark Bay on the WA coast. They are also found in other parts of the Indian and Pacific Oceans in warm shallow seas in areas where seagrass is found.	High potential to occur. The species has been recorded in the region (desktop searches) and suitable habitat is present in the LAUs although in very low density (Section 7.3.16).
Australian Humpback Dolphin (*Sousa sahulensis*) Marine, Migratory EPBC Act, Priority 4 BC Act, Near threatened IUCN	Australian Humpback Dolphins are known to occur along the northern coastline, extending to Exmouth Gulf on the west coast (25°S), and the Queensland / NSW border region on the east coast (34°S). There are few records between the Gulf of Carpentaria in the north and Exmouth Gulf in the west, this is probably due to a lack of research effort and the remoteness of the area.	High potential to occur. The species has been recorded in the region (desktop searches) and suitable habitat is present in the LAUs.
Humpback Whale (*Megaptera novaeangliae*) Marine, Migratory, Vulnerable EPBC Act, conservation dependent BC Act, Least Concern IUCN	Humpback whales utilising Australian waters currently have tropical calving grounds along the mid and northern parts of the east and west coasts of Australia, with feeding grounds in the Southern Ocean. The majority of humpbacks in Australian waters migrate north to tropical calving grounds from June - August, and south to the Southern Ocean feeding areas from September - November. The migratory habitat around mainland Australia is primarily coastal waters less than 200 m in depth and generally within 20 km of the coast.	High potential to occur. The species has been recorded in the region (desktop searches). Typically occur further offshore (>35 km) during migratory routes, although some whales recorded in <10 m water during southern migration (i.e. September).
Spinner Dolphin (*Stenella longirostris*) - Priority 4 BC Act	Found in tropical, subtropical and, less frequently, in warm temperate waters. Their global range is between approximately 30 - 40°N and 20 - 30°S in the Indian, Pacific and Atlantic Oceans. In Australia, there are records of Long-snouted Spinner Dolphins from WA, as far south as Bunbury (33°19'S), as well as from the NT (including numerous records of these dolphins caught in the Arafura and Timor seas as bycatch in the gillnet fishing industry during 1981 - 85). Their primary distribution is in pelagic zones, but they are frequently found over shelf waters. Some forms are	Low potential to occur. The species has been recorded in the region (desktop searches), however are primarily pelagic (occurring in open ocean) but they can be neritic (occurring over the continental shelf) in some regions, therefore suitable habitat is generally lacking from the LAUs.

Species	Range / habitat preference	Likelihood of occurrence
	regularly found in shallow waters, particularly near islands and shallow reefs.	
Blue Whale (*Balaenoptera musculus)* - Endangered, Marine, Migratory EPBC Act, Endangered BC Act, Endangered IUCN	The Blue Whale is a cosmopolitan species, found in all oceans except the Arctic, but absent from some regional seas such as the Mediterranean, Okhotsk and Bering seas. Blue whales feed almost exclusively on krill, with a variety of species being taken by different blue whale populations. They feed both at the surface and also at depth, following the diurnal vertical migrations of their prey to at least 100 m. The migration patterns of blue whales are not well understood, but appear to be highly diverse.	Moderate potential to occur. The species has not been recorded in the region (no records from desktop searches), however is known to occur in the area and in similar habitats to those found within the LAUs.
Indo-Pacific / Spotted Bottlenose Dolphin (*Tursiops aduncus*) - Marine, Migratory EPBC Act	Found in tropical and sub-tropical coastal and shallow offshore waters of the Indian Ocean, Indo-Pacific Region and the western Pacific Ocean. Bottlenose dolphins are distributed continuously around the Australian mainland, but the taxonomic status of many populations is unknown. Indo-Pacific Bottlenose Dolphins have been confirmed to occur in estuarine and coastal waters of eastern, western and northern Australia.	Moderate potential to occur. The species has not been recorded in the region (no records from desktop searches) however suitable habitat occurs within the LAUs.
Southern Right Whale (*Eubalaena australis*) – Endangered, Marine, Migratory EPBC, Vulnerable BC Act, Least Concern, IUCN	In Australian coastal waters, southern right whales occur along the southern coastline including Tasmania, generally as far north as Sydney on the east coast and Perth on the west coast. There are occasional occurrences further north, with the extremities of their range recorded as Hervey Bay and Exmouth.	Low potential to occur. The species has not been recorded in the region (no records from desktop searches) and the distribution for this species occurs significantly south of the LAUs.
Australian Snubfin Dolphin (*Orcaella heinsohni*) – Marine, Migratory EPBC Act, Priority 4 BC Act, Vulnerable IUCN	Stranding and museum specimen records indicate that Australian Snubfin Dolphins occur only in waters off the northern half of Australia, from approximately Broome on the west coast to the Brisbane River on the east coast. Aerial and boat-based surveys indicate that Australian Snubfin Dolphins occur mostly in protected shallow waters close to the coast, and close to river and creek mouths.	Low potential to occur. The species has been recorded in the region (desktop searches), however suitable habitat is generally lacking in the LAUs.

Whales

Humpback whales migrate annually from Antarctic feeding grounds to the Kimberley coast for calving during the winter. The humpback whales predominantly occur further offshore, however some have been observed by O2 Marine in 2018 within 5 km of the Marine Development Envelope. The southern migration is the period when they are closest to shore at an average of 36 km although are often recorded in waters less than 10 m deep during the latter part of the migration (September - November) (O2 Marine, 2020g).

Seven other species of toothed whale and three species of baleen whale have been recorded from the Montebello region. Further evidence from aerial surveys and acoustic surveys supports this, as sightings further offshore indicated a greater range of species existing in small numbers that included species of Brydes Whales, Minke Whales, Pygmy Blue Whales, Killer Whales, Southern Right Whales, Pilot Whales and Sperm Whales. However, these whales are believed to only transit through oceanic waters well offshore from the shallow waters of the LAUs (O2 Marine, 2020g).

Dugong

Dugong (*Dugong dugong*) are found throughout the Pilbara region, particularly close to the coast or in the lee of reef-fringed islands and often in areas where seagrass has previously been recorded. Although Dugong have been previously recorded in the nearshore waters of the Mardie coastline, the nearest known Dugong aggregations have been recorded near Cape Preston in the North and Coolgra Point in the South, generally in areas that consistently support extensive seagrass meadows (O2 Marine, 2020g).

No Dugong were observed in the waters around Mardie during over 700 hours of vessel-based observations. O2 Marine (2020g) concluded that this was most likely due to the lower value of the subtidal BCH in the area as suitable feeding or foraging habitat for Dugong.

Dolphins

The Australian humpback dolphin (*Sousa sahulensis*) and Indo-Pacific Bottlenose Dolphin (*Tursiops aduncus*) are likely to be the most abundant dolphin species in the area inside the 20 m isobath. The Australian Snubfin Dolphin (*Orcaella heinsohni*) has also previously been recorded in the region but is presumed to be an occasional visitor from the Kimberley region. These dolphin species occur throughout the region and are likely to be present in shallow and nearshore waters of the Mardie coastline at any time. Other species of dolphin most likely occur further offshore.

The abundance of dolphins in nearshore areas surrounding the Mardie coast is likely to be highest during winter and the distribution of dolphins is likely influenced by prey availability. Dolphins will move inshore or offshore dependant on prey availability. Oceanographic currents, areas of upwelling, eddies, and increased nutrients all affect the abundance of zooplankton and transport of larval recruitment of finfish, which therefore have a seasonal effect on dolphin distribution (O2 Marine, 2020g).

8.3.4 Elasmobranch

An assessment was undertaken of the likelihood of occurrence for Threatened elasmobranch species identified through the desktop review. The results for the likelihood of occurrence assessment is presented in Table 29.

Table 29: Likelihood of occurrence for threatened elasmobranch (from O2 Marine, 2020g)

Species	Distribution / Habitat Preferences	Likelihood of Occurrence
Dwarf Sawfish (*Pristis clavata*) - Vulnerable EPBC Act, Priority 1 BC Act, Endangered IUCN	The species' Australian distribution has previously been considered to extend north from Cairns around the Cape York Peninsula in Queensland, across northern Australian waters to the Pilbara coast in Western Australia. The Dwarf Sawfish usually inhabits shallow (2 - 3 m) coastal waters and estuarine habitats.	Moderate potential to occur. The species has not been recorded in the region (no records from desktop searches). The western extent of this species range has not been fully resolved, however suitable habitat is present in the vicinity of the Proposal.
Green Sawfish (*Pristis zijsron*) - Vulnerable EPBC Act, Vulnerable BC Act, Critically Endangered IUCN	The green sawfish inhabit shallow coastal marine and estuarine waters of northern Australia, from about Eighty Mile Beach, WA, to the Cairns region. It has been occasionally been caught as far south as Sydney. Green sawfish are known to be pupped near the Ashburton River mouth and utilise the estuary and nearby mangrove creeks, before moving offshore to mature at a length of about 3 m.	High potential to occur. The species is known to occur in the region from recent scientific studies. Suitable habitat is present in the vicinity of the Proposal.

Species	Distribution / Habitat Preferences	Likelihood of Occurrence
Grey Nurse Shark (*Carcharias taurus*) – Vulnerable EPBC Act, Vulnerable BC Act	The Grey Nurse Shark (west coast population) has a broad inshore distribution, primarily in sub-tropical to cool temperate waters. The population of Grey Nurse Shark (west coast population) is predominantly found in the south-west coastal waters of WA and has been recorded as far north as the North West Shelf.	Moderate potential to occur. The species has not been recorded in the region (no records from desktop searches). Predominantly found in cooler coastal waters further south, however, has been found at Muiron Islands and potential suitable habitat does exist in the vicinity of the Proposal.
Narrow Sawfish (*Anoxypristis cuspidate*) - Marine migratory EPBC Act, Endangered IUCN	The Narrow Sawfish is an Indo-West Pacific species occurring from the northern Persian (Arabian) Gulf to Australia and north to Japan. It is a bentho-pelagic species that occurs from inshore and estuarine areas to offshore habitats in depths of up to 100 m. Common in sheltered bays with sandy bottoms and feed on small fish and cuttlefish.	Moderate potential to occur. The species has not been recorded in the region (desktop searches) and the exact distribution is uncertain. Potential habitat is present in the vicinity of the Proposal.
Whale Shark (*Rhincodon typus*) - Vulnerable, Marine, Migratory EPBC Act, Specially protected BC Act, Endangered IUCN	Found worldwide in tropical and subtropical oceans. In Australia, the Whale Shark is most commonly seen in waters off northern Australia. Yearly Whale Shark numbers in Ningaloo Marine Park are estimated to vary between 300 - 500 individuals. Research conducted in 2003 on Whale Sharks aggregating at Ningaloo Reef found that this species routinely moved between the sea surface and depth. Sharks spent at least 40% of their time in the upper 15 m of the water column and at least 50% of their time at depths equal to or less than 30 m.	Low potential to occur. The species has not been recorded in the region (no records from desktop searches) and are generally found in waters deeper than present near the Proposal.
Great White Shark (*Carcharodon carcharias*) - Vulnerable, Marine, Migratory EPBC Act, Vulnerable BC Act, Vulnerable IUCN	In Australia, Great White Sharks have been recorded from central Queensland around the south coast to north-west WA but may occur further north on both coasts. They inhabit inshore waters around rocky reefs, surf beaches and shallow coastal bays; waters on the outer continental shelf and slope; and the open ocean. These sharks most commonly live in depths above 100 m.	Low potential to occur. The species has not been recorded in the region (no records from desktop searches). Has been found at Muiron Islands although predominantly found in cooler coastal waters further south. Suitable habitat is lacking in the vicinity of the Proposal.
Giant Manta Ray (*Manta birostris*) - Marine, Migratory EPBC Act, Marine, Migratory BC Act, Vulnerable IUCN	The Manta Ray lives in tropical, marine waters worldwide, but is also found occasionally in temperate seas. In Australia it is recorded from south-western WA, around the tropical north of the country and south to the southern coast of NSW. The species is known to occur in the Ningaloo Marine Park, Muiron Islands Marine Management Area, Montebello Islands Marine Park, Eighty Mile Beach Marine Park, Lalang-garram / Camden Sound Marine Park and Rowley Shoals Marine Park.	Moderate potential to occur. The species has not been recorded in the region (no records from desktop searches). Potential habitat however does occur near the Proposal.
Reef Manta Ray (*Manta alfredi*) - Marine, Migratory EPBC Act, Marine, Migratory BC Act, Vulnerable IUCN	Reef manta rays are found primarily in the Indian and Pacific Oceans, including coastal waters surrounding Australia, Japan, South Africa, Thailand and Hawaii. This species is generally found in inshore habitats (within a few km of land) in tropical and subtropical latitudes. They are often sighted near coral and rocky reefs in atolls and bays, likely due to the high densities of zooplankton associated with these areas (O2 Marine, 2020g).	Moderate potential to occur. The species has not been recorded in the region (no records from desktop searches). Potential habitat however does occur near the Proposal

Sharks

Sharks inhabit a wide range of coastal and offshore habitats and depths. During the Stantec (2018) survey several sharks were observed along the nearshore ocean environment of their Study Area including: Whitetip Reef Shark, Blacktip Reef Shark, Grey Reef Shark, Bull Shark and Tiger Shark.

Rays

Stingray, Eagle Ray, Shovelnose Ray, Giant Manta Ray and Reef Manta Ray were observed during a survey by Stantec (2018) in the Mardie coastal nearshore waters. Manta rays have been frequently sighted sparsely distributed in depths further offshore in depths of 50 - 150 m (O2 Marine, 2020g).

Sawfish

Relatively little is known about the distribution and abundance of sawfish species in north WA. The North-west Marine Region is considered an important area for the species group because the region and adjacent inshore coastal waters and riverine environments contain nationally and globally significant populations of sawfish species. Two species of sawfish are considered likely to occur in the LAUs, including the Green Sawfish (*Pristis zijsron*) and the Narrow Sawfish (*Anoxypristis cuspidata*). In addition, the western extent of the dwarf sawfish's (*Pristis clavata*) range has not been fully resolved, and this species may therefore also occur. Green sawfish in particular are expected to be present in the creeks and rivers of the Mardie coastline, and in other areas of the Pilbara they are known to use the mouths of major rivers (i.e. Ashburton River) as pupping grounds. Sawfish then move into adjacent creeks at approximately 3 - 6 months old, before moving offshore to mature at a length of about 3 m (O2 Marine, 2020g).

8.3.5 Marine Reptiles

An assessment was undertaken of the likelihood of occurrence for threatened marine reptile species identified through the desktop review. The results for the likelihood of occurrence assessment is presented in Table 30.

Table 30: Likelihood of occurrence for threatened marine reptiles (from O2 Marine, 2020g)

Species	Habitat Preference	Likelihood of Occurrence
Loggerhead Turtle (*Caretta caretta*) - Endangered, Migratory, Marine EPBC Act, Endangered BC Act, Vulnerable IUCN	In Australia, Loggerhead Turtles nest on open, sandy beaches concentrated in southern Queensland and from Shark Bay to the North West Cape in WA. They live at or near the surface of the ocean and move with the ocean currents, choosing a wide variety of tidal and sub-tidal habitat as feeding areas and showing fidelity to both their foraging and breeding areas. (DotE, 2015). The Loggerhead Turtle occurs in the waters of coral and rocky reefs, seagrass beds and muddy bays throughout eastern, northern and western Australia.	High potential to occur. The species has been recorded in the region (desktop searches) and suitable habitat is present in the vicinity of the Proposal.
Leatherback Turtle (*Dermochelys coriace*) - Endangered, Migratory, Marine EPBC Act, Vulnerable BC Act, Vulnerable IUCN	The Leatherback Turtle is a pelagic feeder, found in tropical, subtropical and temperate waters throughout the world. Large body size, high metabolism, a thick adipose tissue layer and regulation of blood flow them to utilise cold water foraging areas unlike other sea turtle species. For this reason, this species is regularly found in the high latitudes of all oceans including the South Pacific Ocean in the waters offshore from NSW, Victoria, Tasmania and WA.	Low potential to occur. The species has not been recorded in the region (no records from desktop searches) with their desired habitat lacking in the vicinity of the Proposal.

Species	Habitat Preference	Likelihood of Occurrence
Green Turtle (*Chelonia mydas*) - Vulnerable, Migratory, Marine EPBC Act, Vulnerable BC Act, Endangered IUCN	Green Turtles nest, forage and migrate across tropical northern Australia. They usually occur between the 20°C isotherms, although individuals can stray into temperate waters. In Australia, the key nesting and inter-nesting areas (where females live between laying successive clutches in the same season) occur on offshore islands off the Pilbara coast.	High potential to occur. The species has been recorded in the region (desktop searches) and suitable habitat is present in the vicinity of the Proposal.
Flatback Turtle (*Natator depressus*) - Vulnerable, Migratory, Marine EPBC Act, Vulnerable BC Act	The Flatback Turtle is found only in the tropical waters of northern Australia, Papua New Guinea and Irian Jaya, and is one of only two species of sea turtle without a global distribution. On the North-West Shelf, the major rookeries are on the mid-eastern coast of Barrow Island and at Mundabullangana Station near Cape Thouin on the mainland. These turtles are known to occur in the Pilbara region during all sensitive life-history phases (mating, nesting and inter-nesting).	High potential to occur. The species has been recorded in the region (desktop searches) and suitable habitat is present in the vicinity of the Proposal.
Hawksbill Turtle (*Eretmochelys imbricate*) - Vulnerable, Migratory, Marine EPBC Act, Vulnerable BC Act, Critically Endangered IUCN	Hawksbill Turtles are found in tropical, subtropical and temperate waters in all the oceans of the world. In Australia, the key nesting and inter-nesting areas (where females live between laying successive clutches in the same season) occur on offshore Islands off Onslow. Reefs from Cape Preston to Onslow are considered important feeding grounds.	Moderate potential to occur. The species has been recorded in the region (desktop searches) and suitable habitat is present in the vicinity of the Proposal.
Short-nosed Seasnake (*Aipysurus apraefrontalis*) - Critically Endangered EPBC Act, Critically Endangered BC Act, Critically Endangered IUCN	The Short-nosed Seasnake is endemic to WA, and has been recorded from Exmouth Gulf to the reefs of the Sahul Shelf, in the eastern Indian Ocean. The species prefers the reef flats or shallow waters along the outer reef edge in water depths to 10 m.	Moderate potential to occur. The species has not been recorded in the region (desktop searches) however, there is suitable habitat in the vicinity of the Proposal, and the Proposal is within the known distribution of the species.

Turtles

The following information has been sourced from Pendoley (2019a; Appendix 7.1).

Only a small part of potential marine turtle nesting beach lies within the development envelopes, a narrow section of the beach labelled as 'Mardie Creek East' in Figure 92. The Pendoley (2019a) survey identified only very minor nesting effort by Flatback turtles and a single hawksbill turtle, along the 15 km stretch of coastline to the east of the creek. These results indicated that the mainland beaches are not currently a regionally important rookery. The results of the temperature loggers also confirmed that mainland beaches were significantly warmer than the offshore islands, impacting the success rate of any marine turtle nests on these beaches.

With the exception of the single hawksbill nest recorded on the mainland in December, turtles nested most successfully on the offshore islands (Figure 92); 34 – 42 % of Flatback and 36 – 50 % of hawksbill nesting attempts on the islands resulted in a nest. None of the three Flatback nesting attempts on the mainland resulted in a nest. This variation in nesting success may be related to the varying nesting habitat characteristics between the island and mainland monitoring sites. For example, the island sites featured a wide supratidal zone, a well-defined primary dune, and fine-medium grained sand size that may have facilitated the successful deposition of a clutch, whereas the mainland sites featured a narrow supratidal zone, little or no primary dune development, and medium-coarse grained sand size that may have hindered successful clutch deposition.

The main species recorded on the offshore islands was Flatback turtles, with relatively less nesting effort seen for hawksbill and green turtles at the same locations. The snapshot monitoring data from Round, Middle, and Angle Islands confirmed similar species composition and abundance at these sites. These results are consistent with turtle activity throughout the Pilbara where Flatback and Hawksbill nesting is dominant on nearshore island habitat, and Flatback turtles are the most common mainland nesting species (Pendoley *et al.,* 2016).

Baseline artificial light results found the overhead skies at the Proposal are typically very dark and representative of pristine, natural dark skies unaffected by artificial light. The only light source visible from all mainland and offshore light monitoring sites was the Sino Iron facilities located over 30 km away on the easterly horizon.

The hatchling orientation results indicate marine turtle hatchlings successfully oriented seaward, regardless of the orientation of the beach (e.g. Sholl Island north and south) or the visibility of the glow from the Sino Iron facilities. While hatchling orientation generally coincided with the direction of the horizon glow from the Sino Iron facilities, it is unlikely that the relatively small spatial extent of the sky glow visible from the nesting beach influenced hatchling orientation over the 30 km distance.

Sea Snakes

All true sea snake species are strongly associated with benthic habitats, and occur in coastal, shallow water habitats (typically <100m depth). The Short-nosed sea snake (*Aipysurus apraefrontalis*) is typically found in reef flats or shallow waters along the outer reef edge in water depths to 10 m (Cogger, 2000; Guinea, 1993, 1995; McCosker, 1975). The species has been observed during daylight hours, resting beneath small coral overhangs or coral heads in 1 - 2 m of water (McCosker, 1975). Guinea and Whiting (2005) reported that "very few Short-nosed Seasnakes moved even as far as 50 m away from the reef flat."

Based on the above habitat description and the mapped subtidal BCH types within the Study Area, suitable habitat for the Short-nosed Sea Snake is unlikely to occur in proximity to the development envelopes. The nearest suitable habitat is located more than 5 km away from the Proposal. Given the Short-Nosed Sea Snake is predicted to remain within 50 m of the reef flat, it is considered unlikely that it would be observed on a low-profile reef system more than 5 km away that provides little to no refuge.

It is noted that whilst coral species are present in the Study Area, they do not form a complex reef system with a reef edge, reef flat and lagoon. Rather sediment-tolerant coral species are present in low abundance in areas where low profile limestone is exposed.

In studies done in the nearby Exmouth Gulf and Onslow region, a total of 17 sea snakes were captured via trawl net from three surveys between March and November 2004 (Kangas *et al.,* 2006). Thirteen sea snakes were captured from sites located in the southern part of Exmouth Gulf, and a further three sea snakes were caught in the central area of Exmouth Gulf. These included five different species of sea snake, which included the Critically Endangered short-nosed sea snake (*Aipysurus apraefrontalis*) and listed marine species dubois' sea snake (*Aipysurus duboisii*), olive sea snake (*Aipysurus laevis*), olive-headed sea snake (*Disteira major*) and stoke's sea snake (*Disteira stokesii*). No sea snakes were caught from the OPMF area during surveys undertaken in 2004 (Kangas et al. 2006), thus indicating that the Onslow region does not have the same importance for sea snakes as the Exmouth Gulf (02 Marine, 2020g).

8.3.6 Fish

Desktop assessments identified 31 listed marine species from the order of ray finned fishes, sygnathiformes which includes the family Sygnathidea (seahorses, pipefishes, pipe horses and seadragons). Seahorse preferences for suitable habitat can be very diverse. Four species reported from the region each have individual preferences for suitable habitat ranging from soft bottom debris, algal rubble reefs, seagrass beds and coral reefs (Kangas *et al.,* 2006). This information suggests there is a moderate potential that some of these species may occur in the development envelopes.

Finfish diversity in the region is high with at least 456 species known to exist in the Montebello / Mardie region. Mangrove communities are particularly important in the region as they play a role in providing suitable habitat and nursery areas for fishes and crustaceans, including commercially important species (O2 Marine, 2020g).

Stantec (2018) recorded six species of fish from the families Serranidae, Lutjanidae, Lethrinidae, Mullidae, Carangidae and Siganidae. O2 Marine (2020g) also recorded Gobidae (mudskipper) at three sites during the intertidal surveys.

8.3.7 Invertebrates

A diverse range of marine invertebrate fauna exist in the Mardie region, comprising of mostly tropical species associated with macroalgal communities. These macroalgal communities are supported by coral reef, mangroves and subtidal sand and soft bottom habitats. Mangrove communities are known to support a range of invertebrate fauna. Rocky shores also support a variety of mollusk species and other invertebrates (O2 Marine, 2020g). These include gastropod molluscs of the families Neritidae, Littorinidae, Potamididae and Ellobiidae, some barnacles, sesarmid and ocypodid crabs and several species of mud lobster and ghost shrimps. All species belong to taxa that are widespread in the Indo-Pacific region or are endemic to shores of the NW Shelf but have biogeographic affinities with that region (O2 Marine, 2020g).

8.3.8 Intertidal Marine Fauna Community

An assemblage of fishes and invertebrates is commonly associated with mangrove ecosystems, with some dependant on mangrove ecosystems. Conspicuous among these are fishes known as mud-skippers, certain gastropod molluscs of the families Neritidae, Littorinidae, Potamididae and Ellobiidae, some barnacles, sesarmid and ocypodid crabs and several species of mud lobster and ghost shrimps. A mentioned above, all species belong to taxa that are widespread in the Indo-Pacific region or are endemic to shores of the North-west Shelf but have biogeographic affinities with that region. Many of the fish in mangrove creeks are occasional and sporadic visitors to the system that enter opportunistically during high tides and include groups such as sharks, longtoms, trevallies, queenfish, mackerel, pike and flatheads.

Marine fauna in the algal mat zone are rare, although insects and insect larvae are sometimes seen under the algal mats. The salt flats are predominantly devoid of marine invertebrates (O2 Marine, 2020g).

8.3.9 Subtidal Marine Fauna Community

The nearshore area of the Mardie coastline contains a low to moderate abundance of fish and invertebrates, with species richness typically ranging from low in the nearshore areas to high further offshore and surrounding the reef-fringed islands. Marine species within the nearshore area are predominantly tropical and are short lived with high productivity, resulting in life-history traits of high fecundity and high productivity and high input into reproduction during their relatively short life spans. Most species are locally and regionally widespread with dominant species comprising a high proportion (i.e. ~80 - 90%) of marine fauna present. Dominant fishes and invertebrates typically recorded are those known to inhabit muddy / sediment (trawling grounds) habitats which include ponyfish, goatfish, flathead or crabs and prawns, and the mantis shrimp. However, some dominant fish also suit reef and weed habitat (Kangas *et al.,* 2006).

8.3.10 Introduced Marine Pests

This section has been sourced from O2 Marine (2020h, Appendix 2.6) unless stated otherwise.

To date no introduced marine species listed as species of concern on the National Introduced Marine Pests Coordination Group (NIMPCG, 2006) have been recorded in the Mardie region (Huisman et al., 2008). This is possibly largely due to the absence of IMP surveys in the Mardie area. However nearby at Cape Preston, URS conducted an IMP survey and found no marine pest species listed by the National IMP Coordination Group (O2 Marine, 2020h). The nearest introduced species known, is one IMP that has been recorded at Barrow Island, approximately 50km to the north-west of the project site at Mardie. The species recorded is *Didemnum perlucidum*. This species is known to have established a self-sustaining population (O2 Marine, 2020h). This species presents some risk of impacting upon the marine environment, including risk to BCH which would adversely impact upon the marine fauna that rely on these areas for protection and as a food source. Other locations where this species has been recorded is at the Port of Dampier.

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).

Six IMP alerts for WA were current at the time of the O2 Marine (2020h) report , including observations of Asian Green Mussel *Perna viridis* on a vessel at Barrow Island, Asian Paddle Crab *Charybdis japonica* in the Swan Estuary, Perth, Black Striped Mussel *Mytilopsis sallei*, European green crab *Carcinus maenas*, Japanese Kelp *Undaria pinnatifida* and Northern Pacific seastar *Asterias amurensis*. None of these species are known to have established self-sustaining populations in WA waters but all represent a serious threat.

Wells (2018) conducted a review of IMS in the Pilbara (based on results of publicly available studies) and found that 15 IMS are present, however only one species listed on the Australian National IMS list, the ascidian *Didemnum perlucidum,* has established a self-sustaining population.

8.3.11 COMMERCIAL FISHERIES

The North Coast bioregion contains several commercial fisheries, including tropical finfish, pearling and prawn trawling. The numerous creek systems, mangroves and rivers, ocean beaches, offshore islands, coral reef systems and continental shelf waters of the North Coast bioregion provide important habitat for many important commercial and recreational fish species, including saddletail snapper, red emperor, cods, coral and coronation trout, sharks, trevally, tuskfish, tunas, mackerels and billfish.

Within the Mardie and Montebello region commercial fisheries such as pearling and prawning are of particular importance. The Onslow Prawn Managed Fishery (OPMF) operates along the western part of the North-West Shelf targeting King Prawns (*Penaeus latisulcatus*), brown tiger prawns (*Penaeus esculentus*) and endeavour prawns (*Metapenaeus* spp.). The boundaries of the OPMF are all the WA waters between the Exmouth Prawn Fishery and the Nickol Bay prawn fishery east of 114°39.9' on the landward side of the 200m depth isobath, covering an area of 43,799 km^2.

The waters within the OPMF are divided into three fishing areas: Area 1 - 3. In addition, there are also three dedicated nurseries, Ashburton Nursery, Coolgra Point Nursery and Fortescue Nursery. The development envelopes intersect with the OPMF 'Fortescue Nursery Area' (Figure 95). The nursery areas are managed as Size Management Fishery Grounds to allow sections of these areas to be fished on a seasonal basis when prawns are considered to have grown to an appropriate size and the area deemed suitable. The fishing season typically operates between March and November (O2 Marine, 2020h).

It is unlikely the Proposal will impact the commercial fishing activities within the region as most commercial fish species targeted are found further offshore in depths more suitable for prawns. Nevertheless, the development envelopes intersect with the OPMF, which has been discussed in more detail in Section 8.5.6.

8.3.12 ENVIRONMENTAL WINDOWS

A summary of the environmental windows for conservation significant species relevant to the Proposal are as follows:

- Humpback Whale (nearshore southern migration). The southern migration represents the time when humpback whales with their calves have a higher potential to occur within the development envelopes, although 2 km would represent the boundary limit of their nearshore distribution, typically occurring at an average of 36 km offshore;
- Dolphins generally are known to occur all year round however higher abundances are around June – September;
- Turtle nesting season is typically October – March; and
- Sawfish pupping season is typically September – October.

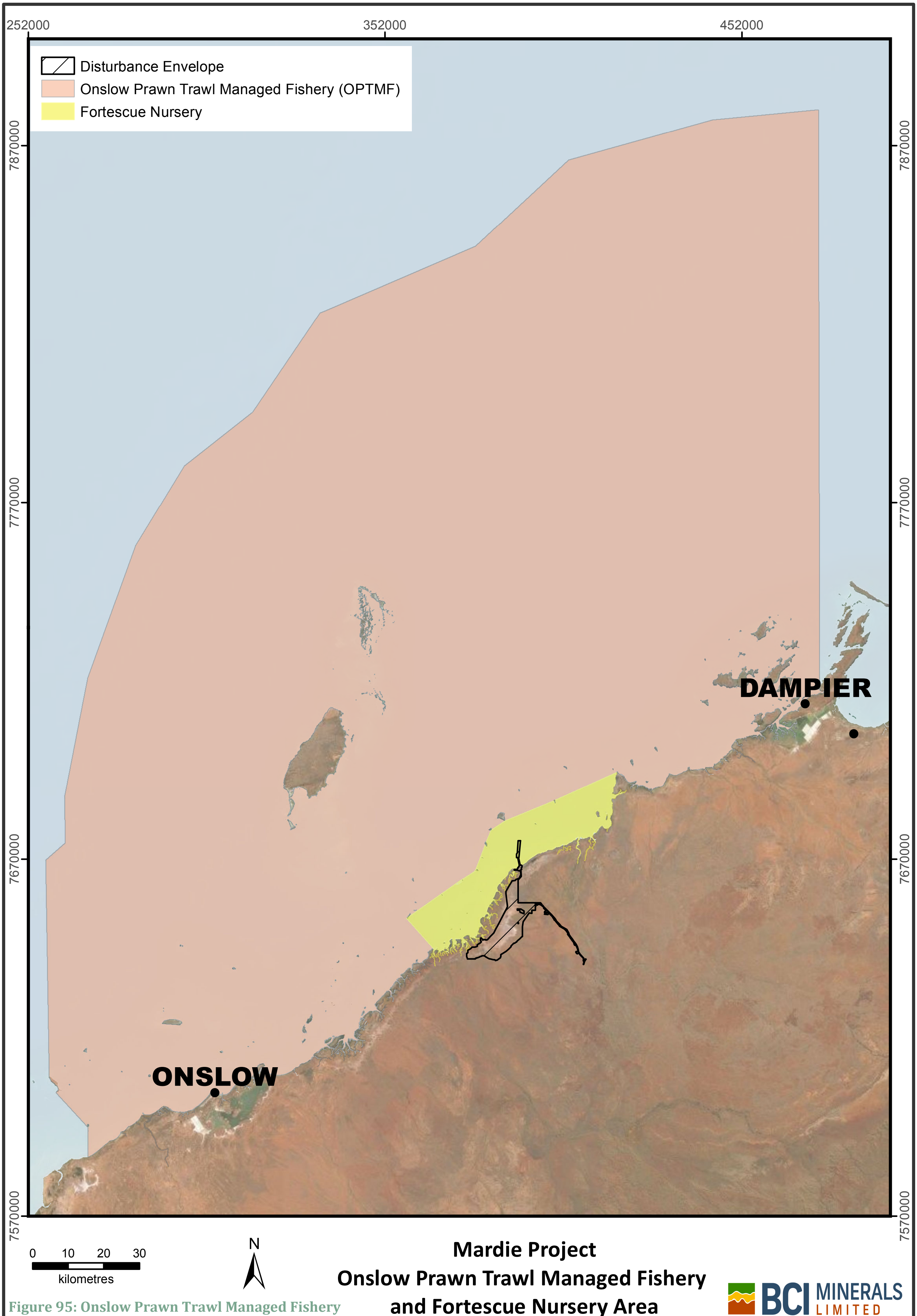


Figure 95: Onslow Prawn Trawl Managed Fishery and Fortescue Nursery Area

8.3.13 Environmental Values

Based on the information provided above, the following environmental values were determined to require assessment for this factor:

- General marine fauna;
- Marine turtles;
- Marine mammals;
- Sawfish;
- Short-nosed seasnake (*Aipysurus apraefrontalis*); and
- OPMF Nursery Area.

8.4 Potential Impacts

Table 31 defines the potential impacts (direct, indirect and cumulative) on the environmental values for this factor in a local and regional context. These impacts are informed by the results of detailed marine fauna studies described in Section 8.3 and provided in Appendix 7.1 and 7.2.

Table 31: Potential impacts on marine fauna

Environmental value and current extent	Potential direct impact	Potential indirect impact	Impacts associated with other proposals	Total cumulative impact
General marine fauna Mangrove communities, tidal creeks and offshore islands were identified as key marine fauna habitat.	• Disturbance of up to 55 ha of sub-tidal marine fauna habitat • Disturbance of up to 5 ha of intertidal marine fauna habitat • Death or injury as a result of vessel strike, dredging or entrapment in seawater intakes	• Introduction of marine pests by dredging vessels or other vessels used in construction and operations activities • Increased predation by aggregation of marine organisms around new infrastructure • Indirect impacts to marine fauna habitat health, including 128 ha of loss from dredging impacts	Disturbance associated with two gas pipelines that run through the development envelopes.	• Loss of up to 183 ha of sub-tidal marine fauna habitat and 5 ha of intertidal habitat (in addition to gas pipeline disturbance) • Death or injury as a result of vessel strike, dredging or entrapment in seawater intakes • Potential indirect impacts
Marine turtles: Flatback, Hawksbill, Green and Loggerhead turtles likely to be present in the surrounding marine environment Minimal turtle nesting occurs on the mainland beaches, with nesting recorded on offshore islands Current light emissions are negligible and are	• Disturbance of up to 55 ha of sub-tidal habitat • Direct disturbance of 50 m width of a low-quality turtle nesting beach • Disturbance of up to 5 ha of intertidal marine fauna habitat • Death or injury as a result of vessel strike,	• Alterations to turtle and hatchling behaviour as a result of light spill and predation • Hearing or behavioural impacts as a result of construction related noise (from activities such as pile driving and dredging) • Increased predation by aggregation of marine organisms around new infrastructure	• Disturbance to general marine turtle habitat associated with two gas pipelines that run through the development envelopes • No other disturbance was recorded on the low-quality nesting beach that occurs within the development envelope • No cumulative light emissions expected, Pendoley	• Loss of up to 183 ha of sub-tidal and 5 ha intertidal habitat in addition to gas pipeline disturbance • Direct disturbance of 50 m width of a low-quality turtle nesting beach • Death or injury as a result of vessel strike, dredging or entrapment in seawater intakes • Potential indirect impacts

Environmental value and current extent	Potential direct impact	Potential indirect impact	Impacts associated with other proposals	Total cumulative impact
unlikely to affect turtle orientation	dredging or entrapment in seawater intakes	• Indirect impacts to marine fauna habitat health, including 128 ha of loss from dredging impacts	determined that the Sino Iron Project light emissions were unlikely to affect turtle orientation	
Marine mammals: Humpback whale, Australian humpback dolphin and Dugong identified as potentially occurring, predominantly offshore.	• Disturbance of up to 55 ha of sub-tidal habitat • Death or injury as a result of vessel strike or dredging	• Hearing or behavioural impacts as a result of construction related noise (from activities such as pile driving and dredging) Indirect impacts to marine fauna habitat health, including 128 ha of loss from dredging impacts	• Disturbance to general marine fauna habitat associated with two gas pipelines that run through the development envelopes • Cape Preston Port lies 40 km to the north-east of the Proposal	• Loss of up to 183 ha of sub-tidal marine fauna habitat in addition to gas pipeline disturbance • Death or injury as a result of vessel strike or dredging • Potential indirect impacts
Sawfish Green Sawfish and Narrow Sawfish identified as potentially occurring.	• Disturbance of up to 55 ha of sub-tidal and 5 ha of intertidal fauna habitat, including within two tidal creeks • Death or injury as a result of vessel strike, dredging or entrapment in seawater intakes	• Hearing or behavioural impacts as a result of construction related noise (from activities such as pile driving and dredging) Indirect impacts to marine fauna habitat health, including 128 ha of loss from dredging impacts	• Disturbance to general marine fauna habitat associated with two gas pipelines that run through the development envelopes • No other tidal creeks impacted within the Study Area	• Loss of up to 188 ha of habitat (in addition to gas pipeline disturbance), including within two tidal creeks • Death or injury as a result of vessel strike, dredging or entrapment in seawater intakes • Potential indirect impacts
Short-nosed seasnake Identified as potentially occurring however is more likely to be found in the vicinity of the offshore islands.	• Disturbance of up to 55 ha of sub-tidal and 5 ha of intertidal habitat • Death or injury as a result of dredging or entrapment in seawater intakes	• Increased predation by aggregation of marine organisms around new infrastructure • Indirect impacts to marine fauna habitat health, including 128 ha of loss from dredging impacts	Disturbance to general marine fauna habitat associated with two gas pipelines that run through the development envelopes	• Loss of up to 188 ha of habitat in addition to gas pipeline disturbance • Death or injury as a result of vessel strike, dredging or entrapment in seawater intakes • Potential indirect impacts
OPMF Nursery Area The Fortescue Nursery Area covers an area of 94,862 ha, within a broader 43,799 km² OPMF	• Disturbance of 55 ha within the Fortescue Nursery Area • Death or injury as a result of dredging or entrapment in seawater intakes	• Increased predation by aggregation of marine organisms around new infrastructure • Indirect impacts to marine fauna habitat health, including 128 ha of loss from dredging impacts	Disturbance to general marine fauna habitat associated with two gas pipelines that run through the development envelopes	• Loss of up to 183. ha of the Fortescue Nursery Area • Death or injury as a result of vessel strike, dredging or entrapment in seawater intakes • Potential indirect impacts

8.5 Assessment of Impacts

8.5.1 General marine fauna

Direct Loss, Degradation or Modification of Marine Fauna Habitat

Intertidal Zone

The Proposal occurs within the broader intertidal zone, however based on the species identified by O2 Marine (2020g), the part of the intertidal zone of most significance to marine fauna (and in particular significant marine fauna) is expectedly the areas that are regularly inundated; the ocean side of the mangrove and rocky shore habitats, tidal creeks and the sandy beach at the northern portion of the development envelopes. Shorebirds are assessed as Terrestrial Fauna in this ERD (refer to Section 10).

Disturbance of up to 5 ha within these intertidal habitats will be required to implement the Proposal. Infrastructure within these areas include the seawater intake, small boat launching facility, and trestle jetty. This disturbance is in addition to two narrow areas of disturbance associated with two existing gas pipelines.

Section 7 assessed the significance of the direct disturbance of BCH and determined that given the scale of the Proposal direct impacts to intertidal BCH are unavoidable. The Proposal will result in the direct disturbance of approximately 8,361 ha of intertidal BCH, however only 5 ha of this would be considered marine fauna habitat. Mardie Minerals has specifically designed the Proposal to ensure that more sensitive and high value intertidal BCH that could be utilised by marine fauna have been almost completely avoided, with very small losses of these BCH predicted.

Based on the BCH assessment, it is considered likely that the disturbance of intertidal habitat would have negligible impact on general marine fauna populations that inhabit the area. Potential impacts to significant marine fauna species are discussed separately in the following sections.

Subtidal Zone

Direct disturbance of up to 55 ha subtidal marine fauna habitat will be required to implement the Proposal and 60 ha is predicted to be irreversibly impacted by the sediment plume caused by the channel dredging, or bitterns disposal. Infrastructure within these areas include the vessel loading wharf, turning basin and dredge channel. The majority of the 55 ha of disturbance is to occur via dredging where high points along the channel will be excavated to allow for safe passage of the shallow-draft transhipment vessel.

Section 6 assessed the significance of the direct and indirect disturbance of subtidal BCH.

Bare substrate has been targeted; 36 ha (65%) of the sub-tidal BCH to be disturbed is bare unvegetated substrate. Mardie Minerals has also designed the Proposal to ensure that more sensitive and high value intertidal BCH (high cover corals, macroalgae) have been avoided in most areas, with very small losses of these BCH predicted.

An irreversible loss of 44 ha and recoverable impact of 69 ha of Coral / Macroalgae BCH is predicted to occur as a result of the Proposal, once indirect impacts are considered. Of the irreversible loss <1 ha is classified as Dense (>25%) cover and is dominated by macroalgae, with the remainder classified as Low (5 - 10%) and Moderate (10 - 20%) Cover, with 5 ha and 39 ha of irreversible loss, respectively.

The high value, biologically diverse reefs with far denser colonisation surrounding the offshore islands are the primary driver of long-term ecosystem health and sustainability of nearshore Pilbara coral communities in this area. The coral BCH within LAU 7 represents only marginal marine fauna habitat and is unlikely to be a significant contributor to coral recruitment within the region. Therefore, whilst this BCH provides suitable habitat for a variety of marine fauna species, the loss of 44 ha is not considered a significant risk to the ecological integrity and biological diversity of marine fauna in the area.

Based on the BCH assessment, it is considered likely that the disturbance of subtidal habitat would only have a minor impact on general marine fauna populations that inhabit the area. O2 Marine (O2 Marine 2020a; Appendix 2.3, 2020b; Appendix 2.4) concluded that the subtidal BCH to be impacted as a result of the Proposal is widespread throughout the Pilbara and does not constitute locally or regionally significant habitat for any significant marine fauna species. Potential impacts to significant species are discussed separately in the following sections.

Vessel Strike

The likelihood of a vessel strike during dredging and construction from proposed vessel movements is considered low due to the small scale (i.e. spatial movements) of the operation and dredge vessel (i.e. slow-moving and small support vessels). Similarly, the risk of vessel strike on marine fauna during the operational stage is considered unlikely due to the slow speed of the transhipment barge and low vessel movements (2 - 4 barge movements per day).

The consequence of vessel strike on marine fauna may result in injury or mortality, although potential impacts from proposal activities are unlikely to result in significant declines in the local or regional populations of species and their distribution, or reductions in the diversity of species. Dolphins are quick moving and would react quickly to avoid potential impact to vessels. Whales are not expected to occur in the immediate dredge vicinity due their preference for deeper waters and therefore not expected to be impacted from vessel activity. Dugongs may be present however potential foraging habitats have been avoided (refer Section 8.5.3).

Maintaining speed limits of 8 knots within coastal waters is a suitable measure to reduce marine fauna injury from vessel strike. Vessel strike risks are known to significantly increase above 8.6 knots (Vanderlaan and Taggart, 2007) and therefore 8 knot speed limits will be implemented for construction and operational support vessels at the Proposal to reduce this risk. In addition vessel operators will be trained to observe and report the location of any sightings of large marine fauna (in particular marine turtles, mammals and sawfish) to other vessel operators in the area to allow them to be tracked (if visible) and avoided.

Dredging – Marine Fauna Injury or Death

Dredging activities for the Proposal are low impact in comparison to common dredging operations such as cutter suction dredge programs. Dredging will instead involve the use of a barge-mounted long-reach excavator. Material will be dug up and placed onto a hopper barge, where it will be transported to the trestle jetty and loaded onto carts for transport to the pond area. This form of dredging greatly reduces the potential for injury or death to marine fauna when compared to cutter suction dredging, as there is no potential for marine fauna to be drawn into the equipment.

Entrapment in Seawater Intakes

Two seawater intakes are required for the Proposal. One is located in a tidal creek and used as an intake for the concentrator and crystalliser ponds (Figure 3), and the other is located on the trestle jetty to allow dilution of the bitterns prior to discharge. O2 Marine (2020g) determined that turtles, and fish species could be present in the vicinity of the proposed seawater intakes and therefore there was the potential for marine fauna to become trapped within the intakes.

An intake flow rate of less than 0.15 m/s is recommended by the US Environmental Protection Agency (2001) as it ensures the protection of 96% of fish species, and is lower than the swim speed of marine turtles (Bell & Richardson, 1978; Bustard & Limpus, 1970; Chung et al., 2009; de Silva, 1995; Frick, 1976; Hirth, 1971; Hughes, 1974; Papi *et al.,* 1995; Prange, 1976; Salmon & Wyneken, 1987; Witherington, 1991, Wyneken 1997). This flow rate has been adopted at a number of seawater intakes in WA and around the world, including Anketell Port, The Wheatstone Development and Adelaide Desalination Plant.

The tidal creek intake pipes are to be located within a screened enclosure (Figure 7). Water within the enclosure rises and falls with the tide, and the intake pumps are to be operated when water depths are greater than MSL. The intakes will draw in water through all sides of the perimeter screen, resulting in an even flow rate around the perimeter of less than 0.15 m/s.

The offshore seawater intake (used for dilution of the bitterns) will draw in up to 20 GL of water per year. A similar screened enclosure (albeit a much smaller size) will be installed at this location to ensure an even flow rate of less than 0.15 m/s around the perimeter of the screen.

This will ensure flow rates are low enough to allow marine fauna to swim against the current and not become trapped against the enclosure screens. Consequently the risk of entrapment of marine fauna at the seawater intakes is considered to be low.

Introduced Marine Pests

Technical information in this section has been sourced from O2 Marine (2020h; Appendix 2.6) unless stated otherwise.

The Proposal will utilise vessels during construction and operation that will be brought to Mardie marine waters from other ports within Australia and overseas. These vessels have the potential to transport IMPs which can potentially impact sub-tidal BCH through (O2 Marine, 2020h):

- Out-competition with native species for resources;
- Predation on native species; and
- Alteration of trophic interactions and food-webs.

The most common forms of transport vector for an IMP being biofouling on vessels, debris and submersible equipment, or in ballast water / sediment and seacocks / sea strainers (CSIRO, 1998). The individual IMP(s) must attach to - or be taken in by - the vessel at the location of origin and then survive the journey as a 'passenger'. The survival and translocation risk of the IMP depends on several factors, including:

- Frequency and duration of vessel visits;
- Vessel operating speeds (e.g. stationary or slow- moving vessels in port areas allow fouling pests to attach, while transit times between ports will affect survivorship in ballast water);
- Type of vessel operations (direct contact with seabed brings higher risk);
- Origin location;

- Level of hull biofouling and prevention (anti-fouling coatings);
- Capacity and use of ballast water throughout journey;
- Voyage duration, the length of time species can survive in ballast water;
- Presence and size of internal vessel areas such as sea chests, anchor cable lockers, propeller shafts;
- Inspection of internal areas and treatment systems used; and
- Dry docking - duration since the last dry-docking or removal from the water.

Risk nodes are the areas to which potential IMP translocation may occur. The conditions at the receiving environment are risk factors which can influence the likelihood of IMP's becoming established. These factors include:

- Similarity of the receiving environment to the IMPs location of origin (habitat / substrate type, bioregional matching, physico-chemical conditions, temperature and salinity regimes);
- Availability of substrate / habitat;
- Availability of prey / food / nutrients;
- Presence of predators;
- Competition with local / native biota;
- Water quality (temperature and salinity regimes); and
- Distance to high risk areas (ports, harbours, aquaculture facilities).

The risk factors described above are incorporated into several private sector and government-supplied risk assessments. Mardie Minerals engaged O2 Marine (2019e) to conduct an IMP risk assessment. There are two key inputs to the risk assessment; the risk of a vessel or equipment introducing a marine pest, and the risk of the IMP becoming established.

The vessel types proposed for use in construction and operation of the Proposal were assessed using rating methods utilised by McDonald *et al*. (2015) and allocated relative risk ratings:

- Bulk carriers and crew transfer vessels were given a risk rating of 1 (low risk);
- The transhipment vessel, barges, tugs and long-reach excavator were given a risk rating of 2 (medium risk); and
- The jack-up barge and dredging barge were given a risk rating of 3 (high risk).

The vessels listed above have not yet been contracted and as such, the origin locations of these vessels are unknown. However, it is likely that at least some of the construction vessels and the bulk carriers will be sourced from China and south-east Asian ports, which share similar environmental conditions with Pilbara marine waters. Many IMP species on the NIMPCG list either originate from or are established in large south-east Asian ports such as Singapore. There is a greater likelihood for introduction of such species to Mardie due to the bioregional matching.

O2 Marine (2020h) assessed the Australian National priority trigger list for marine pests that are considered to be at risk of introduction and causing harm in Australian waters (NIMPCG, 2009a; 2009b) and identified 27 species as having a risk of becoming an IMP at Mardie.

The IMP risk assessment concluded that the construction phase represented the highest risk as it will create new areas of hard sub-tidal substrate which could be colonised by IMPs such as Asian Green Mussel *Perna viridis* or Black Striped Mussel *Mytilopsis sallei*. Two construction vessels - the jack-up barge (pile driving) and the dredging barge are both slow moving and will have direct contact with the substrate, presenting the greatest likelihood of IMP translocation if these vessels are sourced from high risk international ports in south-east Asia. Additionally, the dredged channel and turning basin have higher potential for successful IMP settlement than the surrounding undisturbed substrate. During the operational phase, the bulk carrier anchorages (primary node) are at greatest risk of marine pest introduction where soft substrates are to be the dominant habitat type. Seven high risk species for these soft substrates have potential of being introduced and surviving. All potential hard substrates are secondary nodes and have a lower risk of IMP translocation.

Increased Predation

Artificial structures installed in the marine environment often result in aggregations of marine fauna species, which can cause increases in predation. Jetty structures can provide vertical habitat, whereas many natural habitats slope more gently or have heterogeneous topography (Chapman, 2003; Perkol-Finkel & Benayahu, 2004; Moschella et al., 2005; Lam *et al.,* 2009). Many species of intertidal or subtidal animals and plants are limited in their distribution by the slope of the substratum (Whorff & Sweet, 1995). In addition, artificial intertidal vertical surfaces may crowd species into a limited area compared with the amount of intertidal habitat available on more gently sloping natural shores. Thus, densities may be abnormally increased, or species that do not usually come into contact can be forced to occupy the same area, potentially increasing the strength of interspecific interactions.

Jetty structures can provide unnatural sheltered habitats. The reduced water flow, turbidity or sediment abrasion in these novel sheltered habitats can promote the establishment of assemblages that differ in species richness, composition or relative abundances from those associated with nearby natural exposed rocky habitats (Bulleri & Chapman, 2004; Clynick, 2007; Vaselli, *et al.,*, 2008).

Key ecological processes, such as recruitment (Glasby, 1999; Bulleri, 2005b), foraging (Bulleri, *et al.,* 2004), competition, predation (Kirk *et al.,* 2007) or reproduction (Moreira *et al.,* 2006) may differ between natural and artificial habitats.

The seawater intakes, trestle jetty and loading wharf are the only structures that will be installed in the marine environment. Marine fauna would be expected to aggregate around these structures to some degree, however these structures are relatively small in scale and any increased predation is likely to be localised and not significantly impact the local or regional populations of species and their distribution, or result in reductions in the diversity of species.

Marine Noise

There are several terms relevant to this assessment:

- **Sound Pressure Level** (SPL) is the change in pressure as a sound or pressure wave passes. SPL is measured on a logarithmic scale in decibels (dB) relative to a standard reference pressure;
- **Peak Pressure** (P_{max}) is the maximum instantaneous SPL over the duration of the sound exposure. Measured in dB re 1 µPa;
- **Sound Exposure Level** (SEL) is the time integral of sound pressures received over the duration of exposure, which reflects the total sound energy received during exposure. This measure recognises that the effects of sound are a function of exposure duration as well as maximum instantaneous peak pressure. SEL allows comparison of short exposures to high sound pressure levels with longer exposures to lower pressure levels.

SEL is referenced to both a reference pressure (1 μPa) and an exposure duration (1 s), and has units of dB re 1μPa^{2}s;

- **Permanent Threshold Shift** (PTS) refers to a permanent increase in the threshold sound level that is audible to an organism (permanent hearing loss). PTS may result from a single high-intensity exposure or from repeated exposures that produce less profound, temporary hearing loss; and
- **Temporary Threshold Shift** (TTS) refers to a temporary increase in the lower sound threshold of audibility, with hearing sensitivity later returning to pre-exposure levels. TTS results from fatigue of the auditory cells (Southall *et al.*, 2007). TTS varies in severity (how much louder sound needs to be for an animal to hear it) and in duration, but the severity and duration of TTS are generally correlated. They depend on the sound level, the sound frequency in relation to the animal's hearing frequency range, and the duration, number, and timing of exposures. A threshold shift of 40 dB is likely to be permanent, at least in marine mammals (Southall *et al.*, 2007). Measured recovery times vary from minutes to days, with recovery time typically increasing with the duration of exposure as well as the SPL.

There is wide agreement that P_{max} and SEL are appropriate measures for assessment of sound impacts on marine fauna (McCauley *et al.*, 2000; Southall *et al.*, 2007).

<u>Background</u>

Piling, dredging and other anthropogenic sound sources can have a hierarchy of effects on marine fauna, which depend critically on the distance from the sound source, the sound frequency and intensity, and on the hearing, vocalisation, and other biological characteristics of the organism. For a given source, the effects diminish with range depending on sound attenuation and the organism's sensitivity. Figure 96 shows a simplified example of the potential impacts of marine noise on marine fauna as distances from the source increase.

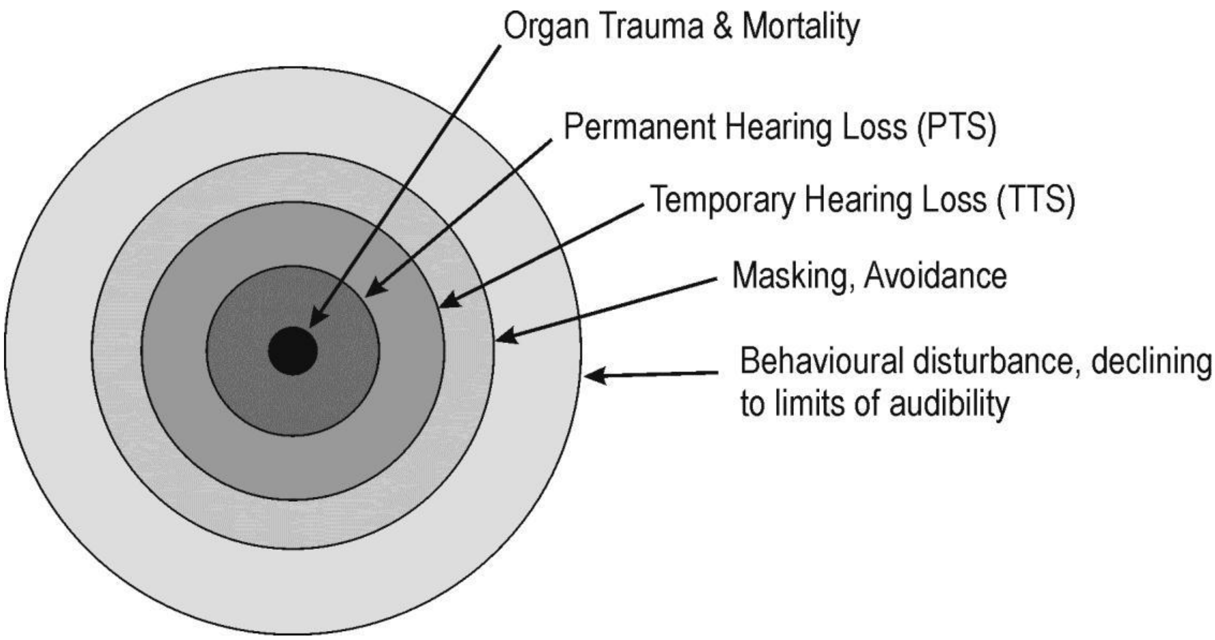


Figure 96: Potential effects of marine noise at increasing distances from the source (SKM, 2013)

Smaller organisms are more vulnerable to sound-induced injury. Fishes are therefore expected to be more vulnerable to injury from marine noise than turtles and marine mammals. Figure 97 provides an indication of mortality rates from marine noise in fish of various sizes.

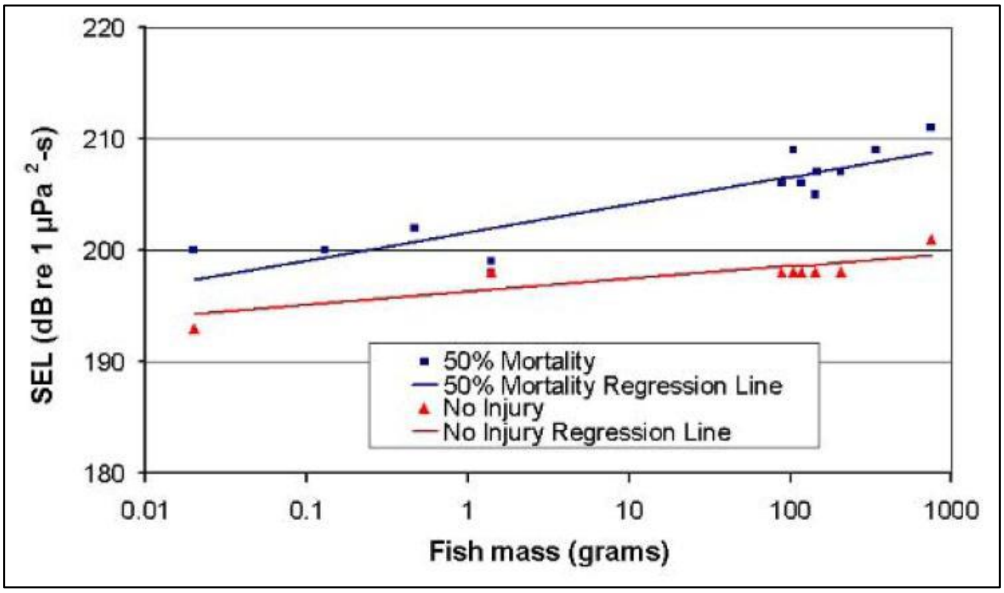


Figure 97: Estimated SEL resulting in 50% mortality and no mortality in fish (SKM, 2013)

The remaining impacts are related to hearing. Marine fauna can use hearing for different purposes, including predator and prey detection, communications, the detection of objects in the environment through echolocation, and possibly navigation. Marine noise has the potential to affect all of these functions, but is likely to be biologically significant at the population level primarily if hearing loss is prolonged (NRC, 2005).

Vulnerability to marine noise depends upon the sound frequency because PTS and TTS results from the same mechanism as hearing stimulation of auditory cells. Sound frequencies significantly above or below those at which the cells respond will not fatigue the cells or induce PTS or TTS. Humpback and other baleen whales are thought to hear predominantly at low frequencies, as are fishes and turtles, though there is considerable variation among species (Nedwell *et al.*, 2004). Dolphins and dugongs are thought to hear best primarily at higher frequencies above 5 - 10 kHz. Based on their high-frequency hearing and the predominantly low-frequency spectrum of piling noise, dolphins and dugongs are expected to be less vulnerable to piling-induced noise than humpback whales and fishes (SKM, 2013).

Vulnerability to PTS and TTS depends not only on the frequency range of an animal's hearing, but also on how sensitive its hearing is within that range. Fishes have less-sensitive hearing than marine mammals (Nedwell *et al.* 2004), and therefore are expected to be less vulnerable to PTS or TTS than humpback whales. Therefore, sound exposure criteria for marine mammals that are used in marine fauna assessments are generally conservative with respect to fishes.

Lower marine noise levels may also result in behavioural impacts. Auditory masking occurs when an animal is unable to detect a biologically relevant sound signal against background noise (Richardson *et al.*, 1995). Sounds that marine fauna use to detect predators and prey, communicate and echolocate are all of much longer duration than a hammer blow due to piling, or in the case of echolocation, are frequently repeated over a longer duration. But repeated noise emissions over a longer time can potentially interfere with marine fauna behaviour.

It has been noted that piling noise has the potential to disturb marine fauna's normal activities or to cause stress or behavioural disturbances (NRC 2005; Richardson *et al.*, 1995). Observed responses to anthropogenic sound in marine fauna include avoidance of the sound source, altered swimming direction or speed including pronounced 'startle' reactions, increased dive times, and changes in vocalisation (NRC 2005). These responses are highly variable and depend on the ecological and behavioural context as well as an animal's experience. (NRC 2005, Richardson *et al.* 1995). Anthropogenic sound can also cause physiological reactions such as changes in heart or respiratory rates, and possibly longer-term physiological changes related to stress, but the effects of stress on marine fauna are poorly understood (NRC, 2005).

<u>Proposal Marine Noise Sources</u>

The Proposal will produce marine noise, predominantly during the construction phase during dredging and pile driving activities during jetty and wharf construction. A long-reach excavator on a barge will be used for dredging. The use of a barge-mounted long-reach excavator is a lower noise alternative to other dredging techniques, as the majority of the noise sources are located on the dredge barge out of the water. As a result, only a small amount of acoustic energy though structure-borne noise is expected to be transferred into the water through the long-reach excavator and other ancillary equipment operating on the barge (Talis, 2019). A SPL of 167 dB re 1 μPa is predicted during dredging activities.

Pile driving involves hammering a pile into the seabed to the point of refusal. The noise emanating from a pile is a function of its material type, its size, the force applied to it and the characteristics of the substrate into which it is being driven. The action of driving a pile into the seabed excites bendy waves (a wave that comprises of a compression wave and a transverse wave) in the pile that propagate along the length of the pile and transfer into the sea and seabed. The transverse component of the wave propagates into the ocean, while the compression component propagates into the seabed. Once in the seabed, the energy will then propagate outwards as compression and shear waves.

Piles can be driven using various methods such as vibration, gravity and hydraulic hammer. The method that is used is dependent on the size of the pile and the substrate into which the pile is being driven. It is planned that hydraulic impact hammers will be used for piling operations at the Proposal. The noise that is generated by an impact hammer hitting the top of the pile is short in duration lasting approximately 100 ms and can therefore be described as an impulsive noise.

A SEL of 205 dB re 1 μPa.s @ 1m is predicted during piling activities.

<u>Marine Fauna and Associated Sound Criteria</u>

A likelihood of occurrence assessment was undertaken by O2 Marine (2020g) to identify key significant marine fauna species that have high potential of occurrence, or have previously been recorded in the development envelopes. These species are considered to be at most risk from underwater noise related impacts. They include:

- Dugong;
- Turtles (Loggerhead Turtle, Green Turtle, Flatback Turtle);
- Humpback Whales;
- Australian Humpback Dolphins; and
- Green Sawfish.

The impacts of underwater noise on Dugongs, and Green Sawfish are not well known and, as a result, the assessment criteria adopted for these species has been inferred based on their hearing bandwidths. This study has relied on the following literature:

- **Dugongs**. There is very little known about their TTS and behavioural response levels. As their hearing bandwidths are similar to low frequency cetaceans it has been assumed that their TTS and behavioural responses are similar to that of a low frequency cetacean. As a result, the TTS threshold levels for low-frequency cetaceans defined in 'Technical Guidance for Assessing the Effects of Anthropogenic Sound on Marine Mammal Hearing' (National Oceanic and Atmospheric Administration, 2016) will be utilised for this assessment;
- **Marine Turtles**. The threshold levels for TTS and behavioural response will be adopted from work undertaken by the Centre of Marine Science and Technology (2000) for behavioural response of turtles to seismic airguns;
- **Humpback Whales and Australian Humpback Dolphins**. It is assumed that the threshold levels for TTS and behavioural response for low and mid frequency cetaceans as defined in National Oceanic and Atmospheric Administration (2016) are appropriate for this study; and
- **Green Sawfish**. There is almost no publically available information on the sensitivity of Sawfish to noise. As they are classed as a ray it has been assumed that they are hearing generalists with a hearing bandwidth similar to turtles. It is therefore assumed that their TTS levels will be similar to that of turtles.

Based on the literature discussed above, the marine noise criteria in Table 32 has been used in this assessment for marine fauna.

Table 32: Received noise levels where there is a risk of TTS or behavioural response

Marine fauna	Hearing bandwidth	Possible TTS	Possible behavioural response
Turtles and Green Sawfish	0.1 – 0.8 kHz	Peak: 222 dB re 1 μPa SEL: 183 dB re 1 μPa².s	SPL Root Mean Square (RMS): 166 dB re 1 μPa SEL: 175 dB re 1 μPa².s
Humpback Whales and Dugong	7 – 35 kHz	Peak: 219 dB re 1 μPa SEL: 179 dB re 1 μPa².s	SPL RMS: 120 dB re 1 μPa SEL: 140 dB re 1 μPa².s
Australian Humpback Dolphins	150 – 160 kHz	Peak: 230 dB re 1 μPa SEL: 185 dB re 1 μPa².s	SPL RMS: 120 dB re 1 μPa SEL: 140 dB re 1 μPa².s

<u>Predicted Marine Noise Levels</u>

Talis (2019; Appendix 6.4) modelled the predicted marine noise emissions from dredging and piling activities. The modelled noise sources were located in proximity to the proposed activities, in the deepest possible position for each noise source. Both model scenarios were run at high tide (i.e. 3 m above mean sea level), and mean tide and low tide were also modelled for piling activities. As the sources have been modelled at the deepest point for both activities, the modelling outputs can therefore be considered as conservative and worst case.

The locations of the noise sources that were modelled by Talis (2019) were chosen as they were generally representative of the potential dredging and piling locations (Figure 98). Figure 99 and Figure 100 shows the predicted noise contours produced as a result of dredging and piling activities respectively (Talis, 2019). As the marine fauna identified for this assessment are all 'environmental values' the potential impacts on these species are discussed in Section 8.5.2 – 8.5.4.

Other Indirect Impacts

Marine fauna or their habitat may be indirectly impacted by the Proposal as a result of:

- Disposal of bitterns impacting water quality and/or marine fauna habitats;
- Increased turbidity due to activities such as dredging;
- Alterations to surface water regimes;
- Leaks or spillages of hypersaline brine; and
- Leaks or spillages of hydrocarbons or chemicals.

Bitterns disposal will result in a mixing zone with reduced water quality (a LEPA). There will be no resident marine fauna within the LEPA however as it has been located within the predicted dredging ZoHI footprint to avoid additional habitat impacts. There will be significant stratification within the dredge channel portion of the LEPA for up to eight days at a time, with high salinity (and expected low dissolved oxygen) water at the base of the channel and fresher and more oxygenated water closer to the surface. Marine fauna that enter the high salinity stratified layer are however not expected stay for a long period, given the water density and salinity, low oxygen levels, and the lack of BCH within this area. Marine fauna are therefore likely to pass through, or avoid completely, this layer continuing their search for food, shelter or other habitat in the areas surrounding the LEPA.

Indirect impacts to marine fauna habitat are discussed in detail in the BCH factor (Section 7) and Marine Environmental Quality factor (Section 6). With the implementation of controls indirect impacts are not predicted to be significant. Emissions from the construction and operation of the concentrator and crystalliser ponds (including bitterns disposal) and export facilities will be regulated under Part V of the EP Act (works approval and licence). Vessel hygiene (to prevent IMPs) is regulated by DPIRD.

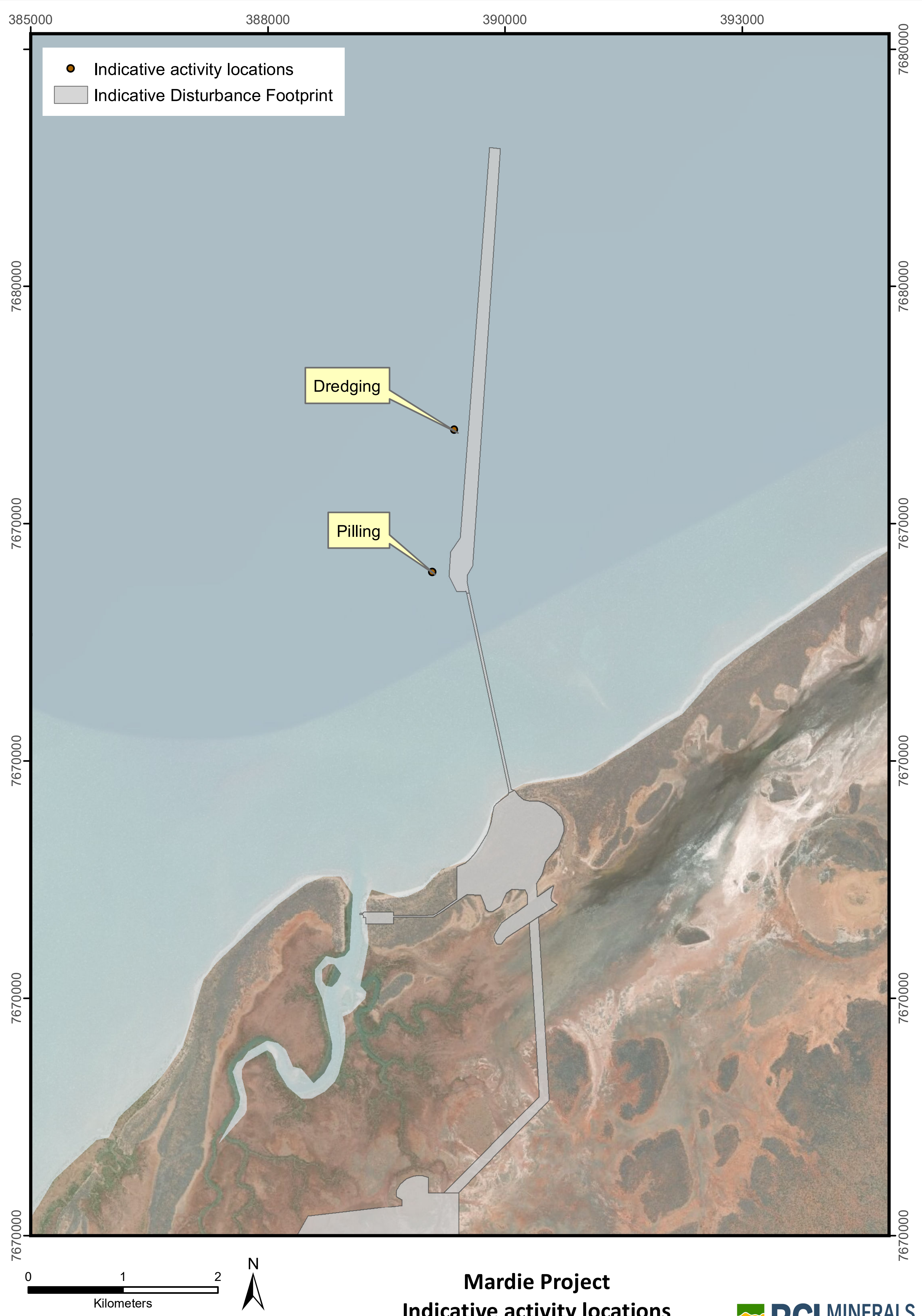


Figure 98: Noise source locations modelled (Talis, 2019)

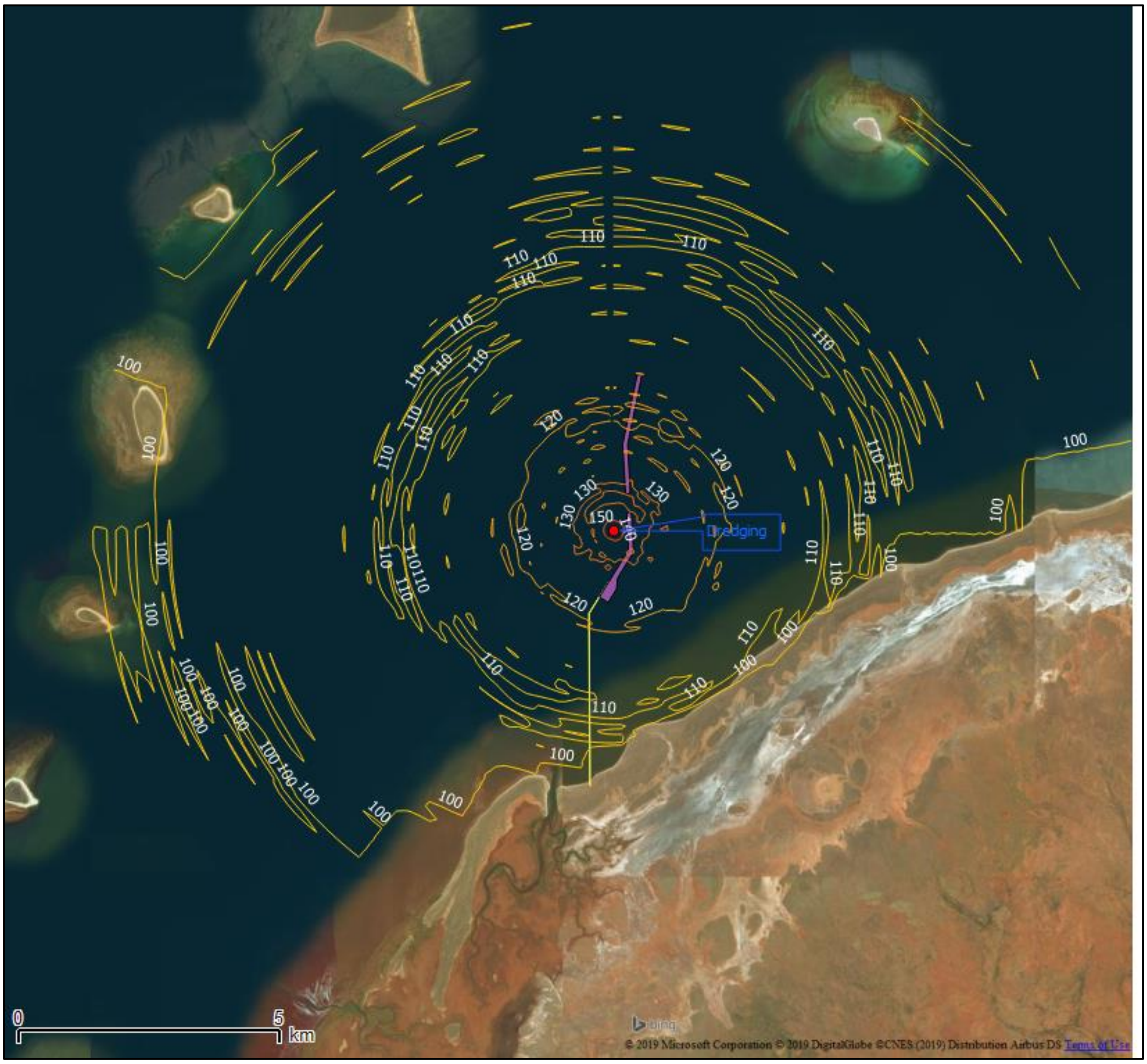


Figure 99: Noise emissions from dredging and barging operations. Note previous jetty and dredge channel shown (Talis, 2019)

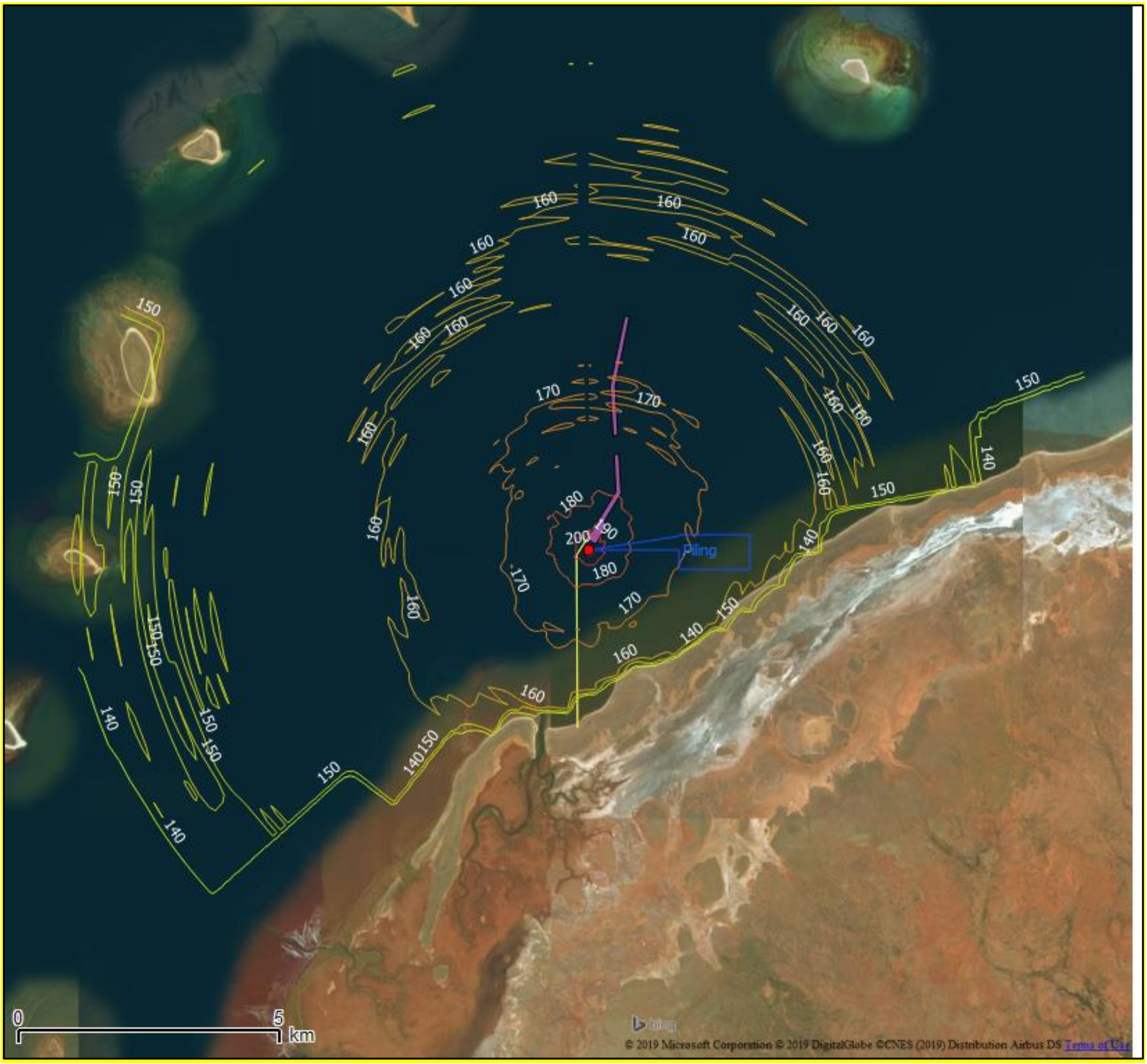


Figure 100: Noise emissions from piling operations. Note previous jetty and dredge channel shown (Talis, 2019)

8.5.2 Marine Turtles

This assessment applies to all marine turtles, but specifically the Flatback, Hawksbill, Green and Loggerhead turtles, which were determined by Pendoley (2019a) as being likely to be present in the surrounding marine environment. Information is provided in this section if it adds to the general assessment in Section 8.5.1, i.e. if any of the potential impacts have more relevance to marine turtles then it will be discussed further in this section.

Habitat Disturbance

Seagrasses and algae BCH provide important feeding habitats for significant marine fauna species such as turtles, so removal can have substantial effects on survival, distribution and feeding habits (Gales *et al*., 2004). Pendoley found that the nearshore islands and tidal creeks represent the most important feeding areas for turtles. BCH surveys of the region support findings that the development envelopes are comprised of relatively poor quality (i.e. low cover and dynamic) vegetated habitats for foraging compared to areas where turtles typically congregate. Therefore, the development envelopes are unlikely to represent critical habitat for marine turtles.

The potential impacts of the Proposal on mangrove communities is discussed in detail in Section 6. This assessment summarised that the potential mangrove impacts were not significant in a regional context, and the potential of the mangrove communities to support marine fauna was considered in that assessment.

Surveys conducted on the sandy beach to the north of the Proposal (Pendoley, 2019a) indicated that the mainland beaches are not currently a regionally important turtle rookery. The proposed disturbance of this beach is limited to a narrow section (less than 50 m) to install the trestle jetty structure.

Given the above, the direct impacts to this beach is not expected to be significant to local marine turtle populations.

Light Spill

<u>Background</u>

Lighting is an important threat to marine turtles that can become significant if left unmitigated. Light pollution along, or adjacent to, nesting beaches or rookeries may cause alterations to critical nocturnal behaviours, particularly the selection of nesting sites and the passage of emerging turtle hatchlings from the beach to the sea. Potential impacts include a decrease in nesting success, beach avoidance by nesting females and disorientation resulting in increased mortality (O2 Marine, 2020g). Significant decreases in turtle nesting have been recorded in places like Florida (USA) and Queensland as development has resulted in the lighting of more and more turtle nesting beaches (Limpus, 1995; Rich and Longcore, 2006).

While turtles tend to prefer dark beaches, they do also nest in lit areas. When they do, however, the survival of their hatchlings is jeopardised (Witherington and Martin, 2000). As hatchlings emerge from nests they can be disoriented or mis-oriented by artificial lights. Artificial lighting may also deter mature turtles from emerging from the water to nest (Mortimer, 1982; Raymond, 1984; Witherington, 1992; Mattison *et al.,* 1993). In particular, a female laying eggs for the first time in her life is more likely to avoid beaches affected by light. Witherington (1992) showed in field experiments that loggerhead and green turtles displayed a significant tendency to avoid brightly illuminated stretches of beach. In areas where glow from artificial lights is present behind the dunes, loggerhead turtles have been shown to prefer to nest in the darker area shaded by tall buildings or dune vegetation (Salmon et al., 1995). Avoidance of lighted beaches may lead to a gradual decline in the number of turtles using a beach, with changes not evident for decades because of the long life cycles involved.

Hatchling turtles primarily rely on vision to find the sea by orienting towards the brightest direction (Salmon et al, 1992). Sea finding occurs when hatchlings orient away from dark, elevated horizons (Limpus, 1971; Salmon et al, 1992) towards the low, light horizon over the sea and make a frenzied dash for the water once they emerge from the nest. Under natural conditions, the brightest direction is almost always away from elevated horizons (e.g. dunes, vegetation) towards the horizon over the sea due to the reflection of celestial light off the water. Artificial lighting can disrupt this pattern (Tuxbury and Salmon, 2005). Turtles which are disoriented or mis-oriented by artificial lights often do not find the sea promptly and may die due to dehydration, predation or exhaustion (Witherington and Martin, 2000). Two hours of crawling towards a landward light source temporarily impairs the subsequent ability of loggerhead hatchlings to crawl seaward, by interfering with their ability to respond appropriately to the cues normally used to locate the ocean. Hatchlings may also waste part of the limited energy stored in the egg yolk, reducing their capacity to swim offshore away from coastal predators (Lorne and Salmon, 2007).

Hatchlings can therefore be badly mis-oriented if bright lights or atmospheric glow occur away from the sea (Witherington and Martin, 2000; Hodge *et al.,* 2007). This is frequently the case where buildings, roadways, marine infrastructure or other developments occur near the coast. For example, hatchlings can be misdirected towards streetlights and crushed by vehicles (Witherington and Martin, 2000) or, once in the sea, thousands of hatchlings may be attracted to lights over the ocean where they become trapped and readily predated by gulls, sharks or fish (Limpus *et al*., 2003).

The impact of lighting on marine turtles is heavily influenced by wavelength (colour), intensity, glow, direction and elevation. In practical terms, bright light that has high directivity causes the greatest disruption. Broadly speaking, bright, highly directive white lights containing short (blue-green) wavelengths create the greatest problems for turtle hatchling orientation but even long wavelength lights (orange-red) that are intense enough and directive enough will disrupt hatchling orientation, especially in the absence of sun or moon light. As far as lighting design is concerned, the combination of intensity, colour, elevation and reflectivity of the surroundings appear to act together to influence turtle behaviour. Glow from an artificial light field reflected off overhead cloud is also problematic (EPA, 2010).

In summary, the effects of colour, intensity, proximity and direction of a light source combine to determine its attractiveness to a turtle hatchling. These factors, combined with the tendency to move away from dark horizons, determine the orientation adopted by a hatchling turtle (EPA, 2010).

<u>Proposal Lighting Impacts</u>

The survey conducted by Pendoley (2019a) identified that marine turtles nested most successfully on the offshore islands (Figure 92). These offshore islands lie more than 8 km from the closest potential Proposal light source, which exceeds the 1.5 km 'darkness zone' recommended by EPA (2010). Turtle hatchlings and nesting on these beaches are therefore unlikely to be significantly impacted by the Proposal given this large distance, and the fact that minimal lighting is required for the Proposal.

Only a small part of potential marine turtle nesting beach lies within proximity to the development envelopes, a section of the beach shown in Figure 92. The Pendoley (2019a) survey identified only very minor nesting effort by flatback turtles and a single hawksbill turtle, along the 15 km stretch of coastline to the east of Mardie creek. These results indicated that the mainland beaches are not currently a regionally important rookery. The results of the temperature loggers also confirmed that mainland beaches were significantly warmer than the offshore islands, impacting the success rate of any marine turtle nests on these beaches.

Given the lack of turtle nesting activity on the mainland in the area the Proposal's light emissions are unlikely to significantly impact turtle hatchlings and populations. Nevertheless, lighting for coastal and jetty facilities will consider design recommendations provided in the National Light Pollution Guidelines for Wildlife (DotEE, 2019) in order to ensure that lighting impacts are as low as practicable.

The impact of artificial light emissions from the vessels (dredge, support vessels) based on the potential light spill and glow reaching significant turtle habitats and/or nesting beaches and rookeries is expected to be negligible. The Wheatstone Project established a distance of 1.5 km from turtle nesting beaches as the area within which light emissions would need to be managed (Chevron, 2016), whereas the Proposal vessel movements will be more than 1.5 km from the nearest turtle nesting beach (Figure 93).

Marine turtles may also be attracted to light spill on the water beneath the trestle jetty. The length of the jetty has been reduced as far as practicable and lighting along the jetty will be the minimum required for safe navigation. In addition, the mitigation measures in Section 8.6 will ensure that light spill is minimised.

Increased Predation

Turtle hatchling survival in the wild is heavily influenced by predation. The Proposal may result in an increase in shorebird numbers in the lower salinity pond areas as they have been recorded utilising salt ponds elsewhere in the Pilbara (Phoenix, 2020b; Appendix 9.1). These lower salinity ponds are the southern ponds, located more than 10 km from the closest island nesting beach, and 4 km from the low-quality mainland nesting beach. The MSSA is already noted as a significant migratory shorebird habitat and therefore the shorebird population is well established in the area (i.e. ponds are not being introduced to an area that previously had no significant habitat). Increases in shorebird numbers close to turtle nesting beaches are therefore expected to be negligible, and increases in marine turtle predation would be minimal given the distance to the key offshore nesting beaches.

Marine Noise

This section applies the findings of the marine noise assessment described in Section 8.5.1 to marine turtles.

The model results determined that noise emissions from dredging and barging operations would not exceed any marine turtle noise criteria, meaning that behavioural impacts would not be expected, even if turtles were in close proximity to the dredging or barging activities.

Piling activities will result in an exceedance of the TTS threshold at mean and high tides at distances less than 100 m. The TTS threshold is never exceeded at low tide. Behavioural responses are predicted at distances less than 500 m during mean and high tides, with no impacts at low tide (Figure 101).

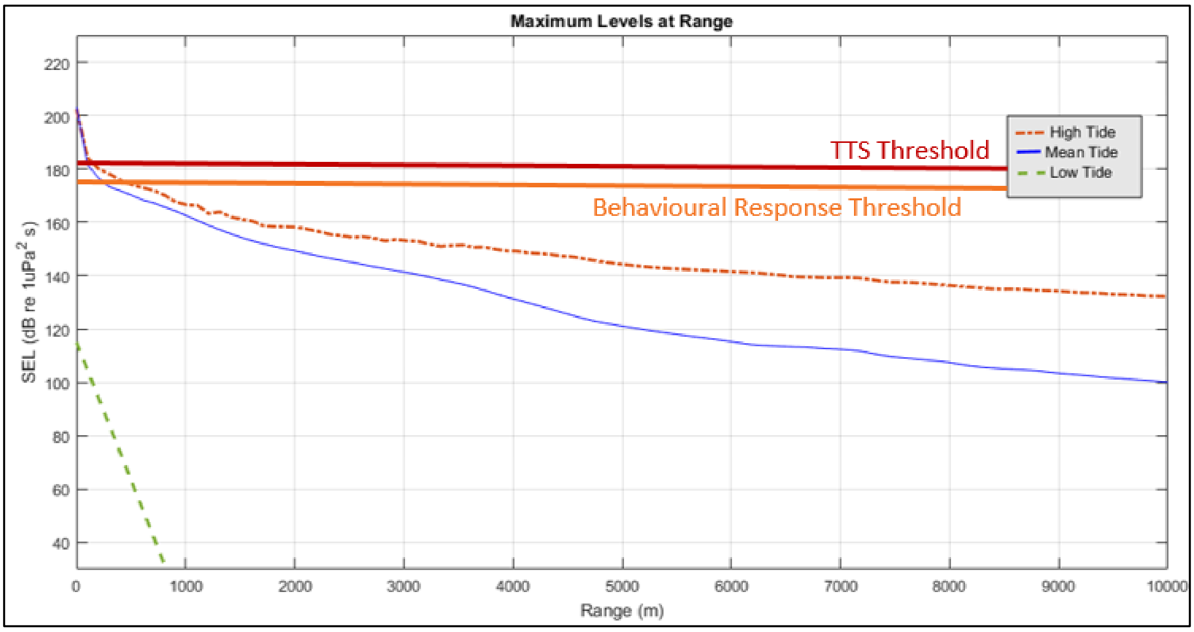


Figure 101: Maximum noise levels for marine turtles (and Green Sawfish) during piling activities (single strike)

The results of the Talis (2019) model show that marine turtles could be impacted by piling activities during the construction of the trestle jetty and loading wharf. Mitigation measures will need to be implemented to ensure that these potential impacts are minimised (Section 8.6).

8.5.3 Marine Mammals

This assessment applies to all marine mammals, however it focusses on the Humpback whale, Australian humpback dolphin and Dugong as they are conservation significant fauna species that were identified as potentially occurring in the area (predominantly offshore). Information is provided in this section if it adds to the general assessment in Section 8.5.1, i.e. if any of the potential impacts have more relevance to marine mammals then it will be discussed further in this section.

Habitat Disturbance

Section 7 contains a detailed assessment of the potential impacts to BCH, and the context of this assessment in relation to marine mammals is summarised below:

- 55 ha of sub-tidal BCH is proposed to be disturbed to develop the berth pocket and dredge channel;
- An additional 60 ha of sub-tidal BCH is predicted to be irreversibly impacted by dredging activities;
- None of the sub-tidal BCH within the development envelopes is considered high-value to any marine mammals (i.e. no seagrass beds occur);
- All types of BCH where losses will occur are found elsewhere nearby and are also widespread throughout the region; and
- With the implementation of controls indirect impacts are not predicted to be significant.

Vessel Strike

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 due to the small scale (i.e. spatial movements) of the operation and dredge vessel (i.e. slow-moving and small support vessels). Similarly, the risk of vessel strike on marine mammals during the operational stage is considered unlikely due to the slow speed of the transhipment barge (8 – 12 knots), the short journey length (approximately 50 km per return trip) and low frequency of vessel movements (1 - 2 return trips per day).

Dolphins are quick moving and would react quickly to avoid potential impact to vessels. Whales are not expected to occur in the immediate dredge vicinity due their preference for deeper waters and therefore not expected to be impacted from vessel activity. Dugongs may be present however specific foraging habitats have been avoided (refer Section 8.5.3).

Mitigation measures are proposed to reduce this risk to an acceptable level (Section 8.6).

Marine Noise

This section applies the findings of the marine noise assessment described in Section 8.5.1 to marine mammals, specifically the Humpback Whale, Dugong and Australian Humpback Dolphin, given their conservation status.

Figure 102 shows the marine noise levels predicted during dredging and barging activities (low frequency = Humpback Whales and Dugongs; mid frequency = Australian humpback dolphin), and Figure 103 and Figure 104 shows the marine noise levels predicted during piling activities. The results are compared against marine mammal threshold criteria in Table 33.

The results of the Talis (2019) model show that marine mammals could be impacted by dredging, barging and piling activities. Mitigation measures will be implemented to ensure that these potential impacts are minimised (Section 8.6).

Table 33: Assessment of predicted noise levels against threshold criteria

Marine mammals	Dredging and barging activities		Piling activities	
	Possible TTS	Possible behavioural response	Possible TTS	Possible behavioural response
Humpback Whales and Dugong	No exceedance	Distances less than 1,500 m	Distances less than: • 500 m at high tide • 300 m at mean tide • Only at the pile at low tide	Distances less than 10 km at high and mean tides. Only in close proximity to the pile at low tides.
Australian Humpback Dolphins	No exceedance	Distances less than 200 m	Only at the pile at high and mean tide. No exceedance at low tide.	Distances less than 4 - 5 km at high and mean tides. Only in close proximity to the pile at low tides.

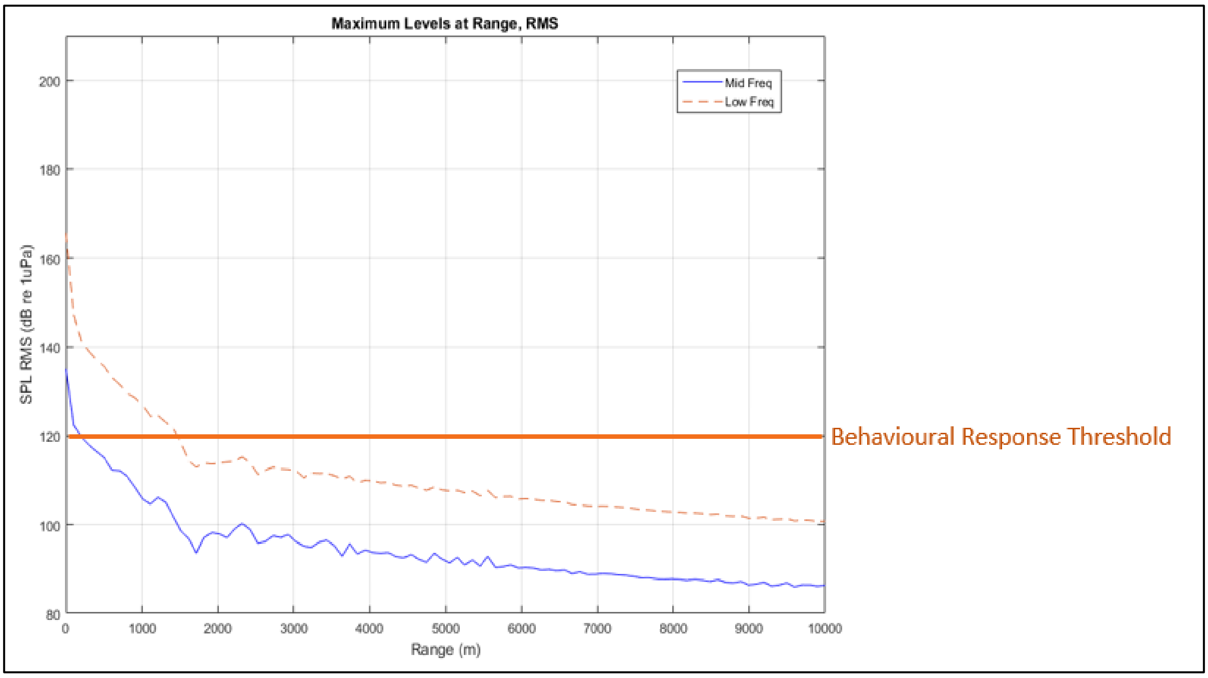


Figure 102: Maximum noise levels for marine mammals during dredging and barging activities

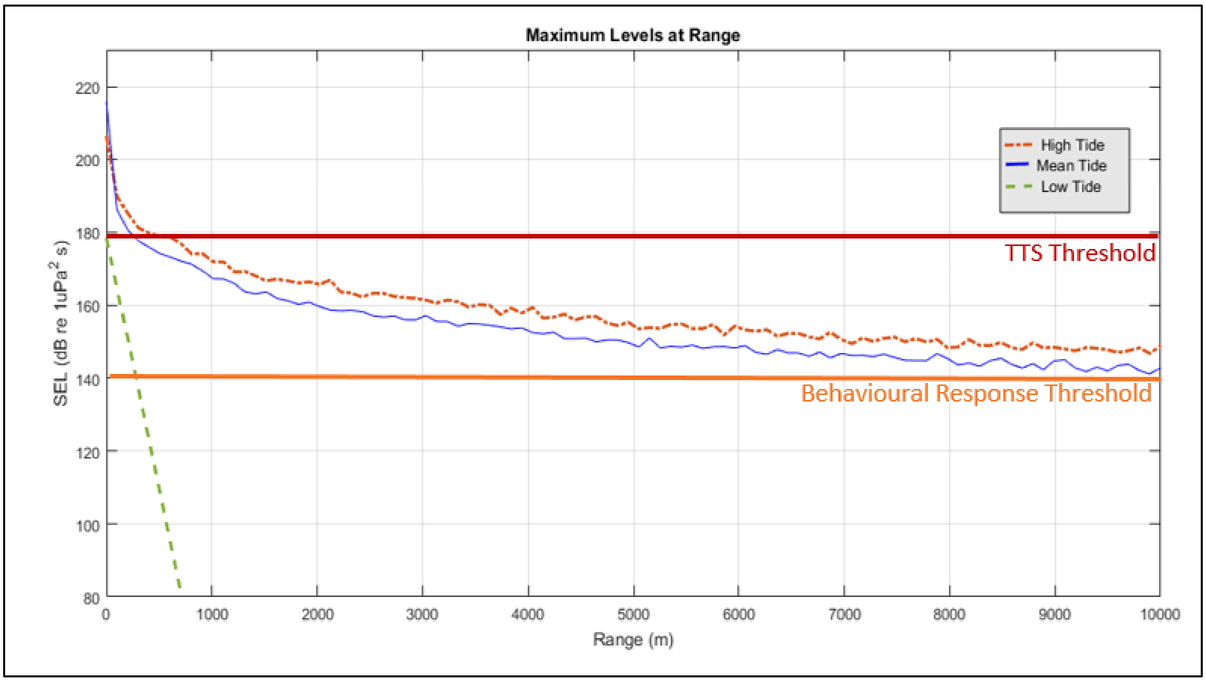


Figure 103: Maximum noise levels for Humpback whales and Dugong during piling activities (single strike)

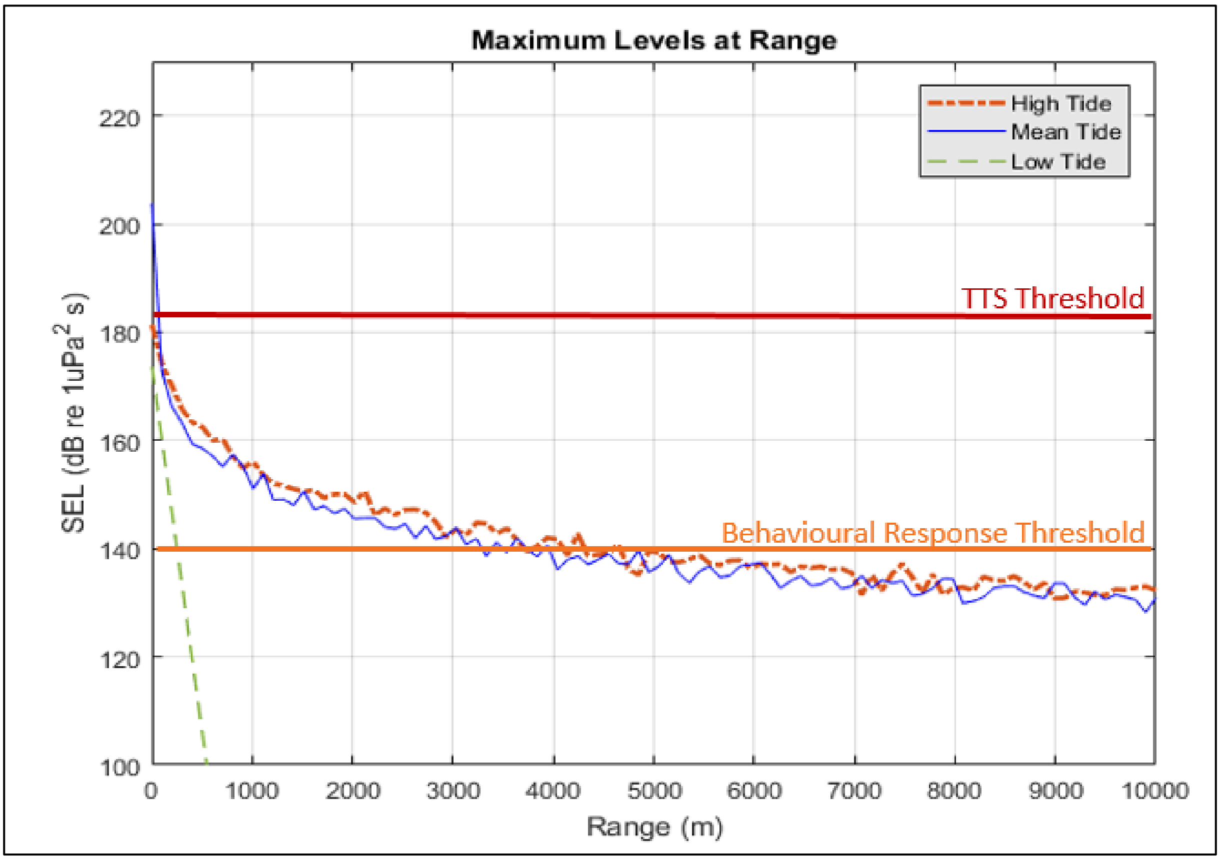


Figure 104: Maximum noise levels for Australian humpback dolphin during piling activities (single strike)

8.5.4 Sawfish

This assessment focusses on the Green and Narrow Sawfish as they are conservation significant species that were identified as potentially occurring in the LAUs. Information is provided in this section if it adds to the general assessment in Section 8.5.1, i.e. if any of the potential impacts have more relevance to sawfish then it has been discussed further in this section.

Habitat Disturbance

Of the BCH impacted, mangroves and tidal creeks are considered to be of most significance to sawfish species. Sawfish may utilise tidal creeks and mangrove communities for foraging and shelter. The potential impacts of the Proposal on mangrove communities is discussed in detail in Section 5. This assessment summarised that the potential mangrove impacts were not significant in a regional context, and the potential of the mangrove communities to support marine fauna was considered in that assessment.

The tidal creeks are considered to be important nursery areas for Green Sawfish, however the Proposal only includes minor works within two of the 15 tidal creeks in the LAUs (limited to a seawater intake and a small boat launching facility). Acoustic studies have shown that sawfish do not travel more than 700 m upstream from the mouth of the river. As this minor disturbance is more than 700 m upstream it is unlikely that any sawfish will be present at the seawater intake or small boat launching facility (O2 Marine, 2020g).

Given the number of similar tidal creeks within the LAUs and regionally, and the minimal direct disturbance, the Proposal is not expected to have a significant impact on tidal creek habitat for sawfish.

Marine Noise

This section applies the findings of the marine noise assessment described in Section 8.5.1 to sawfish, in particular the Green Sawfish.

The model results determined that noise emissions from dredging and barging operations would not exceed any Green Sawfish noise criteria, meaning that behavioural impacts would not be expected, even if Green Sawfish were in close proximity to the dredging or barging activities.

Piling activities will result in an exceedance of the Green Sawfish TTS threshold at mean and high tides at distances less than 100 m. The TTS threshold is never exceeded at low tide. Behavioural responses are predicted at distances less than 500 m during mean and high tides, with no impacts at low tide (Figure 101).

The results of the Talis (2019) model show that sawfish (in particular the Green Sawfish) could be impacted by piling activities during the construction of the trestle jetty and loading wharf. Mitigation measures will be implemented to ensure that these potential impacts are minimised (Section 8.6).

8.5.5 Short-nosed Seasnake (Aipysurus apraefrontalis)

Information is provided in this section if it adds to the general assessment in Section 8.5.1, i.e. if any of the potential impacts have more relevance to the short-nosed seasnake then they have been discussed further in this section.

Habitat Disturbance

The short-nosed seasnake (*Aipysurus apraefrontalis*) is typically found in coral reef habitats. Coral reefs are not found in coastal waters surrounding Mardie, but rather the highest diversity of benthic habitats and assemblages (coral, macroalgae, and non-coral benthic macroinvertebrates) are found around nearshore islands with fringing coral reefs and / or isolated reef patches. This species was considered moderately likely to occur near the Proposal but is more likely to be found in the vicinity of the offshore islands.

The Proposal will result in the loss of 44 ha of coral/macroalgae BCH, which is equivalent to 23.4 % of the total mapped within LAU 7. This habitat is of low value to the short-nosed seasnake due to the sparse nature of the corals (86.7% of coral in LAU 7 is < 25% coverage). Additionally, this BCH type is well represented regionally. The Proposal is therefore unlikely to disturb any significant habitat for this species.

8.5.6 OPMF Nursery Area

This section focusses on information relevant to the OPMF, although information can also be interpreted for the likely impact on target species from other fisheries. Ongoing consultation will continue with commercial fisheries to resolve any issues raised regarding the Proposal.

Information is provided in this section if it adds to the general assessment in Section 8.5.1, i.e. if any of the potential impacts have more relevance to the OPMF Nursery Area then they have been discussed further in this section

Habitat Disturbance

Vegetated coastal habitats are also known to be important for supporting fisheries production and biodiversity (Loneragan *et al.*, 2013). These vegetated habitats are hypothesised to provide an enhanced food supply, increased survival due to the provision of refuges from predation, and reduced wave action and water flow that stabilises sediments for fish and invertebrates (Manson *et al.,* 2005). For example, tiger prawn stocks are associated with sheltered coastal waters and seagrass habitat, which forms the main juvenile habitat for these species (Loneragan *et al.,* 2012). In turn, these areas are rich in productivity and biodiversity, and provide important hunting grounds for secondary order predators such as coastal dolphins, sharks and sawfish.

The Proposal will require the irreversible loss of 183 ha of the Fortescue Nursery Area portion of the OPMF, which is equivalent to less than 0.2% of the total nursery area. The relatively low cover and diversity of BCH within the development envelopes compared to the BCH surrounding the nearshore islands and extending further offshore suggests that the development envelopes are of low value to support fisheries production and biodiversity. Furthermore, only a very small proportion of the development envelopes are to be disturbed for the Proposal, therefore these impacts are expected to have negligible effect on fisheries production and biodiversity in the region.

Based on the above the Proposal is considered unlikely to disturb significant habitat or areas of habitat for the OPMF.

Other Indirect Impacts

Other indirect impacts to OPMF species are discussed in Section 8.5.1, and impacts to habitat are discussed in detail in the BCH factor (Section 7). Based on the outcomes of that assessment indirect impacts to OPMF habitat are not predicted to be significant.

Based on the above the Proposal is considered unlikely to result in a significant impact to the values of the area as a nursery for the OPMF.

8.6 MITIGATION

Mardie Minerals has mitigated the potential impacts to this factor according to the mitigation hierarchy; avoid, minimise, rehabilitate, offset. Offsets are not expected to be required for this factor.

8.6.1 AVOID

The key avoidance mechanism implemented by Mardie Minerals was the design of the development envelopes to avoid key environmental features. Mardie Minerals has conducted numerous ecological surveys and this information has been utilised to design the Proposal and its development envelope boundaries to avoid the following:

- The majority of the sandy beach at the north of the Proposal; and
- The majority of mangrove and tidal creek habitats.

In addition to the above, the following avoidance mitigation measures have been incorporated:

- Impacts associated with significant dredging activities and ocean-going vessel movements close to shore has been avoided by the use of a transhipment loading method;
- Impacts associated with the use of a cutter-suction dredge have been avoided by utilising a simpler barge-mounted long-reach excavator method;
- Vessels will not be permitted to venture or operate outside of port operational waters unless conducting monitoring or rescue operations; and
- Impacts associated with marine barriers have been avoided by the use of a trestle jetty instead of a marine causeway.

8.6.2 MINIMISE

The following mitigation measures are proposed to ensure that direct and indirect impacts to marine fauna are minimised:

1. **Implement the DSDMP.** A DSDMP has been provided in Appendix 4.1 and includes a comprehensive set of management actions and environmental performance measures related to marine fauna;
2. **Minimise potential noise impacts to marine fauna for the duration of the marine pile-driving operations by implementing the following controls:**
    a. Deployment of a Marine Fauna Observer (MFO) on each vessel undertaking marine pile driving operations and ensure they are trained in marine fauna observations and mitigation measures, including the requirements of the *Wildlife Conservation (Closed Season Marine Mammals) Notice 1998*. The MFO will keep a log of cetaceans, dugongs, sawfish and marine turtles observed;
    b. No marine pile driving activities shall commence until the MFO has verified that no cetaceans or dugongs have been observed within a radius of 1,000 m or marine turtles or sawfish within a radius of 300 m from any marine pile driving operations during the 20 minute period immediately prior to commencement of marine pile driving operation;
    c. If the MFO, or any other person, observes a marine turtle or sawfish enter within 100 m of marine pile driving operations, or cetacean or dugong within 500 m of marine pile driving operations, that marine pile driving operation is to be suspended;
    d. Marine pile driving that has been suspended in accordance with condition will not recommence until the cetacean, or dugong has moved beyond 1,000 m from the suspended marine piling operation or the marine turtle or sawfish beyond 300 m of their own accord, or the cetacean, dugong, sawfish or marine turtle has not been observed within 500 m of the marine pile driving operations for a period of 20 minutes. Marine pile driving that has been suspended for more than 15 minutes shall recommence with soft start-up procedures as required;
    e. Prior to commencement of full power marine pile driving, Mardie Minerals shall implement soft start-up procedures that slowly increase the intensity of noise emissions over a period of no less than 15 minutes.
    f. Marine pile driving commenced prior to sunset can continue between the hours of sunset and sunrise, unless marine pile driving is suspended for more than 15 minutes.
3. **Minimise the risk of introducing marine pests by implementing the measures listed in Section 5.6.2 (BCH)**:

   a. All vessels should comply with Commonwealth Department of Agriculture and Water Resources – Biosecurity Requirements as well as all State legislation relating to management of introduced marine organisms; and
   b. Any vessels visiting the Port of Mardie from international or interstate waters are required to complete the WA Department of Primary Industries and Regional Development 'Vessel Check' risk assessment (https://vesselcheck.fish.wa.gov.au).
4. **Minimise the risk of fatal vessel strikes to marine fauna**. Consistent with the DoE guidelines for reducing vessel strikes, Mardie Minerals will ensure that all Proposal vessel operators will be trained to observe and report the location of any sightings of large marine fauna (in particular marine turtles, mammals and sawfish) to other vessel operators in the area to allow them to be tracked (if visible) and avoided. In addition, implementing a 12-knot speed limit for large vessels within Proposal waters will act to reduce marine mammal injury from vessel strike. While the probability of vessel strike is already low, reducing vessel speed from 15 knots to 12 knots has been shown to decrease the likelihood of fatal injury (to large whales) by 30% (Vanderlaan and Taggart, 2007);
5. **Report any sightings of large marine fauna (i.e. mammals, turtles, sawfish) to all Mardie Minerals vessels in order to minimise vessel strike incidents**. All sightings of marine fauna that occur within the operational areas of the Mardie Port to be reported to operational vessels to minimise vessel strike incidents;
6. **Implement the MEQMMP as described in Section 6.6.2 and provided in Appendix 3.1;**
7. **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;
8. **Seawater intakes are to be fitted with intake screens designed to prevent marine fauna from being drawn into the intake, and designed such that intake speeds are limited to a maximum of 0.15 m/s**. This speed has been defined as slow enough to allow marine fauna to escape entrapment;
9. **Develop an 'illumination plan' for coastal and marine infrastructure.** The plan will be developed at the detailed design stage of the Proposal. Each light source will be described in terms of its purpose, location, footprint, intensity and spectral composition. The plan will ensure that appropriate lighting is installed that minimises impacts to marine turtles. Marine and coastal construction and operational activities will be conducted in accordance with design recommendations provided in EPA (2010) and DotEE (2019). Key mitigation includes:
   a. Lighting will be the minimum number and intensity required for safe operation;
   b. Light emitting diodes will be used where practicable, specifically PC Amber, 2000 CCT and filtered 2700 – 3000 CCT will be used where practicable;
   c. Long wavelength (550 – 700 nm; yellow to red) lights will be used wherever practicable. Use of short wavelength (400 – 500 nm; blue) lights will be avoided / minimised wherever practicable.
   d. If high pressure sodium lights are required to be used then amber filters will be fitted;
   e. White lights that emit ultraviolet light will not be used;
   f. Facilities will be designed to avoid light spill onto the beach and sea surface;
   g. Natural topography shielding will be considered when positioning lighting;

h. Night construction will be minimised during turtle nesting season;
i. Light fixtures will be mounted in low positions, directed downwards, shielded and aligned to direct light on the target area only;
j. Lights will be turned on only when required;
k. Long-period flashing lights will be used for navigation beacons or safety markings;
l. Personnel will be educated on the need to minimise light spill and the controls to be implemented;
m. An as-built audit will be conducted to verify that lighting impacts on the turtle nesting beach are minimal. Further actions will be taken to reduce lighting impacts if the audit determines that the Proposal lights are illuminating the nesting beach;
n. A marine turtle hatchling survey will be conducted within 12 months of the completion of construction to determine if there is any evidence of mis-orientation or disorientation of turtle hatchlings that could be attributed to the Proposal. If evidence is found then review lighting to reduce impacts further;

10. **Ensure key environmental windows (Section 8.3.12) are considered when planning construction activities**. Where practicable Mardie Minerals will align the timing of relevant construction activities to avoid these environmental windows; and
11. **Implement measures to minimise indirect impacts to marine fauna habitat (refer to Section 6)**.

8.6.3 Rehabilitate

The port area is expected to be located on a lease under the *Port Authorities Act 1999* and if this occurs a MCP will not be required under the *Mining Act 1978* for the marine infrastructure. Mardie Minerals will liaise with PPA regarding the port infrastructure, as it may be of value for ongoing use by PPA. If not, the closure objective for this factor will be to remove all infrastructure and stabilise all altered lands such that there are no ongoing impacts to marine fauna or habitats. The marine components of the Proposal are relatively easy to rehabilitate, and the following measures will be taken:

- All marine infrastructure including the jetty, wharf, seawater intakes, boat launching facility and navigation infrastructure will be removed and taken offsite; and
- The dredge channel will be left to gradually fill with sediment.

8.7 Predicted Outcome

The EPA's environmental objective for this factor is "to protect marine fauna so that biological diversity and ecological integrity are maintained" (EPA, 2016g).

The assessment conducted in Section 8.5 determined that there were a number of potential impacts that required controls to ensure they were made acceptable:

- Vessel strike;
- Entrapment in seawater intakes;
- IMPs;
- Marine noise emissions, particularly during pile driving activities; and
- Light impacts on marine turtles.

The mitigation measures for these potential impacts are well understood and established for marine projects (refer to Section 8.6).

Implementing a 12-knot speed limit for large vessels within Proposal waters will act to reduce marine mammal injury from vessel strike. While the probability of vessel strike is already low, reducing vessel speed from 15 knots to 12 knots has been shown to decrease the likelihood of fatal injury (to large whales) by 30% (Vanderlaan and Taggart, 2007).. In addition, vessel operators will be required to report the location of any sightings of large marine fauna (in particular marine turtles, mammals and sawfish) to other vessel operators in the area to allow them to be tracked (if visible) and avoided. Given the low numbers of vessels to be used at the Proposal and the implementation of controls the Proposal is expected to be able to be implemented without significant vessel strike impacts to marine fauna.

The Proposal will have two seawater intakes and both pose a risk of marine fauna entrapment if not designed and operated appropriately. Mardie Minerals has committed to two specific mitigation measures for these intakes; screens will be installed to prevent all but the smallest of marine fauna from being drawn into the intake pipe, and the intake has been designed such that the intake velocity is maintained below 0.15 m/s at all times. This velocity is recommended by the US Environmental Protection Agency (2001) as it ensures the protection of 96% of fish species, and is lower than the swim speed of marine turtles (Bell & Richardson, 1978; Bustard & Limpus, 1970; Chung et al., 2009; de Silva, 1995; Frick, 1976; Hirth, 1971; Hughes, 1974; Papi et al., 1995; Prange, 1976; Salmon & Wyneken, 1987; Witherington, 1991, Wyneken 1997). With the implementation of these two controls the risk of marine fauna entrapment is expected to be lowered to an acceptable level.

With the application of regulated controls, the Proposal is considered to present a 'low risk' of introducing marine pests to Mardie marine waters. Standard industry controls (enforced by Department of Agriculture (DA) (Cth)) relating to ballast water and vessel hygiene provide a level of confidence that IMPs will not be introduced. The commitment to additional mitigation measures described in Section 4.2.6 is expected to reduce the risks of marine pest introduction to acceptable levels.

Modelled marine noise from dredging activities is not significant, and marine noise mitigation measures are now well established within the marine construction industry for pile driving activities. Mardie Minerals has committed to measures that were applied as Ministerial conditions for the Balla Balla Export Facilities (Ministerial Statement 945) and it is expected that similar conditions will be applied to this Proposal. With the application of these measures it is expected that pile driving will be able to be conducted without significant impacts on marine fauna.

The Proposal is located more than 8 km from the nearest significant turtle nesting beach and therefore a darkness zone of at least 1.5 km will be maintained as recommended in EPA (2010). There is a nesting beach at the north end of the Proposal, however this was determined to be rarely used and low-quality (Pendoley, 2019a). Given the presence of marine turtles in the area, light mitigation measures will be implemented to reduce the risk of light interfering with turtle navigation.

Water quality impacts from dredging and bitterns disposal (assessed in Section 6) and direct and indirect BCH impacts (assessed in Section 7) are assessed as not being significant under those factors with the implementation of mitigation measures. Consequently the impacts on marine fauna are subsequently not expected to be significant. Bitterns disposal and emissions from the port loading facilities and the salt production process will be managed under Part V of the EP Act via a Works Approval and Licence.

Several significant fauna species listed under the BC Act and EPBC Act are known or expected to inhabit the waters surrounding the Proposal. Mardie Minerals considered these species when incorporating mitigation measures into the design, and has proposed operational commitments to ensure that potential impacts on these species are not significant.

With the implementation of controls, Mardie Minerals considers that the Proposal can be implemented in a manner that meets the EPA's objective for this factor.

9 FLORA AND VEGETATION

9.1 EPA OBJECTIVE

The EPA Objective for this key environmental factor is to protect flora and vegetation so that biological diversity and ecological integrity are maintained.

9.2 POLICY AND GUIDANCE

Relevant EPA and Commonwealth Government guidance documents for flora and vegetation are listed below:

Western Australian Government

Key EPA Documents

- Statement of Environmental Principles, Factors and Objectives 2016 (EPA, 2016a);
- Statutory Guideline for Mine Closure Plans (DMIRS,2020);
- EIA (Part IV Divisions 1 and 2) Administrative Procedures 2016;
- EIA (Part IV Divisions 1 and 2) Procedures Manual 2016; and
- Instructions on how to prepare EP Act Part IV Environmental Management Plans (EPA, 2018a).

Relevant EPA Factor Guidelines

- Environmental Factor Guideline - Flora and Vegetation (EPA, 2016h).

Relevant EPA Technical Guidance

- Technical Guidance – Flora and Vegetation Surveys for EIA (EPA, 2016i);
- Guidance Statement 6 – Rehabilitation of Terrestrial Ecosystems (EPA, 2006);
- Environmental Protection Bulletin 20 – Protection of naturally vegetated areas through planning and development (EPA, 2013); and
- Checklist for documents submitted for EIA of proposals that have the potential to significantly impact on Sea and Land factors (EPA, 2016j).

Other Policy and Guidance

- *Biosecurity and Agriculture Management Act 2007*;
- Technical Guide – Flora and Vegetation Surveys for EIA (EPA & Department of Parks and Wildlife (DPaW), 2015);
- WA Environmental Offsets Policy (EPA, 2011);
- WA Environmental Offsets Guidelines (EPA, 2014); and
- WA Offsets Template.

Commonwealth Government

Key Documents

- Generic guidelines for the content of a draft EPBC Act PER/EIS (including the objects and principles of the EPBC Act, 1999) (DotEE, 2016b);
- Other Minister of the Environment (Cth) approval decision making considerations;
- EPBC Act Environmental Offsets Policy (DSEWPaC, 2012) – including the Offset Assessment guide;

- Environmental Management Plan Guidelines (DotE, 2014a);
- Environmental Management Plan Guidelines, - template (DotEE, 2018a);
- EPBC Act Condition Setting Policy (DAWE, 2020);
- EPBC Act Outcomes-based conditions policy (DotE, 2016c); and
- EPBC Act Environmental Offsets Policy (DSEWPaC, 2012).

Relevant Technical Guidance

- Relevant EPBC listed species specific survey guidelines and protocols; and
- Relevant EPBC listed species specific Recovery plans, Threat Abatement Plans, Approved Conservation Advices and other documents.

9.3 Receiving Environment

The section below has been sourced from Phoenix Environmental Sciences (2020a; Appendix 8.1) and Stantec (2018; Appendix 2.2).

9.3.1 Bioregional Context

The Proposal is situated primarily (99.6%) within the Roebourne subregion (PIL4) of the Pilbara bioregion with an insignificant proportion (0.4%) falling within the Chichester subregion (PIL1). The Roebourne subregion is described as (Kendrick & Stanley, 2001):

> *Quaternary alluvial and older colluvial coastal and subcoastal plains with a grass savannah of mixed bunch and hummock grasses, and dwarf shrub-steppe of Acacia stellaticeps or A. pyrifolia and A. inaequilatera. Uplands are dominated by Triodia hummock grasslands. Ephemeral drainage lines support Eucalyptus victrix or Corymbia hamersleyana woodlands. Samphire, Sporobolus and mangal occur on marine alluvial flats and river deltas. Resistant linear ranges of basalts occur across the coastal plains, with minor exposures of granite. Islands are either Quaternary sand accumulations, or composed of basalt or limestone, or combinations of any of these three. The subregion experiences an arid (semi-desert) tropical climate with highly variable rainfall, often influenced by cyclonic activity in the northwest of WA and falling during summer. Subregional area is 2,008,983 ha.*

9.3.2 Survey Effort

Phoenix was commissioned to conduct a detailed flora and vegetation survey for the Proposal, consistent with the commitments provided in the ESD. Extensive reconnaissance and detailed field surveys were conducted to verify and build on desktop reviews compiled using existing information of the Proposal and its surroundings. The field survey effort for the Proposal can be summarised as follows:

- A single day site reconnaissance by helicopter: 17 August 2017;
- Three day site reconnaissance by helicopter: 8 - 10 December 2017;
- Six day first phase detailed flora survey: 14 - 19 May 2018;
- Nine day second phase detailed flora survey: 15 - 23 August 2018; and
- Four day survey of extended survey areas: 10 – 13 September 2019.

The surveys were completed over a defined 29,141 ha Study Area, which encompasses the entire terrestrial portion of the Ponds and Terrestrial Infrastructure Development Envelope, and extends outside this development envelope in some areas (Figure 105). The Study Area includes significant areas (47.5%) that are devoid of vegetation, such as the extensive saltflats and mudflats, areas of open water and tidal creeks, and previous disturbances (Table 37). Consequently, survey effort concentrated on those areas where vegetation was present, with the exception of fringing mangrove vegetation, which was already described and mapped by Stantec (2018) and later by O2 Marine (2020a; Appendix 2.3) as part of the intertidal BCH studies (Section 6).

The detailed survey of the Study Area was conducted over two seasons in accordance with the recommendations in the EPA's Technical Guidance (EPA, 2016f) for the Eremaean botanical province. The initial detailed survey was conducted in May 2018 by Dr Grant Wells and Alice Watt, six weeks post-wet season, with the second survey conducted in August 2018 by Dr Grant Wells, Alice Watt and Laurinda Timmins approximately six weeks following the highest winter rainfall. The detailed surveys assessed 51 permanent quadrats, 11 transects and 11 relevés. Targeted searches for significant flora were also conducted, by searching for previous species records identified in the desktop review and in suitable habitat encountered while traversing the Study Area. At least three quadrats were sampled in all vegetation types, except those with very limited extent within the Study Area – this aspect is discussed in more detail in Section 9.3.4.

A supplementary survey was conducted by Martin Henson and Alice Watt in September 2019 to the extended the Study Area and conduct targeted searches for *Minuria tridens*. With the addition of the supplementary survey a total of 64 quadrats, 11 *Tecticornia* transects (incorporating 30 quadrats) and 20 relevés were surveyed across the Study Area, providing a total of 114 survey locations

Stantec were commissioned to undertake a preliminary desktop and field assessment of mangal and algal communities in September 2017. This work included mapping of the mangroves, algal mats and *Tecticornia* spp. shrublands along the 80 km of coastline and was utilised by Mardie Minerals in their planning and design of the Proposal in a way that minimised direct and indirect impacts to vegetation and flora (Appendix 8.1).

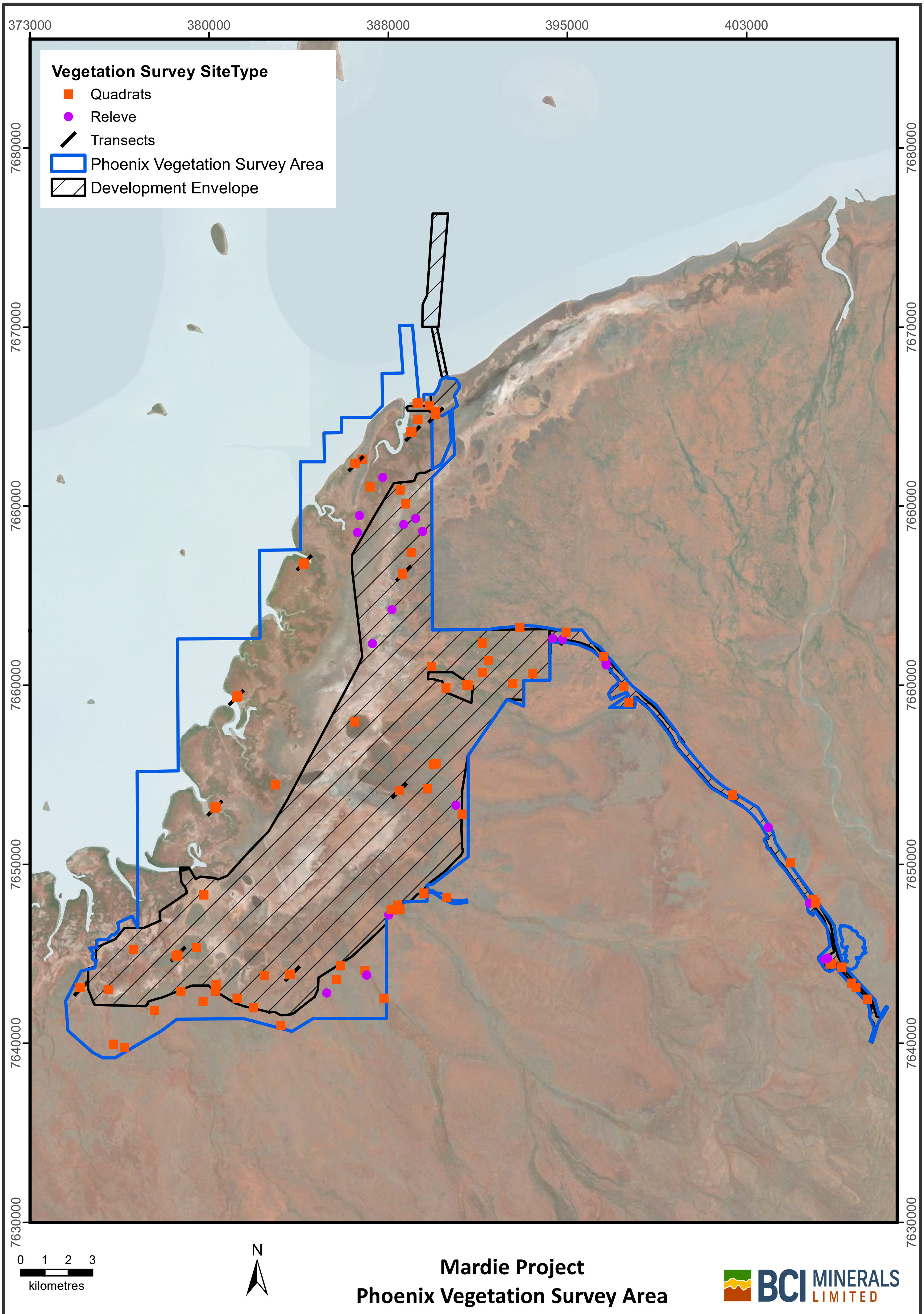


Figure 105: Flora and vegetation study area

Alignment with Technical Guidance

Phoenix conducted a review of the implemented survey methods against the relevant EPA technical guidance (EPA, 2016i). Overall the survey methods aligned with the technical guidance, although the large size of the Study Area resulted in some challenges (Table 34). The number of sites per vegetation type was variable due to the complex nature and scale of the Study Area, however, three quadrats were sampled in all vegetation types except those with very limited extents, where additional quadrats would either overlap or would be unlikely to provide any additional information.

Significant flora searches were not conducted over all suitable habitat due to the very large size of the Study Area, available timeframes and associated accessibility issues. At the time of the review targeted searches had not conducted over an area 1,110.8 ha that was added (3.8% increase) to the Study Area after the original survey in order to assess design changes (target searches will be conducted once suitable conditions prevail). The spatial extent of significant flora populations was not able to be recorded for all significant species (in particular *Tecticornia*) as these are not identifiable in the field and must be identified from specimens at a later stage.

Table 34: Alignment of survey with EPA guidelines

Key points	Compliant?	Implications for EIA
Preparation for survey Survey led by botanist with at least five years' experience in the bioregion Survey conducted under flora collection licences and landowner permission obtained	Yes	None
Desktop study Relevant databases searched at appropriate search extent. Description of regional setting (e.g. vegetation, land systems and soils).	Yes	None
Survey Reconnaissance survey To verify the information obtained from the desktop study, characterise the flora and delineate the vegetation units present.	Yes	None
Detailed survey Survey effort – multiple sampling events	Yes	None
Sampling techniques appropriate i.e. site type, quadrat size, vegetation condition rating	Yes	None
Survey design Survey area extent appropriate	Yes	None
Survey effort – adequate sampling of vegetation	Mostly compliant regarding survey effort - number of sites per vegetation type variable due to highly variable extents in Study Area, at least three quadrats sampled in all vegetation types, except those with very limited extent in Study Area.	A conservative approach has been taken regarding vegetation types with limited extents. These vegetation types have been considered locally

Key points	Compliant?	Implications for EIA
		significant unless stated otherwise.
Site selection	Yes, sites were selected from aerial imagery and from observations by helicopter and on the ground during the reconnaissance and detailed surveys.	None
Survey timing appropriate	Surveys were conducted within the timeframes provided in the technical guidance (EPA 2016b) and included collection of *Tecticornia* specimens during all survey events including the summer reconnaissance survey. However seasonal conditions were not optimal.	The assessment has assumed that additional flora species may be present and may have been recorded if seasonal conditions were optimal.
Flora population census	Significant flora searches not conducted over all suitable habitat due to very large size of Study Area and accessibility. Targeted searches also not conducted in the extrapolated area. Extent of significant flora was not recorded for all significant species (in particular *Tecticornia*) as these were identified after the field survey.	The assessment has assumed that additional significant flora species may be present (i.e. the assessment is not limited to only recorded species).
Flora Collection and identification of specimens Vouchering New species	Yes	None
Vegetation Structural vegetation description Floristic composition vegetation classification Vegetation description Defining TECs and PECs	Yes	None
Mapping	Yes	None
Reporting	Yes	None

Survey Limitations

Table 35 describes the limitations encountered during the Phoenix (2020a) survey and their implications to the assessment to vegetation and flora

Table 35: Phoenix (2020a) survey limitations

Limitations	Limitations for this survey?	Comments	Implications for EIA
Availability of adequate contextual information at a regional and local scale	Yes	There was a limited number of reports available for review and several of those used occurred at some distance from the current Study Area. In addition, there is limited information pertaining to the P3 PEC, Horseflat land system of the Roebourne Plains, to facilitate rigorous statistical determination of whether vegetation types encountered are representative of this community.	The assessment has considered that additional flora species may be present that were not identified during desktop searches. A conservative approach has been taken when mapping the extents of the Horseflat land system of the Roebourne Plains PEC.

Limitations	Limitations for this survey?	Comments	Implications for EIA
Competency / experience of survey personnel, including taxonomy	No	The lead botanists for the survey Dr Grant Wells and Dr Grace Wells have conducted numerous surveys in the Pilbara bioregion over the last 14 years. Frank Obbens who undertook a large proportion of the taxonomy has over 20 years' experience. In addition, assistance from taxonomic specialists from the WA Herbarium, Dr Kelly Shepherd and Michael Hislop, was obtained where required. Dr Shepherd identified all *Tecticornia* specimens and Mike Hislop identified the Priority flora.	None
Proportion of flora recorded and/or collected, any identification issues	Yes	Several of the specimens collected could not be identified definitively to species level as a result of being sterile, possibly the result of below average rainfall in the first phase survey period.	The assessment has assumed that additional flora species may be present (i.e. the assessment is not limited to only recorded species).
Was the appropriate area fully surveyed (effort and extent)	Yes	The use of the helicopter did allow targeted searches for different vegetation types and subsequently it is considered that all broad floristic types were sampled. However, the Study Area was very large and subsequently searches for significant flora were not conducted over all suitable habitat. A small addition to the Study Area (1,110 ha) was made following completion of the surveys; vegetation mapping within this area was extrapolated from adjacent mapped polygons. Targeted searches have not been conducted in these areas.	The assessment has assumed that additional significant flora species may be present (i.e. the assessment is not limited to only recorded species).
Access restrictions	No	The use of a helicopter ensured all areas in the study area were accessible.	None
Timing, rainfall, season	Yes	Despite timing the detailed survey events to be undertaken six weeks following rainfall, below average falls resulted in notably dry conditions over a large proportion of the Study Area.	The assessment has assumed that additional flora species may be present (i.e. the assessment is not limited to only recorded species).
Disturbances which affected the results of the survey	No	The majority of the vegetation in the Study Area was in Very Good to Excellent condition and very little of the Study Area was recently burnt.	None

9.3.3 Flora

The following information has been sourced from Phoenix (2020a; Appendix 8.1) unless noted otherwise.

The field surveys recorded a total of 238 flora taxa representing 41 families and 115 genera identified to species level were recorded in the 29,020 ha Study Area. Species richness ranged from 1 to 46 species between quadrats. The assemblage included 230 native species and eight introduced species, including 169 perennial species, 66 annual or short-lived species and three unknown lifecycles.

Phoenix reported that the level of floristic diversity present in the Study Area was lower than that indicated from the desktop assessment (414 taxa from 66 families and 187 genera, from a 780,000 ha search area). This difference is considered to be due to the following variables:

- The Study Area being only being 4% of the desktop search area;
- A significant proportion of the Study Area (46.2%) is devoid of vegetation (coastal beaches, mudflats and claypans) or unvegetated (open water and cleared areas);
- The low level of habitat diversity (the study area is dominated by only two land systems);
- Much of the landward area is heavily impacted by weeds and cattle grazing; and
- Lower than average rainfall over much of the survey period.

Threatened and Priority Flora

Thirty-four significant flora species were identified in the desktop review as potentially occurring in or around the Study Area (Table 36). These were all priority flora species under the BC Act, however one species, *Eleocharis papillosa*, was also listed as Threatened under the EPBC Act.

Targeted searches of the Study Area were undertaken for significant flora species identified in the desktop review. The searches focused on habitats considered likely to support such flora, in addition to previously recorded locations of significant plants or populations in close proximity to the study area.

One Threatened Flora listed under the EPBC Act (*Minuria tridens*) was recorded during the field surveys. This species is also listed as a P1 Priority Flora under the BC Act. It was recorded at one location within the Study Area; a single plant was located on a sand dune in *Triodia epactia* and *Cenchrus ciliaris* grassland. This record lies outside any of the Proposal development envelopes (Figure 113). *M. tridens* was not identified through the desktop review as the only other previous record of this species in WA was from near Cue, located on the roadside of the Great Northern Highway in the Eastern Murchison subregion (over 800 km away). As a result of finding the single plant, the dune system on which it was located was searched extensively, including on neighbouring tenure, outside of the initial study area, but no other specimens were recorded.

Only one other Priority flora species was recorded in the Study Area during the survey; *Goodenia nuda* (P4) (Figure 106). This species was recorded at a single location near the southern boundary of the Study Area in a low *Eucalyptus victrix* woodland over tall open *Acacia coriacea* subsp. *pendens* shrubland over low *Eragrostis brownii*, *Eulalia aurea* and *Triodia wiseana* grassland. This record also lies outside any of the development envelopes (Figure 106). A total of 117 previous records of the species have been reported across the Gascoyne, Little Sandy Desert and Pilbara Bioregions.

The desktop review identified a previous record for the Priority 3 flora species *Owenia acidula* from within the Study Area. A foot search was conducted for the species in the vicinity of this record and the supporting habitat was recorded. A helicopter flying at low altitude was used to search for other areas of similar habitat, which were then searched in detail on foot. No new records of this species were located. The presence of the species somewhere within the Study Area cannot be discounted however, due to the prior record of the species and large areas of suitable potential habitat.

Seven other Priority Flora species were identified by Phoenix (2020a) as possibly occurring within the Study Area, following a habitat assessment (Table 36):

- *Goodenia pallida* (P1);
- *Helichrysum oligochaetum* (P1);
- *Tephrosia rosea* var. Port Hedland (A.S. George 1114) (P1);
- *Trianthema* sp. Python Pool (G.R. Guerin & M.E. Trudgen GG 1023) (P2);
- *Corchorus congener* (P3);
- *Gymnanthera cunninghamii* (P3); and
- *Solanum albostellatum* (P3).

Table 36 lists the other Priority Flora that were assessed and considered unlikely to be present within the Study Area.

Table 36: Likelihood of occurrence for conservation significant flora in the Study Area (Phoenix, 2020a)

Species	Conservation Status	Likelihood of occurrence
Abutilon sp. Onslow	P1	Unlikely, Study Area outside of known range
Atriplex flabelliformis	P3	Unlikely, Study Area outside of known range
Bonamia brevifolia	P1	Unlikely, no suitable soil type in Study Area
Bothriochloa decipiens var. *cloncurrensis*	P1	Unlikely, Study Area outside of known range
Carpobrotus sp. Thevenard Island (M. White 050)	P3	Unlikely, Study Area outside of known range
Cucumis sp. Barrow Island (D.W. Goodall 1264)	P2	Unlikely, Study Area outside of known range
Eleocharis papillosa	Vu, P3	Unlikely, Study Area outside of known range, no suitable habitat
Eragrostis surreyana	P3	Unlikely, no suitable habitat
Eremophila forrestii subsp*. viridis*	P3	Unlikely, Study Area outside of known range, no suitable habitat
Gomphrena pusilla	P2	Unlikely, Study Area outside of known range
Goodenia sp. East Pilbara	P3	Unlikely, Study Area outside of known range, no suitable habitat
Indigofera sp. Bungaroo Creek	P3	Unlikely, Study Area outside of known range
Lepidobolus quadratus	P3	Unlikely, Study Area outside of known range
Rhynchosia bungarensis	P4	Unlikely, lack of suitable habitat
Solanum cataphractum	P3	Unlikely, lack of suitable habitat
Stackhousia clementii	P3	Unlikely, lack of suitable habitat
Stackhousia umbellata	P3	Unlikely Study Area outside of known range
Stylidium weeliwolli	P3	Unlikely Study Area outside of known range
Swainsona thompsoniana	P3	Unlikely, Study Area outside of known range
Tecticornia globulifera	P1	Unlikely, lack of suitable habitat
Tecticornia medusa	P3	Unlikely, lack of suitable habitat
Tecticornia sp. Christmas Creek	P1	Unlikely, lack of suitable habitat
Terminalia supranitifolia	P3	Unlikely, lack of suitable habitat
Triodia sp. Robe River	P3	Unlikely, lack of suitable habitat
Triumfetta echinata	P3	Unlikely Study Area outside of known range

Unidentified or Undescribed Species

A total of 29 taxa could not be identified to species level, in most instances due to insufficient taxonomic characters as plants were sterile (lacking reproductive structures) possibly the result of below average rainfall in during the survey period. A further five taxa were identified to species level but lacked sufficient taxonomic characters to determine the sub-species or variety (Phoenix, 2020a).

One samphire taxon identified as *Tecticornia* sp. affinity to *T. halocnemoides* large ovate seed aggregate (LOSA) was considered by taxonomic specialist, Dr Kelly Shepherd, to represent an undescribed species and therefore could potentially be a new species. It was recorded at seven locations (Figure 113), including five locations outside the development envelopes. Four other *Tecticornia* specimens could not be identified to species level and may also represent undescribed taxa. The locations of these potential undescribed and sterile *Tecticornia* species is shown on Figure 113.

All other unidentified taxa were not considered to be significant (Phoenix, 2020a). The two *Abutilon* specimens not identified to species level were not considered representative of the P1 *Abutilon* sp. Onslow identified in the desktop assessment, as leaf margins were crenate rather than entire and leaf size was larger than that recorded (DBCA, 2019a) for this Priority Flora.

The *Aristida* specimen was not considered likely to represent a listed significant flora as no significant *Aristida* species have been recorded for either the Roebourne or Chichester subregions where the Study Area is located.

The *Atriplex* specimens did not resemble specimens of the Priority Flora *Atriplex flabelliformis* identified in the desktop assessment and more closely resembled other *Atriplex* species. In addition, it was considered unlikely that the Priority species would be present in the Study Area as it lies outside of the recorded range of the species (DBCA, 2019a).

The *Eucalyptus* specimen is unlikely to represent a significant flora as the two Priority *Eucalyptus* species known from the Pilbara bioregion occur several hundred kilometres from the Study Area.

The *Gomphrena* specimen was compared at the WA Herbarium to specimens of *Gomphrena pusilla* identified in the desktop assessment. The old dried flowers of the collected specimen were not commensurate with the inflorescence of the Priority species.

The *Goodenia* specimen was compared to specimens of *Goodenia pallida* identified in the desktop assessment but the leaves were not commensurate with those of this Priority Flora.

The *Ipomoea* specimen was a robust perennial plant and not commensurate with the annual Priority species *Ipomoea racemigera* recorded for the Pilbara bioregion.

The *Pterocaulon* specimens was considered unlikely to represent the Priority 3 species *P. xenicum* recorded for the Pilbara bioregion as the closest record for this species occurs hundreds of kilometres from the Study Area.

There are two Priority flora *Sida* taxon recorded for the Pilbara bioregion both of which inhabit rocky hills and ridges and have distributions located hundreds of kilometres from the Study Area. Subsequently, the *Sida* specimen was considered unlikely to represent either of the Priority species due to the large distance and lack of suitable habitat.

The *Solanum* specimen had stems covered densely with spines which was not commensurate with the near-spineless stems of *Solanum albostellatum* and had a different leaf shape to *Solanum cataphractum* and subsequently was not considered to resemble either of the Priority flora identified in the desktop assessment.

The *Swainsona* seedling was not considered to represent the Priority flora *Swainsona thompsoniana* identified in the desktop assessment as stems were densely hairy rather than glabrous and the flower was a dark purple colour rather than mauve and therefore not commensurate with the Priority flora.

The remaining specimens that could not be identified to species level were all considered unlikely to represent any listed significant flora as no significant flora of the genera are recorded for the Pilbara bioregion (Phoenix, 2020a).

Range Extensions

Cassytha aurea var. *aurea* was recorded from one location within the Study Area, which represents an approximate 80 km, north-east extension to the mapped distribution of this species (DBCA, 2019b). The record location has been excluded from the development envelopes (Figure 113). The potential presence of other specimens being present within the development envelopes is not considered significant, as the species has a recorded range that extends from Muchea north of Perth to Onslow, an extent of over 1,000 km (Western Australian Herbarium, 1998).

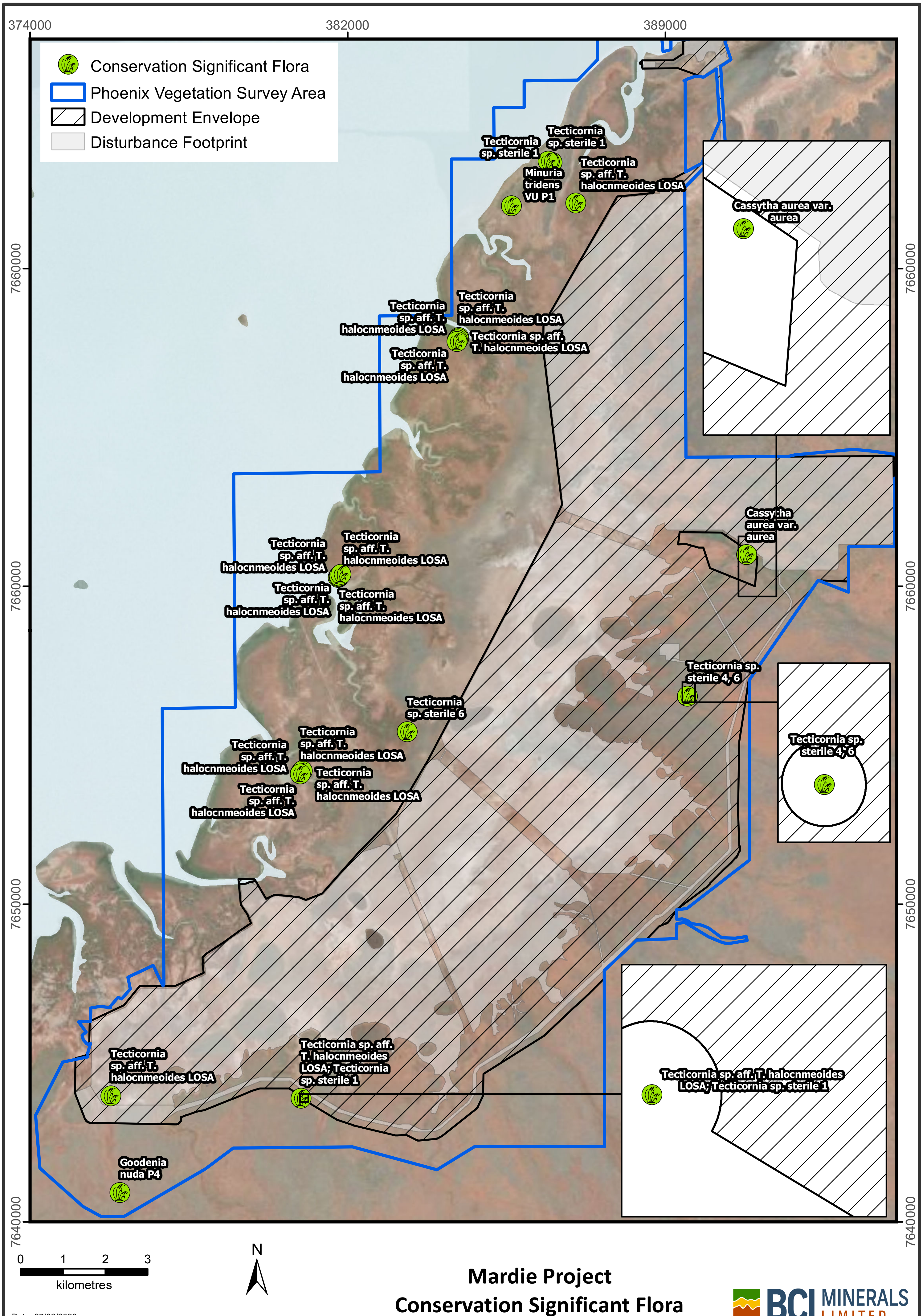


Figure 106: Locations of significant flora recorded during the field survey

Introduced Flora

Eight introduced flora species were recorded in the Study Area. Two of these species are listed as both Weeds of National Significance (WoNS) and Declared Pests; *Prosopis glandulosa* x *velutina* and *Prosopis pallida*.

The WoNS / Declared Pest *Prosopis* spp. (commonly referred to as Mesquite) was widespread across the study area ranging from isolated shrubs to tall closed shrublands (Figure 107). With the exception of the tidal mudflats and tidal creeks, the species occurred in all habitats within the Study Area including flat/undulating sandy plains, coastal sand dunes, sandy islands on the tidal mudflats, sandy rises on the tidal mudflats, riparian vegetation of creeks and drainage lines and low lying clay plains. The majority of the *Prosopis* spp. plants sighted during the survey were unable to be identified to a species level as they were in a sterile condition, precluding the capacity to map the distribution of the two species recorded individually.

Both of the *Prosopis* species recorded in the Study Area are allocated to the category 2 (C2) category, requiring eradication (DPIRD, 2018). The *Prosopis* infestation at Mardie Station has a long history, dating back to the 1930's and is recognised as the largest single core infestation (150,000 ha) in Australia (NHT, 2003). The Pilbara Mesquite Management Committee formed in 2000 has acknowledged that eradication of the species at Mardie is unachievable and instead the priority is to prevent the spread of the pest to neighbouring areas (NHT, 2003).

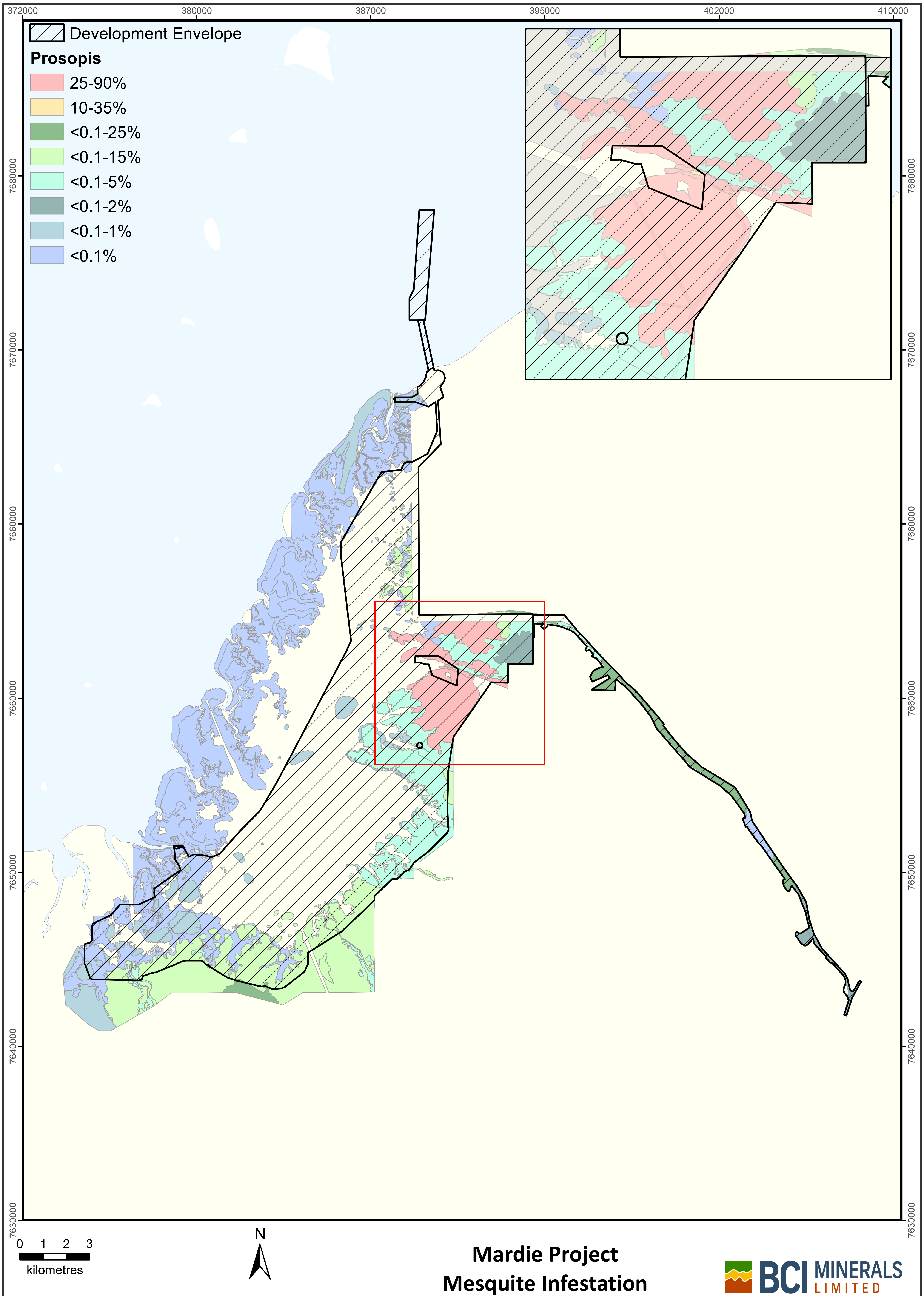


Figure 107: Location of introduced flora species records and Mesquite (Prosipis) infestation

9.3.4 Vegetation

The following information has been sourced from Phoenix (2020a) unless noted otherwise (Appendix 8.1).

Land Systems

The Study Area covers eight land systems, however it is dominated by two systems which together cover approximately 80% of the Study Area (Figure 108):

- **Littoral** (~17,817 ha) - Bare coastal mudflats (unvegetated), samphire flats, sandy islands, coastal dunes and beaches, supporting samphire low shrublands, sparse *Acacia* shrublands and mangrove forests; and
- **Onslow** (~5,521 ha) – Undulating sand plains, dunes and level clay plains supporting soft spinifex grasslands and minor tussock grasslands.

Vegetation Condition

The condition of vegetation in the Study Area ranged from Completely Degraded to Excellent (Figure 109). Areas naturally devoid of vegetation in the Study Area (45.4%) were assigned a Not Applicable (N/A) condition rating. All areas rated as Completely Degraded comprised cleared areas only.

Where present, the majority of the vegetation in the Study Area (80.6%) was recorded to be in Very Good to Excellent condition, largely as a result of the *Tecticornia* spp. shrublands and mangroves on the tidal mudflats being subject to little or no disturbance. A small proportion of the Study Area (0.8%) was recorded to be Completely Degraded, i.e. these areas had been cleared and were virtually devoid of any native vegetation. The remaining 19.4% of vegetation in the Study area was in Degraded to Good condition with disturbance primarily in the form of weed infestations, particularly **Prosopis* spp. and **Cenchrus ciliaris*, but also grazing damage from livestock and vehicle tracks.

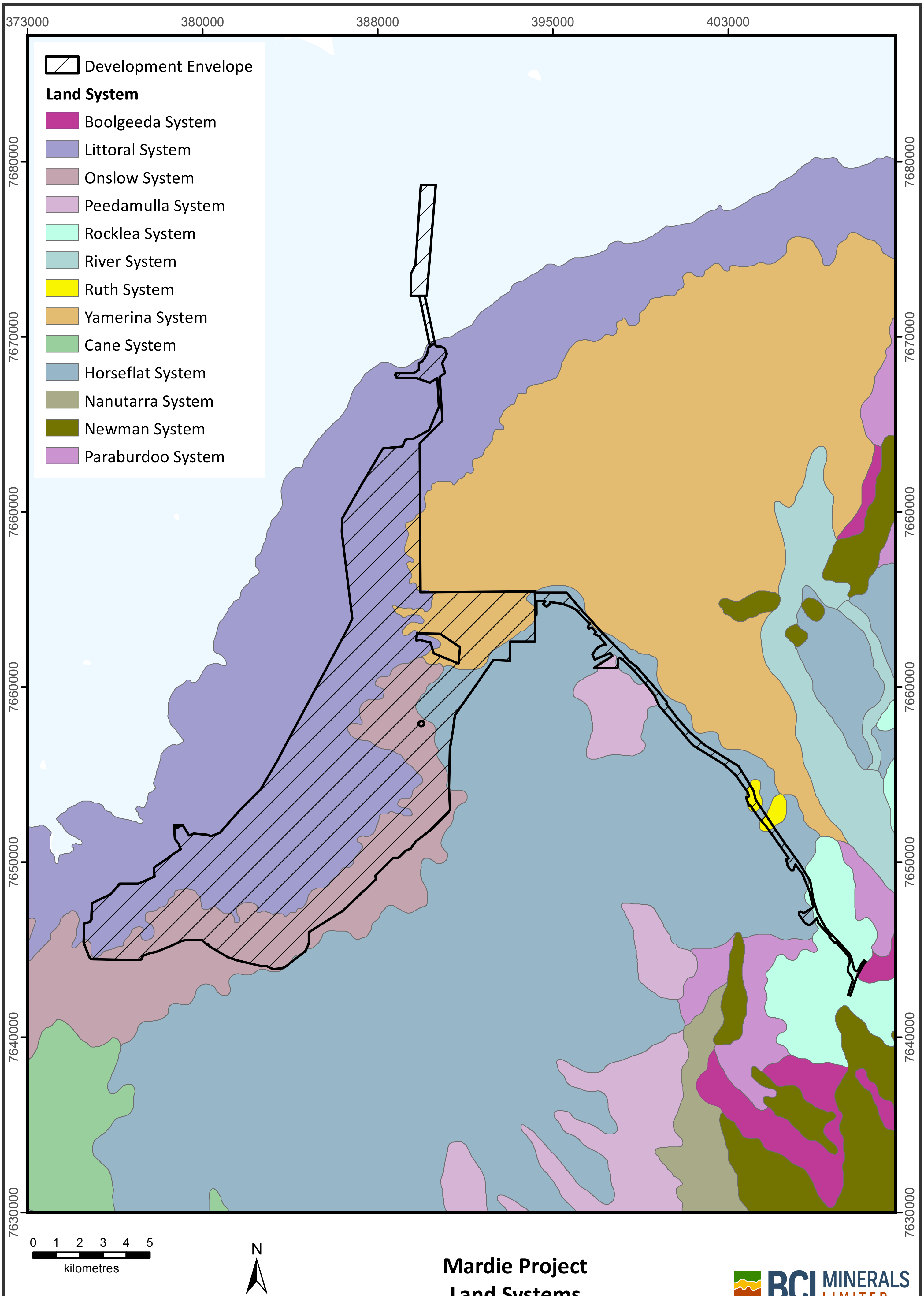


Figure 108: Land systems of the study area

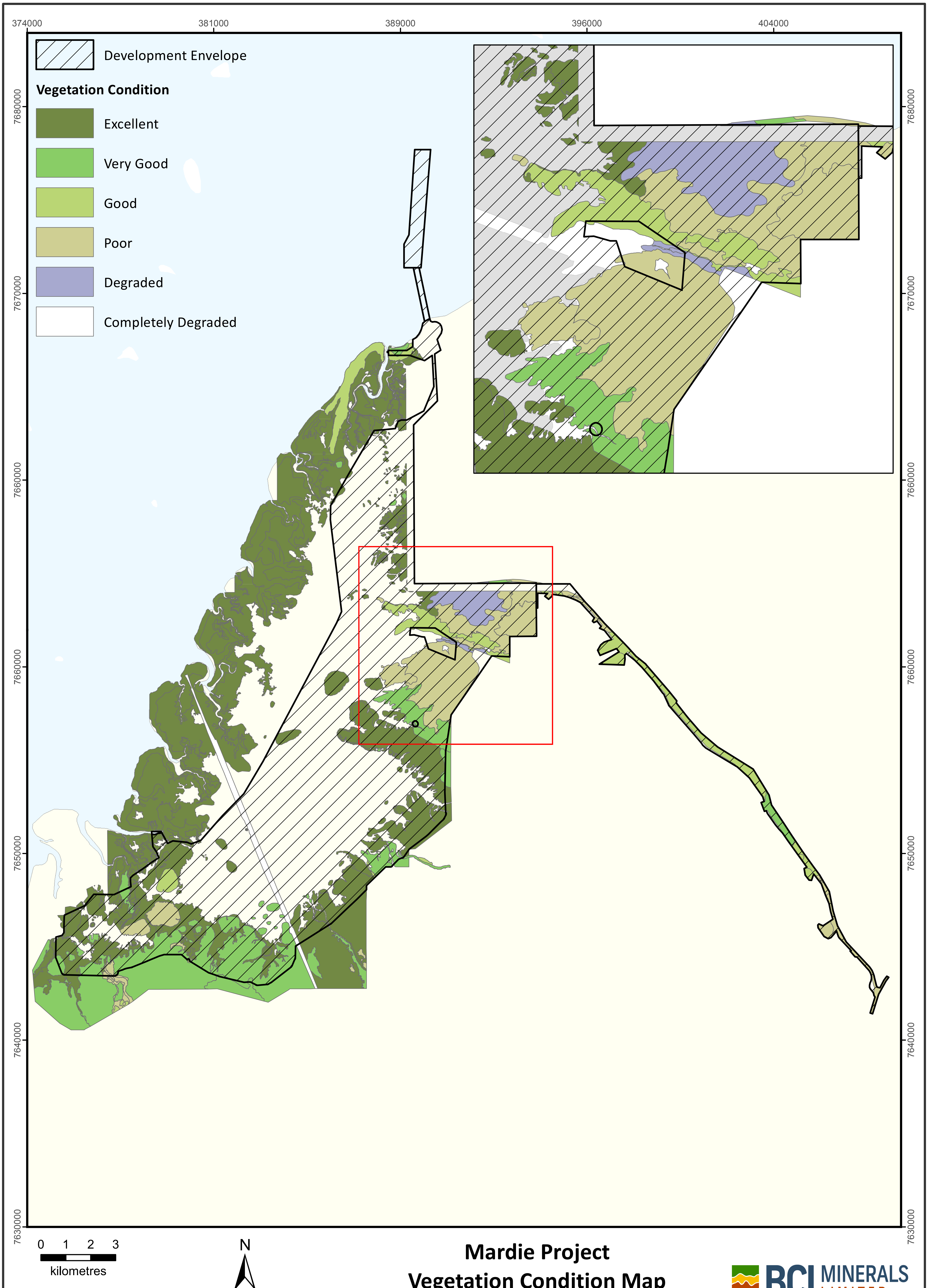


Figure 109: Vegetation condition

Vegetation Associations

Five vegetation associations are located within the Study Area based on regional vegetation mapping by Shepherd *et al.* (2002) (Figure 110). All vegetation associations are extensively represented in the Roebourne and Chichester subregions and currently have over 89% pre-European extent remaining and are therefore have the status of 'Least Concern'. Kendrick & Stanley 2001 report that Vegetation Association 600 is a priority for reservation, as it was not represented in any formal reserves; however interaction with the Proposal is minimal (Table 37).

Table 37: Vegetation associations within the development envelope

Vegetation Association and description	Pre-European extent (ha)	Current extent (ha)	% remaining	Extent within development envelopes (ha)
82: Hummock grasslands, low tree steppe; snappy gum over *Triodia wiseana*	2,563,583	2,550,899	99.51	78 (<0.01% of pre-European extent)
117: Hummock grasslands, grass steppe; soft spinifex	82,706	78,097	94.43	139 (0.17%)
127: Bare areas; mud flats	177,750	159,595	89.79	9761 (9.99%)
600: Sedgeland; sedges with open low tree savannah; *Eucalyptus* sp. aff. *Aspera* over various sedges	67,036	66,955	99.88	65 (0.10%)
601: Mosaic: Sedgeland; various sedges with very sparse snakewood / Hummock grasslands, shrub-steppe; kanji over soft spinifex.	109,687	109,618	99.94	8,021 (5.13%)

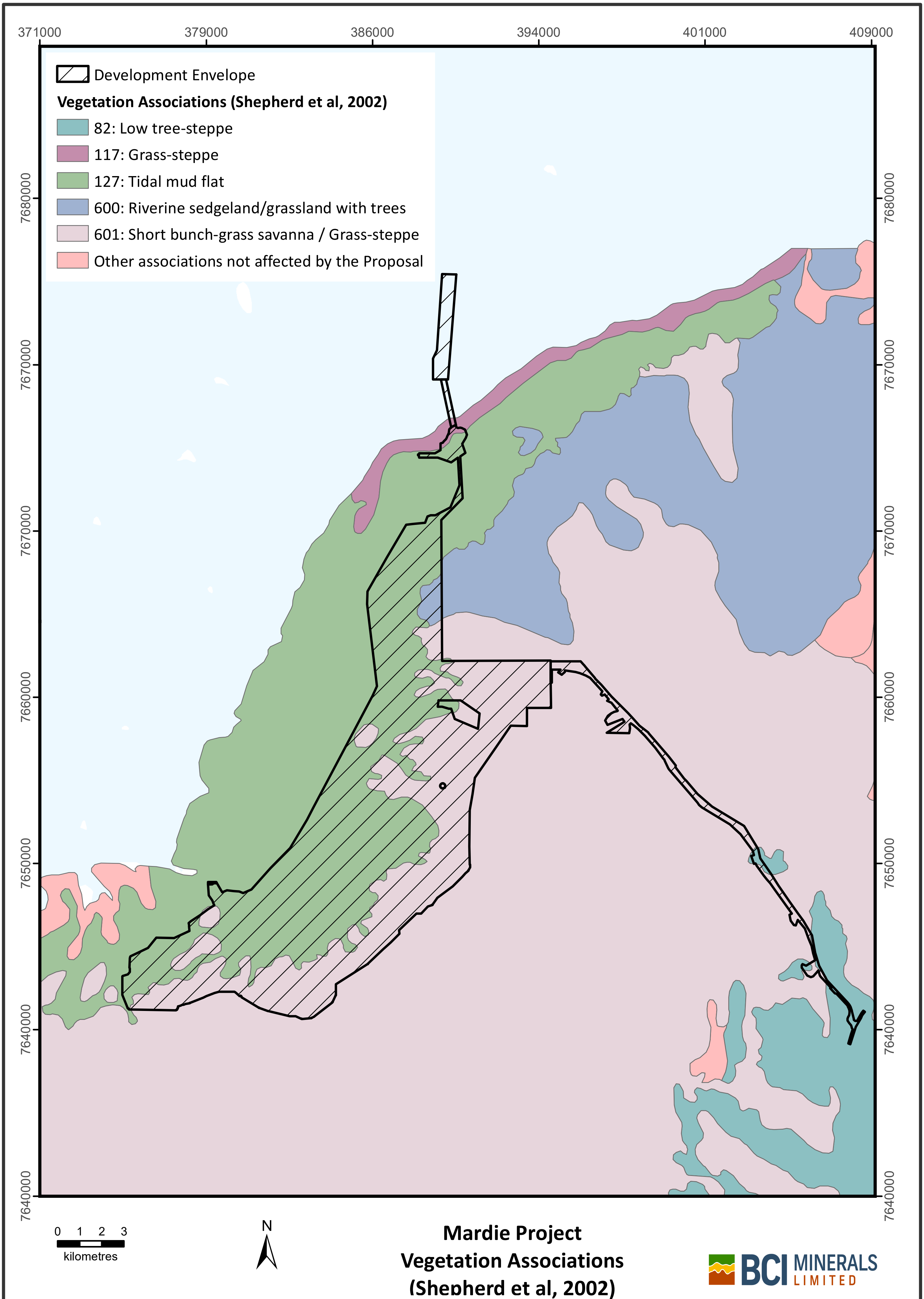


Figure 110: Vegetation associations

Vegetation Types

Fourteen vegetation types were mapped by Phoenix (2020a) within the Study Area during the field survey (Figure 111), including:

- One low open *Tecticornia* spp. shrublands complex on tidal mudflats and sandy rises on tidal mudflats;
- A mangrove community on tidal mudflats and tidal creeks;
- Four spinifex (*Triodia* spp.) grasslands;
- A *Spinifex longifolia* grassland;
- A *Melaleuca argentea* and *Sesbania formosa* woodland;
- A shrubland over *Triodia* spp. grassland;
- Two low open *Eucalyptus* and/or *Corymbia* spp. woodland over *Acacia* spp. shrubland over *Triodia* spp. hummock grassland;
- A low mixed grassland, *Eragrostis* spp.;
- A **Prosopis* spp. tall shrubland, and
- A low shrubland over *Sporobolus virginicus* grassland.

A large proportion of the Study Area (46.2%) was devoid of the flora and vegetation that were the subject the surveys. These areas comprised coastal beaches, tidal mudflats, tidal creeks, ocean, algal mat, areas that were naturally devoid of vegetation and completely degraded/cleared areas including gas pipeline corridors, pastoral tracks and areas that had been cleared for pastoral activities.

The majority of vegetation types defined for the Study Area align with vegetation types defined for other surveys in the region indicating a broader distribution outside of the Study Area (Phoenix, 2020a).

Threatened and Priority Ecological Communities

One Endangered Threatened Ecological Community (TEC) listed under the EPBC Act (Robe Valley Mesas – Subterranean invertebrate communities of mesas in the Robe Valley region) and three Priority Ecological Communities (PECs) listed under the BC Act were identified in the desktop study. One of the PECs, "Horseflat Land System of the Roebourne Plains" (Priority 3) was considered as likely to be found within or adjacent to the Study Area. The presence of the Horseflat land system of the Roebourne Plains PEC was confirmed during the field survey (Figure 112), and further verified through consultation with DBCA. 483 ha of this PEC was recorded within the Study Area

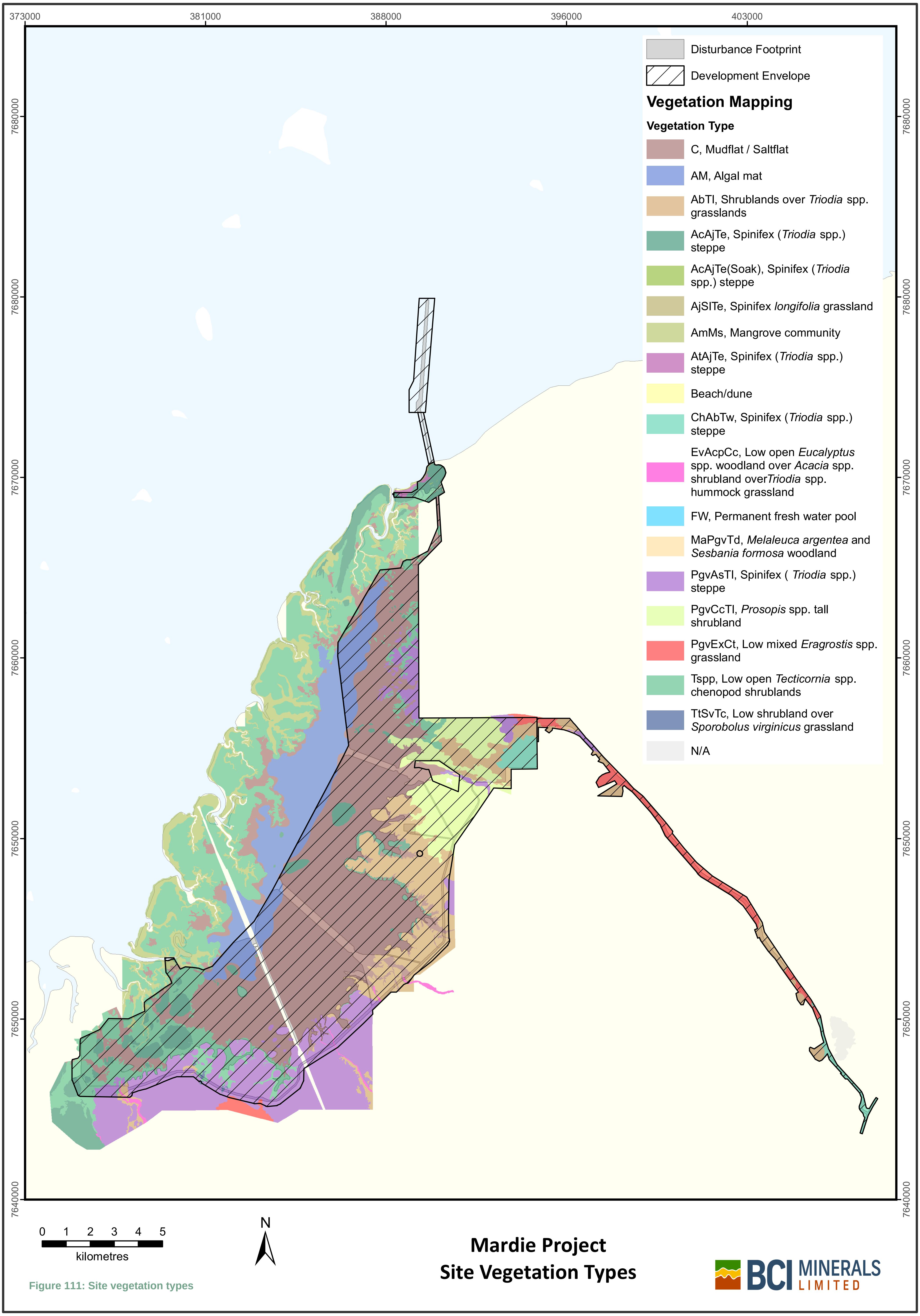
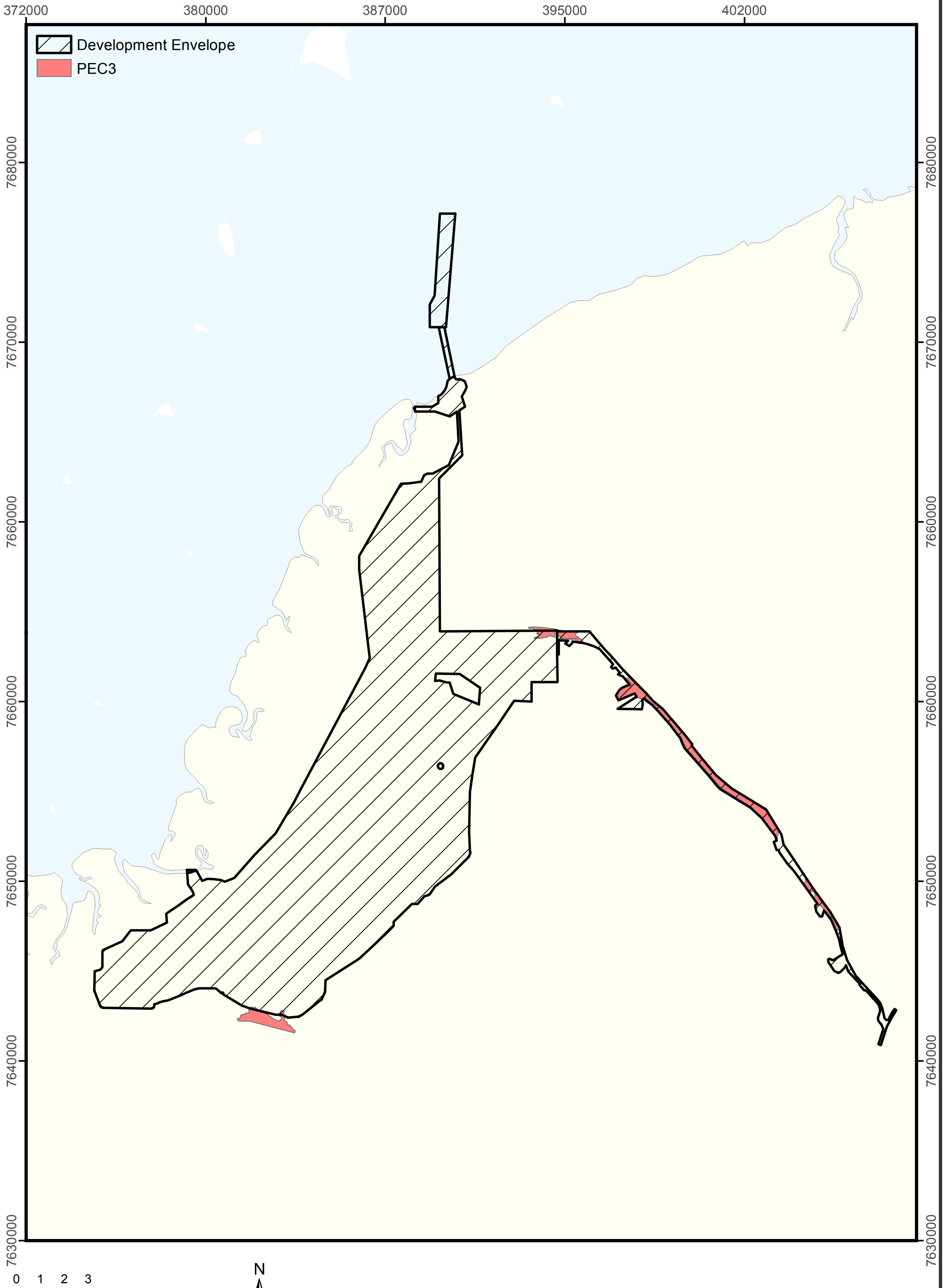


Figure 111: Site vegetation types



Date: 12/02/2020

Mardie Project

Extent of PEC (Horseflat land system)

BCI MINERALS LIMITED

Figure 112: Location of PEC with regard to development envelopes

Locally Significant Vegetation

Eight vegetation types were noted by Phoenix (2020a) as being locally significant as they had restricted distributions within the Study Area and/or represented a refuge for flora species not recorded elsewhere in the Study Area. Portions of all of these vegetation types occur within the development envelopes. These vegetation codes and descriptions are listed in Table 38 and shown in Figure 113. Table 38 also describes why each vegetation type was considered locally significant.

Table 38: Locally significant vegetation types within the Study Area and Development Envelopes

Vegetation Code and description	Reason for local significance	Extent within Study Area (ha)	Extent within Development Envelopes (ha)
AcAjTe: Spinifex (*Triodia* spp.) steppe	Provides habitat for the Threatened Flora (EPBC) *Minuria tridens*	1,277.17	17,80
AcAjTe (Soak): Spinifex (*Triodia* spp.) steppe	Requires confirmation and description from field surveys. While not expected (Gratn Wells pers comm, 2020), should this be confirmed as a unique vegetation type it would be considered locally significant due to restricted distribution	0.60	0.60
AjSlTe: Spinifex (*Triodia* spp.) steppe	Occupied a small area and contained plant species not recorded elsewhere in the Study Area	6.53	4.47
AtAjTe: Isolated mid *Adriana tomentosa* var. *tomentosa*, *Trichodesma zeylanicum* var. *zeylanicum* and *Rhagodia preissii* subsp. *obovata* shrubs over isolated low **Aerva javanica*, *Corchorus walcottii* and *Indigofera linifolia* shrubs over mid closed *Triodia epactia* and *Whiteochloa airoides* hummock grassland on coastal sand dune.	Occupies a small area and contained plant species not recorded elsewhere in the Study Area (none of which are listed flora)	25.08	13.14
EvAcpCc: Low open *Eucalyptus* spp. woodland over *Acacia* spp. shrubland over *Triodia* spp. hummock grassland	Provides potential habitat for the P4 species *Goodenia nuda* and covered a small area (less than 1% of vegetation) in the Study Area	71.91	15.90
MaPgvTd: *Melaleuca argentea* and *Sesbania formosa* woodland	Occupied a very small area, was dominated by two species (*Melaleuca argentea* and *Sesbania formosa*) not recorded elsewhere in the Study Area (neither are listed flora), was at threat from weed invasion and impacts from grazing and represented habitat for the range extensions flora *Cassytha aurea* var. *aurea*.	1.62	0.01
TtSvTc: Low shrubland over *Sporobolus virginicus* grassland	Occupied a small area and contained plant species not recorded elsewhere in the Study Area (none of which are listed flora)	13.67	12.53
Tspp: low open *Tecticornia* spp. chenopod shrublands over low open mixed grasslands	Habitat for one *Tecticornia* taxon considered representative of an undescribed species and a further four *Tecticornia* taxa that could	5,212.71 Stantec (2018) also mapped	1,371.40

Vegetation Code and description	Reason for local significance	Extent within Study Area (ha)	Extent within Development Envelopes (ha)
	not be described to species level and may potentially represent undescribed species.	13,111 ha of *Tecticornia* shrublands in its 82,800 ha regional study (Appendix 8.1).	

9.3.5 Environmental Values

Based on the information provided in Section 8.3, the following environmental values were determined to require assessment for this factor:

- General flora and vegetation, which covers all vegetation types listed in Phoenix (2020a) and Shepherd *et al.* (2002) that were not considered BCH, in order to assess broad local and regional impacts;
- *Minuria tridens* (Threatened Flora - EPBC Act, Priority 3 Flora – BC Act) and its potential habitat (vegetation type AcAjTe);
- *Goodenia nuda* (Priority 4 Flora - BC Act) and its potential habitat (vegetation type EvAcpCc);
- Eight other potential Priority Flora species that were not recorded but could potentially occur;
- Unidentified and potentially undescribed *Tecticornia* species;
- *Tecticornia* spp. shrubland vegetation (as defined by Phoenix (2020a), 'Low open *Tecticornia* spp. Chenopod shrublands'), including locally significant vegetation type TtSvTc, due to the provision of habitat for one *Tecticornia* taxon considered representative of an undescribed species and/or the further four *Tecticornia* taxa that could not be described to species level and may potentially represent undescribed species;
- The Horseflat Land System of the Roebourne Plains Priority 3 Ecological Community; and
- Locally significant vegetation.

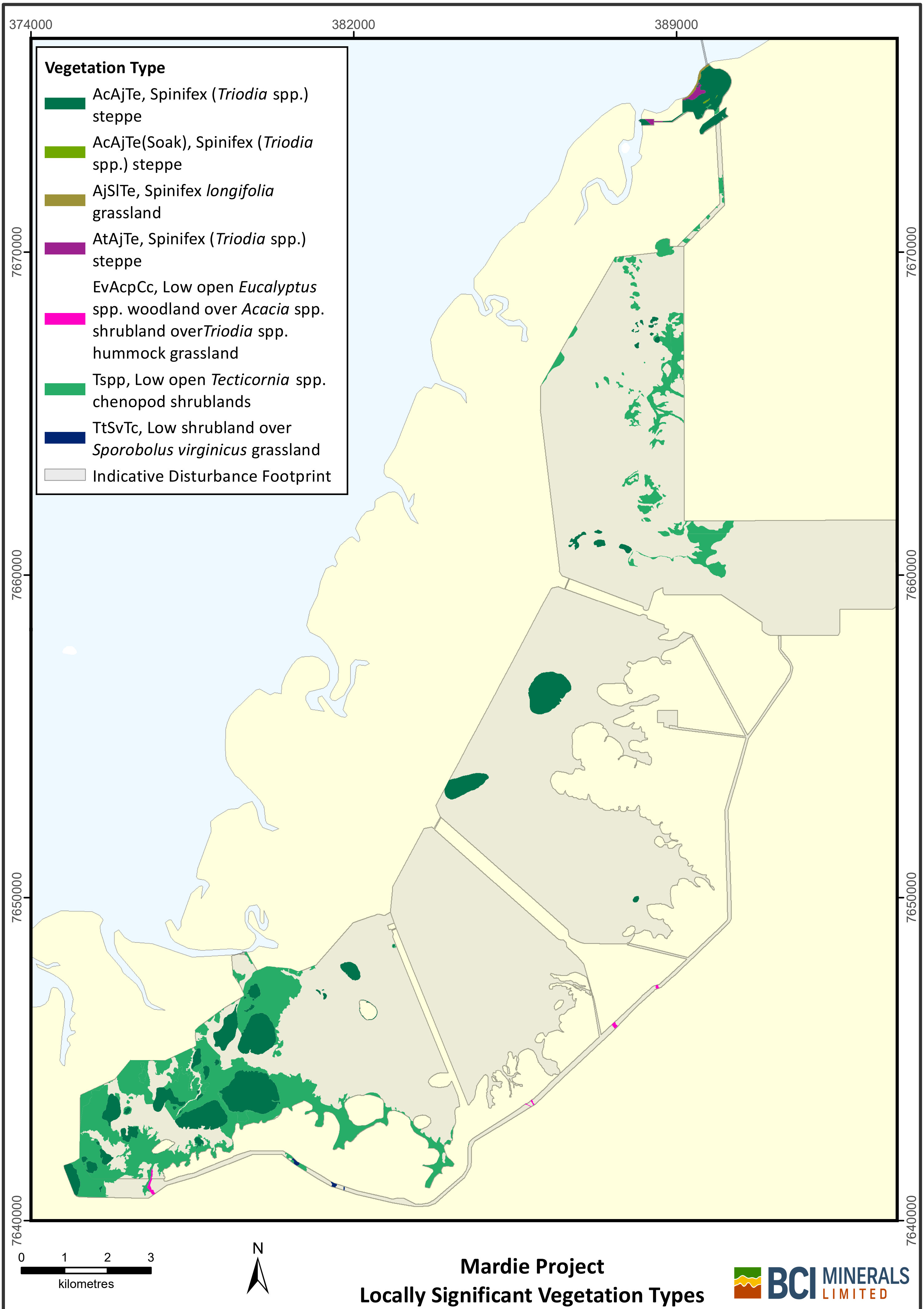


Figure 113: Location of locally significant vegetation types

9.4 Potential Impacts

Table 39 defines the potential impacts (direct, indirect and cumulative) on the environmental values listed above in a local and regional context.

Given the ecological significance of mangal communities Mardie Minerals commissioned O2 Marine to conduct a detailed mapping exercise that focussed on the areas of this habitat type that may be impacted by the Proposal. The outcomes of this mapping exercise are detailed in O2 Marine (2020a) and equated to a total of 17 ha of SC Mangroves being impacted. The O2 Marine (2020a) mapping therefore supersedes the Phoenix (2020b) mapping and as such has been used for impact assessment in this ERD.

Table 39: Potential impacts on flora and vegetation

Environmental value and current extent	Potential direct impact	Potential indirect impact	Impacts associated with other proposals	Total cumulative impact
General terrestrial flora and vegetation - All vegetation associations have more than 89% of their pre-European extent remaining (Least Concern).	11,142 ha of ground disturbance, of which an estimated 7,306ha will not require any disturbance of vegetation (disturbance is to be on the unvegetated mudflat and saltflat surfaces)	Reduction in vegetation health as a result of: • Minor levels of dust settlement on vegetation during construction • Unintentional spillage or seepage of brine from concentrator and crystalliser ponds or pipelines • Introduction or spread of weed species, with particular regard to Mesquite, which is a WoNS • Approximately 181 due to alteration of hydrological regimes • Reduced rehabilitation success due to high salinity	234 ha disturbance associated with two gas pipelines running through the Study Area(84 ha of vegetation, 150 ha of bare mudflats) 18,155 ha of disturbance of vegetation association 127 at various locations along the Pilbara coastline	Approximately 4000 ha of direct disturbance of native vegetation with some potential indirect vegetation health impacts. Approximately 7,456 ha direct disturbance of bare mud flats.
Minuria tridens (Threatened Flora - EPBC Act, Priority 3 Flora – BC Act), recorded approximately 2 km from the development envelopes. AcAjTe vegetation type was identified to be potential habitat.	No direct impact to recorded location of this species, all records outside the development envelopes. No disturbance to area of AcAjTe vegetation type that includes the *Minuria tridens* record. Up to 592 ha disturbance to AcAjTe vegetation type elsewhere in the Study Area.	As described in 'General terrestrial flora and vegetation'.	No other records of *Minuria tridens* have been noted within 800 km of the Proposal. The AcAjTe vegetation type does not appear to have been disturbed as a result of the development of two gas pipelines.	No known records to be disturbed. No disturbance to area of AcAjTe vegetation type that includes the *Minuria tridens* record. Up to592 ha of disturbance to potential habitat (46% of local extent) with some potential indirect vegetation health impacts.
Goodenia nuda (Priority 4 Flora - BC Act), recorded outside the	No direct impact to recorded location of this species, all records outside the	As described in 'General terrestrial flora and vegetation'.	No other proposals are expected to impact the local *Goodenia nuda* records.	No known records to be disturbed. Up to 5.4 ha disturbance to potential habitat

Environmental value and current extent	Potential direct impact	Potential indirect impact	Impacts associated with other proposals	Total cumulative impact
development envelopes. EvAcpCc vegetation type was identified to be potential habitat.	development envelopes. Up to 5.4 ha disturbance to EvAcpCc vegetation type.		The EvAcpCc vegetation type does not appear to have been disturbed as a result of the development of two gas pipelines.	(7.5% of local extent) with some potential indirect vegetation health impacts.
Seven other potential Priority Flora species that were not recorded but could potentially occur.	No direct impact to known records of these species as none were recorded in the Study Area. Disturbance to individuals or potential habitat is possible if a species is present.	As described in 'General terrestrial flora and vegetation'.	84 ha disturbance associated with two gas pipelines running through the Study Area.	No known records to be disturbed. Approximately 4,898 ha disturbance to general flora habitat with some potential indirect vegetation health impacts.
***Tecticornia* spp. shrubland vegetation** – 5226 ha of this vegetation has been mapped within the Study Area. TtSvTc vegetation type forms 13.7 ha of this overall vegetation and was identified as locally significant.	Up to 1,108ha disturbance, including up to 2.6 ha of the TtSvTc vegetation type.	Reduction in vegetation health as a result of: • Unintentional spillage or seepage of brine from concentrator and crystalliser ponds or pipelines • Alteration of hydrological regimes • Reduced rehabilitation success due to high salinity	43 ha disturbance associated with two gas pipelines running through the Study Area.	Up to 1,152 ha disturbance (22% of mapped extent), including up to 2.6 ha of the TtSvTc vegetation type (19.3% of mapped extent). Some potential indirect health impacts.
Unidentified and potentially undescribed *Tecticornia* species – None of these species were recorded within the development envelopes. Unidentified species records are spread across the Study Area.	No direct impact to recorded locations of these species. Up to 1,108 ha disturbance to potential *Tecticornia* spp. habitat (refer below).	Reduction in vegetation health as described above.	It is not possible to determine cumulative on unidentified species. 43 ha disturbance of *Tecticornia* spp. habitat associated with two gas pipelines running through the Study Area. Species habitat extends north and south of the Proposal.	No direct impact to recorded locations of unidentified or undescribed species. Up to 1,152 ha disturbance to potential *Tecticornia* spp. habitat (refer above). Some potential for indirect health impacts.
Horseflat Land System of the Roebourne Plains PEC - 371.3 ha of this PEC has been mapped within the development envelopes (0.76% of total extent).	Up to 231 ha disturbance (0.47% of local mapped extent).	As described in 'General terrestrial flora and vegetation'.	This PEC extends over a large area within the Pilbara and several other proposals occur within its total range.	231 ha disturbance (0.47% of total mapped extent). Some minor potential indirect health impacts.
Locally significant	Up to 4.0 ha disturbance (62% of mapped extent).	As described in 'General terrestrial flora and vegetation'.	This vegetation type does not appear to have been disturbed	Up to 4.0 ha disturbance (62% of mapped extent).

Environmental value and current extent	Potential direct impact	Potential indirect impact	Impacts associated with other proposals	Total cumulative impact
vegetation type AjSlTe			as a result of the development of two gas pipelines.	Some minor potential indirect health impacts.

9.5 Assessment of Impacts

The following sections assess the potential impacts on each environmental value identified in Section 9.4.

9.5.1 Interaction with Benthic Communities and Habitat Factor

The development envelopes include areas of intertidal samphire vegetation that are rarely inundated and as such form a zone that could be assessed under the BCH factor and / or the flora and vegetation factor. This section assesses impacts on flora and vegetation within the context of the EPA objective for this factor, i.e. 'the protection of flora and vegetation so that biological diversity and ecological integrity are maintained'. This means that if significant flora are located within an area mapped as BCH then the impacts have been assessed in this section in the context of the protection of that flora species. Vegetation types that were identified by Phoenix (2020a) as being significant were also assessed in this section, even if they overlapped with the BCH mapping.

9.5.2 General Terrestrial Flora and Vegetation

Table 40 summarises the extent of the potential direct and indirect impacts on general flora and vegetation. Additional assessments are provided in the following sections.

Indirect impacts referred to in Table 40 relate to hydrological changes and are discussed in the following section. They have been included in Table 40 to provide an overview of the total impact extents on each vegetation type.

Table 40: Potential impacts on general flora and vegetation

Flora / Vegetation / Feature	Regional extent (ha / numbers)	Extent in Study Area (ha)	Extent in Development Envelope (ha)	Extent in Disturbance Footprint (ha)	Indirect Impacts (Ha)	Cumulative impacts (ha) (% of Regional extent)
Vegetation associations						
82	2,550,899	210	78	78	0	78 (<0.01%)
117	78,097	367	139	101	0	101 (<0.1%)
127	159,595	16,609	9,761	8,837	101 drier 504 wetter	9,442 (5.9%)
600	66,955	184	65	65	0	65 (0.1%)
601	109,618	8,869	5,624	2,067	7 wetter	2,228 (2.0%)

Flora / Vegetation / Feature	Regional extent (ha / numbers)	Extent in Study Area (ha)	Extent in Development Envelope (ha)	Extent in Disturbance Footprint (ha)	Indirect Impacts (Ha)	Cumulative impacts (ha) (% of Regional extent)
PECs						
Horseflat land system of the Roebourne Plains PEC (Priority 3)	49,432	483	372	231	No significant indirect impacts expected	231
Vegetation types (Phoenix, 2020a)						
AbTl	N/A	2,100.73	1,912.44	533.23	53.58 flooded	586.83 (27.9%)
AcAjTe	N/A	1,277.17	717.80	562.12	0	562.12 (44.0%)
AcAjTe(Soak)	N/A	0.60	0.60	0.60	0	0.60 (100%)
AjSlTe	N/A	6.53	4.47	4.00	0	4.00 (61.3%)
AmMs	N/A	1,673.09	26.33	22.09	59.0 wetter 47.0 drier	128.09 (7.7%)
AtAjTe	N/A	25.08	13.14	8.34	0	8.34 (33.3%)
ChAbTw	N/A	260.93	259.08	233.90	0	233.90 (89.6%)
EvAcpCc	N/A	71.91	15.90	5.38	7.27	12.68 (17.6%)
MaPgvTd	N/A	1.62	0.01	0.00	0	0 (0%)
PgvAsTl	N/A	3,159.90	1,614.44	494.74	112.23	606.94 (19.2%)
PgvCcTl	N/A	1,282.56	1,201.20	559.31	0	559.31 (43.6%)
PgvExCt	N/A	482.97	373.16	230.63	0	230.63 (47.8%)
Tspp	N/A	5,225.10	1,371.40	1,105.92	452.5 wetter 54.0 drier 3.9 flooded	1,615.4 (31.0% of local extent)
TtSvTc	N/A	13.67	12.55	2.64	4.5 flooded	7.14 (52.2%)
Threatened Flora						
Minuria Tridens	N/A	1 record	0 records	0 records	No indirect impacts expected	No relevant cumulative impacts
Priority Flora						
Goodenia nuda (Priority 4)	Approximately 200	2 record	0 records	0 records	No indirect	No relevant cumulative impacts

Flora / Vegetation / Feature	Regional extent (ha / numbers)	Extent in Study Area (ha)	Extent in Development Envelope (ha)	Extent in Disturbance Footprint (ha)	Indirect Impacts (Ha)	Cumulative impacts (ha) (% of Regional extent)
	individuals recorded.				impacts expected	

Direct Disturbance

The Proposal will result in the direct disturbance of up to 3,771.97 ha of vegetation, as well as 868.63 ha of algal mat and 6,580.41 ha of mudflats, creeklines and previously cleared areas. There are several items of note during this assessment:

- The disturbance is to occur within a largely uncleared landscape as all vegetation associations currently have at least 89% of their pre-European extent remaining (Shephard *et al.*, 2002);
- A large proportion (53%) of the Development Envelope is devoid of vegetation);
- The vegetation generally represents widespread communities and is well represented at a regional level (Phoenix, 2020a);
- The development envelopes do not contain any recorded Threatened Flora, Priority Flora, range extensions flora, undescribed flora, or TECs;
- Only a small proportion of the Horseflat Land System of the Roebourne Plains PEC occurs within the development envelopes, and this is almost entirely within the access road corridor, where disturbance will be narrow and linear;
- Large portions of the vegetation are heavily impacted by a Mesquite infestation; and
- There has been minimal clearing in the local area, limited to that required for pastoral purposes and gas pipelines.

When assessing the disturbance associated with the Proposal at a regional scale, the majority of the disturbance will occur within two vegetation associations; '127: Bare areas, mud flats', and '601: Mosaic: Sedgeland'. The current extent of vegetation association '127: Bare areas, mud flats' is 159,595 ha, 89.8% of its pre-European extent. The Proposal targets the bare mudflat areasin order to minimise vegetation clearing, and 9,761 ha of the development envelope intersects with the mapped boundary of this vegetation association, which equates to 5.5% of its pre-European extent. This vegetation association also extends over a large length of the Pilbara coast, including a portion of the area proposed for the Eramurra Industrial Salt Project (note that the Ashburton Salt Project does not intersect with this vegetation association). This Project had not completed its assessment under Part IV of the EP Act at the time of the ERD publication therefore accurate disturbance calculations were unable to be conducted, however based on the Section 38 Referral documentation the disturbance is predicted to be less than 8,000 ha. This appears to be a conservative approach given that there appears to be less of this vegetation association at the Eramurra Industrial Salt Project. Based on the assumption that this Proposal and the Eramurra Industrial Salt Project proceeds, cumulative disturbance across the two proposals may be in the order of 17,000 ha, or 9.6% of its pre-European extent. This will bring the total extent to 80.19% pre-European extent remaining, which is still well within the category of 'Least Concern' (Shepherd, 2002).

The current extent of vegetation association '601: Mosaic: Sedgeland' is 109,618 ha, which equates to 99.9% of its pre-European extent. 5,624 ha of the development envelopes intersect with the mapped boundary of this vegetation association, however only 2,067 ha is predicted to be disturbed, which equates to 5.1% of its pre-European extent. This vegetation association is limited to areas inland from the Proposal, and therefore there are no other significant cumulative impacts that need to be considered. The Proposal may therefore bring the total extent to 94.8% pre-European extent remaining, which is still well within the category of 'Least Concern' (Shepherd, 2002).

An assessment has been provided below of the impacts of the direct disturbance of the vegetation types that will be directly or indirectly impacted by more than 30% of their local extent. Where more detail is warranted it has been provided in subsequent sections:

- **AcAjTe** – 532.1 ha of this vegetation type is proposed to be disturbed. This equates to 44% of the extent within the Study Area. This vegetation type was assessed as locally significant by Phoenix (2020a) due to it providing habitat for *Minuria tridens* (TF). A detailed assessment of impacts to this vegetation type is therefore provided in Section 9.5.3;
- **AjSlTe** – 4.0 ha of this habitat type is proposed to be disturbed. This equates to 61% of the extent within the Study Area. This vegetation type was assessed as locally significant by Phoenix (2020a) due to its limited extent and that is supported flora species not recorded elsewhere in the Study Area. A detailed assessment of impacts to this vegetation type is provided in Section 9.5.10;
- **AjSlTe (Soak)** – 0.6 ha of this habitat type is proposed to be disturbed, which is the entire mapped (extrapolated) extent within the Study Area. This vegetation type was assessed as locally significant by Phoenix (2020a) due to its limited extent and that is supported flora species not recorded elsewhere in the Study Area. A detailed assessment of impacts to this vegetation type is provided in Section 9.5.10;
- **AtAjTe** – 8.3 ha of this habitat type is proposed to be disturbed. This equates to 33.1% of the extent within the Study Area. This vegetation type was noted as being locally significant by Phoenix (2020a) due to its limited extent and that it supported flora species not recorded elsewhere in the Study Area. Given the local values of this vegetation type, Mardie Minerals has committed to minimising disturbance to this vegetation type and limiting disturbance to a maximum of 8.3 ha (refer to Section 9.6.2) to ensure that that majority of this vegetation (67%) is retained;
- **ChAbTw** – 233.9 ha of this habitat type is proposed to be disturbed. This equates to 90% of the extent within the Study Area. This vegetation type was recorded along the haul road and eastern edge of the crystalliser ponds (Figure 111), which means that it is highly likely that this vegetation type would occur outside the Study Area. This vegetation type was also not identified as being locally significant by Phoenix (2020a). This impact is therefore considered unlikely to be significant;
- **PgvCcTl** – 559.3 ha of this habitat type is proposed to be disturbed. This equates to 44% of the extent within the Study Area. This vegetation type was recorded along the eastern edge of the Study Area (Figure 111), which means that it is highly likely that this vegetation type would occur outside the Study Area. This vegetation type was also not identified as being locally significant by Phoenix (2020a). This impact is therefore considered unlikely to be significant;
- **PgvExCt** – 230.6 ha of this habitat type is proposed to be disturbed. This equates to 48% of the extent within the Study Area. This vegetation type was recorded along the haul road (Figure 111), which means that it is highly likely that this vegetation type would occur outside the Study Area. This vegetation type was also not identified as being locally

significant by Phoenix (2020a). This impact is therefore considered unlikely to be significant;

- **Tspp** – 1,115.0 ha of this habitat type is proposed to be disturbed. This equates to 21% of the extent within the Study Area, and 8.4% of the regional extent mapped by Stantec. This vegetation type has been assessed in detail in Section 9.5.7; and
- **TtSvTc** – 2.7 ha of this habitat type is proposed to be disturbed. This equates to 19.0% of the extent within the Study Area. This vegetation type has been assessed in detail in Section 9.5.7.

Changes to Surface Water Regimes

As detailed in Table 40 and Section 5 (Inland Waters), there will be some vegetation that will be subject to changes to the local surface water regimes. There are four ways that changes to overland flows caused by the Proposal could potentially indirectly impact vegetation:

1. Less fresh water reaches the vegetation downstream of the ponds if fresh water flows are diverted away from these areas;
2. Less fresh water reaches the vegetation upstream of the ponds if fresh water flows are diverted around the area;
3. Increased fresh water inundation occurs within vegetation downstream of the ponds if the habitats are close to the diversion channel outlets; and
4. Increased fresh water inundation occurs within vegetation upstream of the ponds if fresh water flows pool against the embankment.

The concentrator ponds have been designed to include two large drainage channels to allow overland flow through the development envelopes. In addition, the size of the southern-most pond has been reduced significantly to allow the main channel of Peters Creek to continue to flow to the ocean. RPS (2019; Appendix 1.1) modelled the potential changes to the overland freshwater flows due to the presence of the ponds and determined that there would be some moderate changes to the flow regime as a result of the Proposal. Section 5 (Inland Waters) provides more detail about this modelling and predicted results.

Vegetation association '127: Bare areas, mud flats' was the only vegetation association that was predicted to be impacted by changes to surface water flows, with 101 ha receiving less fresh water and 504 ha receiving more water during flow events, totalling only 0.3% of the regional extent. Given that this association is described as being free of vegetation the changes to surface water flows are not expected to significantly impact the extent of this vegetation association.

Only two terrestrial vegetation types were predicted to be impacted by changes to surface water flows and had a cumulative impact of more than 30% (Table 40); Tspp and TtSvTc. These vegetation types have been assessed in detail in Section 9.5.7.

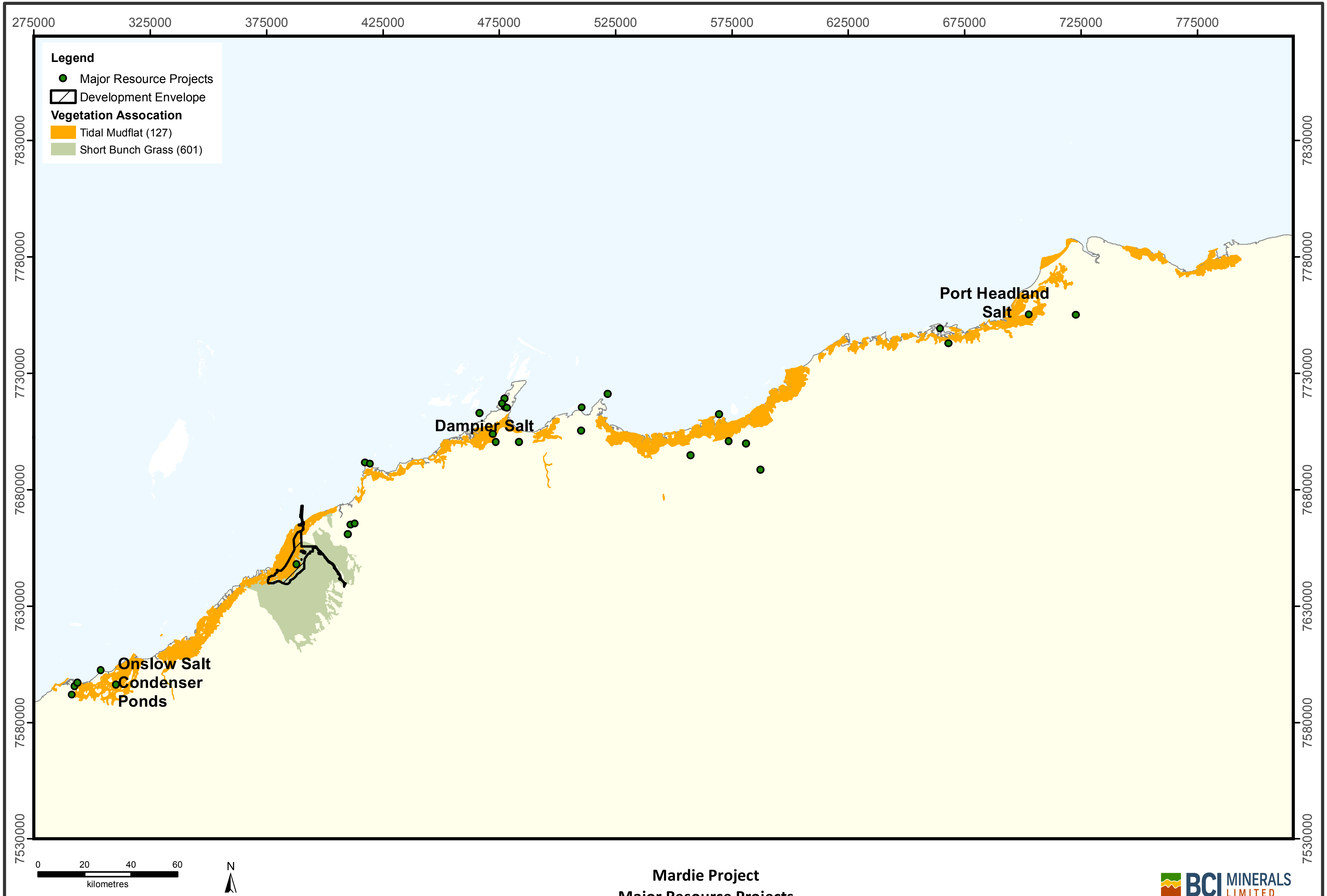
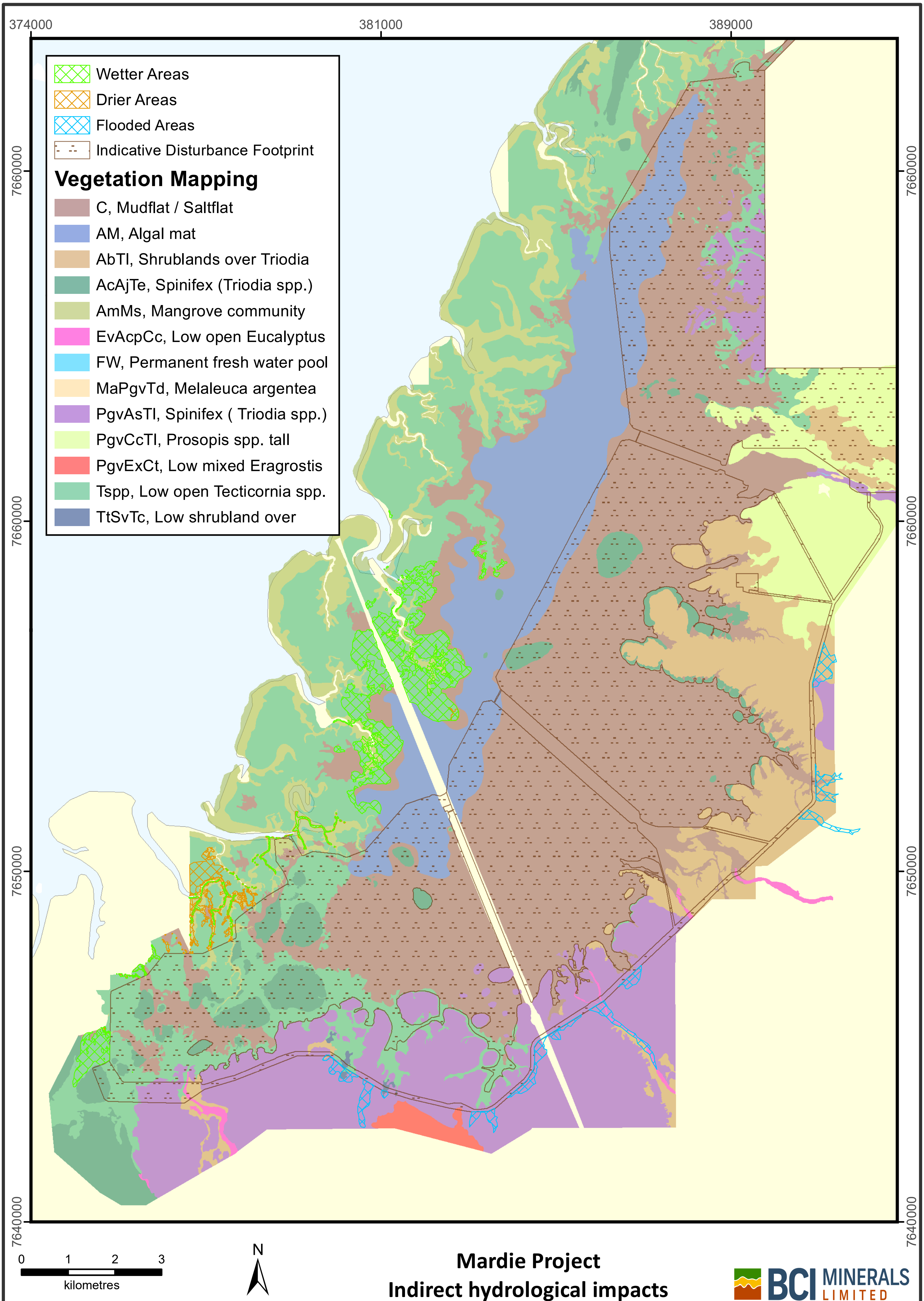


Figure 114: Extent of vegetation associations 127 and 601



Mardie Project
Indirect hydrological impacts to vegetation

BCI MINERALS LIMITED

Figure 115: Change in hydrological characteristics within fauna habitats

Brine Seepage, Leaks and Spills

As described in detail in Section 5.5, some seepage of brine from the ponds is expected over time. Seepage from the concentrator ponds is not expected to migrate far and, given the groundwater in the claypans is already hypersaline, no impacts to vegetation are predicted. Seepage from the secondary crystallisers, which are located on upland areas, does have the potential to impact on areas of down-gradient vegetation.

A spill or leak of brine from the ponds or pipelines could result in impacts to the health of the surrounding vegetation. Brine is the resource for the Proposal and as such the ponds and pipelines have been designed to minimise the risk of loss.

Pipelines will transfer brine containing the final product between several ponds and are designed to minimise leaks and product losses. In addition mitigation measure will be implemented to reduce this risk further (refer to Section 9.6). 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 vegetation, where present. Areas containing vegetation that may be at risk from saline seeps, leaks and spills are shown in Figure 111 and described in Table 39. As the information shows, the priority risk area is the vegetation surrounding Mardie Pool, including the restricted and relictual vegetation type (MaPgvTd). The mitigation measures proposed to safeguard against such potential impacts are described in Section 5.6.

Weeds

Weeds have the potential to be introduced to the area or spread as a result of the Proposal, with the greatest risks associated with earthmoving during the construction period. The Proposal is located on Mardie Station which houses the single largest infestation of mesquite in Australia. The control of the spread of mesquite will require significant coordinated effort (refer to Section 9.6).

Dust Emissions

Dust emissions may occur during construction, however the majority of the construction will occur within areas of mudflats and the intertidal zone, which will remain damp and is therefore unlikely to produce significant dust emissions. Excessive dust emissions will be managed using industry-standard dust control measures and given that the local vegetation is well adapted to dusty conditions the Proposal is unlikely to impact vegetation health outside its development envelopes during this period. During operations the potential for dust emissions is expected to be minimal.

Rehabilitation and Closure

The Proposal will result in large areas of ponds that contain salts or brine and as such revegetation may be impeded by the presence of salt post-closure. The concentrator ponds are generally located on areas of bare clay pans, therefore the restoration of natural processes is expected to be possible once salts have been harvested where present and the walls flattened or opened up to tidal and catchment flows. Crystalliser ponds located on upland areas will be rehabilitated to a state that supports the pastoral land use, by removing residual salt and saline basement soils, and respreading the pond walls and levees to create a suitable substrate for revegetating.

9.5.3 *MINURIA TRIDENS*

Minuria tridens (Threatened Flora - EPBC Act, Priority 3 Flora – BC Act), was recorded well outside the development envelopes (Figure 106) and no plants of this species were found within the development envelopes despite targeted searches by Phoenix (2020a)

Only one specimen of *Minuria tridens* had previously been recorded in WA, and subsequent surveys have been unable to locate the specimen. There is therefore no information regarding what constitutes 'critical habitat' in WA (Nano & Pavey, 2008). In the Northern Territory, this species typically occurs on south facing slopes or steep rocky cliffs in low shrubland on dolomite, limestone and calcrete-impregnated sandstone hills and ranges (Cooke 1986; Nano & Pavey 2008). Associated shrubland is mixed with Rock Fuchsia Bush (*Eremophila freelingii*), Witchetty Bush (*Acacia kempeana*), Silver Cassia (*Senna artemisioides*) and White Indigo (*Indigofera leucotricha*) (Nano *et al.,* 2012; Nano & Pavey, 2008) with spinifex (*Triodia* spp.) largely absent and Buffel Grass (*Cenchrus ciliaris*) in more disturbed areas (Nano *et al.,* 2012).

In the absence of habitat information Mardie Minerals has assumed that the vegetation type AcAjTe could form potential habitat. This vegetation type covers a large area, with more than 1,307 ha occurring within the Study Area and aligns with the Ld3 vegetation type defined and mapped at Cape Preston and Karratha, indicating a broader distribution outside the Study Area. More than 559 ha (43%) of the extent of AcAjTe within the Study is located outside the development envelopes, including the continuous portion of habitat where the *Minuria tridens* records were found (Figure 113).

Additional targeted surveys are also proposed to identified any records of this species and avoid disturbance if practicable (refer to Section 9.6.2).Based on the above, direct impacts to this species are not expected to be significant. As described in Section 9.5.2, there is the potential for some indirect impacts, however these are not expected to have a significant impact on the AcAjTe vegetation type and will not impact the recorded specimen.

9.5.4 *GOODENIA NUDA*

Goodenia nuda (Priority 4 Flora - BC Act) was recorded in an area that was excluded from the development envelopes, which ensures this record will not be directly impacted (Figure 106).

The EvAcpCc vegetation type in which the record was found is almost entirely (78%) located outside the development envelopes, and more than 82% will remain unimpacted by the Proposal (Figure 113).

Based on the above, direct impacts to this species are not expected to be significant.

As described in Section 9.5.1, there is the potential for some indirect impacts, however these are not expected to have a significant impact on the EvAcpCc vegetation type and will not impact the recorded specimen.

9.5.5 Other Potential Priority Flora

Eight other Priority Flora species were noted by Phoenix (2020a) as potentially occurring within the Study Area (refer to Section 9.3.2):

- *Goodenia pallida* (P1);
- *Helichrysum oligochaetum* (P1);
- *Tephrosia rosea* var. Port Hedland (A.S. George 1114) (P1);
- *Trianthema* sp. Python Pool (G.R. Guerin & M.E. Trudgen GG 1023) (P2);
- *Corchorus congener* (P3);
- *Gymnanthera cunninghamii* (P3);
- *Owenia acidula* (P3); and
- *Solanum albostellatum* (P3).

These species were not recorded during the surveys, however suitable habitat is present within the Study Area. The assessment below has sourced records from NatureMap (DBCA, 2020), accessed in April 2020.

Goodenia pallida (P1) has been recorded 20 km south of Cape Preston and 30 km east of Cape Preston in the Pilbara Region. It has been recorded on red soils in terrestrial habitats, and suitable habitat may occur in the eastern side of the development envelopes. Given the Proposal is predominantly located on the upper intertidal zone, large extents of potential habitat for this species are expected to occur outside the development envelopes.

Helichrysum oligochaetum (P1) has been recorded in 18 different locations across the Gascoyne and Pilbara regions. While suitable habitat may occur in the development envelopes, this species is extremely widespread and appears to occur across numerous habitats.

Tephrosia rosea var. Port Hedland (A.S. George 1114) (P1) has been recorded in 53 different locations across the Great Sandy Desert and Pilbara regions, with the majority of records at Port Hedland or Port Samson. While suitable habitat may occur in the development envelopes, this species is widespread and appears to occur across numerous coastal and terrestrial habitats.

Trianthema sp. Python Pool (G.R. Guerin & M.E. Trudgen GG 1023) (P2) has been recorded in six locations, with the closest record being 40 km south-east of the Proposal and the furthest located 140 km to the east. It has been recorded in terrestrial habitats, and suitable habitat may occur in the eastern side of the development envelopes. Given the Proposal is predominantly located on the upper intertidal zone, large extents of potential habitat for this species are expected to occur outside the development envelopes.

The remaining Priority 3 Flora species have widespread records and numerous records throughout the Pilbara Region, with *Corchorus congener*, *Gymnanthera cunninghamii* and *Owenia acidula* found across more than one IBRA region. *Solanum albostellatum* (P3) has only been recorded in the Pilbara IBRA region, however the closest record is over 90 km away.

BCI has committed to pre-clearance targeted searches for Priority Flora species and avoidance of any recorded individuals or populations if practicable to do so (refer to Section 9.6.2). Based on the above, and the surveys completed to-date, the likelihood of the Proposal having a significant impact on any of these Priority Flora species is considered to be low.

9.5.6 *Tecticornia* spp. Shrubland Vegetation

Tecticornia spp. shrubland vegetation mapped by Phoenix (2020a) was determined to be regionally significant due to the provision of habitat for potential undescribed and unidentified *Tecticornia* species. The TtSvTc vegetation type occurs within the broader *Tecticornia* spp. shrubland vegetation boundary and was considered to be locally significant as it represents habitat for potentially undescribed *Tecticornia* species.

Distinct *Tecticornia* spp. shrubland vegetation types were not able to be defined as *Tecticornia* species are unable to be identified in the field, meaning that the boundary between different species assemblages is not able to be accurately defined.

There are however some clear distinctions and variations within this vegetation type, with ecological value varying greatly across the mapped extent. The portions of this vegetation type that occur closer to the coast have the highest density of vegetation, generally averaging more than 50% cover. The vegetation density generally drops as you move further from the coast, generally averaging 20 - 50% cover mid-way between the coast and the western boundary of the development envelope, and less than 10% cover within the development envelopes. Grant Wells (pers. comm. 5 June 2019) also noted a clear distinction between the coastal *Tecticornia* spp. shrubland vegetation and those found further inland, stating that the coastal portion was "typically denser communities with higher plant density and foliage cover compared to the shrublands on the eastern side…which were notably sparser". The *Tecticornia* spp. shrubland vegetation found further inland also contain flora species that are known to be terrestrial, such as *Eragrostis falcata* grasses, which range across WA and are found frequently on salt lakes and saline flats (Grant Wells pers. comm. 5 June 2019).

Figure 73 provides an example of the higher density coastal *Tecticornia* spp. shrubland vegetation in comparison to the vegetation found further inland (Figure 74).

Figure 116 and Figure 117 provides examples of the percentage cover at various distances from the coast, using a combination of Phoenix (2020a) quadrat data and high-resolution aerial imagery.

Salinity is predicted to be the primary driver of this zonation (O2 Marine, 2020a; Appendix 2.3). Soil salinity in the Study Area is generally predicted to increase with distance from the coast, with a clear linkage to inundation frequency. In the intertidal zone inundation flushes the soils and maintains a consistent soil salinity. Soils in the upper reaches of the intertidal zone are rarely inundated and as a result the evapoconcentration of tidal waters results in hypersaline conditions. This is evident within the Study Area, where the denser coastal *Tecticornia* spp. shrubland vegetation is inundated regularly whereas the sparser vegetation found further inland are only inundated in extreme events (refer to Section 5.3.5; O2 Marine, 2020a).

Mardie Minerals notes that distinct *Tecticornia* spp. shrubland vegetation types are likely to occur within the broad vegetation description of 'Tspp: *Tecticornia* spp. shrubland vegetation'. Due to an inability to map these vegetation types the assessment in this section focusses on the ecological value of those habitats. The potential impacts to significant *Tecticornia* species that may occur within these distinct vegetation types are discussed separately in Section 9.5.7.

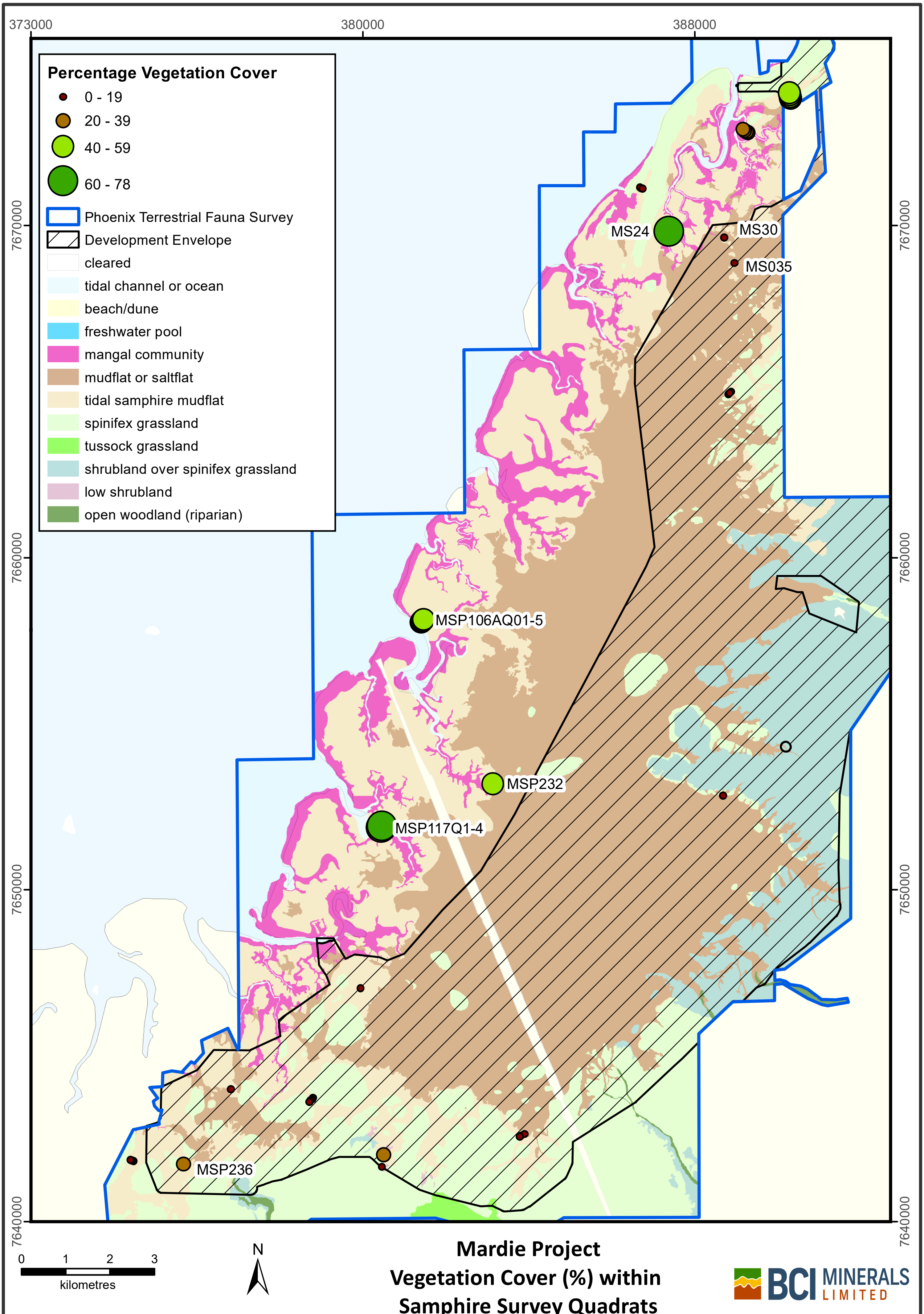


Figure 116: Example of *Tecticornia* spp. shrubland vegetation cover at various distances from the coastline

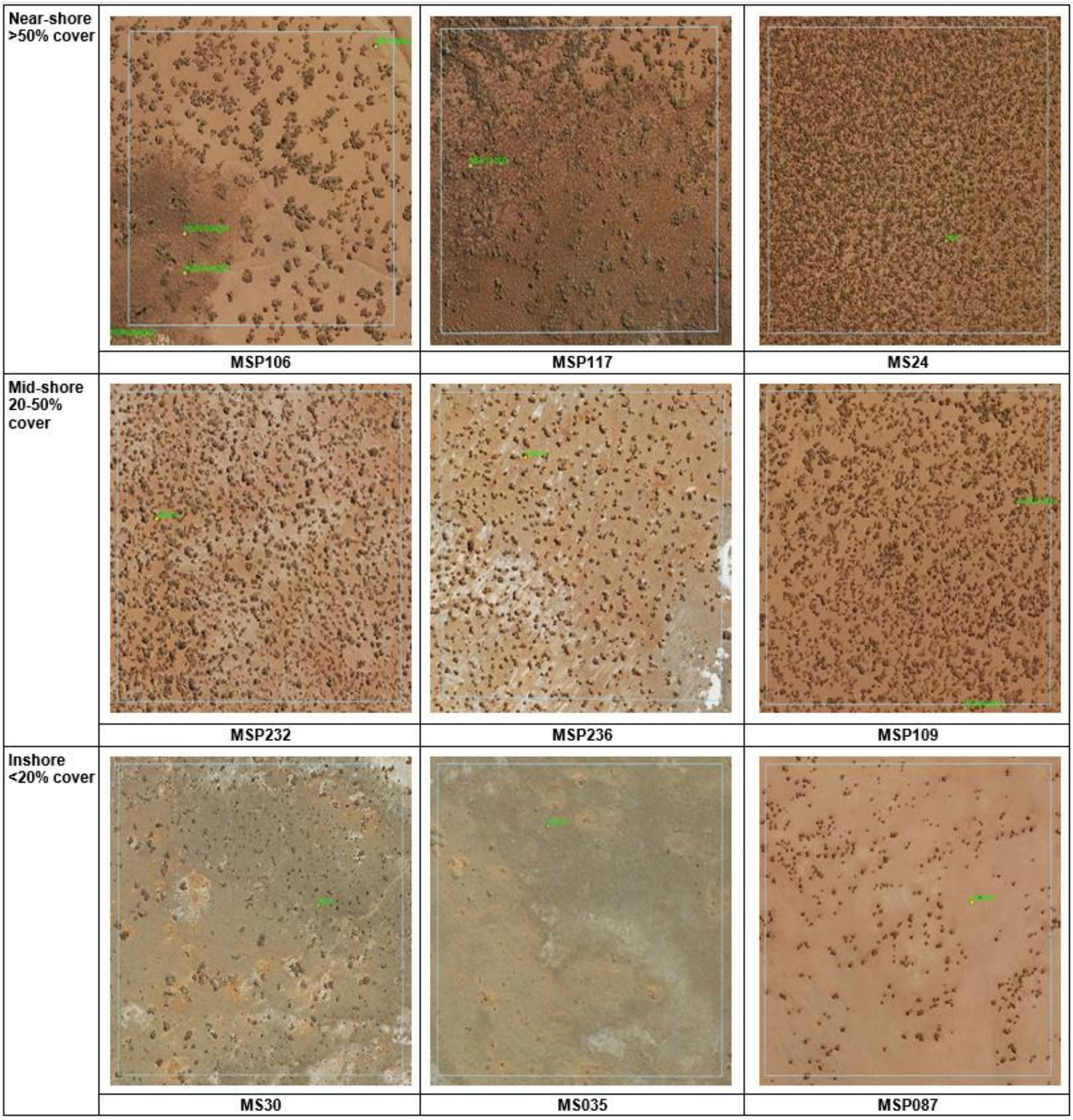


Figure 117: Examples of samphire coverage

Direct Disturbance

The development envelopes contain 1,384 ha of *Tecticornia* spp. shrubland vegetation (Tspp and TtSvTc). Historically, 43 ha of this vegetation is estimated to have been disturbed for the development of the gas pipelines. The proposed disturbances to Tspp vegetation is 1,108.5 ha, which equates to 21% of the total extent mapped within the Phoenix (2020a) Study Area (Figure 113) and 8.4% of the regional extent mapped by Stantec (2018). There have been numerous design revisions that minimise this disturbance; in particular, the size of the southern-most pond has been significantly reduced which excludes a large portion of this vegetation type.

The direct disturbance of 1,108.5 ha of *Tecticornia* spp. shrubland vegetation is not expected to be significant as:

- The portion of this vegetation type that is to be disturbed is almost completely within the sparsely vegetated areas further away from the coast. All of the Phoenix (2020a) quadrats within the disturbance footprint had less than 40% cover, with most less than 10% cover(
- Figure 116);
- Given the sites close to the coast generally had more than 50% cover, it is evident that the portion of *Tecticornia* spp. shrubland vegetation that is to be disturbed is of lower ecological value;
- The majority of the remaining mapped vegetation within the Phoenix (2020a) Study Area lies within exploration tenements held by Mardie Minerals and therefore is unlikely to be made available for development by another proponent for the duration of the Proposal; and
- This vegetation type also extends outside the development envelopes, sharing many characteristics with at least two of the vegetation types mapped at nearby Cape Preston (Biota and M E Trudgen & Assoc, 2001; Maunsell, 2008). Additionally, Stantec (2018) mapped 13,111 ha of Samphire (i.e. *Tecticornia* spp) Community in its 82,800 ha regional study.

2.7 ha of the TtSvTc vegetation type occurs within the development envelopes and is expected to be directly impacted by the inundation of concentrator and crystalliser ponds. This equates to 19.3% of the local extent mapped within the Study Area.

Potential Indirect Impacts

The assessment of indirect impacts on *Tecticornia* spp. shrubland vegetation is more complex, particularly as these species can be impacted by changes to salinity or inundation. The following potential indirect impacts have therefore been assessed in combination:

- Unintentional spillage or seepage of brine from concentrator and crystalliser ponds or pipelines;
- Changes in overland flows due to the presence of the concentrator and crystalliser ponds; and
- Changes in tidal inundation regimes due to the presence of the concentrator and crystalliser ponds.

<u>Unintentional spillage or seepage of brine from concentrator and crystalliser ponds or pipelines</u>

As outlined in Section 5.5 and 9.5.2, , potential impacts associated with the seepage or spillage of brine are expected to be minimal due to its release into a salt-tolerant ecosystem, and the application of mitigation controls (refer to Section 5.6)

<u>Changes to overland flows</u>

Tecticornia are salt-tolerant species, however they are susceptible to prolonged inundation and some species rely on a freshwater input for germination (Purvis *et al.,* 2009). There are therefore three ways that changes to overland flows caused by the Proposal could potentially indirectly impact *Tecticornia* spp. shrubland vegetation:

1. Less fresh water reaches the vegetation downstream of the ponds if fresh water flows are significantly restricted;

2. Less fresh water reaches the vegetation upstream of the ponds if fresh water flows are diverted around the area; or
3. Increased inundation occurs within vegetation upstream of the ponds if fresh water flows pool against the embankment.

As detailed in Section 5.5.2, the concentrator ponds have been designed to include two large drainage channels to allow overland flow through the development envelopes. In addition, the size of the southern-most pond has been reduced significantly to allow the main channel of Peters Creek to continue to flow to the ocean, which is the main drainage channel in the vicinity of the *Tecticornia* spp. shrubland vegetation. RPS (2019a) modelled the potential changes to the overland freshwater flows due to the presence of the ponds and determined that there would be some changes to the flow regime within downstream areas as a result of the Proposal. Section 5 (Inland Waters) provides more detail about this modelling and predicted results.

An estimated 452 ha of *Tecticornia* spp. shrubland vegetation is predicted to experience more freshwater inflows than it currently experiences during run-off events (based on a 20 year ARI flow event). These additional flows are not expected to impact *Tecticornia* species as any flooding will be short in duration given that water will drain to the ocean on low tides. The habitat characteristics would be expected to return to current conditions relatively quickly after each flow event.

An estimated 54 ha of *Tecticornia* spp. shrubland vegetation is predicted to experience less freshwater inflows than it currently experiences during run-off events (based on a 20 year ARI flow event). This reduction in flows may influence the germination of some *Tecticornia* species if they rely on a freshwater pulse to germinate. Mardie Minerals has committed to monitoring of *Tecticornia* health within this area and will investigate and implement mitigation measures if impacts are identified (refer to Section 9.6.2).

An estimated 3.9 ha of *Tecticornia* spp. shrubland vegetation and 4.5 ha of TtSvTc vegetation is predicted to be flooded during significant run-off events (area is based on a 100 year ARI flow event – extents and duration of flooding will be less for smaller events). This flooding is expected to take days to weeks to infiltrate or evaporate. Given that *Tecticornia* species can cope with some extended inundation (up to 1 month) (actis Environmental, 2016) this intermittent flooding is unlikely to significantly impact the small area of vegetation in this area. The habitat characteristics of this vegetation would be expected to return to current conditions relatively quickly after each flood event.

<u>Changes to tidal inundation regimes</u>

The location of *Tecticornia* spp. shrubland vegetation in the landscape is most affected by their level of salinity and inundation tolerance. Their salt-tolerance allows *Tecticornia* species to survive in areas that are inhabitable to most other terrestrial flora species, and their inundation tolerance restricts how far into the intertidal zone they can survive. There are therefore two ways that changes to tidal inundation regimes caused by the Proposal could potentially indirectly impact *Tecticornia* spp. shrubland vegetation:

1. Less salt water reaches the vegetation if tidal flows are significantly restricted, resulting in more competition from less salt-tolerant flora species; and
2. Increased inundation timelines occur due to a reduction in the intertidal catchment, which results in additional stresses to *Tecticornia*.

The pond walls have been relocated away from the coastline and as such their influence on the tidal inundation regime has been minimised. RPS modelled the potential changes to the tidal inundation regime due to the presence of the ponds (2019; 2020; Appendix 1.2) and determined that there would be minimal change to the tidal regime west of the pond walls and either side of the causeway as a result of the Proposal. Section 5 (Inland Waters) provides more detail about this modelling and predicted results. Based on this modelling and the findings of Section 5, *Tecticornia* spp. shrubland vegetation is unlikely to be significantly impacted by the minor changes to the tidal inundation regime.

There are two regions of *Tecticornia* spp. shrubland vegetation that are inland of the development envelopes. There are two small areas to the south, that are mapped as the TtSvTc vegetation type, and several small areas of *Tecticornia* spp. shrubland vegetation east of the north-eastern development envelope boundary that are inland of the ponds totalling 5 ha (Figure 113). The large areas of *Tecticornia* spp. shrubland vegetation to the north on Figure 113 are not expected to be significantly impacted by changes to tidal regimes as the inundation regime of this area will be maintained from inflows to the north across the causeway structure (refer to Section 5 – Inland Waters). The remaining inland areas of *Tecticornia* spp. shrubland vegetation, including the areas mapped as the TtSvTc vegetation type, will be cut off from intertidal flows once the ponds have been constructed.

These areas lie at the very inland edge of the *Tecticornia* spp. shrubland vegetation range. This means that these areas are currently only inundated by tidal flows during extreme storm surge events, and therefore it is more likely that *Tecticornia* are the dominant species in this area due to the underlying shallow hypersaline groundwater, rather than tidal inundation. These areas are therefore not expected to be indirectly impacted by the prevention of tidal inundation to a point where the composition of the vegetation is no longer suitable for *Tecticornia* species.

Based on the detail provided above and in Section 5, changes to tidal inundation regimes are not expected to result in significant indirect impacts on *Tecticornia* spp. shrubland vegetation or the *Tecticornia* species contained within it.

Summary

The Proposal is expected to result in the direct disturbance of up to 1,118 ha of Tspp: *Tecticornia* spp. Shrubland and TtSvTc vegetation, and 54.0 ha of this vegetation type may be indirectly impacted by changes inland surface water flow regimes. This equates to 1,172 ha (23%) of the total extent mapped within the Study Area when cumulative impacts are considered (Figure 113). The portion of this vegetation type that is to be disturbed is almost completely within the sparsely vegetated areas further away from the coast. Almost all of the Phoenix (2020a) quadrats within the disturbance footprint had less than 20% cover, (Figure 116). Given the sites close to the coast generally had more than 50% cover, it is evident that the portion of *Tecticornia* spp. shrubland vegetation that is to be disturbed is of lower ecological value

The avoidance measures implemented during the Proposal design have resulted in 77% of this vegetation type being retained within the Study Area and unlikely to be indirectly impacted by the Proposal. Given that *Tecticornia* spp. shrubland vegetation also extends along the coastline outside the development envelopes (13,111 ha was mapped by Stantec) the Proposal is not expected to significantly impact this vegetation type.

At a local scale, 2.6 ha of the limited 13.7 ha extent of the locally significant TtSvTc vegetation type is expected to be directly impacted via inundation to develop one of the concentrator and crystalliser ponds. The remainder of this vegetation type may be indirectly impacted, as it will be cut off from tidal inundation. There remains some uncertainty about whether the presence of this TtSvTc vegetation type is due to tidal inundation or the shallow hypersaline groundwater. Ongoing monitoring is proposed in Section 9.6 to detect changes in this vegetation type once the ponds are installed.

9.5.7 Undescribed and Unidentified *Tecticornia* Species

As described in Section 9.3.2, several undescribed and unidentified *Tecticornia* species were recorded within the Study Area. All of these species have records outside the development envelopes, and in some cases the development envelopes were amended to specifically exclude them (i.e. *Tecticornia* sp. sterile 4; Figure 106).

These species would be expected to occur elsewhere within the Study Area. Given the difficulties associated with identifying *Tecticornia* in the field it has been assumed that the potential habitat for each of these species is the *Tecticornia* spp. shrubland vegetation types (Tspp and TtSvTc) mapped by Phoenix (2020a; Figure 113). These collective vegetation types have been considered an environmental value and an assessment of potential impacts to this value is provided in the Section 9.5.6.

There are two undescribed and unidentified *Tecticornia* records; *Tecticornia* sp. affinity to *T. halocnemoides* LOSA and *Tecticornia* sp. sterile 1, that occur within the TtSvTc vegetation type. As described in the previous section, the portion that contains these records will not be directly impacted, but may be indirectly impacted by being cut off from tidal inundation. These two records lie at the very inland edge of the *Tecticornia* spp. shrubland vegetation range, above the maximum level of the adjacent evaporation pond. This means that these records are currently only inundated during extreme storm surge events, and therefore it is more likely that *Tecticornia* are the dominant species in this area due to the underlying shallow hypersaline groundwater, rather than tidal inundation. These records are therefore not expected to be indirectly impacted by the prevention of tidal inundation to a point where the composition of the vegetation is no longer suitable for the *Tecticornia* species. Nevertheless, some uncertainty remains about the extent of these indirect impacts, and monitoring is proposed in Section 9.6. Both *Tecticornia* sp. affinity to *T. halocnemoides* LOSA and *Tecticornia* sp. sterile 1 have been found elsewhere in the Study Area in areas that will not be directly or indirectly impacted by the Proposal (Figure 106) and therefore the Proposal is not expected to significantly threaten these species.

Tecticornia sp. sterile 4 and *Tecticornia* sp. sterile 6 were recorded in an area that was subsequently excluded from the development envelopes (Figure 113). While the exclusion area is relatively small, mitigation measures are proposed to maintain as much of the surrounding habitat as practicable during the final design of the Proposal. These records lie inland from the concentrator and crystalliser ponds, however they are expected to lie outside the area that would be affected by changes to tidal inundation due to the following:

- These records are not located within *Tecticornia* spp. shrubland vegetation, which means that *Tecticornia* species are not the dominant flora species in that area; and
- The area lies above the level of the evaporation pond, which means that it would only be inundated during extreme storm surge events, if at all.

Based on the above the area that contains these records is unlikely to be significantly affected by saline tidal inundation and therefore suitable habitat for these species is expected to be retained in that area.

9.5.8 Horseflat Land System of the Roebourne Plains PEC

This PEC has been recorded within the development envelopes, with 372 ha occurring within the access road portion of the Pond and Terrestrial Infrastructure Development Envelope (Figure 112). The local portion of this PEC covers an area of 49,432 ha and as such only 0.47% of the PEC could be impacted by the Proposal. This is expected to be an overestimate as works within this area will be limited to access road upgrades, therefore only a small portion of the development envelope width will be disturbed. This disturbance is not considered to be significant in a local or regional context, and indirect impacts in proximity to the PEC are expected to be minimal (indirect impacts are discussed further in Section 9.5.1).

9.5.9 Locally Significant Vegetation

Eight vegetation types were identified as being locally significant within the Study Area. Several of these vegetation types have already been assessed as their significance is associated with another environmental value:

- AcAjTe was assessed as part of the *Minuria tridens* environmental value (Section 9.5.3);
- EvAcpCc was assessed as part of the *Goodenia nuda* environmental value (Section 9.5.4); and
- Tspp and TtSvTc were assessed as a separate environmental value (Section 9.5.6).

Vegetation type MaPgvTd is not proposed to be disturbed by the Proposal (refer to Section 9.5.2), and AtAjTe will not be significantly impacted (more than 67% of its extent will be retained). These vegetation types are considered adequately assessed in Section 9.5.2.

The potential impacts to the remaining locally significant vegetation (AcAjTe (Soak), AjSlTe and AtAjTe) are assessed below.

AcAjTe (Soak)

Vegetation type AcAjTe (Soak) lies within an area that was extrapolated by Phoenix (determined from aerial photos and nearby field survey sites) and has not yet been subject to a field survey. Phoenix (2020a) determined that the vegetation looked completely different from aerial imagery to any of the vegetation defined from field surveys. It occupies an area of only 0.6 ha and all of this area is likely to be disturbed.

Similar vegetation is predicted to occur outside the development envelopes, noting that the areas are likely to typically be small and spread some distance apart (Grant Wells pers comm. February 2020). Phoenix has since conducted a targeted survey for this vegetation type and the results will be available prior to the assessment of this Proposal.

AjSlTe

This vegetation type was considered locally significant as it occupied a small area (6.5 ha) and contained plant species not recorded elsewhere in the Study Area, although none of the plant species are considered to have special conservation significance. It occurs in a narrow strip along the northern coastline (Figure 113), with 4.7 ha (69%) occurring within the development envelopes and 4.0 ha is expected to be disturbed.

Phoenix described the vegetation type as: "Isolated low **Aerva javanica*, *Atriplex bunburyana* and *Rhagodia preissii* subsp. *obovata* shrubs over tall *Spinifex longifolius* grassland over low *Triodia epactia*, **Cenchrus ciliaris* and *Whiteochloa airoides* grassland on beach foredune." A single quadrat (MSP238) was surveyed for this vegetation type (Figure 118).

Similar vegetation was recorded at Cape Preston (22.2 ha), where it was noted as being widely distributed but restricted to the narrow front face of coastal sand dunes. The species that were recorded in this vegetation type but not recorded elsewhere in the Study Area were: *Spinifex longifolius, Atriplex bunburyana*, and *Threlkeldia diffusa*. None of the species are threatened or geographically restricted. Accordingly, the high proportion of direct disturbance to the mapped extent of this vegetation type within the development envelopes is not considered to be of particular ecological significance.

Figure 118: Vegetation type AjSlTe on the north-facing beach dune at Mardie (Phoenix, 2020a)

9.6 Mitigation

Mardie Minerals has mitigated the potential impacts to this factor according to the mitigation hierarchy; avoid, minimise, rehabilitate, offset. Offsets are not expected to be required for this factor.

9.6.1 Avoid

The key avoidance outcome achieved by Mardie Minerals was the iterative design of the development envelopes to avoid key environmental features. Mardie Minerals has conducted numerous ecological surveys and this information has been utilised to design the Proposal and its development envelope boundaries to avoid the following:

- The majority of coastal vegetation as it was identified as having a higher ecological value;
- All records of Threatened and Priority Flora;

- All records of range extension Flora; and
- The majority of records of undescribed or unidentified *Tecticornia* species.

In addition to the above, the following avoidance mitigation measures have been incorporated:
- The location of the concentrator ponds has targeted areas of bare clay pan to avoid clearing of vegetation; and
- The development envelope boundaries have been developed to allow the use of existing tracks wherever practicable.

9.6.2 Minimise

The following mitigation measures are proposed to ensure that direct and indirect impacts to flora and vegetation are minimised:

1. **Implement industry best-practice management measures for flora and vegetation**:
    a. Vegetation clearing will be managed through internal ground disturbance procedures;
    b. Boundaries of areas to be cleared or disturbed will be identified by GPS coordinates and maps of boundaries will be provided to equipment operator;
    c. Progressive clearing will be undertaken;
    d. Raised blade disturbance will be conducted where practicable on tracks to minimise vegetation removal;
    e. The disturbance footprint will be developed to the minimum required to ensure safe and adequate construction and operation, and compliance with approved limits;
    f. Water or dust suppressants will be applied to disturbed areas and product transfer / storage areas as required to minimise dust generation;
    g. Emergency response capabilities will be maintained to reduce fire outbreaks;
    h. 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 (mesquite controls discussed further below);
    i. Feral animal controls will be implemented;
2. **Obtain and comply with the following approvals**:
    a. Ministerial Statement to be issued under Part IV of the EP Act;
    b. Mining Proposal to be approved under the *Mining Act 1978*;
    c. Mine Closure Plan (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 12.1;
    d. Works Approval and Licence to be issued under Part V of the EP Act for solar salt manufacturing and bulk material loading;
3. **Manage mesquite in accordance with the Mesquite Management Strategy developed by PMMC. Develop/implement a Mesquite Management Plan in conjunction or consultation with PMMC and Mardie Station.** Management measures will be developed and implemented in accordance with the management strategy devised by the PMMC. A number of eradication studies have been undertaken by the PMMC on Mardie Station and Mardie Minerals will utilise the eradication and management techniques resulting from these studies. Management actions will include the following:
    a. Weed mapping;

   b. Wash-down bays located in different areas of site;
   c. Cleaning of vehicles moving between weed infestation areas, cleared areas and areas with no weeds;
   d. Restrictions on soil movement between infestation areas, cleared areas and areas with no weeds;
   e. The use of a Holman Plough or other agreed method to ensure the effective removal of Mesquite when clearing land required for the proposal;
   f. Development of control measures for cleared areas; and
   g. Liaison with PMMC to develop and implement eradication program.
4. **Conduct additional field surveys of the extrapolated areas of the Study Area to confirm vegetation descriptions and boundaries are correct, and to verify the presence of AcAjTe (Soak) vegetation type outside the development envelopes.** If the AcAjTe (Soak) vegetation type is not found outside the development envelopes then Mardie Minerals will revise the Proposal design to avoid this area**;**
5. **Conduct pre-clearance targeted Threatened and Priority Flora surveys within areas of potential habitat that is to be disturbed;**
6. **Avoid any new records of Threatened and Priority Flora identified where practicable;**
7. **Minimise clearing within Horseflat Land System of the Roebourne Plains PEC;**
8. **Minimise clearing within AcAjTe vegetation type which may provide habitat for the EPBC Threatened Flora *Minuria Tridens*;**
9. **Minimise clearing of the AtajTe vegetation type, and limit disturbance to a maximum of 8.3 ha;**
10. **Maintain as large a buffer as practicable around unidentified or undescribed flora species in order to maintain suitable surrounding habitat;**
11. **Develop and implement a *Tecticornia* Monitoring and Management Plan**. This Plan will be designed to monitor the health and distribution of *Tecticornia* spp. shrubland vegetation and will include:
   a. Targeted pre-construction *Tecticornia* surveys within areas that may be directly or indirectly impacted;
   b. Installation and survey of baseline monitoring sites;
   c. Annual health assessment and comparison with baseline surveys;
   d. Annual boundary mapping;
   e. Long-term sea level monitoring to determine if this vegetation type is migrating inland as the sea level rises;
   f. Potential corrective actions, such as artificial inundation, will be investigated, and will include consultation with *Tecticornia* experts (i.e. Dr Kelly Shepherd or Bindy Datsun)
12. **Monitor the potential changes to tidal inundation regimes as discussed in Section 5 (Inland Waters).** This monitoring will be conducted to verify the model and associated indirect impact assessments;
13. **Design and construct concentrator and crystalliser ponds to be safe and stable according to DMIRS requirements**;
14. **Implement the following controls to further reduce the risk of impact from unintentional brine pipeline spills**:
   a. Pipelines will be fitted with leak detection;
   b. Water flows will be shut off if leaks are detected;

c. Pipelines will be inspected regularly, especially during extreme heat or fire events and after significant rainfall and storms;
d. Pipelines will be located off access road surfaces;
e. If pipelines have to cross access roads then they will be buried or elevated;
f. Investigations will be conducted into the cause of any spills, and remedial actions will be taken to minimise the chance of reoccurrence; and
g. Spills response training for site-based personnel.

9.6.3 Rehabilitate

At the completion of the Proposal the site will be rehabilitated to reinstate flora and vegetation where appropriate. A MCP will be required under the *Mining Act 1978* and an interim MCP has been provided in Appendix 12.1. The key rehabilitation measures from the MCP that relate to flora and vegetation are summarised below:

1. Salts will be harvested from each pond prior to closure;
2. Concentrator pond walls will be flattened or opened up to allow tidal flows to enter the ponds;
3. All infrastructure will be removed if not retained by Mardie Station or PPA;
4. All disturbance areas to be revegetated will be respread with topsoil (or ripped and seeded if suitable topsoil is not available e.g. infested with Mesquite) and rehabilitated; and
5. All crystalliser ponds will be rehabilitated to an acceptable landform.

The MCP will be submitted to DMIRS for assessment and approval prior to the construction of the Proposal, and will be reviewed and revised every three years.

9.7 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).

Mardie Minerals has incorporated extensive avoidance and minimisation measures into the Proposal design and operational processes, however direct impacts to flora and vegetation are unavoidable. The Proposal will result in the estimated direct disturbance of 3,803.5 ha of terrestrial vegetation and 6,436 ha of bare mud flats. All vegetation associations to be disturbed will have more than 80% of their pre-European extent remaining, even once cumulative disturbance associated with the Proposal and the Eramurra Industrial Salt Project have been deducted. This means that all of the vegetation associations will remain in the 'Least Concern' category (Phoenix, 2020a).

Direct impacts to significant flora and vegetation are not considered to be significant once mitigation measures are implemented. All significant flora records have been avoided, and disturbance within significant vegetation will be avoided or minimised such that impacts are not significant when assessing at an appropriate scale (i.e. regional scale for vegetation associations, local scale for significant vegetation types).

The key potential indirect impacts to flora and vegetation are associated with hydrological changes and the risk of spreading mesquite:

- The risk of mesquite spread will be appropriately managed through the introduction of weed and soil hygiene controls developed in consultation with the PMMC, and as such, the Proposal is not expected to result in additional mesquite impacts; and
- Hydrological changes are not expected to impact the majority of susceptible vegetation given the drainage features incorporated into the design and the predicted minimal changes to tidal regimes (refer to Section 5). Some areas of *Tecticornia* spp. shrubland vegetation may be indirectly impacted as a result of reduced fresh water flow or being cut off from tidal inundation, however Mardie Minerals will develop and implement a *Tecticornia* Monitoring and Management Plan, which will include adaptive management measures that are intended to reduce this impact. Given the small size of the potentially affected areas compared to their local extent and distribution, and the implementation of a *Tecticornia* Monitoring and Management Plan, these indirect impacts are expected to be able to be mitigated such that they are not considered to be significant.

The Proposal includes large areas of ponds that contain salts or brine and as such revegetation may be impeded for some time post-closure, although the majority of areas affected are claypans and 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 MCP being revised every three years), with the purpose of refining the closure strategies already identified in the MCP (Appendix 12.1), including:

- Salts will be harvested from the concentrator ponds and the walls flattened or opened up to allow tidal flows to reinstate within the former pond areas. Over time this is expected to return the area to a state where current salt-tolerant species can revegetate the pond areas; and
- Similarly, salts will be recovered from the crystalliser ponds, which are to be located on terrestrial vegetation (typically infested with Mesquite) and the pond areas revegetated in a typical manner.

In summary, the resultant potential impacts to flora and vegetation are not expected to be significant given that:

- The Proposal is located in an area with very little existing disturbance;
- The development envelopes exclude all significant flora records and the majority of significant vegetation types;
- The presence and potential for spread of mesquite will be managed in conjunction with PMMC and the pastoralist through a Mesquite Management Plan;
- Emissions and discharges associated with the production and export of salt will be regulated under Part V of the EP Act;
- Indirect impacts are not expected to be significant and the majority are easily mitigated;
- Rehabilitation will occur as described in the MCP to be assessed under the *Mining Act 1978* (Appendix 12.1); and
- Hydrological processes will gradually return to existing conditions post-closure.

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 measures is expected to ensure that there are no significant residual impacts to flora and vegetation.

10 TERRESTRIAL FAUNA

10.1 EPA OBJECTIVE

The EPA Objective for this key environmental factor is to protect terrestrial fauna so that biological diversity and ecological integrity are maintained.

10.2 POLICY AND GUIDANCE

Relevant guidance documents for terrestrial fauna are listed below:

Western Australian Government

Key EPA Documents

- Statement of Environmental Principles, Factors and Objectives 2016 (EPA, 2016a);
- Guidelines for Preparing Mine Closure Plans (DMP and EPA, 2015);
- EIA (Part IV Divisions 1 and 2) Administrative Procedures 2016;
- EIA (Part IV Divisions 1 and 2) Procedures Manual 2016; and
- Instructions on how to prepare *EP Act* Part IV Environmental Management Plans (EPA, 2018a).

Relevant EPA Factor Guidelines

- Environmental Factor Guideline – Terrestrial Fauna (EPA, 2016l).
- Relevant EPA Technical Guidance
- Technical Guidance – Sampling methods for terrestrial vertebrate fauna (EPA, 2016m);
- Technical Guidance – Terrestrial fauna surveys (EPA, 2016n); and
- Technical Guidance – Sampling of short range endemic invertebrate fauna (EPA, 2016o).

Other Policy and Guidance

- WA Environmental Offsets Policy (EPA, 2011);
- WA Environmental Offsets Guidelines (EPA, 2014); and
- WA Offsets Template (EPA, 2014).

Commonwealth Government

Key Documents

- Generic guidelines for the content of a draft EPBC Act PER/EIS (including the objects and principles of the EPBC Act, 1999) (DotEE, 2016b);
- Other Minister of the Environment (Cth) approval decision making considerations;
- EPBC Act Environmental Offsets Policy (DSEWPaC, 2012) – including the Offset Assessment guide;
- Environmental Management Plan Guidelines (DotE, 2014a);
- Environmental Management Plan Guidelines, - template (DotEE, 2018a);
- EPBC Act Condition Setting Policy (DAWE, 2020);
- EPBC Act Outcomes-based conditions policy (DotE, 2016c); and
- EPBC Act Environmental Offsets Policy (DSEWPaC, 2012).

Relevant Technical Guidance

- Relevant EPBC listed species specific survey guidelines and protocols;
- Relevant EPBC listed species specific Recovery plans, Threat Abatement Plans, Approved Conservation Advices and other documents; and
- Marine bioregional plan for the North-west Marine Region (DSEWPaC, 2012b).

10.3 Receiving Environment

The section below has been sourced from the following reports:

- Level 2 targeted terrestrial fauna survey for the Mardie Project(Phoenix, 2020b; Appendix 9.1); and
- Detailed flora and vegetation and fauna survey for the Mardie Project (Phoenix, 2020a; Appendix 8.1); and
- Assessment of Mangal and Algal Communities for the Mardie Solar Project (Stantec, 2018; Appendix 2.2).

10.3.1 Survey Effort

A desktop review and numerous field surveys have been conducted over the disturbance areas proposed in this ERD.

Two study areas were defined:

1. The 'Terrestrial Fauna Study Area (TFSA)' which is 29,141.3 ha in size and is shown on Figure 119; and
2. The 'Migratory Shorebird Study Area (MSSA)' is 64,201.1 ha in size and is associated with the coast and coastal habitats. The MSSA covers an area that extends from 7.5 km west of the Fortescue River mouth, southwest to 41.5 km east of Onslow and is shown in Figure 120. The MSSA comprised two programs:
    a) The 'local program' – 18 aerial transects focused on habitats in proximity to the development envelopes; and
    b) The 'regional program' – Eight aerial transects focused on habitat south of the TFSA / development envelopes.

The MSSA has been determined to be a contiguous 'shorebird area' as per EPBC Act Policy Statement 3.21 - *Industry guidelines for avoiding, assessing and mitigating impacts on EPBC Act listed Migratory shorebird species* (DotEE, 2017), which is described as:

> "The geographic area used by the same group of shorebirds over the main non-breeding period, effectively the home range of the local population when present. Shorebird areas may include multiple roosting and feeding habitats. While most Migratory shorebird areas will represent contiguous habitat, non-contiguous habitats may be included as part of the same area where there is evidence of regular bird movement between them."

A desktop review of relevant databases, literature and spatial data preceded the field surveys to assess the potential for presence of conservation significant vertebrate fauna and Short-Range Endemic (SRE) species and habitats in the study areas.

Initial habitat characterisation was undertaken using various remote geographical tools, including aerial photography, land system maps and topographic maps. Habitats with the potential to support conservation significant fauna and SRE invertebrates were then identified through these data sources, based on known habitats of such species within the Pilbara bioregion and previous survey reports. Tentative sites were selected for the terrestrial fauna surveys so that all habitat types were represented.

Site selection was aided by a site reconnaissance undertaken in August 2017. A helicopter was used to gain access to all habitats of the study areas, including tidal mangrove creeks, sandy / rocky beaches and tidal islands. At the broadest scale, site selection considered aspect, topography and land systems. At the finer scale, consideration was given to proximity to water bodies (drainage lines and creeks), vegetation complexes and condition and soil type. Sites were primarily chosen to represent the best example of distinct habitats within the broader habitat associations of the study areas.

The field survey effort can be summarised as follows:

- Migratory shorebird survey comprising –
  - Aerial surveys;
  - Ground counts;
- Marine turtle survey (refer to Section 8):
- Targeted Night Parrot (*Pezoporus occidentalis*) survey using autonomous recording units;
- Targeted Northern Coastal Free-tailed Bat (*Ozimops coborgianus*) survey, as well as a mangrove and terrestrial bat species inventory;
- A terrestrial vertebrate fauna observation survey comprising:
  - Fauna habitat assessment and mapping;
  - Active searches and opportunistic records;
  - Nocturnal searches;
  - Camera trapping;
  - Avifauna census using timed observation and call identification; and
- SRE invertebrate survey focusing primarily on salt flats and associated islands, comprising of active searches.

The timing of the field survey work was as follows:

- Reconnaissance survey to ground truth desktop review in 17 August 2017;
- Migratory shorebird survey over three periods from 4 – 9 December 2017 (phase 1), 12 – 16 January 2018 (phase 2), 24 – 26 July 2018 (phase 3) and 21 – 25 February 2019 (Phase 4);
- Marine turtle survey in 5 December 2017 and 13 January 2018;
- Targeted North Coastal Free-tailed Bat survey from 4 – 9 December 2017;
- Targeted Night Parrot survey from December 2017 – March 2018;
- Terrestrial fauna survey, including vertebrate fauna and SRE invertebrates from 14 – 21 March 2018; and
- Supplementary terrestrial fauna survey for vertebrate fauna in August 2019.

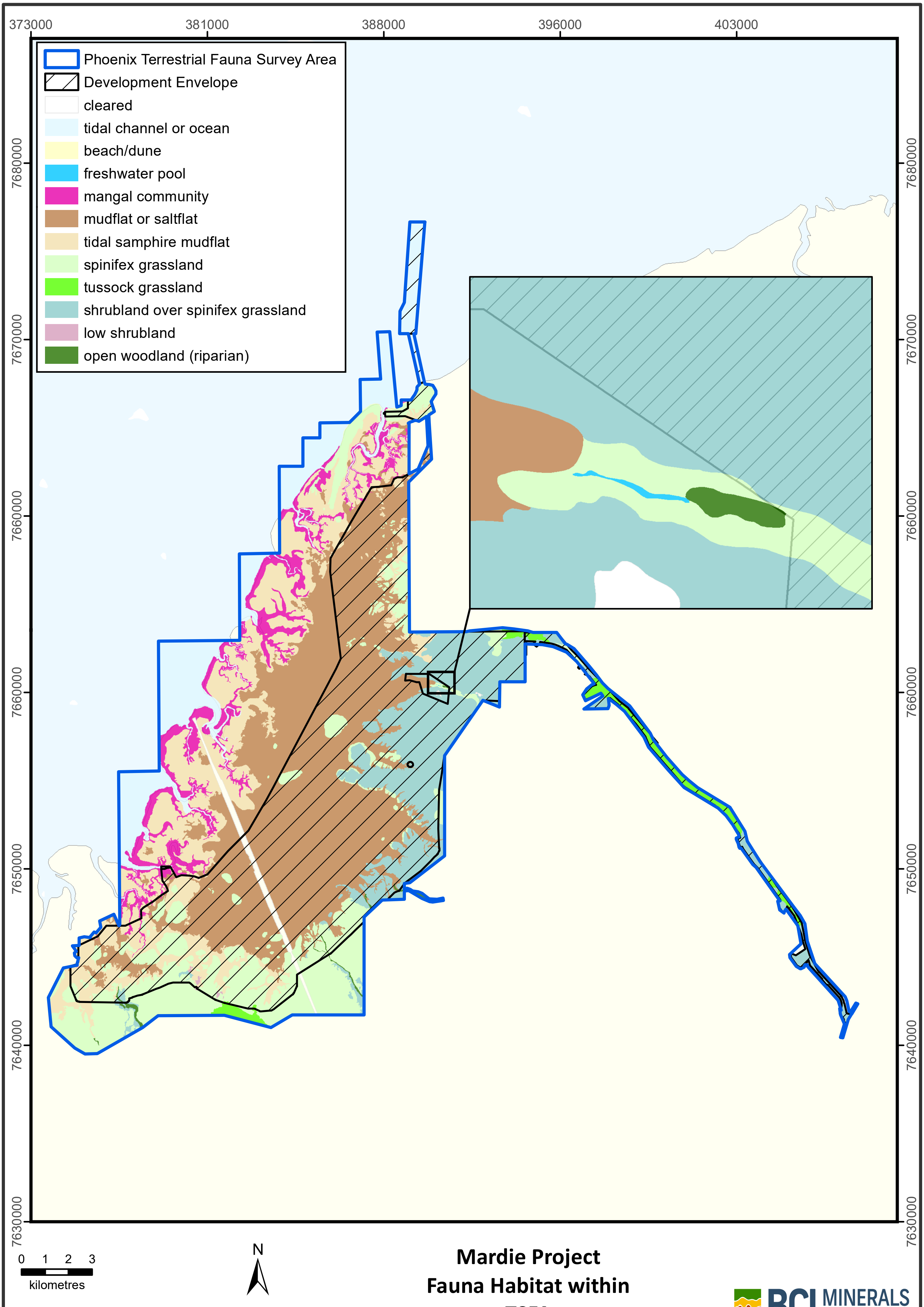
The suite of fauna surveys undertaken are equivalent to a targeted Level 2 survey in accordance with EPA guidance. EPA 2016a (sampling methods) states that: “If the Level 1 survey indicates the need for further work through a Level 2 survey it may range from a targeted survey of selected species to a comprehensive survey” (Phoenix, 2020b).

Based on the findings of the reconnaissance survey, targeted level 2 sampling was considered more appropriate than a systematic level 2 survey because:

- Although the study areas had not been surveyed previously, the general area along the Pilbara coast south of Karratha is very well studied and provided context for expected faunal assemblage;
- Mardie Station is heavily impacted by cattle and aggressive weeds (e.g. Buffel Grass and *Prosopis* spp.), therefore high faunal diversity was unlikely to occur;
- The conservation significant fauna species identified with potential to occur are best detected using 'non-trapping methods, e.g.
    - Northern Free-tailed Bat, Pilbara Leaf-nosed bat, Ghost bat – ultrasonic recordings;
    - Night Parrot – audio recordings;
    - Pilbara Olive Python – active searching;
    - Northern Quoll – habitat assessment and camera trapping where necessary;
    - Marine turtles – aerial surveys; and
    - Migratory shorebirds – aerial surveys.

The location of Terrestrial Fauna survey sites is shown in Figure 121.

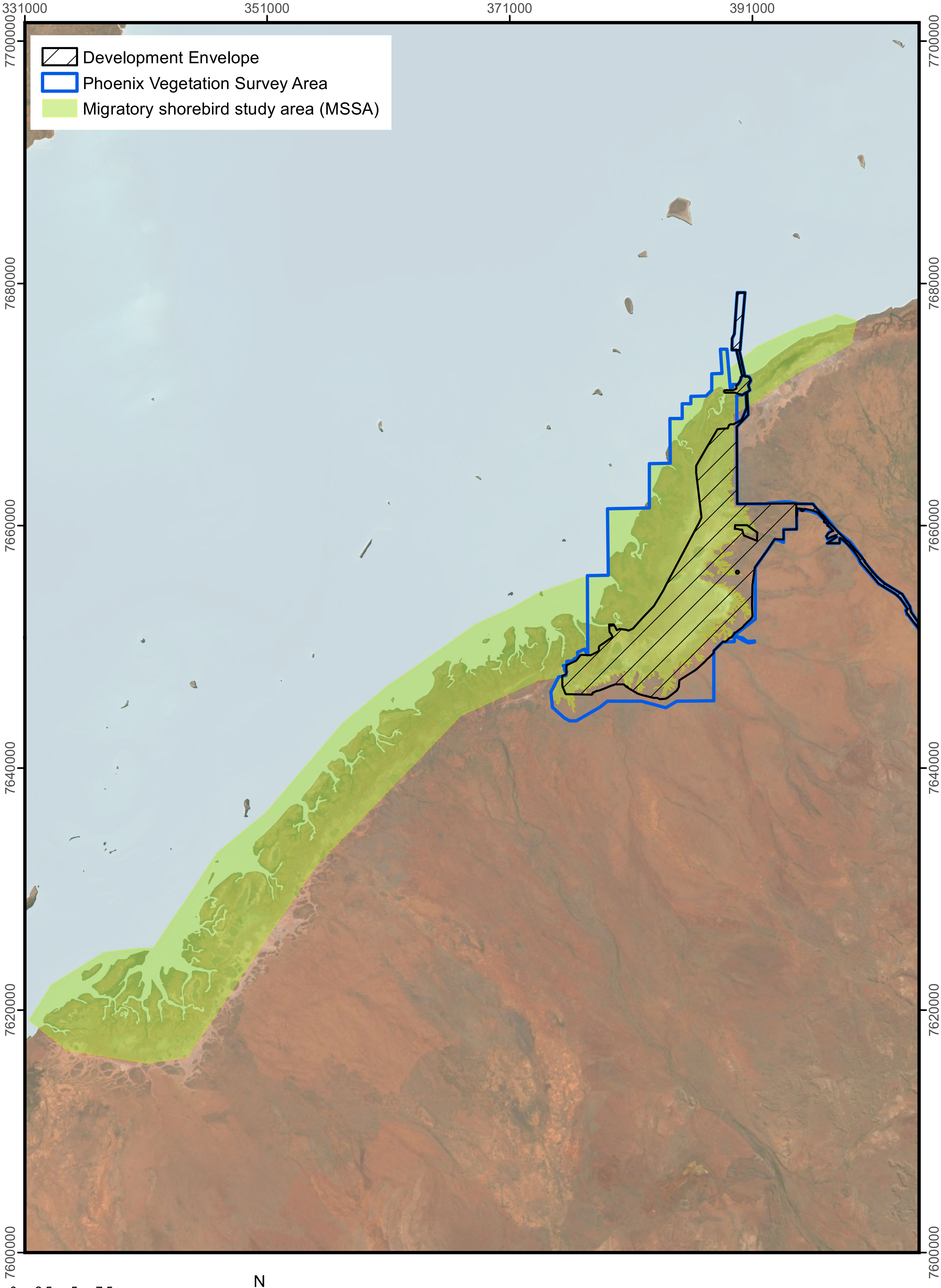
Stantec were commissioned to undertake a preliminary assessment of mangal and algal communities in September 2017. This work included mapping of the mangroves, algal mats and Tecticornia spp. shrublands along the 80 km of coastline and was utilised by Mardie Minerals in their direct planning and design of the Proposal in a way that minimised direct and indirect impacts to terrestrial fauna habitat (Appendix 8.1). This survey also provides regional context for fauna habitats.



Mardie Project
Fauna Habitat within
TSFA

BCI MINERALS LIMITED

Figure 119: Terrestrial Study Area and habitats



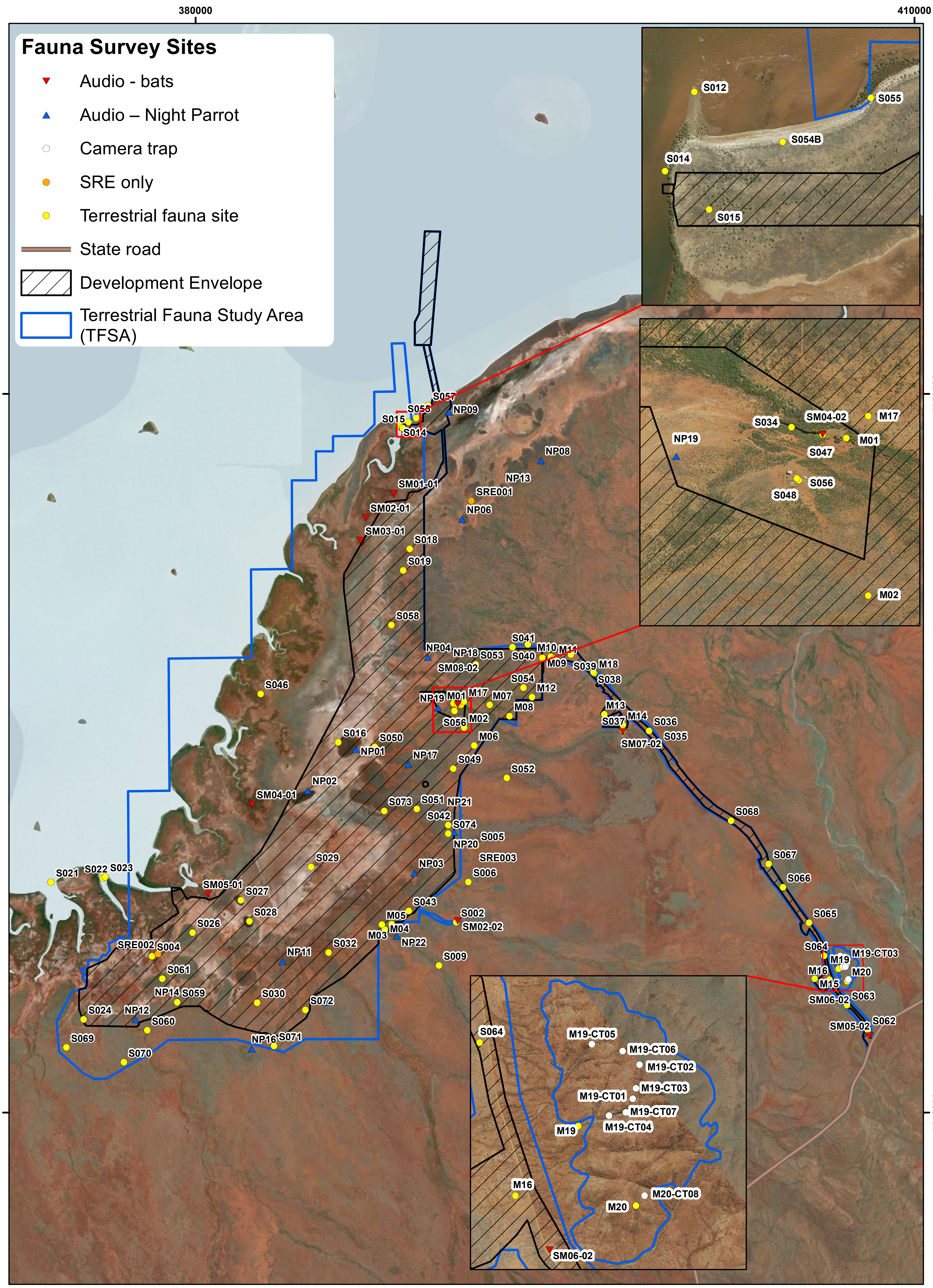
0 2.5 5 7.5
kilometres

N

Mardie Project
Terrestrial Fauna Survey Effort

BCI MINERALS LIMITED

Figure 120: Migratory Shorebird Study Area



0 1 2 4 6
Kilometers

N

Mardie Project
Terrestrial Fauna Study Area and Survey Sites

BCI MINERALS LIMITED

Figure 121: Terrestrial Fauna survey area

Migratory Shorebirds

Migratory shorebird surveys were conducted over four phases by personnel from Phoenix and Ornithological Technical Services; a specialist avifauna consultancy. Phases 1-3 comprised a 'local program' focussed on shorebird habitats within and in proximity to the development envelopes, including an overwintering survey. Phase 4 expanded on the local program to include a 'regional program', which sampled areas south of the development envelopes within the MSSA. Similar habitats were sampled in the local and regional programs; these included tidal channels, beaches, mangrove areas and the extensive mudflat / saltflat areas to the east.

The Program for Regional and International Shorebird Monitoring (PRISM) (2018) details survey methods for monitoring non-breeding shorebirds. They recommend sampling be undertaken wherever possible within discrete, manageable spatial units, such that an instantaneous sample can be achieved, preferably within 2 - 3 hours, centred around tidal movements (as the area of available habitat changes with time and being aligned with peak tides means the most 'stable' area of habitat availability is surveyed) and thereby reducing the risk of observer fatigue.

The study area for both the local and regional programs was large and thus, the methodology was designed to achieve as close to an instantaneous survey as possible. The regional program was divided into two units of approximate equal area (Table 41), with each being similar in size to the local program area, so that they could reasonably be surveyed on each daily tide cycle. These units were surveyed consecutively and repeatedly during phase 4.

Aerial (helicopter) counts were necessary due to the inaccessible nature of the project site and were completed in conjunction with ground counts in areas of high density or activity. Aerial transects were typically three hours in duration, centred on the peak low and high tide each day. A total of 26 survey events were completed equating to a minimum 78 hours of aerial survey time.

The local program comprised 18 aerial transects focused on habitats in proximity to the development envelopes and the regional program comprised eight aerial transects throughout the southern two-thirds of the MSSA. The survey program methods therefore largely met the considerations detailed in PRISM (2018).

The relative area, percentage and extrapolation factor for each program is provided in Table 41. An extrapolation factor is given as it was necessary to apply this factor to each species to estimate the abundance of each species across the entire MSSA habitat, given that the entire area could not be surveyed in a single event (i.e. a single tide). The extrapolation assumed all species recorded were distributed evenly. This extrapolation in shorebird surveys is common practice e.g. PRISM; Revision of the East Asian-Australasian Flyway Population Estimates for 37 listed Migratory Shorebird Species (Hansen *et al,* 2016); and Interim Recovery Plan for the Threatened Migratory Shorebirds visiting Western Australia (DBCA, 2018).

All sample events were undertaken using an R44 helicopter, which was considered the most effective method to access such a large area of inaccessible coastline and associated habitat. The alternative survey craft were boat or fixed-wing plane which were determined to be unviable. Boats were not considered suitable as:

- Survey by boat would have taken much longer in each phase to achieve coverage. This means that a 'snap-shot' could not be attained as significant numbers of birds could move in and out of the area during any survey period;
- Mangrove roosting birds are difficult to flush, identify and count (DotEE, 2017);

- Large parts of the MSSA were not accessible by boat, particularly landward roosting and feeding grounds which would not have even been identified without aerial support; and
- Flocks could not be reliably tracked and therefore the risk of double-counting was considered too high.

Therefore, using a boat would likely have resulted in a very limited and/or biased dataset. Fixed-wing planes were also not considered suitable due to the following reasons:

- The inability to rapidly respond to bird movements, slow down or stop, would have resulted in large numbers being missed or double-counted on return; and
- No ground counts could be achieved.

Survey from helicopter was therefore chosen as the most viable method, capable of overcoming the above limitations. It was particularly effective at detecting birds active in the extensive mangroves of the MSSA (a habitat unit where assessment is often inadequate; DotEE 2017) as the helicopter was able to fly along both seaward and landward faces, or over the top of mangroves, as necessary.

For each sample event 3 - 4 'transects' were flown; these commenced in the north and tracked south, then north and then south and north again. On high tides, they commenced on the landward side of the MSSA and on low tides they commenced on the coast over the exposed tidal mudflats, reefs and near-shore islands, finishing over the inland mudflats.

Where large congregations were encountered, the helicopter hovered or slowly circled so that the full complement of a flock could be identified and counted. Care was taken to track flocks so as to not double-count birds. The helicopter was also landed so that ground counts could be completed at certain areas, e.g. in areas of high foraging / roosting density / activity or where key Proposal infrastructure was to be sited. Care was always taken to avoid disturbance of feeding or roosting activity, primarily by flying low and slow toward any congregations identified. It was apparent that this typically resulted in the birds taking to the wing for short periods of time before landing back in the same location. As a result, some point recordings were made over a different habitat to that in which they were initially observed; pulling apart such records from the large dataset attained was not possible. There were no observed events of congregations departing an area permanently due to disturbance by the helicopter observations.

While conducting the surveys, a primary observer was positioned in the front of the helicopter who called out species names and numbers, these were recorded by a secondary observer who also made other observations, identified and tracked flocks, as required.

It was estimated during the surveys that identifications could reliably made on average 150 m either side of the helicopter. Based on this, an area of around 13,300 ha was typically, reliably surveyed on each tide in the MSSA (calculations from local and regional program 21 - 31 February 2019), which represents approximately 60% of the total MSSA.

A 'site' comprised both single and multiple species records, as required. In total, 1,948 site point locations were marked during the four survey phases in the 78 hours of aerial and ground count surveys.

Table 41: Area breakdown of the two MSSA programs

Name	Km^2	Relative % of contiguous shorebird area	Extrapolation factor
Local program	245.3	40.5%	2.6
Regional program (north)	157.4	26%	4.0
Regional program (south)	203.1	33.5%	3.1
Total	**641.9**	**100**	

While DAWE (DotEE, 2017) acknowledges that it may be impossible to achieve a complete ('instantaneous') shorebird survey, the approach and resources used in the Mardie MSSA survey program are considered to have more than adequate scope and reliability to ensure the DAWE survey objectives were still met.

Night Parrot Survey Effort

One historic (unverified) record of the Night Parrot (*Pezoporus occidentalis*) (1967; DBCA, 2017c), occurs approximately 30 km south of the TFSA. Phoenix zoologists used a helicopter to visit the site of the 1967 record in order to assess the habitat and compare it to the habitats of the TFSA. The record was from the Robe Homestead, on the Robe River. Spinifex hummock size and age appeared much greater than seen anywhere in the TFSA and no creekline of the magnitude of the Robe River intersects the TFSA.

Automated Recording Units (ARUs) targeting Night Parrot were deployed at 21 sites within the TFSA using three SongMeter SM2 and three SM4 units in areas considered the most prospective nesting (i.e. mature *Triodia* grassland habitat) or foraging (i.e. samphire habitat) habitat, associated with islands on the salt flats, on the eastern boundary of the salt flats and in the spinifex grassland east of the salt flats (Figure 121).

Devices were initially deployed by Phoenix personnel in December 2017; BCI field staff recovered and re-deployed the devices in January - February 2018 and recovered them on 15 - 16 March 2018.

Additional sites were sampled on 21 August – 24 October 2018. Twenty-one sites were sampled in total. All but three of the sites recorded at least ten nights of audio recordings, above the minimum recommendation of six nights in DPaW (2017a), with a total of 283 recording nights obtained.

Data Analysis

<u>EAAF Migratory Shorebirds</u>

The data gathered on Migratory shorebirds was assessed against the criteria for determining nationally and internationally important habitats in Australia, including total abundance for each sample event and for individual species records against the most recent published EAAF population estimates for 37 species of shorebird (Hansen *et al.,* 2016), where the total abundance of a species in each of the 26 sample events was calculated.

To determine the estimated abundance for each species across the MSSA, it was necessary to multiply the maximum recorded abundance by the extrapolation factor for the survey component area, as detailed in Table 41. While shorebirds are highly mobile and not always evenly distributed, this was considered the most reliable and accurate method available for estimating the total abundance for a species within the MSSA, particularly given that the recorded abundance for a species in any given sample event is likely an underestimate of the actual resident numbers as the entire area could not be reliably surveyed. By applying a 300 m buffer to the helicopter transects in phase 4 (the maximum estimated distance for reliable spotting determined in the field), it is estimated that a total of 385 km^2 was reliably surveyed, equating to 60% of the MSSA.

The data was also analysed spatially at the scales of the MSSA (local and regional programs) and the development envelopes.

The analysis of total shorebird population considered only the 37 species listed under *EPBC Act Policy Statement 3.21* (DotEE, 2017) with the total abundance in each sample event again calculated. Other 'shorebird' species listed as Migratory, such as the Gull-billed Tern, where not considered in these calculations.

<u>Night Parrot Acoustic Data</u>

Acoustic data gathered to determine the presence of the Night Parrot was analysed using the software package Kaleidoscope®. The sequential analysis process was auto-detection followed by manual inspection, with any calls tagged for review.

<u>Bat Acoustic Data</u>

Ultrasonic acoustic data gathered to determine the diversity and presence of bats within the TFSA was first analysed using the software package Kaleidoscope® by Phoenix. No auto-detection was applied, and all resultant calls detected within each cluster were manually assessed.

Each complete data set was then sent to Kyle Armstrong (Specialised Zoological) for confirmation (Specialised Zoological 2018a, b).

10.3.2 Review against Relevant Survey Guidelines

The methods, timing and techniques appropriate for each component (i.e. terrestrial fauna or migratory shorebirds) or particular species were reviewed against relevant state and federal survey guidelines (Table 42). The review has concluded that the only un-conforming method was for bats, where only one or two recording nights were completed at each site, whereas the *Survey guidelines for Australia's threatened bats* (Commonwealth of Australia, 2010) requires a minimum of four nights be completed. However, adequate information was collected during the survey to understand the presence and likely habitat utilisation of significant bat species within the TFSA, therefore this non-conformance is not considered a limitation on the survey.

Table 42: Review of survey methods against relevant State and Commonwealth guidelines

Component/ species	Relevant guideline	Survey level/effort	Compliance
Terrestrial fauna surveys	*Technical Guidance: Sampling methods for terrestrial vertebrate fauna* (EPA, 2016m). *Technical Guidance: Terrestrial fauna surveys* (EPA, 2016n)	Targeted/ comprehensive survey (level 2) – see multiple techniques, seasons and species targeted below	**Compliant** Multiple methods employed across multiple seasons, targeting species considered likely to occur based on the reconnaissance survey and desktop review (Phoenix, 2017a) and as further knowledge of site gained.

Component/ species	Relevant guideline	Survey level/effort	Compliance
	Environmental Factor Guideline: Terrestrial fauna (EPA, 2016k).		No pit fall trapping was undertaken, none of the conservation significant species identified in the desktop assessment require pitfall trapping as a survey method. Further over 65% of total expected assemblage recorded, which is comparable with most surveys that utilise pitfall trapping as a sample method.
SREs	*Technical Guidance: Sampling of short range endemic invertebrate fauna* (EPA, 2016o).	Comprehensive survey (level 2)	**Compliant** Habitat mapping completed during reconnaissance survey (Phoenix, 2017a) followed by active foraging in the season following annual rainfall peak, in the most prospective habitats of the survey area.
37 EAAF Migratory shorebirds	*EPBC Act Policy Statement 3.21—Industry guidelines for avoiding, assessing and mitigating impacts on EPBC Act listed migratory shorebird species* (DotEE, 2017)	Four survey phases encompassing: • 26 sample events (22 in summer, four in winter); • Summer and winter periods; • Aerial and ground counts; • ~641 km^2 surveyed; • >78 hours of aerial survey completed; and • Extended in 2019 a further 60km south to encompass all contiguous habitat.	**Compliant** DAWE (2017) states that "Ideally, survey effort should be comprised of a minimum of: - Four surveys for roosting shorebirds- One survey in December, two surveys in January and one survey in February - Four surveys for foraging shorebirds, including two surveys at spring low tide and two surveys at neap low tide" While it is noted that only a single January survey 'phase' was completed, the minimum effort was clearly met because in each phase 4–6 transects (surveys) were completed, being 2–3 transects at low and high tide, over consecutive days. Indeed, on this basis the minimum effort was exceeded by a factor of 5.5. Further this survey represents the single most comprehensive shorebird survey ever conducted on the Pilbara coast.
Night Parrot	*Interim guideline for preliminary surveys of Night Parrot (Pezoporus occidentalis) in Western Australia* (DPaW, 2017a).	• 21 ARU sites • Operated 13.5 nights on average • Completed over multiple seasons, during good conditions • Targeted breeding/ nesting and foraging habitat	**Compliant**
Olive python/reptiles	*Survey guidelines for Australia's threatened reptiles. Guidelines for detecting reptiles listed as threatened under the Environmental Protection and Biodiversity Conservation Act 1999* (DSEWPC, 2011b).	• Road cruising and nocturnal searches in most prospective area, during ideal conditions in March 2018.	**Compliant**

Component/ species	Relevant guideline	Survey level/effort	Compliance
Bats	*Survey guidelines for Australia's threatened bats: Guidelines for detecting bats listed as threatened under the Environment Protection and Biodiversity Conservation Act 1999* (Commonwealth of Australia, 2010).	• 12 echolocation sites • One – two nights recording at each site • Sites located across the terrestrial and intertidal (mangrove) components of the TFSA.	**Uncompliant** Guideline requires four nights at each site, however, all expected significant species detected and provided an understanding of habitat utilisation in the TFSA. Therefore, the number of sampling nights is not considered a limitation on the survey results.

10.3.3 SURVEY LIMITATIONS

The limitations of the terrestrial fauna surveys (Phoenix, 2020b) have been considered (Table 43) in accordance with Technical Guidance: Terrestrial fauna surveys (EPA 2016b).

Table 43: Terrestrial Fauna survey limitations

Limitations	Survey limitation?	Comments
Competency/experience of survey personnel, including taxonomy	No	The field team and report authors have extensive experience in terrestrial fauna surveys within the Pilbara region and were competent in sampling the target fauna, with specialised zoologists engaged were appropriate.
Scope and completeness - were all target groups sampled, were all planned survey methods implemented successfully, was the Study Area fully surveyed?	No	Target groups were adequately sampled, except for Night Parrot which requires sampling east of the mudflats/salt flats. This was completed in 2018.
Intensity - in retrospect, was the intensity adequate?	No	The intensity was appropriate, as evidenced by the large species list attained, with respect to the potential list developed for the desktop review (Phoenix 2017a).
Proportion of fauna identified, recorded and/or collected	No	Over 50% of the potential species identified in the desktop review have been recorded. As this was a targeted Level 2 survey and not a systematic Level 2 trapping survey, the intent was not to collect the full assemblage.
Availability of adequate contextual information	No	Previous survey reports from the vicinity of the area were available for the desktop review.
Timing, weather, season, cycle	Yes	Conditions during March 2018 were extremely hot with air temperature according to the helicopter thermometer (not official BOM recording for Mardie) reaching 51°C on one day. As such animal activity was low by 9 am at most sites/habitats and undoubtedly many more species, particularly reptiles, would have been recorded if cooler conditions had prevailed. That being said, over the various survey rounds undertaken between 2017 and 2019 a large portion of the expected fauna have been observed and many species (46) not identified in the desktop review (Phoenix 2017a) were recorded.
Disturbances which affected the results of the survey	No	No disturbances were apparent that may have affected the survey results.
Remoteness and/or access problems	No	Access constraints were overcome with the use of a helicopter.

10.3.4 FAUNA HABITAT

Table 44 lists the twelve broad fauna habitats were mapped within the TFSA (Figure 119). Several of these habitats were also mapped by Stantec (2018) over a broader study area. The mapped extents of these habitats have also been provided in Table 44.

Table 44: Fauna habitats of the TFSA

Habitat	Mapped extent within TFSA (ha)	Percentage of TFSA	Mapped extent within Stantec study area (ha)	Percentage of Stantec study area
Mudflat or saltflat	10,371.5	35.6%	12,880 (Mudflats / saltflat) 4,554 (Algal Mat Community)	21.0%
Tidal samphire mudflats	5,212.7	17.9%	13,111 (Samphire & Samphire / Mudflat Community)	15.8%
Spinifex grassland	4,492.2	15.4%	26,741 (Spinifex Sandplains Community)	32.3%
Shrubland over spinifex grassland	3,644.2	12.5%	N/A	N/A
Tidal channel and ocean	2,780.6	9.5%	14,960 (Ocean/Tidal Creek) 110 (Rock Reef)	18.2%
Mangrove community	1,689.3	8.0%	7,849 (Mangal Community)	9.5%
Tussock grassland	483.0	1.7%	N/A	N/A
Cleared	241.6	0.8%	218 (Gas Pipeline)	0.3%
Spinifex grassland on rocky hills	120.9	0.4%	N/A	N/A
Open woodland (riparian)	73.5	0.3%	89 (River/Creek System)	0.1%
Beach and dune	17.1	0.1%	2,331 (Sand Dune Community)	2.8
Low shrubland	13.7	<0.1%	N/A	N/A
Fresh water pool	1.0	<0.1%	N/A	N/A
Total	**29,141.3**	**100.0%**	**82,833**	**100.0%**

Mudflat or Saltflat

Mudflat or saltflat dominated the TFSA (35.6%) and a significant portion of the Stantec study area (21.0%). A total of 35 fauna species were recorded in or flying across this habitat. The mudflat/saltflat habitats are largely devoid of vegetation and supported very few fauna species. Aerial transects in this habitat often went minutes without observing a single Migratory bird; where they were observed they were typically individuals or small groups (e.g. Red-capped Plover).

Tidal Samphire Mudflats

Samphire shrublands occur near the coast, between tidal mangrove creek channels. These were often inundated by the tide cycle and during spring tides can be greater than 30 cm underwater a number of kilometres from the coast. This habitat is used by Migratory shorebirds for feeding and bush birds and mangrove specialists, such as Mangrove Golden Whistler and Sacred Kingfisher. It also supports Northern Coastal Free-tailed Bat (Ozimops cobourgianus; Priority 1, DBCA list). A total of 50 species were ascribed to this habitat type.

Spinifex Grasslands

This habitat type principally occurs on the upland areas along the eastern side of the TFSA, as well as on islands within the mudflats / saltflats and near the coast. This habitat recorded the most diverse fauna assemblage (65 species). A large extent of spinifex grassland was heavily impacted by cattle and Mesquite (~857 ha). However, there were also large areas of high quality, mature spinifex hummock grassland, particularly south of the homestead, east of the mudflats/saltflats.

Shrubland over Spinifex Grassland

Shrublands occurred sporadically across the TFSA within the broader spinifex grassland habitat or as a transition zone adjacent to creeklines. This habitat was more structurally complex than the surrounding spinifex grasslands. A total of 20 species were recorded from this habitat.

Tidal Channel and Ocean

The tidal creek channels act as important conduits for the tidal waters that inundate the samphire mudflats and mudflats / saltflats during spring tides. They also provide fishing grounds for larger sea birds such as Osprey and White-bellied Sea -eagles, as well as marine turtles.

This habitat also included sand bars / spits, mudflats and rocky reefs that are utilised by numerous shorebirds. These habitats are inundated and then exposed daily with the tidal regime. Collectively this habitat 'group' recorded the second-highest richness with 55 species recorded.

Mangal Community

The mangrove stands are important habitat for Northern Coastal Freetailed Bat (P1), Migratory shorebirds for roosting, as well as bush birds and mangrove specialist birds, including Mangrove Grey Fantail, Mangrove Golden Whistler, Yellow Whiteeye and Sacred Kingfisher, all of which were common to most of the mangrove sites in the Phoenix (2020b) survey. Brahminy Kite and White-bellied Sea-eagles were also very common in this habitat.

The mangal communities were far more prominent in the southern half of the TFSA, where large expanses were inundated daily. A total of 43 species were recorded from this habitat.

Tussock Grassland

This habitat was relatively rare within the TFSA comprising less than 2% of the area. It was typically comprised of **Prosopis glandulosa* x *velutina* over low *Eragrostis xerophila* tussock grassland over isolated low *Corchorus tridens* forbs on flat plains. It is not considered to support significant or restricted species.

Spinifex Grassland on Rocky Hills

The only area of rocky hills in the vicinity of the Proposal occurs north of the haul road, approximately 3 km from its eastern terminus (Figure 123). Here the vegetation is comprised of

Triodia species and mixed mid-low shrubs on skeletal soils. Boulder piles are present in which Northern Quoll occur. Western Pebble-mound Mouse was also recorded on the lower, undulating stony slopes.

Open Woodland (Riparian)

A number of creeklines draining the areas to the east of the TFSA, traverse the eastern side of the development envelopes before dispensing water into the mudflats / saltflats. Channel pools were still present during the survey from cyclonic rainfall east of the TFSA.

Riparian habitats in the Pilbara are important for many species, especially birds, due to structural complexity of the vegetation and array of foraging and nesting opportunities they afford (Burbidge *et al*., 2010). In the TFSA, riparian creekline habitat was dominated by Whiteplumed Honeyeater, Pied Butcherbird, Corellas, Blue-winged Kookaburra, Magpie-lark and numerous generalist predators such as Whistling Kite and Australian Kestrel. The Pilbara Leaf-nosed Bat was recorded foraging in this habitat type. A total of 45 species were recorded from this habitat.

Beach / Dune

This habitat (0.1% of the TFSA) recorded the least species (five): Green Turtle and Hawksbill Turtle nesting attempts (assessed as Marine Fauna) and three bird species.

Low Shrubland

This is a relatively rare community comprising *Trianthema turgidifolium*, *Neobassia astrocarpa* and *Pluchea rubelliflora* shrubland over *Sprobolus virginicus* grassland over isolated low *Trianthema cussackianum* forbs on low lying plains. This habitat was not sampled directly. It is unclear if any species are restricted to this rare habitat, but it is considered likely to support species on occasion that inhabit the broader surrounding habitats. An audio recorder targeting Night Parrot (site NP10) was located in close proximity to this habitat.

Freshwater Pool

This habitat type includes Mardie Pool, an important permanent freshwater resource for terrestrial fauna is located in the eastern part of the TFSA but has been excluded from the development envelopes. While this area is under threat from Mesquite encroachment, the waters contained fish (not sampled) and recorded unique species for the survey including Pilbara Leaf-nosed Bat (foraging), Pheasant Coucal, Swamp Harrier and Rufous Night Heron. The pool occurs at the interface of the mudflats / saltflats, and a detailed description of the hydrological characteristics of the pool is provided in Section 5 (Inland Waters).Migratory bird habitats

The MSSA, which encompasses the relevant habitats of the TFSA, comprises several Migratory shorebird habitats (Figure 122), which are repeatedly submerged and exposed to various extents under the tidal cycle:

- Ocean mudflats and sandbars (foraging) – huge expanses of feeding habitat offshore at low tide. Important for Bar-tailed Godwit, Grey-tailed Tattler, Ruddy Turnstone, however, birds are dispersed and not found in particularly large congregations;
- Beaches (roosting / loafing) – few species using beaches (e.g. Common Sandpiper Beach Stone-Curlew, Oyster Catchers);
- Reefs and rocky shores (foraging / loafing) – important for larger species such as White-faced Heron and two Oyster Catcher species and Common sandpipers;

- Mangal communities on river channels (roosting / loafing) – predominantly Herons and Whimbrel;
- Samphire intertidal zones (foraging) – extensive usage during mid-high tides. A matrix of roosting habitat also present. Important for Eastern Curlew; and
- Inland mudflats (foraging / loafing) – very few species using, e.g. Red-capped Plover, Oriental Pratincole.

Important Habitat

Within the MSSA the following habitats (Table 44) were deemed to be important to Migratory birds (in order of importance):

1. Tidal samphire mudflats – for foraging;
2. Ocean mudflats and sandbars – mainly for foraging; and
3. Mangal communities on river channels – for roosting / loafing.

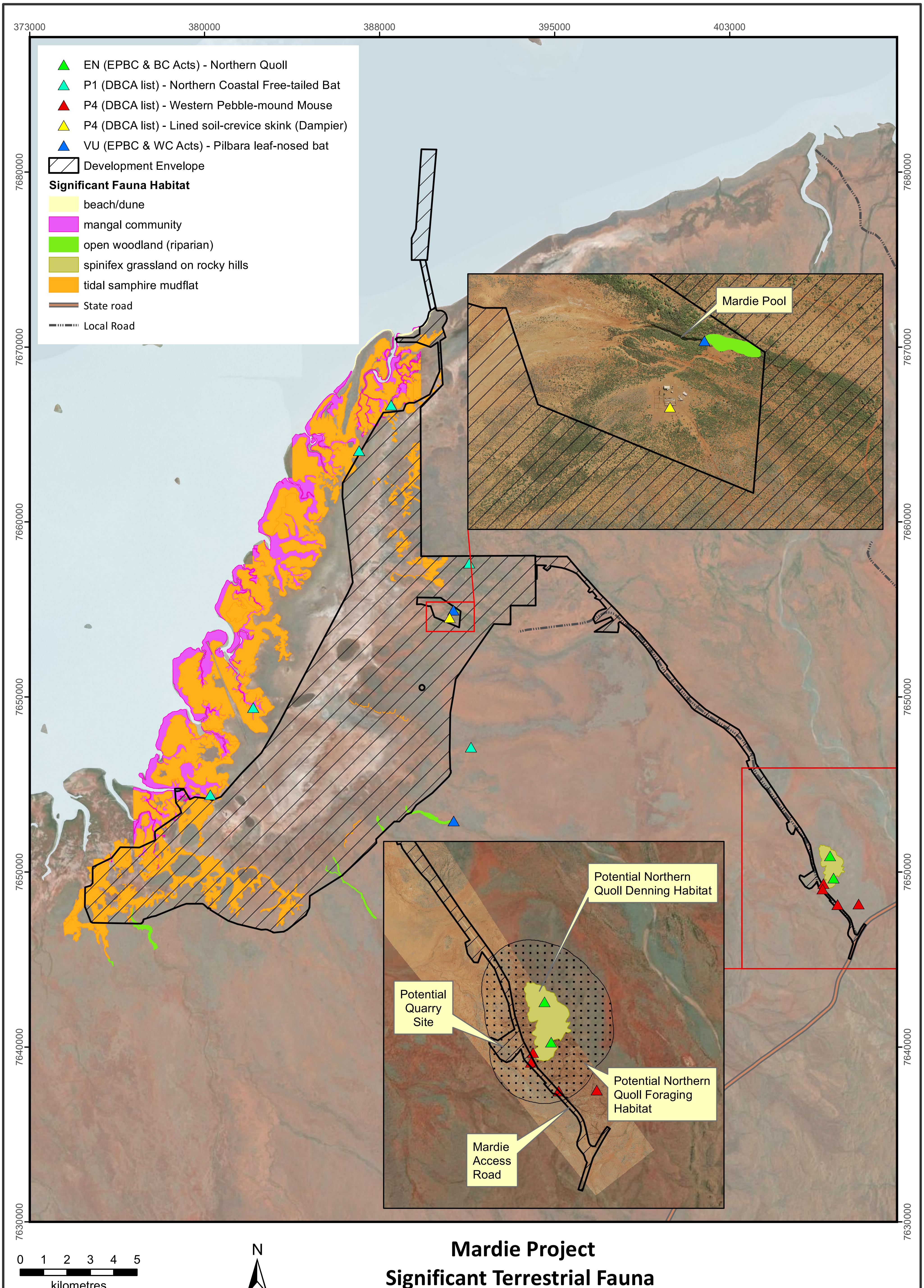
The tidal samphire mudflat habitats require larger tides to be fully inundated but generally remain inundated for longer periods. This habitat type is the most widespread and longest inundated (and therefore available for feeding) within the MSSA. They support the Critically Endangered Eastern Curlew almost exclusively along with five other Threatened species but to a lesser extent. With a matrix of roosting sites, this habitat is considered the most important in the MSSA, for a large variety of shorebirds and waterbirds. The tidal samphire mudflats occur unbroken from north to south, with the width ranging from 2.5 – 7 km. As they occur between and inland of the tidal creeks, they are the last to fill and empty completely. This means birds that favour such habitat can feed almost continuously during daylight hours; moving with the tide, remaining within their preferred water depth and being able to quickly move to higher ground to loaf or roost as needed.

The extent of ocean mudflats and sandbars, and rocky reefs exposed and available for feeding and roosting / loafing is determined by the relative size of the tides on any day. Coastal mudflats and sandbars are important and depending on the tide cycle can be extremely large in area (occurring at least 2 km offshore at times), but typically are available for less time than the samphire intertidal zones. This habitat is the most important for a Grey-tailed Tattler, Bar-tailed Godwit and Ruddy Turnstone, as well as the various tern species, such as Gull-billed Tern.

Mangal communities extend along the coastline where it dominates the coast for tens of kilometres. This habitat is extremely wide in areas (>1 km) and in those sections, as there are no dunes present, tidal inundation flows quickly through the forest, leaving little time for feeding in the samphire intertidal zones immediately behind. Section 7.3.7 provides additional information regarding the function and value of mangal communities in the local and regional ecosystem.

Occasional records were observed in the mudflats / saltflats, mainly at the western extents but activity was much lower in this habitat type.

Figure 122: Migratory bird habitats recorded within the MSSA (from Phoenix, 2020b)



Mardie Project
Significant Terrestrial Fauna
(Excluding Migratory Birds) and Habitats

BCI MINERALS LIMITED

Date: 4/03/2020

Figure 123: Significant fauna habitat and records (excluding migratory birds)

10.3.5 General Fauna

A total of 179 species were recorded in the TFSA and MSSA on the five site visits undertaken between August 2017 and August 2019, including one amphibian, 26 reptiles, 129 birds and 23 mammals (fifteen native and eight introduced). This represents 67% of the species identified as potentially occurring from the Phoenix (2020b) desktop review.

The single amphibian, *Litoria rubella*, was recorded; however, given the nature of arid zone frogs (i.e. rapid rainfall response) and habitat diversity in the TFSA, it is highly likely additional species are present, such as the other three frog species identified in the desktop review (Phoenix, 2020b), none of which are considered significant..

Birds were the most diverse Class of vertebrates recorded, which is consistent with the findings of the desktop review. This is to be expected where the largest proportion of the survey effort has focused on birds, principally migratory shorebirds. On an individual species basis, the MSSA supports at least 60 species of waterbird including significant numbers of numerous Tern species, e.g. Gull-billed Tern (*Gelochelidon nilotica*), Lesser Crested Tern (*Sterna benghalensis*), Crested Tern (*Sterna bergii*), Whiskered Tern (*Sterna hybrida*), Little Tern (*Sternula albifrons*), as well as Pied Oyster Catcher (*Haematopus longirostris*), White-faced Heron (*Ardea novaehollandiae*) and Little Egret (*Ardea garzetta*). Stilts were rare. A Black-necked Stork (*Ephippiorhynchus asiaticus*) was recorded daily moving about the MSSA in phase 4. A single Australia White Ibis (*Threskiornis moluccus*) was recorded in winter 2018 (phase 3), after being absent for the 15 previous sample events, and then again in phase 4 (events 17–26), when a flock of approximately 26 was recorded repeatedly.

In terms of predators, Brahminy Kite (*Haliastur indus*), Osprey (*Pandion cristatus*) and White-bellied Sea-Eagle (*Haliaeetus leucogaster*) are common throughout the MSSA.

10.3.6 Significant Fauna

For the purposes of this assessment the term 'significant fauna' refers to:

- Fauna species listed under the EPBC Act or BC Act that were recorded or considered likely to occur within the study areas, as well as the Night Parrot;
- Species with restricted distribution;
- Species with a degree of historical impact from threatening processes; and
- Species that provide an important function required to maintain the ecological integrity of a significant ecosystem.

A total of 31 significant terrestrial fauna (i.e. excluding turtles) were recorded or considered likely to occur within the survey areas, including five mammals, three reptiles and 24 birds.

The significant fauna that were recorded or considered likely to occur within the survey areas are listed in Table 45.

Table 45: Significant fauna recorded or likely to occur within the study areas

Species	Common name	Conservation status	Likelihood of occurrence
Mammals			
Dasyurus hallucatus	*Dasyurus hallucatus*	*Dasyurus hallucatus*	*Dasyurus hallucatus*
Ozimops cobourgianus	*Ozimops cobourgianus*	*Ozimops cobourgianus*	*Ozimops cobourgianus*
Rhinonicteris aurantia (Pilbara)	*Rhinonicteris aurantia* (Pilbara)	*Rhinonicteris aurantia* (Pilbara)	*Rhinonicteris aurantia* (Pilbara)
Pseudomys chapmani	*Pseudomys chapmani*	*Pseudomys chapmani*	*Pseudomys chapmani*
Reptiles			
Ctenotus angusticeps	Airlie Island Ctenotus	P3 (DBCA list)	Likely
Notoscincus butleri	Lined -soil crevice skink	P4 (DBCA list)	Recorded
Liasis olivaceus barroni	Pilbara-Olive-Python	VU (EPBC Act); VU (BC Act)	Likely
Birds			
Actitis hypoleucos	Common Sandpiper	Mig. (EPBC Act; BC Act)	Recorded
Arenaria interpres	Ruddy Turnstone	Mig. (EPBC Act; BC Act)	Recorded
Anous stolidus	Common Noddy	Mig. (EPBC Act; BC Act)	Likely
Apus pacificus	Fork-tailed Swift	Mig. (EPBC Act; BC Act)	Likely
Calidris alba	Sanderling	Mig. (EPBC Act; BC Act)	Recorded
Calidris acuminata	Sharp-tailed Sandpiper	Mig. (EPBC Act; BC Act)	Likely
Calidris canutus	Red Knot	EN/Mig. (EPBC Act); Mig.(BC Act)	Recorded
Calidris ferruginea	Curlew Sandpiper	CR/Mig. (EPBC Act); VU/Mig.(BC Act)	Recorded
Calidris ruficollis	Red-necked Stint	Mig. (EPBC Act; BC Act)	Recorded
Calidris tenuirostris	Great Knot	CR/Mig. (EPBC Act); VU/Mig. (BC Act)	Recorded
Charadrius leschenaultii	Greater Sand Plover	VU/Mig. (EPBC Act); Mig. (BC Act)	Recorded
Charadrius mongolus	Lesser Sand Plover	EN/Mig. (EPBC Act; BC Act)	Recorded
Charadrius veredus	Oriental Plover	Mig. (EPBC Act; BC Act)	Recorded
Chlidonias leucopterus	White-winged Black Tern	Mig. (EPBC Act; BC Act)	Recorded
Falco hypoleucos	Grey Falcon	VU (BC Act)	Possible
Falco peregrinus	Peregrine Falcon	OS (BC Act)	Possible
Gelochelidon nilotica	Gull-billed Tern	Mig. (EPBC Act; BC Act)	Recorded
Glareola maldivarum	Oriental Pratincole	Mig. (BC Act)	Recorded
Hirundo rustica	Barn Swallow	Mig. (EPBC Act; BC Act)	Possible
Hydroprogne caspia	Caspian Tern	Mig. (EPBC Act; BC Act)	Recorded

Species	Common name	Conservation status	Likelihood of occurrence
Limosa lapponica	Bar-tailed Godwit	Mig. (EPBC Act; BC Act)	Recorded
Motacilla flava	Yellow Wagtail	Mig. (EPBC Act; BC Act)	Possible
Numenius madagascariensis	Eastern Curlew	CR/Mig. (EPBC Act); VU/Mig. (BC Act)	Recorded
Numenius phaeopus	Whimbrel	Mig. (EPBC Act; BC Act)	Recorded
Numenius minutus	Little Curlew	Mig. (EPBC Act; BC Act)	Possible
Pandion cristatus (haliaetus)	Osprey	Mig. (EPBC Act; BC Act)	Recorded
Pezoporus occidentalis	Night Parrot	EN (EPBC Act); CR (BC Act)	Possible
Pluvialis fulva	Pacific Golden Plover	Mig. (EPBC Act; BC Act)	Recorded
Pluvialis squatarola	Grey Plover	Mig. (EPBC Act; BC Act)	Recorded
Sterna dougallii gracilis	Roseate Tern	Mig. (EPBC Act; BC Act)	Likely
Sterna bergii	Crested Tern	Mig. (EPBC Act; BC Act)	Recorded
Sterna hirundo	Common Tern	Mig. (EPBC Act; BC Act)	Recorded
Sterna nereis	Fairy Tern	VU (EPBC Act; BC Act)	Possible
Sternula albifrons	White-shafted Little Tern, Little Tern	Mig. (EPBC Act; BC Act)	Recorded
Tringa brevipes	Grey-tailed Tattler	Mig. (EPBC Act; BC Act); P4 (DBCA)	Recorded
Tringa nebularia	Common Greenshank	Mig. (EPBC Act; BC Act)	Recorded
Tringa stagnatilis	Marsh Sandpiper	Mig. (EPBC Act; BC Act)	Possible
Xenus cinereus	Terek Sandpiper	Mig. (EPBC Act; BC Act)	Recorded

Mammals

The field surveys identified four mammals that were considered to be 'significant fauna'. An additional mammal species was identified during the desktop review as likely to occur; the Short-tailed Mouse (*Leggadina lakedownensis*).

The Pilbara Leaf-nosed Bat (*Rhinonicteris aurantia* Pilbara) is listed as Vulnerable under both the EPBC Act and the BC Act, and was recorded at two riparian open woodland habitats; at 9 pm at Mardie Pool, and at 3 am at a creekline approximately 10 km south of Mardie Pool that was flowing due to rainfall from ex-Tropical Cyclone Joyce in January 2018 (Figure 123). Pilbara Leaf-nosed bats roost in warm and humid caves. At night, individuals disperse outside of their caves to forage in the open, often over open water. In the Pilbara, this habitat is almost exclusively present in large creek beds and gorges. Pilbara Leaf-nosed bats also forage over *Triodia* grasslands, usually flying close to the ground up to 3 m high. No roosting habitat was present in the TFSA and the records indicate foraging activity. Mardie Pool (Figure 123) is likely to be regularly used for foraging by this species.

The Northern Coastal Free-tailed Bat (*Ozimops cobourgianus*) is listed by DBCA as a Priority 1 fauna and was widespread across the TFSA, including the coastal tidal habitats (mangal community, tidal samphire shrublands) and also on riparian open woodland habitat, east (inland) of the mudflat playa (Figure 123). The Northern Coastal Free-tailed Bat is a geographically isolated, mangrove-obligate species that occurs in rainforest, monsoon forest riparian zones and mangrove communities.

Northern Quoll is listed as Endangered under the EPBC Act and BC Act and was recorded on two cameras in August 2019 from low rocky hills north of the access road (spinifex grassland on rocky hills habitat), outside the development envelopes (Figure 123). This habitat is considered denning / shelter habitat for the species but does not occur in the development envelopes.

The Western Pebble-mound Mouse (Priority 4) was recorded in the August 2019 survey in the same habitat as the Northern Quoll but from the undulating stony plain around the periphery of the rocky hills (Figure 123). It was recorded both within and outside the development envelopes, however its most suitable habitat is the 'spinifex grassland on rocky hills' habitat which occurs entirely outside the development envelopes.

The Short-tailed Mouse (*Leggadina lakedownensis*) is listed by DBCA as a Priority 4 fauna and was considered likely to occur within the TFSA, but was not recorded during the field surveys. This species occupies a variety of habitats including hummock and tussock grasslands, tropical woodlands, samphire, sedgelands and stony ranges, and suitable habitat (i.e. low *Tecticornia shrublands*) was recorded in the TFSA.

Reptiles

The field surveys identified four reptiles that were considered to be 'significant fauna'. Three of these were marine turtles which are considered 'Marine Fauna' in this ERD and have been discussed in Section 8. Two additional reptile species were identied during the desktop review as likely to occur; the Pilbara Olive Python (*Liasis olivaceus barroni*) and the Airlie Island Ctenotus (*Ctenotus angusticeps)*.

Notoscincus butleri (Priority 4) was recorded in August 2019 from old shearing sheds on Mardie Station outside the development envelopes. It was not returned from the desktop review and the record is a range extension for the species.

The Pilbara Olive Python (*Liasis olivaceus barroni*) is listed as Vulnerable under both the EPBC Act and the BC Act and is commonly found in rocky areas in association with watercourses and pools and often associated with areas of permanent pooling water near rocky habitats, such as gullies, gorges and rocky ranges or boulder sites. This species was not recorded during two nocturnal searches but suitable habitat is present at Mardie Pool (Figure 123). The species may also be found on occasion on the southern creeklines.

The Airlie Island Ctenotus (*Ctenotus angusticeps)* is listed as Priority 3 fauna DBCA, and is strongly associated with Low *Tecticornia halocnemoides* subsp. *tenuis* and *Muellerolimon salicorniaceum* shrubland on clay soils which was recorded in the TFSA. This species was not recorded but suitable flora, soils and general habitat characteristics are present in the TFSA.

Migratory Shorebirds

The field surveys identified 26 birds that were considered to be 'significant fauna'. Four additional bird species were identified during the Phoenix (2020b) desktop review as likely to occur (Table 45).

Recorded and Potential Species

The East Asia-Australasian Flyway (EAAF) migratory shorebird survey recorded 20 of the 37 species listed under EPBC Act Policy Statement 3.21 (DotEE, 2017). All 20 species were recorded in the summer sampling events, and twelve were recorded overwintering; no new species were confined to the overwintering survey (phase 3). The average species richness of the three summer phases was 11.3 species per sample event, whereas species richness was lower during winter (phase 3), at 7.2 species per sample event. Average richness between tides in summer sample events were immaterial.

The recorded species are listed in Table 46 and the collated locations of Migratory bird records is shown on Figure 75 to Figure 78.

Table 46: Migratory bird species recorded within the MSSA

Species	EPBC Act	BC Act	DBCA
Common Sandpiper (*Actitis hypoleucos*)	Migratory	Migratory	-
Ruddy Turnstone (*Arenaria interpres*)	Migratory	Migratory	-
Sanderling (*Calidris alba*)	Migratory	Migratory	-
Red Knot (*Calidris canutus*)	Endangered , Migratory	Migratory	-
Curlew Sandpiper (*Calidris ferruginea*)	Critically Endangered, Migratory	Vulnerable, Migratory	-
Red-necked Stint (*Calidris ruficollis*)	Migratory	Migratory	-
Great Knot (*Calidris tenuirostris*)	Critically Endangered, Migratory	Vulnerable, Migratory	-
Greater Sand Plover (*Charadrius leschenaultii*)	Vulnerable, Migratory	Migratory	-
Lesser Sand Plover (*Charadrius mongolus*)	Endangered, Migratory	Endangered, Migratory	-
Oriental Plover (*Charadrius veredus*)	Migratory	Migratory	-
White-winged Black Tern (*Chlidonias leucopterus*)	Migratory	Migratory	-
Gull-billed Tern (*Gelochelidon nilotica*)	Migratory	Migratory	-
Oriental Pratincole (*Glareola maldivarum*)	-	Migratory	-
Caspian Tern (*Hydroprogne caspia*)	Migratory	Migratory	-
Bar-tailed Godwit (*Limosa lapponica*)	Migratory	Migratory	-
Eastern Curlew (*Numenius madagascariensis*)	Critically Endangered, Migratory	Vulnerable, Migratory	-
Whimbrel (*Numenius phaeopus*)	Migratory	Migratory	-
Osprey (*Pandion cristatus (haliaetus)*)	Migratory	Migratory	-
Pacific Golden Plover (*Pluvialis fulva*)	Migratory	Migratory	-
Grey Plover (*Pluvialis squatarola*)	Migratory	Migratory	-
Crested Tern (*Sterna bergii*)	Migratory	Migratory	-
Common Tern (*Sterna hirundo*)	Migratory	Migratory	-
White-shafted Little Tern, Little Tern (*Sternula albifrons*)	Migratory	Migratory	-
Grey-tailed Tattler (*Tringa brevipes*)	Migratory	Migratory	Specially protected
Common Greenshank (*Tringa nebularia*)	Migratory	Migratory	-

Species	EPBC Act	BC Act	DBCA
Terek Sandpiper (*Xenus cinereus*)	Migratory	Migratory	-

Habitat Assessment

Under the EPBC Act, 'important habitat' is a key concept for migratory species (DotEE, 2017b). Important habitats in Australia for migratory shorebirds under the EPBC Act include those recognised as nationally or internationally important. The accepted and applied approach to identifying internationally important shorebird habitat has been through the use of criteria adopted under the Ramsar Convention on Wetlands (DotEE, 2017b).

According to that approach, wetland habitat should be considered:

- Internationally important if it regularly supports:
  - 1% of the individuals in a population of one species or sub-species of waterbird; or
  - A total abundance of at least 20,000 waterbirds.
- Nationally important if it regularly supports:
  - 0.1% of the flyway population of a single species of Migratory shorebird;
  - A total abundance of at least 2,000 Migratory shorebirds; or
  - At least 15 Migratory shorebird species.

As assessment of the findings of the surveys within the MSSA against the above criteria is provided in Table 47.

Table 47: Assessment of Migratory shorebird habitat within the MSSA

International Criteria	MSSA Characteristics
Regularly supports 1% of the individuals in a population of one species or sub-species of waterbird	Likely to meet criteria. 3 species were expected to meet this criteria once data was extrapolated across the MSSA: • Grey-tailed Tattler • Ruddy Turnstone • Whimbrel
Regularly supports a total abundance of at least 20,000 waterbirds	Unlikely to meet criteria. The data does not suggest the MSSA supports more than 20,000 waterbirds
National Criteria	**MSSA Characteristics**
Regularly supports 0.1% of the flyway population of a single species of Migratory shorebird	Meets criteria. 6 species were recorded that meet this criteria: • Bar-tailed Godwit • Eastern Curlew (also Critically Endangered, EPBC Act; Vulnerable, BC Act) • Grey-tailed Tattler • Ruddy Turnstone • Sanderling • Whimbrel An additional 8 species were expected to meet this criteria once data was extrapolated across the MSSA: • Common Greenshank • Curlew Sandpiper (also Critically Endangered, EPBC Act; Vulnerable, BC Act) • Greater Sand Plover (also Vulnerable, EPBC Act) • Oriental Plover • Pacific Golden Plover • Red Knot (also Critically Endangered, EPBC Act; Vulnerable, BC Act) • Red-necked Stint • Terek Sandpiper

International Criteria	MSSA Characteristics
Regularly supports a total abundance of at least 2,000 Migratory shorebirds	Likely to meet criteria. No sample event recorded a total abundance that met this criteria. However, it must be remembered that each sample event only ever sampled a portion of the MSSA and therefore when the total abundance is multiplied by the extrapolation factor for that sub-component area then it is likely to meet this criteria.
Regularly supports at least 15 Migratory shorebird species	Meets criteria (during summer). The surveys recorded 19 and 20 of the EAAF Migratory species for the local and regional program respectively.

Higher numbers of birds were observed in January and February compared to December. Abundance in summer was always greater for high tide events, suggesting more feeding opportunities are presented in the samphire wetlands than on the ocean-side mudflats exposed

The area appears to be particularly important to the larger ‘wetland species’ (within the context of the Pilbara), Whimbrel, Curlew Sandpiper and Eastern Curlew, which is likely a reflection of the large extent of largely uninterrupted mangrove tidal creeks and associated intertidal samphire wetlands that dominate all but the northern sections of the MSSA.

Other Potential Significant Bird Species

Potential habitat was also identified in the TFSA and MSSA for an additional 12 significant bird species (Table 48), four of which were considered likely to occur but were not recorded

Table 48: Significant bird species potentially occurring within the study areas but not recorded

Species	Status	Likelihood of occurrence	Potential habitat
Common Noddy (*Anous stolidus*)	Migratory - EPBC Act, BC Act	Likely	Occurs mainly in the ocean off the Queensland coast, but also off the north-west and central WA coast. During the breeding season, it occurs on or near islands, on rocky islets and stacks with precipitous cliffs, or on shoals or cays of coral or sand. During the non-breeding period, the species occurs in groups in the open ocean.
Fork-tailed Swift (*Apus pacificus*)	Migratory - EPBC Act, BC Act	Likely	Species is a widespread species that forages in variety of habitats including those within the study areas.
Sharp-tailed Sandpiper (*Calidris acuminata*)	Migratory - EPBC Act, BC Act	Possible	Inhabits muddy edges of shallow fresh or brackish vegetated wetlands, including lagoons, swamps, lakes and pools near the coast, and dams, waterholes, soaks, bore drains and bore swamps, saltpans and hypersaline salt lakes inland.
Grey Falcon (*Falco hypoleucos*)	Vulnerable - BC Act	Possible	May forage within grassland and shrubland habitats. Has large foraging ranges and could easily travel from nests in the ranges east of the TFSA (~20 km).
Peregrine Falcon (*Falco peregrinus*)	Specially Protected - BC Act	Possible	Preferred habitat includes cliffs and wooded watercourses. Nesting occurs mainly on cliff ledges, granite outcrops, quarries and in trees with old raven or Wedge-tailed Eagle nests. Has large foraging ranges and could easily travel from nests in the ranges east of the TFSA (~20 km).
Barn Swallow (*Hirundo rustica*)	Migratory - EPBC Act, BC Act	Possible	Inhabits open country in coastal lowlands and, in or over freshwater wetlands, woodland, shrublands and tussock grassland.
Yellow Wagtail (*Motacilla flava*)	Migratory - EPBC Act, BC Act	Possible	Utilises a wide variety of habitats.

Species	Status	Likelihood of occurrence	Potential habitat
Little Curlew (*Numenius minutus*)	Migratory - EPBC Act, BC Act	Possible	Spends the non-breeding season in northern Australia from Port Hedland to the Queensland coast. Most often found feeding in grassland and sedgeland with scattered, shallow freshwater pools or areas seasonally inundated. It will also use open woodlands with a grassy or burnt understorey, dry saltmarshes, coastal swamps, mudflats or sandflats of estuaries or beaches on sheltered coasts.
Night Parrot (*Pezoporus occidentalis*)	Endangered - EPBC Act, CR BC Act	Possible, however 20 targeted Night Parrot ARU sites were sampled over several months, with no calls detected.	Appears to favour areas of dense vegetation comprising old-growth (often >50 years unburnt) spinifex (*Triodia* spp.), especially hummocks that are ring-forming for roosting and nesting. These may be in expanses or isolated patches, and may be associated with dense chenopod shrubs. Foraging habitats that are likely to include various native grasses and herbs, and may or may not contain shrubs or low trees.
Roseate Tern (*Sterna dougallii gracilis*)	Migratory - EPBC Act, BC Act	Likely	Inhabits rocky and sandy beaches, coral reefs, sand cays and offshore islands. Rarely occur in inshore waters or near the mainland, usually venturing into these areas only accidentally, when nesting islands are nearby.
Fairy Tern (*Sterna nereis nereis*)	Vulnerable – EPBC Act and BC Act	Possible	In WA, the species is present along the entire coastline, with rare records from the far north (Kimberley) and off the Nullarbor Plain. Usually nests on islands, estuaries or sandy beaches.
Marsh Sandpiper (*Tringa stagnatilis*)	Migratory - EPBC Act, BC Act	Possible	Occurs along the WA coast and throughout parts of eastern Australia. The species inhabits coastal and inland wetlands, estuarine and mangrove mudflats, beaches, swamps, lakes and several other types of wetlands.

All bird species considered to possibly occur are Migratory birds, except for the Peregrine Falcon, Grey Falcon and Night Parrot. The falcons both have large foraging ranges and could easily travel from nests in the ranges east of the TFSA (~20 km). Night Parrot is discussed further below.

Night Parrot

A 'moderately certain' sighting of the Night Parrot was recorded in 1967 (DBCA, 2017b), just west of the Robe River homestead, approximately 30 km south of the Proposal. The helicopter was used in the March 2018 survey to visit this site (site S017; Phoenix, 2020b). The vegetation was comprised of open woodland (riparian), with semi-mature spinifex hummocks. This is similar to the basic structure of small areas of open woodland (riparian) habitat within the TFSA, but the Robe River is an order a magnitude larger than any watercourses present within the TFSA.

Twenty-one targeted Night Parrot ARU sites were sampled over several months, with no calls detected. Therefore, while it is reasonable to assume the species is not present it cannot be entirely discounted (Phoenix, 2020b).

Spinifex grassland would be considered the most likely potential habitat for Night Parrot. This habitat type principally occurs east of the concentrator and crystalliser ponds, but also on islands within the mudflats / saltflats and near the coast (Figure 119). A large extent of spinifex grassland was heavily impacted by cattle and the abundance of Mesquite (~857 ha). However, there were also large areas of high quality, mature spinifex hummock grassland, particularly south of the homestead, east of the Ponds and Terrestrial Infrastructure Development Envelope (Phoenix, 2020b).

10.3.7 Short-range Endemic Fauna

Survey effort for SREs focussed largely on the island habitats within the mudflats, as this was identified in the initial review as the most likely habitat to support SREs (Phoenix, 2017a).

A single invertebrate within a group known to include SREs was recorded from amongst samphire shrubs at the base of a mudflat 'island'; a mygalomorph trap-door spider in the family Nemesiidae, *Aname melosa*. Several other similar sites were searched, and no additional specimens were obtained. This species is one of the most widespread Nemesiidae in the Pilbara. Castalanelli *et al.* (2014) recently determined *Aname melosa* to be comprised of ten genetic clades just within the Pilbara, and consequently, to be the most striking example of where genetic analysis did not agree with the morphology. Accordingly, the ten clades are still considered part of a single species that occurs broadly across the Pilbara and which is therefore not an SRE.

Dead shells of Camaenidae land snails were observed on nearly all mudflat islands visited but no live specimens were collected to allow for identification. Marine molluscs were also distributed widely across many of these islands suggesting recent and/or repeated marine inundation.

No specimens from the genus of the unidentified Mouse Spider (*Missulena* sp. indet.), identified in the desktop review as likely to occur in spinifex grasslands of the TFSA, were recorded during the field survey.

10.3.8 Introduced Fauna

Evidence of introduced animal presence was common in the TFSA, including agricultural species (cattle) and pest species (feral cat, red fox, black rat, dog and horse). Mardie Station has a long history of stock grazing, originally sheep and then cattle. Pastoral grazing on the property has resulted in considerable modification of the natural environment, including transformation of large areas of Horseflats grasslands to a buffel grass-dominated grassland. Pockets of intact *Triodia* grasslands do remain, but they are small and isolated and predominantly occur well beyond the various stock water points or creeklines.

Both grazing pressure and presence of feral cat and red fox, as key introduced predator species, are likely to have substantively influenced the distribution and abundance of native fauna species in the TFSA.

10.3.9 Environmental Values

The information provided in Section 10.3.4 – 10.3.8 was utilised to determine the environmental values that require assessment for this factor. Values were included for assessment based on the following parameters, taken from the Environmental Factor Guideline; Terrestrial Fauna (EPA, 2016k):

- Fauna species listed under the EPBC Act or BC Act that were recorded or considered likely to occur within the study areas, as well as the Night Parrot;
- Species with restricted distribution;

- Species with a degree of historical impact from threatening processes; Species that provide an important function required to maintain the ecological integrity of a significant ecosystem; and
- Habitat types that are important to the life history of a significant species, i.e. breeding, feeding and roosting or aggregation areas, or where they are unique or isolate habitats in the landscape or region.

Table 49 assesses each habitat type against the significance criteria.

Table 49: Significant fauna habitats of the study area

Habitat	Habitat type that is important to the life history of a significant species	Unique or isolated habitats
Mudflat or saltflat	No	No
Tidal samphire mudflats	Yes – provides habitat for Migratory shorebirds	No
Spinifex grassland	No	No
Tidal channel and ocean	N/A – assessed under Section 6	
Mangal community	Yes – provides habitat for Migratory shorebirds and other significant fauna	Yes – isolated to coastal fringe
Tussock grassland	No	No
Cleared	No	No
Spinifex grassland on rocky hills	Yes – provides habitat for Northern Quoll and Western Pebble-mound Mouse	Yes – provides isolated habitat
Open woodland (riparian)	Yes – provides habitat for Pilbara Olive Python and Pilbara Leaf-nosed Bat	Yes – constrained to creeklines
Beach and dune	N/A – assessed under Section 6	
Low shrubland	No	No
Fresh water pool	Yes – provides habitat for Pilbara Olive Python and Pilbara Leaf-nosed Bat	Yes – only two pools recorded

The following environmental values were therefore determined to require assessment for this factor:

- General fauna species and habitat (provides a general assessment of fauna assemblages and habitat);
- Tidal samphire mudflats habitat;
- Open woodland (riparian) habitat (including Fresh water pool);
- Pilbara Leaf-nosed Bat;
- Northern Coastal Free-tailed Bat;
- Pilbara Olive Python;
- Northern Quoll; and
- Migratory birds, including those protected under the EPBC Act.

As the Short-tailed Mouse was not recorded and occupies a range of different habitats it is to be assessed in the context of 'general fauna species and habitat'.

The Airlie Island Ctenotus (P3 – DBCA) generally inhabits the landward fringe of salt marsh communities in samphire shrubland or marine couch grassland in the intertidal zone along mangrove (Grey Mangrove (*Avicennia marina*) with occasional Red Mangrove (*Rhizophora stylosa*) margins (Phoenix, 2020b). Given that no known populations have been recorded within proximity to the Proposal the habitat assessment for tidal samphire mudflats habitat is considered to be sufficient to assess impacts to this species.

Potential impacts tidal channel and ocean, mangal communities and beach and dune habitats have previously been assessed in detail in Section 6 (BCH) and therefore has not been re-assessed in this section. The previous assessment is however referred to when assessing potential impacts on specific species that utilise this habitat (i.e. Migratory birds).

Spinifex grassland on rocky hills habitat was not included in the assessment as it did not occur within the development envelopes and therefore will not be directly impacted by the Proposal. Indirect impacts in this location (the eastern end of the access road) are unlikely to be significant.

10.4 Potential Impacts

Table 50 defines the potential impacts (direct, indirect and cumulative) on the environmental values for this factor in a local and regional context.

Given the ecological significance of mangal communities Mardie Minerals commissioned O2 Marine to conduct a detailed mapping exercise that focussed on the areas of this habitat type that may be impacted by the Proposal. The outcomes of this mapping exercise are detailed in O2 Marine (2020a) and equated to a total of 17 ha of SC Mangroves being impacted. The O2 Marine (2020a) mapping therefore supersedes the Phoenix (2020b) mapping and as such has been used for impact assessment in this ERD.

Table 50: Potential impacts on terrestrial fauna

Environmental value and current extent	Potential direct impact	Potential indirect impact	Impacts associated with other proposals	Total cumulative impact
General fauna species and habitat. Current habitats are relatively undisturbed, all vegetation associations have more than 89% of their pre-European extent remaining (Least Concern).	Up to 11,142 ha disturbance, including 7,340 ha of barren saltflats	Alteration of habitat characteristics as a result of changes to surface water regimes. Predation or competition from an increased risk of introduced fauna. Concentrator and crystalliser ponds attracting fauna and potential fauna entrapment. Alteration of behaviour as a result of noise or light emissions. Ponds result in a barrier to fauna movement. Reduction in habitat health as a result of: • Increased sedimentation during construction • Leaks or spillages of hypersaline brine, hydrocarbons or chemicals	243 ha of disturbance associated with the two gas pipeline corridors that intersect the development envelopes.	Approximately 11,464 ha of direct disturbance of fauna habitat with some potential indirect vegetation health impacts.

Environmental value and current extent	Potential direct impact	Potential indirect impact	Impacts associated with other proposals	Total cumulative impact
		• Introduction or spread of weed species		
Tidal samphire mudflats habitat. 5,213 ha mapped within TFSA.	Up to 1,115 ha of disturbance	Reduction in habitat health as a result of: • Increased sedimentation during construction • Alterations to surface water regimes • Leaks or spillages of hypersaline brine, hydrocarbons or chemicals	43 ha was disturbed in order to construct the two gas pipeline corridors	Up to 1,158 ha of disturbance with some potential indirect impacts.
Open woodland (riparian) habitat (including Freshwater pool) 74 ha mapped within study areas.	Up to 6 ha of disturbance (freshwater pool excluded from the DE)	Reduction in habitat health as a result of: • Increased sedimentation during construction • Alterations to surface water regimes • Leaks or spillages of hypersaline brine, hydrocarbons or chemicals • Introduction or spread of weed species	The open woodland (riparian) habitat does not appear to have been disturbed as a result of the development of two gas pipelines.	Up to 6 ha of disturbance with some potential for indirect habitat health impacts.
Pilbara Leaf-nosed Bat. *Triodia* grasslands may provide foraging habitat. 8,137 ha mapped within the Study Area. Mardie Pool lies outside the development envelopes.	Approximately 2,396ha of disturbance of *Triodia* grasslands foraging habitat.	Alteration of behaviour as a result of noise or light emissions. Reduction in habitat health as a result of: • Increased sedimentation during construction • Alterations to surface water regimes • Leaks or spillages of hypersaline brine, hydrocarbons or chemicals • Introduction or spread of weed species	41 ha of *Triodia* grasslands were disturbed in order to construct the two gas pipeline corridors.	Up to 2,437 ha of disturbance to *Triodia* grasslands foraging habitat, with some minor indirect habitat health impacts.
Northern Coastal Free-tailed Bat. 1,689 ha of mangal community habitat and 5,213 ha of tidal samphire shrublands were recorded in the TFSA, which provide potential roosting and	Up to 17 ha of disturbance of mangal community habitat and 1,115 ha of tidal samphire shrubland habitat	Alteration of behaviour as a result of noise or light emissions. Reduction in habitat health as a result of: • Increased sedimentation during construction • Alterations to surface water regimes • Leaks or spillages of hypersaline brine, hydrocarbons or chemicals • Introduction or spread of weed species	An estimated 4 ha of disturbance of mangal community habitat and 43 ha of tidal samphire shrubland habitat was disturbed to construct the two gas pipeline corridors.	Up to 26 ha of disturbance of mangal community habitat and 1,158 ha of tidal samphire shrubland habitat, with some minor indirect habitat health impacts.

Environmental value and current extent	Potential direct impact	Potential indirect impact	Impacts associated with other proposals	Total cumulative impact
foraging habitat.				
Pilbara Olive Python 74 ha of potential habitat mapped within study areas.	Up to 6 ha of disturbance of potential habitat.	Increased competition from introduced fauna. Injury or death of individuals due to vehicle strike Alteration of behaviour as a result of noise or light emissions. Reduction in habitat health as a result of: • Leaks or spillages of hydrocarbons or chemicals • Introduction or spread of weed species	Potential habitat does not appear to have been disturbed as a result of previous development.	Up to 6 ha of disturbance of potential habitat, with some indirect impacts
Northern Quoll No denning / shelter habitat recorded within development envelopes 81.9 ha of the development envelope occurs within 1 km of the Northern Quoll records and could be considered foraging habitat	Up to 64.5 ha of disturbance of potential foraging habitat.	Increased predation or competition from introduced fauna. Injury or death of individuals due to vehicle strike Alteration of behaviour as a result of noise or light emissions. Access road results in a barrier to movement. Reduction in habitat health as a result of: • Leaks or spillages of hydrocarbons or chemicals • Introduction or spread of weed species	An estimated 6 ha of foraging habitat was disturbed to construct the current Mardie Station access road. Indirect impacts associated with the current access road.	Up to 70.5 ha of disturbance of potential foraging habitat, with some indirect impacts
Migratory birds Potential foraging and roosting habitat was recorded within the TFSA: • 1,689ha of mangrove communities • 5,213ha of tidal samphire mudflats • 2,780 ha of tidal channels and ocean habitat	Disturbance of up to: • 17 ha of mangrove communities • 1,115 ha of the tidal samphire mudflats • 72 ha of tidal channel and ocean habitat	Alteration of behaviour as a result of noise or light emissions. Attraction and use of concentrator and crystalliser ponds. As described in the mangrove assessment in Section 6 - BCH. Reduction in habitat health as a result of: • Increased sedimentation during construction • Alterations to surface water regimes • Leaks or spillages of hypersaline brine, hydrocarbons or chemicals	An estimated 4 ha of disturbance of mangrove community habitat and 43 ha of tidal samphire shrubland habitat was disturbed to construct the two gas pipeline corridors.	Disturbance of up to: • 26 ha of mangrove communities • 1,158 ha of the tidal samphire mudflats • 72 ha of tidal channel and ocean habitat Some potential indirect impacts.

10.5 ASSESSMENT OF IMPACTS

The following sections assess the potential impacts on each environmental value identified in Section 10.3.6.

10.5.1 GENERAL FAUNA SPECIES AND HABITAT

Direct Disturbance

The Proposal will result in the direct disturbance of up to 11,142ha of terrestrial fauna habitat. There are several items of note during this assessment:

- The disturbance is to occur within a largely uncleared landscape as all vegetation associations currently have at least 89% of their pre-European extent remaining (Shephard *et al.*, 2002);
- A large proportion (71%) of the development envelopes represents low value unvegetated fauna habitat as it represents 'mudflat or saltflat' mapped by Phoenix (2020b);
- Large portions of terrestrial habitats are heavily impacted by a Mesquite infestation; and
- There has been minimal clearing in the local area, limited to that required for pastoral purposes and the construction of three gas pipelines (242 ha).

When assessing the disturbance associated with the Proposal at a broad scale, the majority of the disturbance will occur within two vegetation associations; '127: Bare areas, mud flats', and '601: Mosaic: Sedgeland'. The current extent of vegetation association '127: Bare areas, mud flats' is 159,595 ha, 89.8% of its pre-European extent. The Proposal targets bare mudflat habitat in order to minimise vegetation clearing, and 9,761 ha of the development envelope intersects with the mapped boundary of this vegetation association, which equates to 5.5% of its pre-European extent. This vegetation association also extends over a large length of the Pilbara coast (Phoenix 2020a), including a portion of the area proposed for the Eramurra Industrial Salt Project (note that the Ashburton Salt Project does not intersect with this vegetation association). This Project had not completed its assessment under Part IV of the EP Act at the time of the ERD publication therefore accurate disturbance calculations were unable to be conducted, however based on the Section 38 Referral documentation the disturbance is predicted to be less than 8,000 ha. This appears to be a conservative approach given that there appears to be less of this vegetation association at the Eramurra Industrial Salt Project. Based on the assumption that this Proposal and the Eramurra Industrial Salt Project proceeds, cumulative disturbance across the two proposals may be in the order of 17,500 ha, or 9.9% of its pre-European extent. The Proposal will therefore bring the remaining extent of vegetation association 127, and the fauna habitats that it supports to approximately 80.19% pre-European extent remaining, which is still well within the category of 'Least Concern' (Shepherd *et al.,* 2002).

The current extent of vegetation association '601: Mosaic: Sedgeland' is 109,618 ha, which equates to 99.9% of its pre-European extent. 5,624 ha of the development envelopes intersect with the mapped boundary of this vegetation association, however only 2,067 ha is predicted to be disturbed, which equates to 3.5% of its pre-European extent. This vegetation association is limited to areas inland from the Proposal, and therefore there are no other cumulative impacts that need to be considered. The Proposal will therefore bring the remaining extent of vegetation association 601, and the fauna habitats that it supports, to approximately 96.4% pre-European extent, which is still well within the category of 'Least Concern' (Shepherd *et al.,* 2002).

Table 51 lists out the potential direct and indirect impacts to fauna habitats mapped during the surveys. Regional extent has been included if similar habitat types were mapped over the broader region by Stantec (2018).

Indirect impacts referred to in Table 48 relate to hydrological changes and are discussed in the following section. They have been included in Table 48 to provide an overview of the total impact extents on each habitat type.

Table 51: Potential direct and indirect impacts to fauna habitats

Fauna Habitat types	Regional extent (ha / numbers)	Extent in TFSA (ha)	Extent in Development Envelope (ha)	Extent in Disturbance Footprint (ha)	Indirect Impacts (ha)	Cumulative Proposal impacts
Mudflat or saltflat	17,424	10,371.5	8,014.6	7,340.3	18.5	7,358.8 ha (71.0% of TFSA extent, 42% of regional extent)
Tidal samphire mudflat	13,111	5,212.7	1,371.4	1,115.0	492.7	1,607.7 ha (30.8% of TFSA extent, 12% of regional extent)
Spinifex grassland	26,741	4,492.2	2,562.6	1,278.2	112.4	1,390.6 ha (26.9% of TFSA extent, 4.5% of regional extent)
Shrubland over spinifex grassland		3,644.2	3,160.0	1,117.4	53.7	1,171.1 ha (31% of TFSA extent, 5% of regional extent)
Tidal channel or ocean	14,960	2,780.6	356.2	71.7	0	72.0 ha (2.6% of TFSA extent, <1% of regional extent)
Mangal community	7,849	1,689.3	26.3	22.1	100.1	122.2 ha (7.2% of TFSA extent, 2% of regional extent)
Tussock grassland	-	483.0	373.2	230.6	0	230.6 ha (48% of TFSA extent)
Cleared	-	241.6	128.2	37.7	N/A	N/A
Spinifex grassland on rocky hills	-	120.9	0.0	0.0	0	0 ha
Open woodland (riparian)	89.0	73.5	15.9	5.4	14.1	19.5 ha (17.3% of TFSA extent, 22% of regional extent)

Fauna Habitat types	Regional extent (ha / numbers)	Extent in TFSA (ha)	Extent in Development Envelope (ha)	Extent in Disturbance Footprint (ha)	Indirect Impacts (ha)	Cumulative Proposal impacts
Beach/dune	2,331	17.1	1.6	0.3	0	0.3 ha (1.7% of TFSA extent, <1% of regional extent
Low shrubland	-	13.7	12.5	2.7	4.4	7.1 ha (55.5% of TFSA extent)
Freshwater pool	-	1.0	0.6	0.0	0	0 ha

An assessment of the impacts of the direct disturbance of fauna habitat has been provided below. Where more detail is warranted it has been provided in subsequent sections:

- **Mudflat or saltflat** – 7,340.0 ha of this habitat type is proposed to be disturbed, mostly by the development of concentrator and crystalliser ponds. This equates to 70.48% of the extent within the TFSA and 42% of the regional extent mapped by Stantec. Given the very low value of this habitat for fauna based on the number of species and populations it supports, this impact is not considered to be significant;
- **Tidal samphire mudflat** – 1,115.0 ha of this habitat type is proposed to be disturbed, mostly within the first two concentrator ponds. This equates to 21.4% of the extent within the TFSA and 9% of the regional extent mapped by Stantec. Given the high value of this habitat for fauna this impact is assessed in more detail in Section 10.5.2;
- **Spinifex grassland** – 1,278.2 ha of this habitat type is proposed to be disturbed. This equates to 28.5% of the extent within the TFSA and 5% of the regional extent mapped by Stantec. Given the broad extent of this habitat type in the region, this impact is not considered to be significant, however it does hold some value as foraging habitat for the Northern Coastal Free-tailed Bat, therefore this impact is assessed in more detail in Section 10.5.7;
- **Shrubland over spinifex grassland** – 1,117.4 ha of this habitat type is proposed to be disturbed. This equates to 30.7% of the extent within the TFSA and 5% of the regional extent mapped by Stantec. Given the broad extent of this habitat type in the region, this impact is not considered to be significant, however it also holds some value as foraging habitat for the Northern Coastal Free-tailed Bat, therefore this impact is assessed in more detail in Section 10.5.7;
- **Tidal channel or ocean** – 72.0 ha of this habitat type is proposed to be disturbed. This equates to 2.6% of the extent within the TFSA and <1% of the regional extent mapped by Stantec. Given the broad extent of this habitat type in the region, this impact is not considered to be significant;
- **Mangal community** – 22.1 ha of this habitat type is proposed to be disturbed. This equates to 1.3% of the extent within the TFSA and <1% of the regional extent mapped by Stantec. Given the high value of this habitat for fauna this impact is assessed in more detail in Section 7.5.2;
- **Tussock Grassland** – 230.6 ha of this habitat type is proposed to be disturbed. This equates to 47.8% of the extent within the TFSA. Given the broad extent of this habitat type in the region, this impact is not considered to be significant, however it also holds some value as foraging habitat for the Northern Coastal Free-tailed Bat, therefore this impact is assessed in more detail in Section 10.5.7;

- **Open woodland (riparian)** – 5.4 ha of this habitat type is proposed to be disturbed. This equates to 7.3% of the extent within the TFSA and 6% of the regional extent mapped by Stantec. Given the high value of this habitat for fauna and its restricted distribution this impact is assessed in more detail in Section 10.5.3;
- **Beach / dune** – 40.3 ha of this habitat type is proposed to be disturbed. This equates to 1.7% of the extent within the TFSA but only <1% of the regional extent mapped by Stantec. Given the broad extent of this habitat type in the region, this impact is not considered to be significant. Note that impacts to this habitat have been assessed as BCH in Section 6.5; and
- **Low shrubland** – 2.7 ha of this habitat type is proposed to be disturbed. This equates to 19.0% of the extent within the TFSA. Given that more than 80% of the local extent of this habitat type will remain undisturbed, and that no conservation significant fauna were found solely in this habitat type, this impact is not considered to be significant.

Changes to Surface Water Regimes

As detailed in Table 51 and Section 5 (Inland Waters), there will be some terrestrial fauna habitats that will be subject to changes to the local surface water regimes. There are four ways that changes to overland flows caused by the Proposal could potentially indirectly impact fauna habitats:

1. Less fresh water reaches the fauna habitats downstream of the ponds if fresh water flows are diverted away from these areas;
2. Less fresh water reaches the vegetation upstream of the ponds if fresh water flows are diverted around the area;
3. Increased fresh water inundation occurs within vegetation downstream of the ponds if the habitats are close to the diversion channel outlets; and
4. Increased fresh water inundation occurs within vegetation upstream of the ponds if fresh water flows pool against the embankment.

The concentrator ponds have been designed to include two large drainage channels to allow overland flow through the development envelopes. In addition, the size of the southern-most pond has been reduced significantly to allow the main channel of Peters Creek to continue to flow to the ocean. RPS (2019; Appendix 1.1) modelled the potential changes to the overland freshwater flows due to the presence of the ponds and determined that there would be some moderate changes to the flow regime as a result of the Proposal. Section 5 (Inland Waters) provides more detail about this modelling and predicted results.

In the context of fauna habitat the influence of the overland freshwater flow changes can be summarised below:

- **Mudflat or saltflat** - 18.5 ha of this habitat type will experience altered fresh water inflows, with 12.3 ha being wetter and 0.8 ha being drier than current conditions. An additional 5.4 ha will be flooded during a 100 year ARI rainfall event. This equates to less than 0.2% of the extent within the TFSA and given the low value of this habitat for fauna this impact is not considered to be significant;
- **Tidal samphire mudflat** - 492.7 ha of this habitat type will experience altered fresh water inflows, with 438.3 ha being wetter and 50.5 ha being drier than current conditions. An additional 3.9 ha will be flooded during a 100 year ARI rainfall event. This equates to 9.5% of the extent within the TFSA and given the high value of this habitat for fauna this impact is assessed in more detail in Section 10.5.2;

- **Spinifex grassland** – 112.4 ha of this habitat type will experience altered fresh water inflows, with 0.2 ha being wetter than current conditions. An additional 112.2 ha will be flooded during a 100 year ARI rainfall event. This equates to 2.5% of the extent within the TFSA and given the temporary nature of the impact, and broad extent of this habitat type in the region, this impact is not considered to be significant;
- **Shrubland over spinifex grassland** – 53.7 ha of this habitat type will experience altered fresh water inflows, with this area being flooded during a 100 year ARI rainfall event. This equates to 1.5% of the extent within the TFSA and given the temporary nature of the impact, and broad extent of this habitat type in the region, this impact is not considered to be significant;
- **Mangal community -** 100.1 ha of this habitat type will experience altered fresh water inflows, with 54.2 ha being wetter and 45.9 ha being drier than current conditions. This equates to 5.9% of the extent within the TFSA and given the high value of this habitat for fauna this impact is assessed in more detail in Section 7.5.2;
- **Open woodland (riparian)** – 14.1 ha of this habitat type will experience altered fresh water inflows, with 6.8 ha being drier than current conditions and 7.3 ha will be flooded during a 100 year ARI rainfall event. This equates to 19.2% of the extent within the TFSA and given the high value of this habitat for fauna this impact is assessed in more detail in Section 10.5.3; and
- **Low shrubland** – 4.4 ha of this habitat type will experience altered fresh water inflows, with this area being flooded during a 100 year ARI rainfall event. This equates to 32.1% of the extent within the TFSA and given the temporary nature of the impact, and that no conservation significant fauna were found solely in this habitat type, this impact is not considered to be significant.

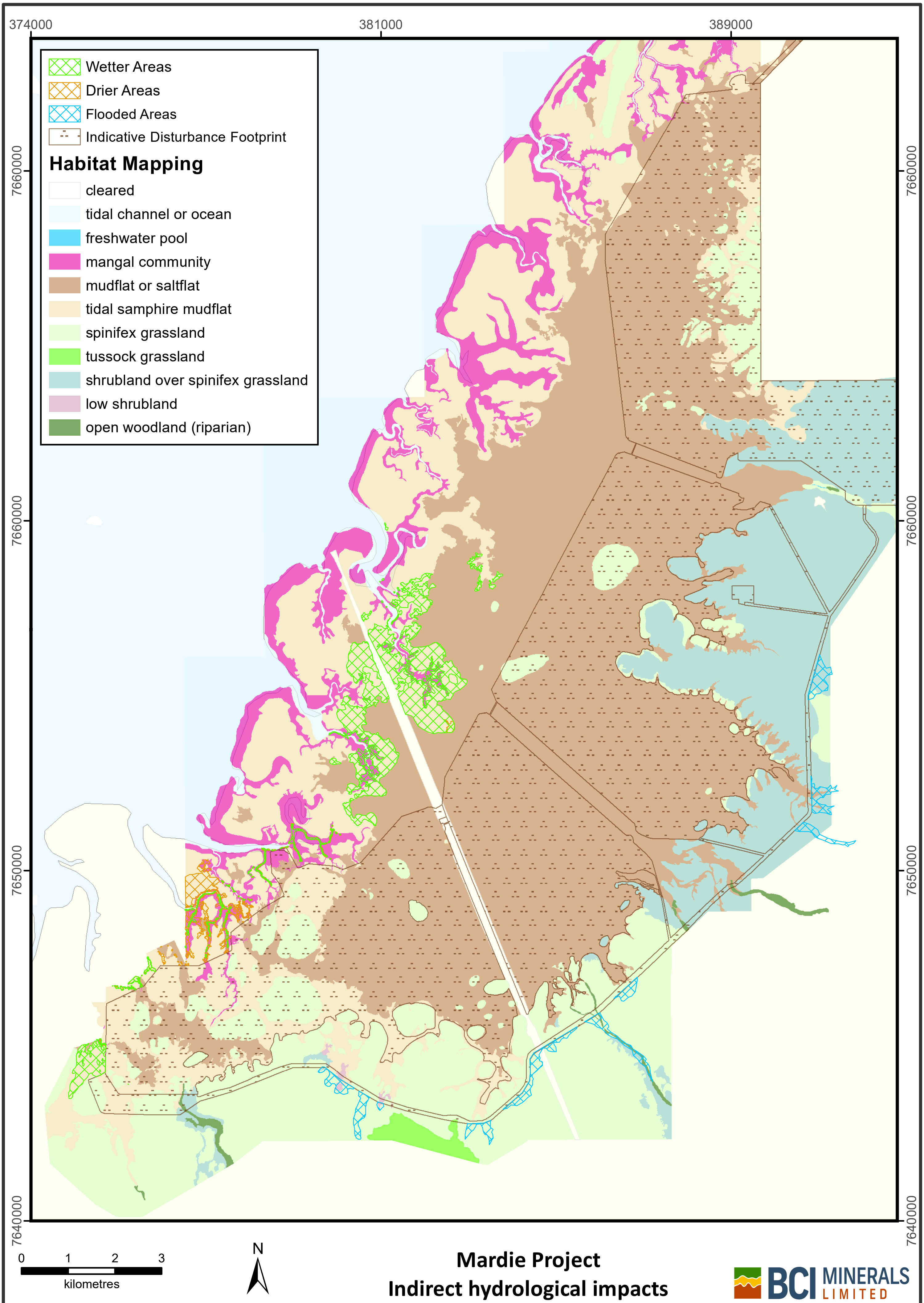


Figure 124: Change in hydrological characteristics within fauna habitats

Introduced Fauna

Several feral animals were recorded within the TFSA, including dogs, foxes and cats (Phoenix, 2020b). 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 10.6.2).

Pond Fauna Attraction

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, the Port Hedland Dampier Saltworks are listed as Important Bird and Biodiversity Areas (IBAs) (Birdlife Australia, 2005–2007), and Houston *et al*. (2012) concluded after studying two salt fields associated with the Fitzroy River estuary, Queensland, that saltfields are "an integral component of the ecology of the landscape, providing complementary resources to that of the natural wetlands."

Pond Fauna Entrapment

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 10.6.2).

Noise and Light Emissions

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 processing plant, which covers only several hectares and is located away from the coastline, and the salt washplant and stockyard, which are located adjacent to the coast. . 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 8.6), these controls will also minimise light impacts on terrestrial fauna.

Erosion and Sedimentation of Terrestrial Habitat

The majority of the disturbance for the Proposal is associated with the flooding of landscape that is inundated to varying degrees by frequent tidal pulses, periodic intense tropical storms and occasional significant catchment discharges. Receiving environments (mangal and samphire habitats) are therefore adept at accommodating changes to local hydrodynamics and sedimentation. .

Excessive erosion at the exits of the lateral drainage channels, as well as the north-south stormwater diversion system, will be prevented by the installation of rock armouring and gabions to stabilise the channel structures and reduce water velocity.

Sediment may be released during construction of the pond walls, particularly during flood and heavy rain events. The wall material is generally high in clay content and will be compacted and rock armoured to ensure sediment losses will are minimal. Mardie Minerals have committed to mitigation measures to reduce the risk of sedimentation (refer to Section 10.6.2).

Barriers to Fauna Movement

The Study Area generally contains two 'zones' of fauna habitat; the coastal zone, which is generally associated with coastal and migratory bird species, and the inland zone, used by terrestrial fauna. In between these zones is several kilometres of bare mudflats, which is generally not utilised or crossed by ground-dwelling fauna species. These mudflats therefore present an existing barrier to fauna movement, other than for birds. As the ponds are generally located on top of these mudflats, the ponds are unlikely to present a new barrier to fauna movement that does not currently exist. The preservation of drainage line corridors will still allow for fauna movement across the pond areas where needed.

Brine Seepage and Spills

Seepage of brine from the ponds is not expected to impact fauna habitat as only small amounts of seepage is predicted, and the down-gradient groundwater is already hypersaline, therefore any seepage will either be less saline or generally equivalent to the current groundwater conditions (refer to Section 5 – 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 10.6). 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 the spill would be limited to an area that is adapted to saline conditions and is regularly inundated with seawater. Brine would be expected to dilute and wash away over a period of several months. 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.

Weeds

Weeds have the potential to be introduced to the area or spread as a result of the Proposal, with the greatest risks associated with earthmoving during the construction period. The Proposal is located on Mardie Station which houses the single largest infestation of mesquite in Australia. The control of the spread of mesquite will require significant controls (refer to Section 10.6). If managed correctly, the Proposal may also reduce the current extent of mesquite infestations as several of the ponds (in particular the crystalliser ponds) are located in areas with particularly dense infestations of Mesquite, which will be cleared prior to construction.

Closure and Rehabilitation

The Proposal will result in large areas of ponds that contain salts or brine and as such the rehabilitation of fauna habitat may be impeded by the presence of salt post-closure. The concentrator ponds are generally located on areas of bare clay pans and salt-tolerant vegetation, therefore rehabilitation is expected to be possible once the salts have been harvested and the walls flattened or opened up to tidal flows. The eastern crystalliser ponds occur outside current salt-tolerant vegetation, however the salt will be easier to remove within these ponds (as they are crystals). These ponds will be able to be rehabilitated in a typical manner (topsoil re-spread and seeding if required) however some soil may need to be removed from the base of the ponds first as it is likely to contain residual salts.

10.5.2 TIDAL SAMPHIRE MUDFLATS HABITAT

This habitat type is well represented through the TFSA (and broader MSSA) however it represents high-value habitat for a number of significant fauna species, including migratory birds. 5,212 ha of this habitat was mapped within the TFSA, and up to 1,371.4 ha of this habitat lies within the development envelopes. There have been numerous design revisions that minimise this disturbance and keep indirect impacts as low as practicable. In particular, the size of the southern-most pond has been significantly reduced which excludes a large portion of this habitat type from the development envelopes.

There are some clear distinctions and variations within this habitat type, with ecological value varying greatly across the mapped extent. The portions of this habitat type that occur closer to the coast have the highest density of vegetation, generally averaging more than 50% cover. The vegetation density generally drops further from the coast, generally averaging 20 - 50% cover mid-way between the coast and the western boundary of the development envelope, and less than 10% cover within the development envelopes. Grant Wells (pers. comm. 5 June 2019) also noted a clear distinction between the coastal samphire vegetation and those found further inland, stating that the coastal portion was “typically denser communities with higher plant density and foliage cover compared to the shrublands on the eastern side…which were notably sparser”.

Figure 73 provides an example of the higher density coastal tidal samphire mudflats habitat in comparison to the same habitat category found further inland (Figure 74).

Figure 116 and Figure 117 provides examples of the percentage cover at various distances from the coast, using a combination of Phoenix (2020a) quadrat data and high-resolution aerial imagery.

Salinity is predicted to be the primary driver of this zonation (O2 Marine, 2019a). Soil salinity in the TFSA is generally predicted to increase with distance from the coast, with a clear linkage to inundation frequency. In the intertidal zone, tidal inundation regularly flushes the soils and maintains a consistent soil salinity. Soils in the upper reaches of the intertidal zone are rarely inundated and as a result the evapoconcentration of tidal waters results in hypersaline conditions. This is evident within the TFSA where the denser coastal samphire vegetation types are inundated regularly whereas the sparser samphire vegetation types found further inland are only inundated in extreme events (refer to Section 5.3.5). Of most relevance to fauna is that lower salinity soils also provides more suitable habitat for invertebrates, with higher numbers recorded closer to the coast where salinity is lowest (O2 Marine, 2019a).

The samphire vegetation found further inland also contain flora species that are known to be terrestrial, such as *Eragrostis falcata* grasses, which range across WA and are found frequently on salt lakes and saline flats (Grant Wells pers. comm. 5 June 2019). These vegetation types are therefore likely to be aligned at the transition between BCH and terrestrial habitats, and in some cases may not be considered habitat for marine and coastal fauna species.

The discussion above aligns with migratory shorebird records for the Proposal, where almost all of the records were taken from the coastal portion of this habitat type (Figure 75 to Figure 78). It also aligns with expert advice sought from Dr Russell Hanley (O2 Marine, 2020d) which states:

> "While tidal samphires and mudflats were designated as important to migratory shorebirds and other birds by the Phoenix surveys they also report the great majority of the birds observations were in the tidal samphires to the west of the development envelope. The tidal samphires lower on the shore, closer to the mangroves and tidal creek margins had high numbers of birds relative to the areas of this habitat higher on the shore. This likely to be a consequence of lower soil salinities closer to the mangroves and tidal creeks due to more regular and longer inundation of the substrate with a corresponding increase in invertebrate infauna".

Based on the above, the tidal samphire mudflat habitats are determined to have a lower ecological value in the context of its usage by fauna as distance from the coast increases. Further discussion on the functional ecology, regional significance and species diversity of these vegetation types is provided within Phoenix (2020a) and Section 9.

Direct Disturbance

The development envelopes contain 1,371 ha of tidal samphire mudflats habitat, and historically, 43 ha of this vegetation is estimated to have been disturbed for the development of the gas pipelines. The previous and proposed disturbances to this habitat type equates to a cumulative direct disturbance of 1,414 ha.).

The direct disturbance of 1,371 ha of tidal samphire mudflats habitat is not expected to be significant as:

- The portion of this vegetation type that is to be disturbed is almost completely within the sparsely vegetated areas further away from the coast. Almost all of the Phoenix (2020a) quadrats within the disturbance footprint had less than 20% cover (
- Figure 116). Given the sites close to the coast generally had more than 50% cover, it is evident that the portion of *Tecticornia* spp. shrubland vegetation that is to be disturbed is of lower value as fauna habitat, with lower invertebrates expected;
- The majority of the remaining mapped vegetation within the Phoenix (2020a) Study Area lies within operational tenements held by Mardie Minerals and therefore is unlikely to be made available for development by another proponent for the duration of the Proposal; and
- This habitat type also extends outside the development envelopes, sharing many characteristics with at least two of the vegetation types mapped at nearby Cape Preston (Biota and M E Trudgen & Assoc 2001; Maunsell 2008). Additionally, Stantec (2018) mapped 13,111 ha of Samphire Community in its 82,800 ha regional study.

Potential Indirect Impacts

The assessment of indirect impacts on tidal samphire mudflats habitat is more complex, particularly as samphire species can be impacted by changes to salinity or inundation. The following potential indirect impacts have therefore been assessed in combination:

- Unintentional spillage or seepage of brine from concentrator and crystalliser ponds or pipelines;
- Changes in overland flows due to the presence of the concentrator and crystalliser ponds; and
- Changes in tidal inundation regimes due to the presence of the concentrator and crystalliser ponds.

A detailed assessment of potential indirect impacts to *Tecticornia* spp. shrubland vegetation has been provided in Section 9.56 as part of the Flora and Vegetation factor. The tidal samphire mudflats habitat closely aligns with *Tecticornia* spp. shrubland vegetation and therefore the full assessment has not been repeated in this section. Noting that mapping differences exist between the flora and fauna surveys, a summary of the findings of the assessment is provided below:

- 438.3 ha of tidal samphire mudflats habitat is predicted to experience more inundation during significant freshwater flow events, however this is likely to be short-term and the habitat characteristics would be expected to return to current conditions relatively quickly after each flow event. No significant impact to this habitat type is therefore expected as a result of this indirect impact;
- 50.5 ha of tidal samphire mudflats habitat is predicted to experience less inundation during significant freshwater flow events. This reduction in flows may influence the germination of some *Tecticornia* species if they rely on a freshwater pulse to germinate. Mardie Minerals has committed to monitoring of *Tecticornia* health within this area and will investigate and implement mitigation measures if impacts are identified (refer to Section 9.6.2);
- 3.9 ha of tidal samphire mudflats habitat is predicted to be flooded during significant run-off events (area is based on a 100-year ARI flow event). This flooding is expected to take days to weeks to infiltrate or evaporate. It has been observed at Lake Carey that samphires will tolerate inundation for a period of about one month if the water is relatively fresh (<50 g/L) (actis Environmental, 2016), therefore this intermittent flooding is unlikely to significantly impact the small area of habitat in this area. The habitat characteristics would be expected to return to current conditions relatively quickly after each flood event; and
- Tidal inundation changes are minimal and are not predicted to significantly alter inundation regimes within this habitat type.

Summary

The Proposal is expected to result in the direct disturbance of up to an estimated 1,115.0 ha of tidal samphire mudflats habitat, and 50.5 ha of this habitat type may be significantly indirectly impacted by changes to tidal inundation regimes. This equates to 23.1% of the total extent mapped within the TFSA when cumulative impacts are considered, and 9.2% of the total regional extent mapped by Stantec (2018). The portion of this habitat type that is to be disturbed is almost completely within the sparsely vegetated areas further away from the coast. Almost all of the Phoenix (2020a) quadrats within the disturbance footprint had less than 20% (

Figure 116). Given the sites close to the coast generally had more than 50% cover, it is evident that the portion of tidal samphire mudflats habitat that is to be disturbed is of lower value to fauna species..

The avoidance measures implemented during the Proposal design have resulted in more than 76.9% of this habitat type being retained within the TFSA (and almost all of the higher value coastal portions) and unlikely to be indirectly impacted by the Proposal. Given that high value coastal portions of this habitat type extend along the coastline outside the development envelopes the Proposal is not expected to significantly impact this habitat type in a regional context.

10.5.3 Open woodland (riparian) habitat (Inc. Freshwater Pool)

Western-flowing creek line habitats (open woodland (riparian)) were found to support an abundant and diverse terrestrial bird community, and other significant fauna species such as the Pilbara Leaf-nosed Bat. Mardie Pool that occurs on one of these creeks (Figure 123) and is arguably the most important habitat feature of this type. Mardie Pool has been completely avoided by the Proposal by excluding it from the development envelopes. Less than 5.4 of the mapped extent of Open Woodland habitat is expected to be disturbed based on the current disturbance footprint (7.3% of mapped extent). Direct impacts to this habitat are therefore not considered significant.

Mardie Pool is considered to be an environmental value under the Inland Waters Environmental Factor and as such a detailed assessment of direct and indirect impacts has been conducted in Section 5.5.3. This assessment determined that the values of Mardie Pool could be maintained with the implementation of the mitigation measures listed in Section 5.6.2.

An estimated 14.1 ha of this habitat type will experience altered fresh water inflows, with 6.8 ha being drier than current conditions and 7.3 ha will be flooded more than current conditions during a 100 year ARI rainfall event. The 6.8 ha area of habitat that will be drier than current conditions is predicted to experience a gradual decline in health due to the reduced fresh surface water inflows. Mardie Minerals will incorporate offtake drainage within the larger drainage structures to attempt to maintain flows to these areas during flow events (refer to Section 10.6.2).

The 7.3 ha area that will be flooded to a greater depth during a 100 year ARI rainfall event is not predicted to be significantly impacted, as water levels are not expected to take longer than days to weeks to infiltrate or evaporate. The habitat characteristics would be expected to return to current conditions relatively quickly after each flood event.

There are no other indirect impacts to this environmental value that require assessment in addition to those that were assessed in detail in Section 10.5.1.

10.5.4 Pilbara Leaf-nosed Bat

The Pilbara Leaf-nosed Bat (*Rhinonicteris aurantia* Pilbara) was recorded at two riparian open woodland habitats and a creek that was flowing due to recent rainfall (Figure 123). There are no caves in the development envelopes and therefore roost sites are unlikely to be present. Habitat of value to this species is therefore limited to foraging habitat and water sources. Mardie Pool occurs on one of these creeks (Figure 123) and is likely to be regularly used as a water source or foraging by the species, however Mardie Pool is outside the development envelopes and will not be significantly impacted by the Proposal(refer to Section 10.5.4). Western-flowing creekline habitats (open woodland (riparian)) also support foraging by Pilbara Leaf-nosed Bat (refer above).

The other creeks within the development envelopes do not contain permanent water and are more likely to be used seasonally by the species when they are in flow or contain pools. Observations during the Phoenix (2020b) surveys suggest pools persist in some creeks in the local area for several months following rainfall events inland. Only a small percentage of the open riparian woodland surveyed (15.9 ha of 74 ha) is located in the development envelope, only 5.4 ha is expected to be disturbed (7.3% of mapped extent). No impact to such pools is expected, as modelling conducted for overland flows shows (refer to Section 5.5.2). Direct impacts to this habitat are not considered significant and therefore impacts to this species are likely to be low.

There are no indirect impacts to this environmental value that require assessment in addition to those that were assessed in detail in Section 10.5.1.

10.5.5 PILBARA OLIVE PYTHON

The Pilbara Olive Python (*Liasis olivaceus barroni*) was not recorded during the Phoenix (2020b) survey however 'open woodland (riparian)' and 'freshwater pool' habitat was deemed to be potential habitat for this species (Figure 123). Mardie Pool (Figure 123) may be used as a water source or foraging by the species, however it lies outside the development envelopes and will not be significantly impacted by the Proposal.

15.9 ha of the open riparian woodland surveyed (73.5 ha) is located in the development envelope, but less than 5 .4 ha is expected to be disturbed (7.3% of mapped extent). No significant impact to freshwater pools is predicted, as shown by modelling conducted for overland flows (refer to Section 5.5.2), provided mitigation measures described in Section 5.6 are implemented. Direct impacts to this habitat are not considered significant and therefore impacts to this species are likely to be low.

There are no other indirect impacts to this environmental value that require assessment in addition to those that were assessed in detail in Section 10.5.1 and 10.5.3.

Based on the above, the Proposal is considered unlikely to have a significant impact on this species.

10.5.6 NORTHERN QUOLL

Northern Quoll was recorded from low rocky hills north of the haul road (spinifex grassland on rocky hills habitat), outside the development envelopes (Figure 123). This habitat is considered denning / shelter habitat for the species but does not occur in the development envelopes. Potential impacts to this species are therefore limited to the disturbance of foraging habitat and indirect impacts associated with the presence of an access road.

The Proposal includes the widening of the existing Mardie Station access road, which will require the disturbance of 64.5 ha of potential foraging habitat (located within 1 km of denning / shelter habitat). This disturbance represents only a small incremental decrease in foraging habitat, alongside an already disturbed road alignment.

The number of vehicles using the access road will increase due to the Proposal, which will increase the risk of the death or injury of individuals due to vehicle strike. The road will not be used as a haul road and workforce vehicle movements will be relatively low, as personnel will be accommodated on site (i.e. will not drive in on a daily basis) and a significant workforce is not required for the Proposal during operation. Mitigation measures have also been proposed in Section 10.6 to reduce this risk as far as practicable.

There are no other indirect impacts to this environmental value that require assessment in addition to those that were assessed in detail in Section 10.5.1 and 10.5.3.

Based on the above, the Proposal is considered unlikely to have a significant impact on this species.

10.5.7 NORTHERN COASTAL FREE-TAILED BAT

The Northern Coastal Free-tailed Bat (*Ozimops cobourgianus*) is mangrove-obligate species that occurs in rainforest, monsoon forest riparian zones and mangrove communities. It is known to roost in mangrove mosaics along the coastline. This species was recorded across the mangal community and tidal samphire shrublands, and also 'inland' east of the mudflat playa, suggesting fairly wide-ranging foraging activity.

This species is expected to utilise mangrove community habitat for roosting and foraging. 1,690ha of mangrove community habitat was recorded in the TFSA. Potential impacts to mangrove habitats are discussed in detail in the BCH factor section (Section 6) and can be summarised as a loss of 17 ha (1%) of mangroves.
Little is known about the foraging range of this species except that it is rarely detected away from the coast. The species was recorded foraging in the tidal samphire mudflats and east of the development envelopes in the grassland habitat.

Potential impacts to tidal samphire mudflats habitat is discussed in detail in Section 10.5.2 and can be summarised below:

- 5,213 ha of tidal samphire shrublands habitat was recorded in the TFSA;
- The Proposal is expected to result in the direct disturbance of up to 1,115.0 ha of tidal samphire mudflats habitat;
- 54.4 ha of this habitat type is expected to be indirectly impacted by changes to inland surface water flow regimes; and
- This equates to 23.1% of the total extent mapped within the Study Area when cumulative impacts are considered.

Grassland habitat types covered 8,619 ha of the TFSA, and extend east of the TFSA (Phoenix, 2020b). With the exception of the eastern crystalliser ponds only low levels of clearing is proposed in these areas such as access tracks, camps and laydown (Figure 3). Given that this habitat type also extends east of the development envelopes (Phoenix, 2020b) the Proposal is not expected to significantly reduce the grassland foraging habitat for this species.

Based on the above, the Proposal will result in a small reduction in the available mangrove community habitat, however significant areas of mangroves will be retained for roosting and foraging by this species. Foraging areas within tidal samphire shrublands habitat and grasslands habitat will be reduced however given the extent of habitat that will be retained within and outside the TFSA the Proposal is not expected to significantly reduce the foraging habitat for this species.

10.5.8 Migratory Shorebirds

As described in Section 10.3.3, the MSSA potentially meets the criteria for nationally and internationally important habitat for migratory shorebirds as defined by DAWE (DotEE, 2017b). These are:

- May regularly support 0.1% of the EAAF flyway population of a single species of Migratory shorebird – six species were recorded in excess of 0.1% of their flyway population: Bar-tailed Godwit, Eastern Curlew, Grey-tailed Tattler, Ruddy Turnstone, Sanderling and Whimbrel.
    - However by multiplying the maximum abundance of each species by the extrapolation factor for each sub-component area, an additional eight species are expected to occur in nationally significant numbers within the MSSA: Common Greenshank, Curlew Sandpiper, Greater Sand Plover, Oriental Plover, Pacific Golden Plover, Red Knot, Red-necked Stint, Terek Sandpiper;
    - The same extrapolation indicates that three species, Grey-tailed Tattler, Ruddy Turnstone and Whimbrel can reliably be expected to occur in internationally significant numbers (i.e. >1% of the EAAF population) within the MSSA; and
- Supports at least 15 Migratory shorebird species – 20 EAAF species were recorded in the survey.

Due to the above, this section assesses the potential impacts on:

- Habitats within the context of the TFSA and MSSA; and
- Individual birds that are present in numbers that meet the national or international threshold criteria.

The TFSA covers an area of coastline that is equivalent to approximately 30% of the extent of the MSSA. It represents an appropriate local scale EIA area for migratory shorebirds as it contains the entire extent of the development envelopes as well as the adjacent coastline.

The majority of Proposal disturbance is to occur within bare mudflat or saltflat habitat, the habitat that was the least important for shorebirds/waterbirds within the MSSA. However the development envelopes do contain portions of the three migratory shorebird habitats identified and mapped by Phoenix (2020b) within the TFSA:

- Tidal Samphire mudflats;
- Tidal channel and Ocean; and
- Mangal communities.

Potential impacts to these migratory shorebird habitats are discussed in the sections below.

Tidal Samphire Mudflats Habitat

The tidal samphire mudflats habitat is the most widespread habitat recorded within the MSSA. The habitat within the TFSA was not noted as being of any greater significance than elsewhere in the MSSA. As a comparison in the far south of the MSSA there is a large delta where four large creeks converge, which feed an expansive and highly productive area of samphire wetland up to 7 km wide.

Potential impacts to tidal samphire mudflats habitat within the TFSA have been discussed in detail in Section 10.5.2. Of particular interest to migratory shorebirds is the higher value coastal portions of this habitat type. The Phoenix (2020b) surveys reported the great majority of the bird observations in the tidal samphires to the west of the development envelope - the tidal samphires lower on the shore, closer to the mangroves and tidal creek margins had high numbers of birds relative to areas of the same habitat type higher on the shore. This likely to be a consequence of lower soil salinities closer to the mangroves and tidal creeks due to more regular and longer inundation of the substrate with a corresponding increase in invertebrate infauna (O2 Marine, 2020a).

The avoidance measures implemented during the Proposal design have resulted in 90.8% of the broader tidal samphire mudflats habitat being avoided within the MSSA and unlikely to be indirectly impacted by the Proposal. In addition, the Proposal will avoid almost all of the higher-value coastal portion of this habitat.

An assessment of the density of this habitat type was not in the regional surveys conducted by Stantec (2018; Section 6.3.2). However a review of the Stantec mapping (Figure 69) identified that the mapped regional samphire mudflat habitats generally occurred closer to the coast. A reasonable assumption would therefore be that most of the mapped extent would be coastal habitat that is of higher value to migratory shorebirds. Using this assumption, small amount of disturbance proposed within the higher value coastal tidal samphire mudflats habitat would equate to only a small percentage of this habitat within the MSSA.

In terms of likely impact on ecological functions, the tidal samphire mudflats habitat to be impacted by the Proposal is unlikely to make a significant difference to the maintenance of ecological functions and diversity across the MSSA (O2 Marine, 2020a).

There have been numerous design revisions in order to minimise disturbance to this habitat type and keep indirect impacts as low as practicable. A key design revision was the proposed set back from the coast, which has allowed almost all of the higher value coastal tidal samphire mudflats habitat within the MSSA to be avoided. The Proposal is therefore considered unlikely to significantly impact this habitat type such that its use by migratory shorebirds would be affected.

Tidal Channel and Ocean

This habitat type is shown on Figure 119 and contains numerous small sand bars/spits, mudflats and rocky reefs. This habitat type overlaps with the BCH mapping conducted by O2 Marine (refer to Section 6 – BCH), however it was determined to be appropriate to migratory shorebirds as they are assessed as 'Terrestrial Fauna'.

The TFSA also does not contain any areas of tidal channel and ocean habitat that is more concentrated within the TFSA than elsewhere within the MSSA.

This habitat type is utilised by migratory shorebirds mainly for foraging. The Proposal will require 71.7 ha of disturbance within this habitat type for the following purposes (refer to Figure 3):

- Seawater intake within a large tidal creek;
- Trestle jetty; and
- Boat launching facility.

The TFSA contains 2,780.6 ha of this habitat type. When extrapolated across the MSSA the Proposal is considered unlikely to significantly impact this habitat type such that its use by migratory shorebirds would be affected.

Mangal Communities

The TFSA lies in the northern section of the MSSA, within a larger area (tens of km) that that was noted as being dominated by mangal communities.

Mangal community habitat was found to be less important for migratory birds than the tidal samphire mudflats and tidal channel and ocean habitats discussed above (Phoenix, 2020b).

Potential impacts to mangal communities have been discussed in detail in Section 6 (BCH; discussed as mangrove communities in the BCH section) and the outcome of this assessment is summarised below.

O2 Marine (2020b) identified mangroves as being the highest ecologically important BCH within the LAUs, particularly CC mangroves, due to the range of ecological services in which they provide to adjacent BCH and coastal waters. All efforts have been made during the Proposal design phase to maintain maximum mangrove biomass, with all CC Mangroves to be avoided, and 17 ha of SC Mangroves (<1% of TFSA extent) identified for direct removal and no net predicted indirect effects. It is therefore anticipated that any risk or impact to biological diversity and ecological integrity of mangrove communities is not considered to pose a significant risk to ecological integrity and biological diversity of this BCH.

While 17 ha of SC Mangroves will be lost, this in addition to the 4 ha of loss associated with the existing gas pipeline still represent less than 1% of this assemblage that is present across the TFSA and will not impact on the integrity of this assemblage in terms of contributions to local and regional ecological function and connectivity. The Proposal is not predicted to impact either of the two regionally significant mangrove areas that lie either side of the Proposal.

There have been numerous design revisions in order to minimise disturbance to this habitat type and keep indirect impacts as low as practicable. The Proposal is able to be implemented while retaining more than 99% of the available mangrove community habitat within the MSSA. The Proposal is therefore considered unlikely to significantly impact this habitat type such that its use by migratory shorebirds would be affected.

Migratory Shorebird Species

This section seeks to utilise the habitat impact assessment above and apply the findings to the migratory shorebird species that utilise the MSSA.

The habitat assessment highlights how the Proposal avoids direct impacts to the majority of migratory shorebird habitats, and how habitats identified for migratory shorebirds in the MSSA were almost entirely outside the development envelopes. This is evident in Figure 75 to Figure 78, which shows that almost all of the migratory shorebird records occurred outside the development envelopes, and also when analysing the data. When the survey data is analysed at the scale of the development envelopes the species richness (i.e. 15 species) threshold is not met, and no species were detected at nationally or internationally important numbers. The development envelopes therefore would not be considered to be nationally or internationally important habitat.

Mardie Minerals notes the following key facts during this assessment:

- 20 species were recorded within the MSSA;

- There are 14 species that were present within the MSSA in nationally significant numbers, including three that are also present in internationally significant numbers (Table 47);
- Six species are listed as Threatened under the EPBC Act, with four of these also listed as Protected Fauna under the BC Act, and another listed as a Priority species.

Table 52 assesses the potential impacts of the Proposal on these species.

Table 52: Assessment of potential impacts on migratory bird species

Species	Recorded within development envelopes?	Occurrence and significance of habitat
Bar-tailed Godwit (*Limosa lapponica)* - Migratory EPBC Act and BC Act	No	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 not breed in Australia. It occurs throughout the Pilbara coast and several offshore islands. Bar-tailed Godwit was recorded within the MSSA in nationally significant numbers on four occasions (0.22% of the national flyway population). As many as 86 individuals were recorded during the overwintering surveys, suggesting the MSSA represents important overwinter grounds for the species. It was recorded primarily in tidal channel / ocean habitat and over tidal samphire mudflats. No records were observed within the development envelopes, and impacts to its preferred habitat have been minimised such that extensive habitat will remain within the MSSA. The potential impacts to this species are therefore not considered to be significant.
Black-tailed Godwit (*Limosa limosa*) - Migratory EPBC Act and BC Act	No	In Australia the Black-tailed Godwit has a primarily coastal habitat environment. The species is commonly found in sheltered bays, estuaries and lagoons with large intertidal mudflats or sandflats, or spits and banks of mud, sand or shell-grit; occasionally recorded on rocky coasts or coral islets. The use of habitat often depends on the stage of the tide. It is also found in shallow and sparsely vegetated, near-coastal wetlands; such as saltmarsh, saltflats, river pools, swamps, lagoons and floodplains. There are a few inland records, around shallow, freshwater and saline lakes, swamps, dams and bore-overflows. They also use lagoons in sewage farms and salt works. Only one Black-tailed Godwit was recorded throughout the whole survey program therefore this species is considered unlikely to utilise the development envelopes and any impacts would not be significant. Nevertheless, impacts to its preferred habitat have been minimised such that extensive habitat will remain within the MSSA. The potential impacts to this species are therefore not considered to be significant.
Common Greenshank (*Tringa nebularia*) - Migratory EPBC Act and BC Act	Yes	The Common Greenshank is present in summer across all Australian States, mostly on the coast but sometimes inland. Small groups can sometimes be seen when roosting at high-tide. They prefer coastal open mudflats (Phoenix, 2020b). Common Greenshank were recorded in every sample event, albeit in moderate numbers, but representing 2.7% of the aggregate abundance for the MSSA. When those numbers are extrapolated for the entire MSSA it is considered likely that it occurs in nationally important numbers. It was recorded mainly on the tidal samphire mudflats, and in tidal channels and ocean. Four records of this species were within the development envelopes, however the majority (51) were reported in the greater MSSA. Impacts to its preferred habitat have been minimised such that extensive habitat will remain within the MSSA. The potential impacts to this species are therefore not considered to be significant.
Common Sandpiper (*Actitis hypoleucos*) -	No	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,

Species	Recorded within development envelopes?	Occurrence and significance of habitat
Migratory EPBC Act and BC Act		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. The Common Sandpiper was recorded within the MSSA but was not recorded or extrapolated at significant numbers and therefore is not considered a significant species. No records were within the development envelopes. Nevertheless, impacts to its preferred habitat have been minimised such that extensive habitat (>95% of all habitat types) will remain within the MSSA. The potential impacts to this species are therefore not considered to be significant.
Curlew Sandpiper (*Calidris ferruginea*) - Critically Endangered / Migratory EPBC Act, Vulnerable / Migratory 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. Based on habitat preferences reported, they are likely to forage on tidal mudflats, channels and beaches in the MSSA and may roost on beaches, sand-spits, tidal samphire mudflats and mangroves in the MSSA. Curlew Sandpiper was not recorded in nationally significant numbers within the MSSA. It was recorded eight times, from six sample events. A maximum count of 40 individuals in one flock was recorded. When extrapolated, this species is expected to occur at nationally significant numbers. However, when the numbers recorded are compared with the important sites above (Eighty Mile Beach and Port Hedland Saltworks), the MSSA does not represent critical habitat for the Curlew Sandpiper at any time of the year. Nevertheless, impacts to its preferred habitat have been minimised such that extensive habitat will remain within the MSSA. The potential impacts to this species are therefore not considered to be significant.
Eastern Curlew (*Numenius madagascariensis*) - Critically Endangered / Migratory EPBC Act, Vulnerable / Migratory 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 saltflats 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). Eastern Curlew was recorded in nationally important numbers on five occasions within the MSSA. The species occurred almost exclusively within the tidal samphire mudflats. Whilst important habitats for the species occur in the MSSA, there is limited important habitat for the species in the development envelopes and only five individuals were recorded within the development envelopes (6% of records). Impacts to its preferred habitat have been minimised such that extensive habitat will remain within the MSSA. The potential impacts to this species are therefore not considered to be significant.
Great Knot (*Calidris tenuirostris*) - Critically Endangered / Migratory EPBC	No	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

Species	Recorded within development envelopes?	Occurrence and significance of habitat
Act, Vulnerable / Migratory BC Act		coastal habitats with large intertidal mudflats or sandflats, including inlets, bays, harbours, estuaries and lagoons. Great Knot was not recorded in nationally significant numbers (it was recorded in six sample events only), however extrapolated numbers indicate it is likely to meet this criteria within the MSSA. The maximum sample event count was 82 individuals, recorded on the tidal samphire mudflats within the MSSA. No records occurred within the development envelopes. Impacts to its preferred habitat have been minimised such that extensive habitat will remain within the MSSA. The potential impacts to this species are therefore not considered to be significant.
Greater Sand Plover (*Charadrius leschenaultia*) - Vulnerable / Migratory EPBC Act and BC Act	No	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). Greater Sand Plover was not recorded in nationally significant numbers within the MSSA. The maximum summer count was 29, while in winter it was 106 (or 0.053% of the flyway population) suggesting the MSSA may represent important overwintering grounds for the species. The majority of records were in the northern half of the MSSA, on low tides, on coastal mudflats and sand bars in upper reaches of tidal creeks. No records occurred within the development envelopes. Given the low numbers of this species recorded in comparison to the other important sites mentioned above, impacts to this species as a result of the Proposal are not considered significant. Nevertheless, impacts to its preferred habitat have been minimised such that extensive will remain within the MSSA. The potential impacts to this species are therefore not considered to be significant.
Grey Plover (*Pluvialis squatarola*) - Migratory EPBC Act and BC Act	No	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. Only four individuals were recorded over whole survey program within the MSSA but all of these were outside of the development envelopes. The numbers recorded were not nationally important and also were not extrapolated to be nationally important and therefore the MSSA is not considered significant habitat for this species. Nevertheless, impacts to its preferred habitat have been minimised such that extensive habitat will remain within the MSSA. The potential impacts to this species are therefore not considered to be significant.
Grey-tailed Tattler (*Tringa brevipes*) - Migratory EPBC Act and BC Act, P4 DBCA	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. Grey-tailed Tattler was recorded in nationally significant numbers on 13 occasions within the MSSA. Up to 29 individuals were recorded during the overwintering survey. Extrapolation indicates that the MSSA represents

Species	Recorded within development envelopes?	Occurrence and significance of habitat
		internationally important habitat for the species. It prefers tidal mudflats, reef flats, mangrove creeks, sandy beaches and saltworks ponds Phoenix, 2020b). It usually roosts in the branches of mangroves and will utilise the mangroves within the MSSA. Only eight individuals were recorded within the development envelopes suggesting that the majority of its suitable habitat occurs within the greater MSSA. Impacts to its preferred habitat have been minimised such that extensive habitat will remain within the MSSA. The potential impacts to this species are therefore not considered to be significant.
Lesser Sand Plover (*Charadrius mongolus*) – Vulnerable / Migratory EPBC Act and BC Act	No	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 (Phoenix, 2020b). Lesser Sand Plover was not recorded in nationally significant numbers and was also not extrapolated at nationally significant numbers. It was rare within the MSSA with only 27 individuals recorded across 26 sample events, all of which were outside of the development envelopes. This suggests the MSSA does not represent critical habitat for this species and therefore any impacts from the Proposal would not be significant to this species. Nevertheless, impacts to its preferred habitat have been minimised such that extensive habitat will remain within the MSSA. The potential impacts to this species are therefore not considered to be significant.
Oriental Plover (*Charadrius veredus*) – Migratory EPBC Act and BC Act	Yes	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. Oriental Plover was recorded in eight sample events, generally in low numbers, but 190 individuals were recorded in a phase 4 sample event. Once numbers were extrapolated for the MSSA is was found to occur in nationally important numbers. It was recorded within the tidal samphire mudflats. Impacts to its preferred habitat have been minimised such that extensive habitat will remain within the MSSA. The potential impacts to this species are therefore not considered to be significant.
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. This species was recorded within the MSSA but not recorded or extrapolated at nationally important numbers and therefore the MSSA is not considered significant habitat for this species. Some of the records occurred with the development envelopes but the majority (70%) were recorded in the greater MSSA. Impacts to its preferred habitat have been minimised such that extensive habitat will remain within the MSSA. The potential impacts to this species are therefore not considered to be significant.
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 concerning population trends are available, however in

Species	Recorded within development envelopes?	Occurrence and significance of habitat
		Alaska the species is declining. They can be found feeding singly or in flocks in open mudflats, salt marshes and rocky shores. The species was relatively rare in the MSSA, being recorded in only five samples events, four of which were in phase 1. Once extrapolation was applied however, it was found to occur at nationally important numbers. It was recorded within tidal samphire mudflats within the MSSA including those within the development envelopes. Impacts to its preferred habitat have been minimised such that extensive habitat will remain within the MSSA. The potential impacts to this species are therefore not considered to be significant.
Red-necked Stint (*Calidris ruficollis*) - Migratory EPBC Act and BC Act	Yes	In Australasia, the Red-necked Stint is mostly found in coastal areas, including in sheltered inlets, bays, lagoons and estuaries with intertidal mudflats, often near spits, islets and banks and, sometimes, on protected sandy or coralline shores. Occasionally they have been recorded on exposed or ocean beaches, and sometimes on stony or rocky shores, reefs or shoals. They also occur in saltworks and sewage farms; saltmarsh; ephemeral or permanent shallow wetlands near the coast or inland, including lagoons, lakes, swamps, riverbanks, waterholes, bore drains, dams, soaks and pools in saltflats. They sometimes use flooded paddocks or damp grasslands. They have occasionally been recorded on dry gibber plains, with little or no perennial vegetation. Red-necked Stint was common in the MSSA, being recorded in every sample event, and representing 13.1% of the aggregate abundance, making it the third most abundant species. It was not recorded in nationally important numbers in any one sample event however, and it is only after extrapolation for the entire MSSA that the species exceeds the threshold value. Impacts to its preferred habitat have been minimised such that extensive habitat will remain within the MSSA. The potential impacts to this species are therefore not considered to be significant.
Red Knot (*Calidris canutus*) – Endangered / Migratory EPBC Act, Migratory 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. Internationally important sites for the species in north-western Australia include Eighty Mile Beach and Roebuck Bay. Red Knot was not recorded in significant numbers in any one sample event, although it came very close twice (100 individuals on both occasions; being 0.09% of the flyway population). The species is however considered to occur in nationally important numbers based on extrapolation (0.24% of the flyway population). It was recorded across mangal community, tidal channel or ocean, mudflat / saltflat and tidal samphire mudflat habitats. Based on recorded numbers the MSSA is likely to represent important habitat for the Red Knot. Impacts to its preferred habitat have been minimised such that extensive habitat will remain within the MSSA. The potential impacts to this species are therefore not considered to be significant.
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-western Australia, 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 amongst grassy tussocks, and on mudflats and sandflats (Phoenix, 2020b).

Species	Recorded within development envelopes?	Occurrence and significance of habitat
		The aggregate abundance of Ruddy Turnstone to-date represents >7% of the MSSA abundance. It was recorded in nationally significant numbers on ten occasions, including in 70% of phase 4 sample events. When the abundance is extrapolated, the species is found to also occur in internationally important numbers, being an estimated 2.02% of the flyway population. Only six individuals were recorded within the development envelopes however, with the majority found elsewhere in the MSSA. Impacts to its preferred habitat have been minimised such that extensive habitat will remain within the MSSA. The potential impacts to this species are therefore not considered to be significant.
Sanderling (*Calidris alba*) - Migratory EPBC Act and BC Act	No	Sanderling 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 Sanderling was recorded in nationally important numbers (31 or 0.1% of the flyway population) during the passage of Ex Tropical Cyclone Joyce on 15 January 2018. However, no individuals were recorder prior to or after this date and it is likely that the presence of this species within the MSSA is a result of the cyclone. Therefore the MSSA is considered unlikely to contain critical habitat to the species. Additionally, all records were outside of the development envelopes. Nevertheless, impacts to its preferred habitat have been minimised such that extensive habitat will remain within the MSSA. The potential impacts to this species are therefore not considered to be significant.
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. Terek Sandpiper was not a common species within the MSSA; it was recorded regularly but in low numbers. However, the EAAF population estimate is only 50,000 and therefore when the numbers are extrapolated for the entire MSSA, it is considered likely to occur in nationally important numbers. No records were from within the development envelopes however. Impacts to its preferred habitat have been minimised such that extensive habitat will remain within the MSSA. The potential impacts to this species are therefore not considered to be significant.
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. It regularly roosts in mangroves and other structures flooded at high-tide. This species was recorded in nationally significant numbers on seven occasions within the MSSA, largely within the mangrove stands. When extrapolated the species is also found to occur within internationally important numbers. Some records were from within the development envelopes however recorded numbers were regularly higher in the southern part of the MSSA. The MSSA represents important habitat for the species, including as overwintering grounds. Impacts to its preferred habitat have been minimised such that extensive habitat will remain within the MSSA. The potential impacts to this species are therefore not considered to be significant.

10.6 Mitigation

Mardie Minerals has mitigated the potential impacts to this factor according to the mitigation hierarchy; avoid, minimise, rehabilitate, offset. Offsets are not expected to be required for this factor.

10.6.1 Avoid

The key avoidance outcomes achieved by Mardie Minerals was the iterative design of the development envelopes to avoid key environmental features. Mardie Minerals has conducted numerous ecological surveys and this information has been utilised to design the Proposal and its development envelope boundaries to avoid the following:

- The majority of coastal habitats as these were identified as having a higher ecological value;
- The majority of mapped open woodland (riparian) habitat; and
- Mardie Pool and associated habitats.

In addition to the above, the following avoidance mitigation measures have been incorporated:

- The location of the concentrator ponds has targeted areas of mudflats and saltflats habitat which is considered a lower value fauna habitat; and
- The jetty and causeway/flooding crossing have been relocated to the east to avoid mangrove and samphire communities, as well as tidal creeks.

10.6.2 Minimise

The following mitigation measures are proposed to ensure that direct and indirect impacts to terrestrial fauna are minimised:

1. **Implement industry best-practice management measures for fauna**:
    a. Vegetation clearing will be managed through internal ground disturbance procedures;
    b. Boundaries of areas to be cleared or disturbed will be identified by GPS coordinates and maps of boundaries will be provided to dozer operator;
    c. Progressive clearing will be undertaken;
    d. Raised blade disturbance will be conducted where practicable on tracks to minimise vegetation removal;
    e. The disturbance footprint will be developed to the minimum required to ensure safe and adequate construction and operation;
    f. Water or dust suppressants will be applied to disturbed areas and product transfer / storage areas as required to minimise dust generation;
    g. Emergency response capabilities will be maintained to prevent fire outbreaks where possible;
    h. 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 (mesquite controls discussed further below);
    i. Feral animal controls will be implemented;
    j. Pets will not be brought to site;
    k. Utilise low noise equipment where available and suitable;
    l. Pipeline trenches (if required) will be progressively opened and closed;

m. Fauna egress mechanisms will be installed at all trenches, turkeys nests or concentrator and crystalliser ponds;
n. The open portions of pipeline trenches will be inspected less than two hours after sunrise for the presence of trapped fauna;
o. 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;
p. Food wastes will be stored in bins that are not easily accessible to fauna;
q. Low noise equipment will be used where practicable;
r. All incidents resulting in fauna injury or death will be reported internally; and
s. Vehicle speed limits will be set and enforced, with lower limits imposed within Northern Quoll foraging habitat.

2. **Obtain and comply with the following approvals**:
    a. Ministerial Statement to be issued under Part IV of the EP Act;
    b. Works Approval and Licence to be issued under Part V of the EP Act for solar salt manufacturing and bulk material loading;
    c. Mining Proposal to be approved under the *Mining Act 1978*; and
    d. 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 12.1;
3. **Limit total mangal communities habitat disturbance to 17 ha in the Key Characteristics Table**;
4. **Develop and implement a BCH health monitoring program as described in Section 6.** 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 inundation flows;
5. **Verify inundation modelling results after construction to ensure potential indirect impacts to coastal habitats is within predicted outcomes** (refer to Section 5.6);
6. **Monitor erosion at the outlets of the surface water corridors after each significant flow event** (refer to Section 5.6)**;**
7. **Implement off take drainage to Open Woodland (Riparian) habitat if required to provide surface water flows to this habitat;**
8. **Monitor and control seepage from the eastern crystalliser ponds to prevent seepage reaching Mardie Pool** (refer to Section 5.6);
9. **Manage mesquite in accordance with the Mesquite Management Strategy developed by PMMC.** Develop / implement a Mesquite Management Plan in conjunction or consultation with PMMC and Mardie Station (refer to Section 9.6);
10. **Conduct annual migratory shorebird surveys within the MSSA.** The annual surveys will be conducted in a similar manner to the targeted survey conducted by Phoenix (2020b) and will provide information regarding long-term changes in the numbers, species and distributions of migratory shorebirds utilising the MSSA;
11. **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;
12. **Record any fauna entrapment within the ponds as an incident and review whether additional egress mechanisms should be installed;**

13. **Concentrator and crystalliser ponds will be designed and constructed to be safe and stable according to DMIRS requirements**;
14. **The following controls will be used to further reduce the risk of impact from unintentional brine pipeline spills**:
    a. Pipelines will be fitted with leak detection;
    b. Water flows will be shut off if leaks are detected;
    c. Pipelines will be inspected regularly, especially during extreme heat or fire events;
    d. Pipelines will be located off access road surfaces;
    e. If pipelines have to cross access roads then they will be buried;
    f. Investigations will be conducted into the cause of any spills, and remedial actions will be taken to minimise the chance of reoccurrence; and
    g. Spills response training to mitigate damage for site-based personnel.

10.6.3 Rehabilitate

An interim MCP has been provided in Appendix 12.1. At the completion of the Proposal the site will be rehabilitated to reinstate fauna habitat. A MCP will be required under the *Mining Act 1978* and the key rehabilitation measures that relate to terrestrial fauna are summarised below:

1. Salts will be harvested from each pond prior to closure;
2. Concentrator pond walls will be flattened or opened up to allow tidal flows to enter the ponds;
3. All infrastructure will be removed if not retained by Mardie Station or PPA;
4. All disturbance areas to be revegetated will be respread with topsoil (or ripped and seeded if topsoil is no longer viable) and rehabilitated; and
5. All crystalliser ponds will be rehabilitated to an acceptable landform.

The MCP will be submitted to DMIRS for assessment and approval prior to the construction of the Proposal, and will be reviewed and revised every three years.

10.7 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, 2016g).

The Proposal will result in the direct disturbance of up to 11,142 ha of fauna habitat, which includes some habitat types that may be utilised by significant fauna species. Mardie Minerals has however incorporated extensive avoidance and minimisation measures into the Proposal design and operational processes. The avoidance and minimisation measures significantly reduced the direct disturbance of the fauna habitats that may be utilised by significant fauna, including mangrove community, tidal samphire mudflats, tidal channel and ocean , and open woodland (riparian) habitat (including freshwater pool habitat)..

With the implementation of mitigation measures the majority of the potential impacts identified in Section 10.4 were assessed as able to be avoided or minimised such that they were not considered significant. There were however three potential impacts that required greater consideration:

- The direct disturbance of 11,142 ha of general terrestrial fauna habitat and potential indirect impacts;
- Disturbance of 17 ha of mangrove community habitat, which is utilised by migratory shorebirds within the MSSA, and potential indirect impacts associated with hydrological changes; and
- Disturbance of tidal samphire mudflats habitat, which was noted as the most significant habitat utilised by migratory shorebirds within the MSSA.

Given the scale of the Proposal, the disturbance of 11,142 ha (in addition to the 243 ha disturbed for the development of two gas pipelines in the TFSA) was considered in the context of the broader landscape. All vegetation associations to be disturbed will have more than 80% of their pre-European extent remaining, even once cumulative disturbance associated with the Proposal and the Eramurra Industrial Salt Project have been deducted. This means that all of the vegetation associations will remain in the 'Least Concern' category (Phoenix, 2020a). While this focusses on vegetation, it provides a broad regional assessment of fauna habitats in this context.

None of the habitat types mapped within the TFSA and broader MSSA were noted as having a high percentage of their extent impacted by the Proposal, with the exception of mudflat / saltflat habitat, which has minimal value to fauna species, and grassland habitats, which are likely to extend east of the TFSA. The key potential indirect impacts to fauna habitats are associated with hydrological changes and the risk of spreading mesquite:

- The risk of mesquite spread will be appropriately managed through the introduction of weed and soil hygiene controls developed in consultation with the PMMC, and as such, the Proposal is not expected to result in additional mesquite impacts; and
- Hydrological changes are not expected to impact the majority of susceptible vegetation given the drainage features incorporated into the design and the predicted minimal changes to tidal regimes (refer to Section 5). Some small areas of inland tidal samphire mudflats habitat may be indirectly impacted as a result of being cut off from tidal inundation, however adaptive management measures may reduce this impact. Given the small size of the potentially affected areas compared to their extent and distribution locally, these indirect impacts are not considered to be significant.

The Proposal will result in the disturbance of 17 ha of mangrove habitat. All efforts have been made during the Proposal design phase to maintain maximum mangrove biomass which would be of more importance to fauna, with none of the denser CC mangroves identified for direct removal and no net predicted indirect effects. While a 17 ha area of SC mangroves will be lost, this still represents less than 1% of this assemblage and will not impact on the integrity of the assemblage in terms of contributions to local and regional ecological function and connectivity. Mangroves are well represented regionally and the cumulative loss of 21 ha (including 4 ha of existing gas pipeline disturbance) is not deemed to significantly impact any fauna that depend on their use for habitat.

The cumulative direct disturbance of tidal samphire mudflat habitat is best assessed in the context of the MSSA, as it is of most significance to migratory shorebirds (refer to Section 10.5.6). There have been numerous design revisions in order to minimise disturbance to coastal tidal samphire mudflat habitat and keep indirect impacts as low as practicable. As a result, the Proposal is able to be implemented while retaining almost all of the higher value coastal portions of this habitat within the MSSA.

Based on the above, the Proposal is considered unlikely to significantly impact migratory bird habitats such that its use by migratory shorebirds would be detrimentally affected. The presence of the ponds may also provide additional habitat for some birds. Annual migratory shorebird monitoring will be conducted to provide further information about the use of the MSSA and any potential changes to bird behaviour or usage as a result of the presence of the ponds or reduction in habitat availability.

The Proposal includes 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 claypans and 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 MCP (Appendix 12.1) identified, including:

- All residual salts will be harvested from the concentrator ponds and the walls opened up to allow tidal flows to reinstate within the former pond areas. Over time this is expected to return the area to a state where current salt-tolerant species can revegetate the pond areas; and
- Similarly, salts will be recovered from the crystalliser ponds, which are to be located on terrestrial vegetation (typically infested with Mesquite) and the pond areas revegetated in a typical manner.

Sea level rise associated with climate change was discussed in Section 6 however it is worth noting in this section, specifically to review how it will affect the habitats utilised by migratory shorebirds. Sea level rise is predicted to result in a gradual inland migration of coastal habitats and the increasingly frequent submergence of the tidal samphire mudflat habitat assessed in this ERD, until it no longer becomes viable for the presence of samphire species. The Proposal will prevent the inland migration past the point of the pond walls, however given sea level rise calculations the inland migration of the habitats would have been prevented from migrating further inland by higher ground, only 20 years after reaching the pond wall limits.

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 is expected to ensure that there are no significant residual impacts to terrestrial fauna or their habitats.

11 SOCIAL SURROUNDINGS

11.1 EPA Objective

The EPA Objective for this key environmental factor is 'to protect social surroundings from significant harm'.

11.2 Policy and Guidance

Relevant guidance documents for social surroundings are listed below.

WA Government:

Key EPA Documents:

- Statement of Environmental Principles, Factors and Objectives (EPA, 2016a);
- EIA (Part IV Divisions 1 and 2) Administrative Procedures 2016;
- EIA (Part IV Divisions 1 and 2) Procedures Manual 2016; and
- Instructions on how to prepare *EP Act* Part IV Environmental Management Plans (EPA, 2018a).

Relevant EPA Factor Guidelines:

- Environmental Factor Guideline – Social Surroundings (EPA, 2016q).

Relevant EPA Technical Guidance:

- Guidance Statement 41 – Assessment of Aboriginal Heritage (EPA, 2004).

Commonwealth Government:

Key Documents:

- Generic guidelines for the content of a draft EPBC Act PER/EIS (including the objects and principles of the EPBC Act) (DotEE, 2016b);
- Environmental Management Plan Guidelines (DotE, 2014a);
- Environmental Management Plan Guidelines, - template (DotEE, 2018a);
- EPBC Act Condition Setting Policy (DAWE, 2020); and
- EPBC Act Outcomes-based conditions policy (DotE, 2016c).

Relevant Technical Guidance:

- Engage Early - Guidance for proponents on best practice Indigenous engagement for environmental assessments under the EPBC Act (DotE, 2016a).

11.3 Receiving Environment

11.3.1 Recreational and Community

The following factors were used to determine the potential recreational and community uses of the development envelopes and surrounds:

- Availability of public access;

- Evidence of public access;
- Evidence of public camping or shoreline fishing sites;
- Information sourced from Mardie Station; and
- Consultation with local relevant tourism, fishing and boating groups regarding the usage of the marine and coastal waters in proximity to the Proposal.

No evidence of frequent or even occasional public access, camping or fishing was identified within the development envelopes, or along the adjacent coastline. The remote location of the Proposal, and the large mud flats (which are difficult to traverse) means that access via land is difficult and rarely occurs. Mardie Station also confirmed that the public do not access the area via land as there are two sets of locked gates along the Mardie station access road which provides the only access to the Proposal. The most likely access to the area is by boat, however there is little to no evidence of this occurring along the coastline adjacent to the Proposal. Discussions with local fishing organisations indicated that this is mainly due to the shallow waters adjacent to the coast line, mangroves that line the majority of the coastline and the lack of fishing and camping resources along the Mardie coast. During the extensive marine survey work evidence of camping and fishing was observed on the offshore islands, where there are sandy beaches and coral, which provides habitat for fish species targeted by recreational fishing.

Representatives from Mardie Minerals consulted the following local relevant tourism, fishing and boating groups regarding the usage of the marine and coastal waters in proximity to the Proposal:

- City of Karratha;
- King Bay Game Fishing Club;
- Nickol Bay Sporting Fishing Club; and
- Hampton Harbour Boat and Sailing Club

None of the groups identified any notable recreational or community uses of the marine and coastal waters in proximity to the Proposal.

11.3.2 Mardie Station and Homestead

Mardie Minerals has consulted with CITIC Pacific and their 100% owned subsidiary, Pastoral Management Pty Ltd (PMPL – holder of the Mardie Station Pastoral lease) throughout the planning phase of the Proposal. This has comprised many meetings, emails and phone calls regarding the interactions between the operation of the station and the Proposal including development activities, proposed construction plans and proposed operations (refer to section 3.3).

Mardie Mineral's project team members and the station manager have a positive working relationship and are currently working together on Mesquite control in the area. Mardie Minerals has purchased a specialised plough (Holman Plough) specifically designed for the effective removal of Mesquite. Mardie Minerals utilise the plough mainly for the clearing of site access roads and has made the plough available to Mardie Station and the Pilbara Mesquite Management Committee who now use it across the station.

Mardie Minerals and PMPL are currently negotiating an access agreement that will formalise the way that Mardie Station and Mardie Minerals will collaborate and realise significant synergies between the operation of the pastoral station and the Proposal.

11.3.3 ABORIGINAL HERITAGE AND CULTURAL VALUES

Native Title rights and interests comprise either the exclusive right to possession, occupation, use and enjoyment of the relevant land or a set of non-exclusive rights which include, among others, the right to maintain and protect places of significance.

The Yaburara Mardudhunera (YM) People and Kuruma Mardudhunera (KM) People are the Traditional Owners associated with the land that underlies the Proposal. The Proposal is located almost entirely on land in which the YM People have been determined to hold Native Title rights and interests. The southernmost portion of the Proposal overlaps an area which was historically subject to a claim by the KM people. The relevant part of the KM claim was dismissed when another part of the claim (outside the development envelopes) was determined in 2018. This southern area now does not overlap any claims or determinations. Figure 125 illustrates the current claims overlapping the Proposal.

Mardie Minerals continues to work with the YM in regard to the Proposal. Despite the recent dismissal of the KM claim, Mardie Minerals also continues to work with the KM People as they were the most recent group to hold a claim over the southern-most part of the Proposal.

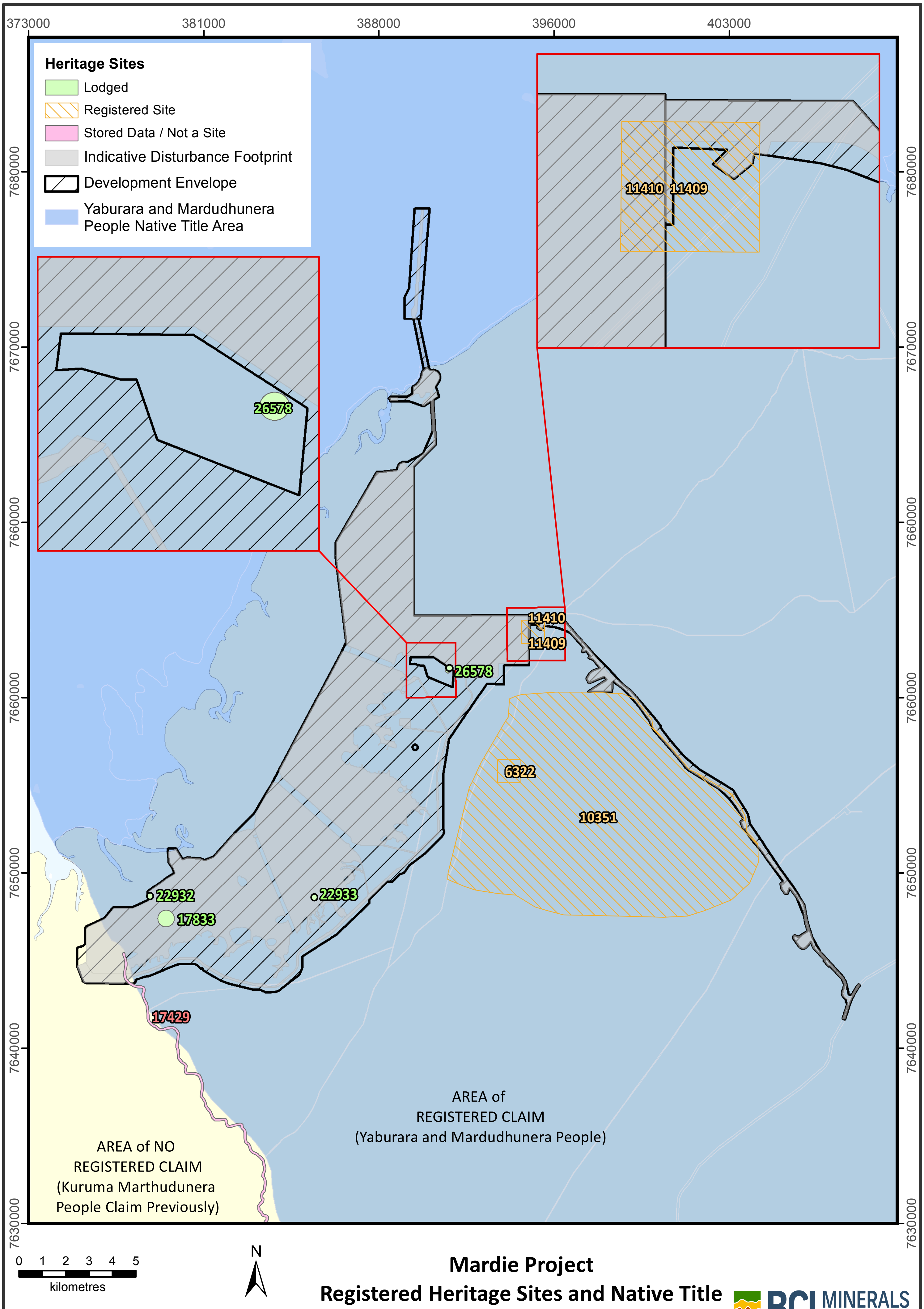


Figure 125: Location of Native Title boundaries, demarcated areas and Registered Aboriginal Heritage Sites

Yaburara Marthadunera People

Mardie Minerals has a long-standing and positive relationship with the YM People which was formalised in November 2012 with the execution of a Land Access Deed between BCI (the parent company of Mardie Minerals) and the YM People. Mardie Minerals has consulted with the YM People in relation to potential impacts of the Proposal on areas of cultural and heritage sensitivity. This has included:

- A heritage survey of the Mardie Project in November 2018 to define the heritage values associated with the Proposal (i.e. in YM country);
- A second heritage survey in December 2018 to complete the heritage survey in areas where the Development Envelopes had changed (i.e. in YM country);
- Review and discussion regarding the findings of the final heritage report on 15 February 2019; and
- Finalisation and approval of the heritage report by the YM Board on 19 February 2019.

Horizon Heritage Management (Horizon Heritage) was engaged by the YM People to undertake a (Horizon Heritage Report, 2019) work program clearance of the Proposal with representatives of the YM People native title holders. The works included archival research, a field investigation and reporting.

Horizon Heritage utilised the Aboriginal Heritage Inquiry System (AHIS) of the Department of Planning, Lands and Heritage (DPLH) to research and determine which heritage survey reports and site files held by the DPLH would be informative to the work program clearance. The research determined both the registered ethnographic and archaeological sites and Other Heritage Places in and around the development envelopes and the nature and frequency of previous heritage surveys. A total of four Registered Aboriginal Sites, five Other Heritage Places and six heritage survey reports were identified. The nine DPLH Registered Sites and Other Heritage Places found within or adjacent to the development envelopes are presented in Table 53 and a summary of each DPLH site is provided below.

Table 53: DPLH registered sites and other heritage places

DPLH Site ID & Name	Place Type	Status	Location (Coordinates)
6322, Mardie Creek Burial	Artefacts / Scatter, Ceremonial, Grinding Patches / Grooves, Midden / Scatter, Skeletal Material / Burial, Camp	Registered, Open, No restrictions	393639mE 7652655mN Zone 50 [Unreliable]
10351, Wiruwandi Plain	Mythological	Registered, Open, No restrictions	397613mE 7651253mN Zone 50 [Reliable]
11409, Mardie Station A	Artefacts / Scatter, Engraving	Registered, Open, No restrictions	394639mE 7658655mN Zone 50 [Unreliable]
114110, Mardie Station B	Artefacts / Scatter, Engraving	Registered, Open, No restrictions	394639mE 7658655mN Zone 50 [Unreliable]
17429, Nyungarrarra (Peters Creek)	Named Place	Stored Data / Not a Site, Other Heritage Place, Open, No restrictions	398540mE 7629707mN Zone 50 [Reliable]
17833, TAP Site 2	Artefacts / Scatter, Shell	Lodged, Other Heritage Place, Open, No restrictions	378938mE 7646377mN Zone 50 [Reliable]

DPLH Site ID & Name	Place Type	Status	Location (Coordinates)
22932, Hadson 2	Artefacts / Scatter	Lodged, Other Heritage Place, Open, No restrictions	378280mE 7647309mN Zone 50 [Reliable]
22933, Hadson Midden 1	Artefacts / Scatter, Midden / Scatter	Lodged, Other Heritage Place, Open, No restrictions	385280mE 7647309mN Zone 50 [Reliable]
26578, Wirawundi Pool (Mardie Pool)	Artefacts / Scatter, Historical, Midden / Scatter, Mythological, Named Place, Natural Feature, Plant Resource, Water Source	Lodged, Other Heritage Place, Open, No restrictions	390998mE 7656996mN Zone 50 [Reliable]

DPLH 6322 Mardie Creek Burial:

This registered burial and occupation site was recorded by M. Lowe and R. Solomon in 1991. This site is located near to Mardie Pool and the Mardie Station Wool Shed. This site is part of a story telling how Mardudhunera people were attacked and killed by another Pilbara tribe. This site is incorrectly mapped on the DPLH AHIS as being located within the Wiruwundi Plain but is in fact near Mardie Pool (Horizon Heritage, 2019). Mardie Minerals has designed the Proposal to avoid Mardie Pool and the heritage values associated with it by excluding the area from the development envelopes (Figure 125).

DPLH 10351 Wiruwandi Plain

This registered mythological site was recorded by Dr. Palmer in 1975 and later by Brown in 1979. It extends from Wearawandie Well in the south to Mardie Wool Shed in the north and west of the Mardie-North West Costal Highway Road. It forms part of the Wiruwandi (Boomerang Wood) Dreaming which also includes a hill and a pool. The Plain does not overlap the development envelopes and is located adjacent to the Proposal.

DPLH 11409 Mardie Station A

This registered artefacts and engraving site was recorded by R. Sharpe of Mardie Station. There is very limited information about this site in the DPLH file. There are no photographs or notes. However, it does appear as though this site is unreliably mapped on the DPLH AHIS and is located well away from the Proposal and is thought to be located on the nearby Yarraloola Station. Therefore, there is no overlap with this site and the development envelopes.

DPLH 11409 Mardie Station B

This registered artefacts and engraving site was recorded by R. Sharpe of Mardie Station. There is very limited information about this site in the DPLH file. There are no photographs or notes. However, it does appear as though this site is also unreliably mapped on the DPLH AHIS and is located well away from the Proposal (Horizon Heritage, 2019). Therefore, there is no overlap with the development envelopes.

DPLH 17429 Nyungarrarra (Peter Creek)

This named place is stored data with DPLH and is not considered a site under the AH Act. It was recorded in 1994 by McDonald, Hales and Associates during a survey of the northern section of the Goldfields Gas Transmission Project. The site is Peters Creek; its Mardudhunera name is Nyungarrarra (meaning 'blue sky'). The creek has significance to the YM Aboriginal people. The development envelopes are expected to overlap the western extent of this site (Figure 125) and a Section 18 application will need to be applied for to disturb this site under the AH Act.

DPLH 17833 Tap Site 2

DPLH considers there is currently insufficient information to register this artefact scatter as a site under the AH Act. It was recorded by Lantzke in 1999 during an archaeological survey of the Mardie Gasfield Exploration Programme. The site consists of a small scatter of shells and flaked stone artefacts made from chert, dolerite and basalt, and is located on the shore of a salt flat island (Figure 125). This place will be impacted by the Proposal; however, the YM People have suggested that salvage and relocation of the artefacts to a demarcated island structure adjacent to Peters Creek will satisfy their heritage management objectives.

DPLH 22932 Hadson 2

This site is under lodged status at DPLH and is yet to be assessed. It was recorded in 1990 by Murphy and McDonald in conjunction with representatives from the Mardudhunera group. This artefact scatter consists of flaked stone artefacts and shell fragments (*Melo* spp. *Anadara* spp.) on a sand plain in a coastal flat (Figure 125). The site will not be disturbed by construction activities but will be flooded. The YM People have suggested that the flooding of the site will provide ongoing protection and will satisfy their heritage management objectives.

DPLH 22933 Hadson Midden 1

This site is under lodged status at DPLH and is yet to be assessed. It was recorded in 1990 by Murphy and McDonald in conjunction with representatives from the Mardudhunera group. This artefact scatter and midden consists of flaked stone artefacts and some shells (Saccostrea spp. Terebralia spp. Anadara spp. and Melo spp.) but, because of the presence of coral blocks and mangrove branches, the shell scatter may be natural. The site will not be disturbed by construction activities but will be flooded. The YM People have suggested that the flooding of the site will provide ongoing protection and will satisfy their heritage management objectives.

DPLH 26578 Wirawandi Pool (Mardie Pool)

This site is under lodged status at DPLH and is yet to be assessed. It was recorded in 2009 by AIC anthropologist Alex Lyneham and Mardudhunera Elder Dorrie Wally. Wirawundi is the Mardudhunera name for Mardie. This pool was utilised by Mardudhunera people for water, food and recreation (swimming). It holds great value to many generations of Mardudhunera people and those that worked on the station, and there is a creation story (Boomerang) associated with the pool. Mardie Minerals will not be impacting Wirawandi Pool and have excluded it from the development envelopes (Figure 125).

The work program clearance was conducted across two trips; one in November 2018 and the second in December 2018. Each trip was attended by representatives of the YM, Horizon Heritage and Mardie Minerals. Due to the size and landscape terrain of the development envelopes and the lack of suitable vehicle and pedestrian access, a helicopter was used to undertake the majority of the work program clearance. This methodology was agreed between YM, Horizon Heritage and Mardie Minerals and was determined as the most appropriate to meet survey objectives.

The work program clearance identified a number of areas to be demarcated, as well as 30 'cultural salvage points' that would require salvage of material prior to the implementation of the Proposal.

The location of the demarcated areas and cultural salvage points are shown in Figure 125. The YM People have requested that the archaeological artefacts located in the heritage places identified are salvaged and relocated to an island to be demarcated adjacent to Peter's Creek prior to Proposal implementation.

Kuruma Marthudunera (KM) People

Mardie Minerals also has a long-standing and positive relationship with the KM People which was formalised in August 2012 with the execution of a Land Access Deed between BCI (the parent company of Mardie Minerals) and the KM People. The KM claim has overlapped the southmost portion of the development envelopes since it was lodged in the 1990's. However, in 2018 the KM claim boundaries were changed, and the claim area no longer overlaps the development envelopes.

Mardie Minerals will still consult with the KM People regarding the heritage and Native title values associated with the land, given their long-standing relationship with the KM, the KM's desire to continue to speak for the land and the lack of another claim. Figure 125 identifies the area where the KM claim previously existed.

Consultation with the KM People in relation to potential impacts of the Proposal on areas of cultural and heritage sensitivity has included:

- A meeting with the KM Board in mid-2018 following the completion of the Pre-Feasibility Study;
- An Implementation Committee meeting in August 2018 which included a briefing to the KM CEO and other Board members;
- An archaeological and ethnographic survey completed 29 April – 1 May 2019 ; and
- Mardie Minerals meeting with the KM Board and CEO completed on 30 May 2019.

The archaeological and ethnographic survey resulted in the definition of the heritage values for the small portion of the Proposal that lies within the area where the KM People previously had a registered claim. Peters Creek is the only Aboriginal Heritage Place that occurs within this area (refer to description of site in the previous section). No other ethnographic or archaeological sites were identified during the survey mainly due to the fact that the landscape is featureless and dominated by coastal mudflats.

11.3.4 SECTION 18 APPROVAL

Mardie Minerals made a section 18 application to disturb all the registered, lodged and stored data sites that the production facilities will overlap. The section 18 notice from the Minister for Aboriginal Affairs stated that the intended use of the land for the purposes of the Project will impact upon only two of the sites within the meaning of Section 5 of the *Aboriginal Heritage Act 1972* (the Act). The sites impacted were determined to be ID 11409 and ID 11410. In addition, the Minister, pursuant to Section 18(3) of the Act has granted consent to disturb the two sites (i.e. ID 11409 and ID 11410) with standard conditions applied regarding salvaging the sites and reporting the salvaging outcomes.

The section 18 notice provides clearance for Mardie Minerals to implement all production facilities for the project. Additional section 18s are currently being drafted for the port and Mardie Road and are expected to be approved in Q3 2020.

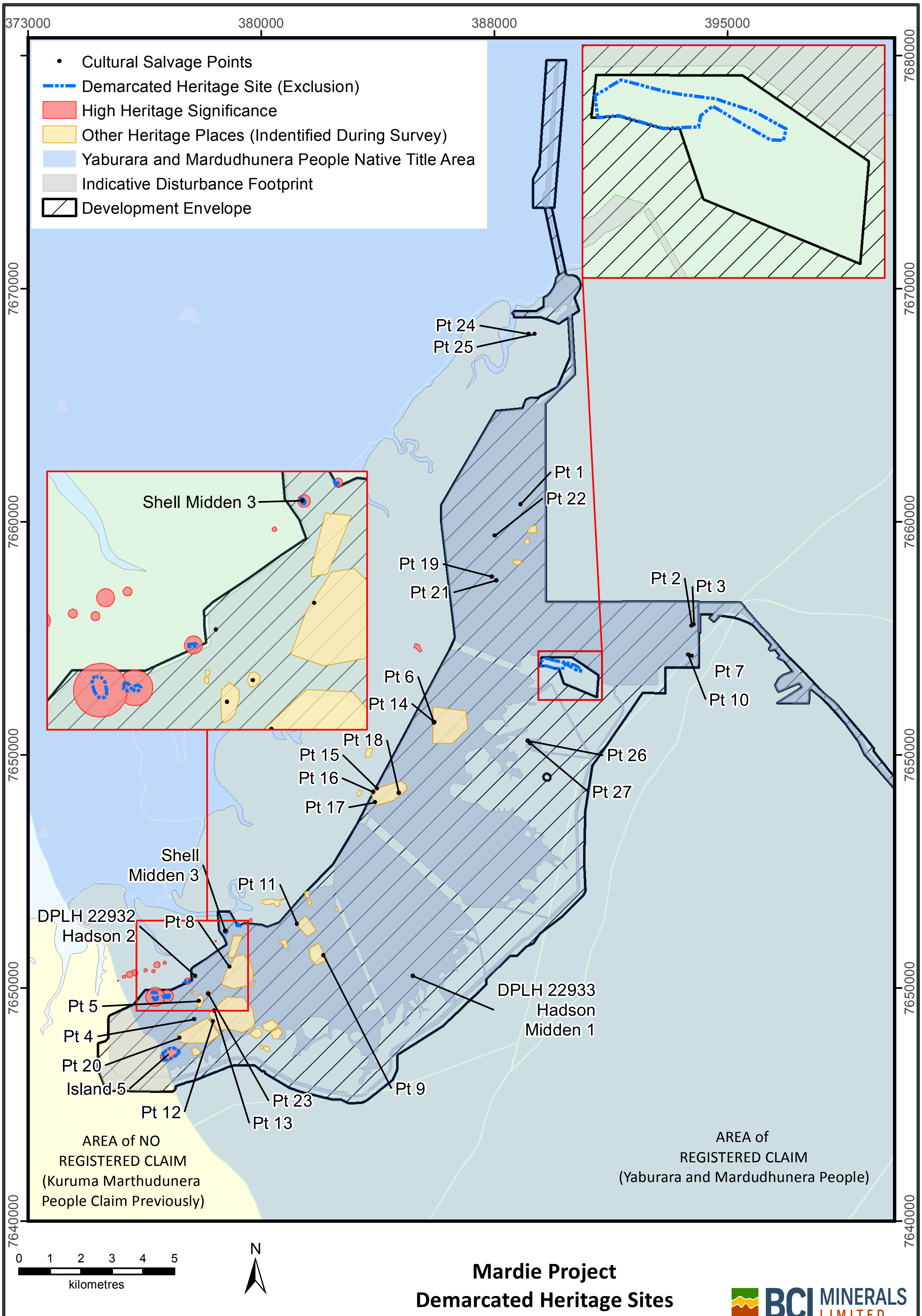


Figure 126: Location of other Heritage Places, salvage sites and areas to be demarcated

11.3.5 TRADITIONAL USES

Feedback has been sought from Horizon Heritage (2019), the heritage consultant for the YM People, in relation to traditional uses of the land for bush tucker or medicine within or adjacent to the development envelopes. Horizon Heritage (2019) noted that the following land and features should be considered in the assessment of traditional uses of the land.

Mangroves and the coastal zone have an abundance of rich marine resources available. The mangrove areas and identified shell scatters and middens prove that the coast was an area rich with resources used by the Aboriginal Traditional Owners in the past. The abundance of shellfish species noted (*Saccostrea* spp. *Terebralia* spp. *Anadara* spp. and *Melo* spp.) demonstrates the use and importance of the coastal zone as a resource area for food and dietary sustenance. The YM People still use coastal areas for recreation activities like fishing, camping and hunting but the large-scale gathering of shellfish was a technique primarily used by their ancestors. In recent and more modern times, access to these areas is limited due to the inaccessible terrain and changing lifestyle of the YM and KM People. Mardie Minerals has noted that in discussions with the YM and KM improved accessibility to the coast will be a welcome benefit of the Proposal implementation.

Mardie Pool (excluded from the development envelopes) is a lodged DPLH Other Heritage Place. Mardie Pool was historically used by Mardudhunera people as a water and food resource. While in more recent times it was used by Aboriginal station workers for recreational activities such as swimming. The pool has fond memories and is of cultural and social value too many generations of Mardudhunera People. The availability of year-round fresh water made Mardie Pool a vital asset and resource to both Aboriginal Traditional Owners and the European pastoralists. The Mardie Pool has been excluded from the development envelopes and will not be impacted by the Proposal. Access to the pool as well as water quality and aesthetics will be improved through the exclusion of cattle as a result of the implementation of the Proposal.

Spinifex grassland, shrubland and woodland areas - Aboriginal Traditional Owners would likely have found fruits or berries (bush tomato), edible roots and leaves, spinifex (resin or wax), flower nectar (Hakea varieties), seeds and gum (Acacia varieties) and native honey (Eucalyptus trees like Snappy Gum and Bloodwood trees) with many having ethnobotanical and cultural significance to Aboriginal Traditional Owners. The wood from mulga trees, snakewood and Acacia was used to make spears, boomerangs, fighting sticks and digging tools, while the seeds of various trees and plants were harvested for flour to use in dampers. Sweet gum was collected from the cracks in the branches and trunks of Acacia (bloodwood) for eating or to use as medicine for skin aliments and burns. These areas will be overlapped to a very minor extent by the development envelopes and are abundant in adjacent areas.

11.3.6 EUROPEAN HERITAGE AND CULTURAL VALUES

A search of WA databases (inHerit) identified one European Heritage site in proximity to the Proposal; Mardie Station. The database specifically describes the Mardie Station homestead and woolshed complex as the listed European Heritage site. The following description is taken from the State Heritage Office website (accessed in March 2019):

> "Mardie Station homestead and woolshed are of historical significance as one of the early sheep stations in the region. The homestead complex has considerable interpretive potential with the capacity to demonstrate the story of station life, connected to networks of transport (stock route, road and maritime), and communications (telegraph and post).

> The remaining in-situ Aboriginal hut, set well outside of the homestead complex, shows the division within the station workforce, the lowly status and poor conditions provided for Aboriginal workers and their families in stark contrast to the station owners and managers. This aspect of station life is rarely represented so well in the region.
>
> The historical precinct of the separate woolshed is well preserved, with evidence from the earliest stages of its use (with the stone structures) and the intact yards, sheds, and associated structures for workers".

All of the features of the Mardie Station European Heritage site will not be disturbed with the homestead and woolshed complex located outside of the development envelopes (Figure 126).

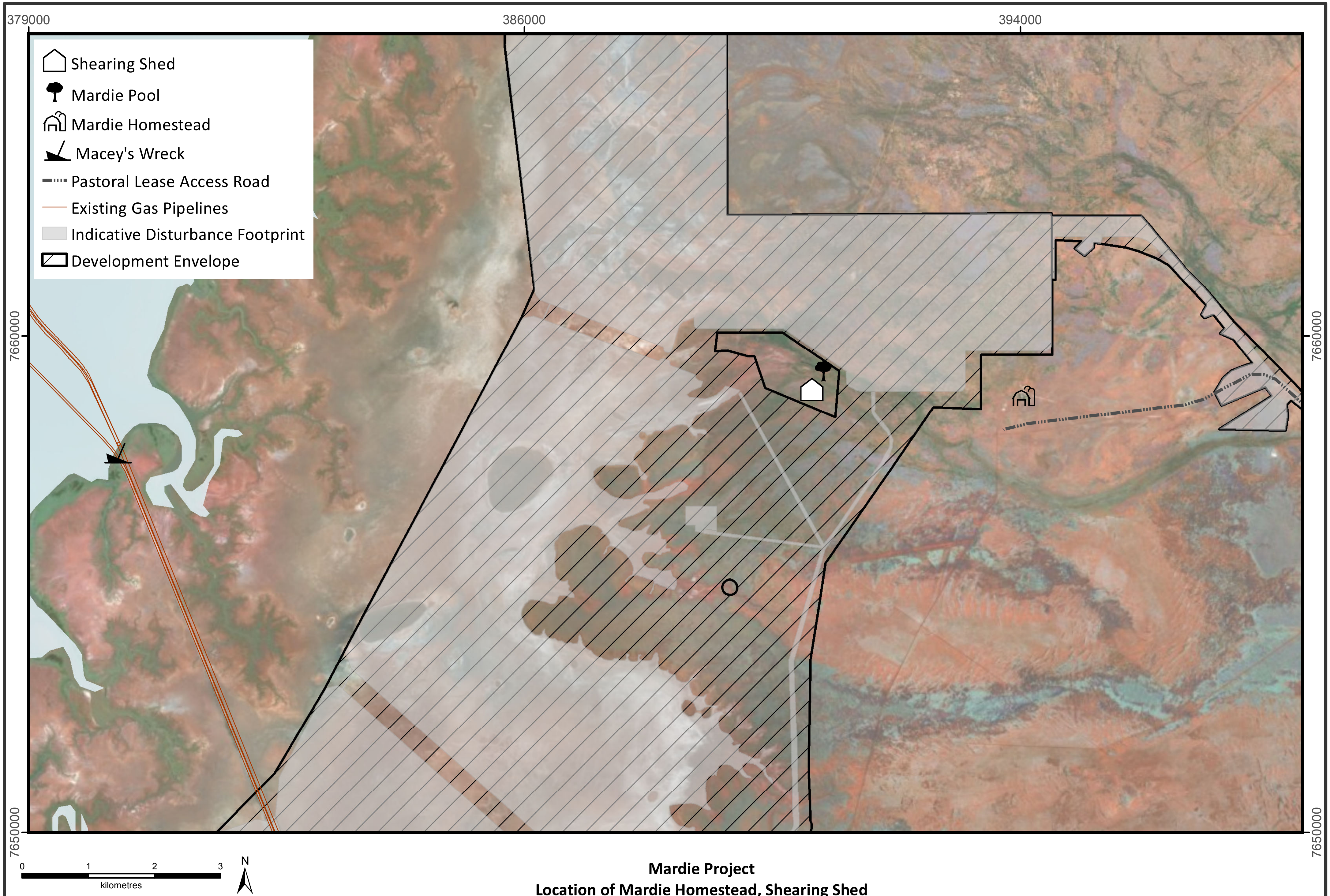
No shipwreck sites have been identified or recorded within the development envelopes. Underwater video surveillance, side-scan sonar and bathymetry surveys conducted to-date has not produced any evidence of maritime heritage sites.

Macey's Wreck (located approximately 4 km west of the Proposal) is an unidentified shipwreck that was discovered on Mardie Station in 1991 by Hadson Energy (now Apache) during the construction of the Apache pipeline. The wreck is unknown, but appears to be a small vessel that was a part of the North West coastal or pearl trade, no earlier than 1880. The wreck is of significance because it is one of the few accessible remains left from the early pearling industry in the north west of Australia. Additionally, bottle bases located in the wreckage may have been used by Aboriginals to make tools and spear heads (WA Maritime Museum, 1991). Figure 127 shows the location of Macey's Wreck in relation to the development envelopes.

11.3.7 Social Values

Based on the information provided above, the following social values were determined to require assessment for this factor:

- Recreational uses of marine and coastal waters;
- Amenity of Mardie Homestead residents and visitors;
- Registered Aboriginal Heritage Sites;
- Demarcated YM Aboriginal Heritage areas; and
- Land used for traditional purposes.



Mardie Project
Location of Mardie Homestead, Shearing Shed and Macey's Wreck

Figure 127: Location of Mardie Homestead, Shearing Shed and Macey's Wreck

BCI MINERALS LIMITED

11.4 POTENTIAL IMPACTS

Table 54 defines the potential impacts (direct, indirect and cumulative) on the social values for this factor in a local and regional context. These impacts are informed by the results of studies described in Sections 5 - 11.

Table 54: Potential impacts on social surroundings

Social value and current extent	Potential direct impact	Potential indirect impact	Impacts associated with other proposals	Total cumulative impact
Recreational uses of marine and coastal waters Sporadic use of marine and coastal waters.	Disturbance of up to 135 ha of coastal and marine habitat	Reduced access to areas occupied by the jetty, turning basin and dredge channel	No other proposals in the area have a significant impact to recreational users. Gas pipelines run along the seabed and can be traversed by boats.	Disturbance of 135 ha of coastal and marine habitat
Amenity of Mardie Homestead residents and visitors Mardie Homestead is located 700 m from the Ponds and Terrestrial Infrastructure Development Envelope.	No direct impacts to the Mardie Homestead or surrounds	Visual amenity impacts as the SoP plant may be visible from the Homestead.	No other proposals are in proximity to Mardie Homestead.	Visual amenity impacts as the SoP plant may be visible from the Homestead. Mardie Minerals and PMPL are currently negotiating an access agreement which will address amenity issues.
Registered Aboriginal Heritage Sites Four Sites located within or in proximity to development envelopes.	Disturbance within the DPLH boundary of two Registered Aboriginal Heritage Sites.	Changes to the hydrological regime associated with one of the sites (Peter Creek).	No other proposals are currently impacting the two Registered Aboriginal Heritage Sites.	Disturbance within the boundary of two Registered Aboriginal Heritage Sites, and changes to the flow path associated with one of these sites.
Demarcated YM Aboriginal Heritage areas Four demarcated areas were recorded within the development envelopes	No direct impacts.	Decline in the quality of the areas due to inundation and unauthorised access.	No other proposals are currently impacting the Demarcated YM Aboriginal Heritage areas.	Decline in the quality of the areas due to inundation and unauthorised access.
Land used for traditional purposes The majority of the coastal zone, and Mardie Pool has been excluded from the development envelopes. Spinifex grassland, shrubland and woodland areas occur within and outside the Ponds	17 ha disturbance of mangrove communities. Up to 2,401 ha disturbance of Spinifex grassland, shrubland and woodland areas.	Alteration of land characteristics due to changes to hydrological processes or weed infestation. Altered access to land.	There are several other proposals within YM and KM land. The closest major project is the Sino Iron Project to the north which is within the boundary of the YM claim.	Cumulative loss of mangrove communities within YM and KM land is difficult to estimate however it is likely to be a fraction of 1% of the total extent. All vegetation associations that contain spinifex grassland, shrubland or woodland within the development envelopes will have >80% of their pre-European extent remaining.

Social value and current extent	Potential direct impact	Potential indirect impact	Impacts associated with other proposals	Total cumulative impact
and Terrestrial Infrastructure Development Envelope.				

11.5 Assessment of Impacts

11.5.1 Recreational uses of marine and coastal waters

There are only low levels of recreational use of the marine and coastal waters along the Mardie coastline, and any uses are sporadic. None of the recreational groups contacted highlighted any concerns with the Proposal. Once operational the majority of the coastal and marine waters will remain accessible to recreational users, with the only exception being the berth pocket.

Based on the above, recreational uses are not expected to be materially impacted by the Proposal.

11.5.2 Amenity of Mardie Homestead residents and visitors

Amenity impacts to Mardie Station have been raised by PMPL in regard to noise and odour from the processing infrastructure. All infrastructure will be low-profile (i.e. concentrator pond walls will be less than 1 m in height) and is not expected to greatly impact visual amenity of the homestead.

The Proposal is a long term and large-scale project and as such Mardie Minerals and PMPL are currently negotiating an access agreement for the Proposal that will address a number of commercial, operational and amenity issues and concerns. The access agreement, when signed, will document that PMPL accepts all potential impacts to Mardie Station operations as a result of the Proposal, including amenity impacts.

11.5.3 Registered Aboriginal Heritage Sites

There were four Registered Aboriginal Heritage Sites located in close proximity to the Proposal. The Mardie Pool and the Wiruwundi Plains sites do not overlap with the development envelopes and therefore will not be impacted by the Proposal. The Mardie Station A & B sites have been recorded as being within the development envelopes; however, the location of the sites is questionable due to the description of the site. It was the conclusion of the survey team and archaeologists that these sites do not exist within the development envelopes and they will therefore not be impacted by the Proposal (Horizon Heritage, 2019). Mardie Minerals was advised by DPLH that these two sites should be included in a section 18 application. As stated above the section 18 application was considered by the Minister for Aboriginal Affairs and approval to disturb the sites was granted on 22 January 2020.

Other Heritage Places identified within the development envelopes through prior surveys and the recently completed 2018 surveys will be impacted to a degree. None of the lodged or stored data sites were considered to meet the definition of a site pursuant to Section 5 of the AH. It was the recommendation of the YM People that all 'Other Places' and the 30 identified salvage sites be salvaged and relocated to Island #5 (Figure 126). The YM People have not heritage-cleared Island 5 and have requested that Mardie Minerals avoid this island. They understand that based on current plans this island will be surrounded by water within one of the ponds. This will make it inaccessible except via water craft. The YM People are satisfied that this will not impact on the integrity of this place and have no objection to this island being surrounded by water. The YM People would like to use Island 5 as the keeping place for any artefactual material requiring cultural salvage from other areas within the development envelopes.

11.5.4 DEMARCATED ABORIGINAL HERITAGE AREAS

There were five Demarcated Aboriginal Heritage areas identified during the YM survey, two of which have since been excluded from the development envelopes (Figure 125). Island number 5 will be demarcated and surrounded by water. The other two sites are shell middens and will be demarcated prior to being inundated as they are located in Pond 1. The YM People are comfortable that this will preserve and protect the site and have not sought to exclude these sites from the development envelopes.

11.5.5 LAND USED FOR TRADITIONAL PURPOSES

The assessment of potential impacts on land used for traditional purposes is closely linked to the assessment of impacts on mangrove communities (Section 6) and flora and vegetation (Section 9). The Proposal has been relocated away from the coastal zone, however it will require the disturbance of a portion of the mangrove communities mapped within the O2 Marine (2020a; Appendix 2.3) Study Area. Indirect impacts are not expected to be significant given the application of controls. The Proposal is therefore unlikely to significantly impact the coastal zone to the extent that it affects its utilisation for traditional purposes. Access to these coastal zones via inland routes may also be improved as a result of the Proposal, as Mardie Minerals has committed to providing access for traditional uses.

Mardie Pool will not be impacted as it has been excluded from the development envelopes, and measures are proposed to minimise indirect impacts (refer to Section 5).

The Proposal will require disturbance within spinifex grassland, shrubland and woodland vegetation, however this disturbance is minimal in the context of the current extent of vegetation available in the area, with all vegetation associations having more than 80% of their pre-European extent remaining after the Proposal disturbance has been included. A large portion of the area to be cleared is also infested with mesquite, which has lowered the quality of the land and subsequently its use by Traditional Owners.

11.6 MITIGATION

Mardie Minerals has mitigated the potential impacts to this factor according to the mitigation hierarchy; avoid, minimise, rehabilitate. Offsets are generally not applied to this factor.

11.6.1 AVOID

The key avoidance mechanism implemented by Mardie Minerals was the design of the development envelopes to avoid key features relevant to this factor, including:

- Two Registered Aboriginal Heritage Sites;
- Two Demarcated Aboriginal Heritage Areas;
- The Mardie homestead and woolshed complex;

- The majority of the coastal zone; and
- Mardie Pool.

In addition to the above, the following avoidance mitigation measures have been incorporated:
- 'Island 5' – a Demarcated Aboriginal Heritage Area, will not be inundated; and
- The location of the concentrator ponds has targeted areas of bare clay pan, which typically has lower levels of Aboriginal Heritage Sites.

11.6.2 MINIMISE

The following mitigation measures are proposed to ensure that direct and indirect impacts to social surroundings are minimised:

1. **Obtain Access Agreement with PMPL;**
2. **Implement industry best-practice management measures for Aboriginal Heritage**:
    a. Undertake Aboriginal Heritage surveys across any areas proposed to be cleared;
    b. Vegetation clearing will be managed through internal ground disturbance procedures;
    c. Boundaries of areas to be cleared or disturbed will be identified by GPS coordinates and maps of boundaries will be provided to dozer operator;
    d. Progressive clearing will be undertaken;
    e. Aboriginal monitors will be present during clearing activities where the likelihood of artefacts being uncovered is high (typically in areas where mesquite infestation limited survey access);
    f. The disturbance footprint will be developed to the minimum required to ensure safe and adequate construction and operation;
3. **Obtain and comply with Section 18 approvals under the *Aboriginal Heritage Act 1978* for any Aboriginal Heritage sites (or Other Heritage Places that are likely to be sites) that are to be disturbed;**
4. **Ensure Aboriginal 'cultural salvage areas' are appropriately salvaged prior to disturbance;**
5. **Minimise clearing and access restrictions within areas used for traditional purposes;**
6. **Maintain and improve Traditional Owners' access to land for traditional uses;**
7. **Develop and implement a Cultural Heritage Management Plan in consultation with the YM and KM People**. The Cultural Heritage Management Plan is to include the following commitments at a minimum:
    a. YM People will be used as cultural monitors for all vegetation clearing within the SoP Plant and Tertiary Crystalliser areas. These areas are heavily vegetated and infested with mesquite and have limited ground surface visibility and access;
    b. The YM People will be engaged to undertake salvage of the 30 identified cultural salvage places. Two YM People in conjunction with a heritage consultant will salvage, relocate and document all identified and salvaged cultural material to a new area of YM's choosing away from any disturbance;
    c. Cultural awareness training will be included in site inductions, to ensure all personnel are made aware of their obligations under the Cultural Heritage Management Plan and AH Act;
    d. Access to country is to be maintained wherever possible and safe to do so;
    e. If human remains, skeletal materials that may be human or materials that may be a human grave are uncovered, then Mardie Minerals and its contractors will stop

work immediately and the materials and the area will be left undisturbed. The YM People will be informed immediately.

11.6.3 Rehabilitate

At the completion of the Proposal the site will be rehabilitated to reinstate fauna habitat. A MCP has been prepared and is provided in Appendix 12.1. The MCP will be required under the *Mining Act 1978* and the key rehabilitation measures that relate to terrestrial fauna are summarised below:

1. Salts will be harvested from each pond prior to closure;
2. Concentrator pond walls will be flattened or opened up to allow tidal flows to enter the ponds;
3. All infrastructure will be removed if not retained by Mardie Station or PPA;
4. All disturbance areas to be revegetated will be respread with topsoil and rehabilitated;
5. All crystalliser ponds will be rehabilitated to an acceptable landform; Mardie Minerals will examine inundated demarcation sites and remediate to the satisfaction of the YM and KM People; and
6. Include KM and YM people as part of the closure plan stakeholders.

The MCP will be submitted to DMIRS for assessment and approval prior to the construction of the Proposal, and will be reviewed and revised every three years.

11.7 Predicted Outcome

The EPA's environmental objective for this factor is to "protect social surroundings from significant harm" (EPA, 2016q).

The Proposal is expected to result in negligible impacts to the recreational or community uses of the area. This is because the area is almost inaccessible for camping and boating; and fishing generally targets the offshore islands rather than the shallow and barren mainland beaches. Nevertheless, the Proposal only has a limited marine footprint, with low numbers of vessels and vessel movements. As a result of the above, the Proposal is not expected to result in significant 'harm' to this social value.

Mardie Homestead is outside of the development envelopes and Mardie Minerals and PMPL are currently negotiating an access agreement that will address any indirect impacts and benefits to the homestead and its participants.

Mardie Minerals has avoided two of the four Registered Aboriginal Heritage sites and has determined through examination of records and site investigations that the other two sites are likely to be outside the Development Envelopes. Mardie Minerals will demarcate and protect the Other Heritage Places identified prior to and during the recent 2018 heritage surveys. This will be done in line with Mardie Minerals Land Access Deed obligations and the recommendations of the 2019 Horizon Heritage report.

The Proposal avoids the majority of the coastal zone, which was considered to be a traditional food source for Traditional Owners. Mardie Pool is outside the development envelopes and will not be directly impacted, and terrestrial vegetation will not be significantly impacted in a regional context. Mardie Minerals has also committed to maintaining access to land for the Traditional Owners, and minimising disturbance within the areas noted to be used for traditional purposes.

As a result of the above, the Proposal is not expected to significantly impact the traditional uses of the land.

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 is expected to ensure that there are no significant residual impacts to social surroundings.

12 OFFSETS

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.

Mardie Minerals commissioned numerous environmental surveys and studies for the Proposal. The surveys determined that there were key environmental values that required protection, including migratory shorebirds, marine turtles and other Threatened or Migratory fauna, as well as significant flora and heritage sites.

Mardie Minerals assessed the findings of the surveys and studies and made significant changes to the Proposal design. Some of these changes carried a significant cost (such as relocating the walls further inland) – affecting the unit costs of the Proposal. Changes were also made to avoid and minimise operational impacts, such as diluting bitterns prior to disposal, using a desalination plant instead of groundwater bores, and using dredge material as onshore construction material.

The application of these avoidance mechanisms in Proposal design and operations has meant that impacts to key environmental values have been significantly reduced. Mardie Minerals understands that this conclusion is in part based on studies and modelling, and as such monitoring has been committed to in order to verify the study and model outputs.

The WA Environmental Offsets Guidelines (Government of WA, 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".

Mardie Minerals has assessed the residual impacts of the Proposal against the residual impact significance model provided in the WA Environmental Offsets Guidelines (Government of WA, 2014). The findings of this assessment is provided in Table 55.

Table 55: 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 criteria						
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 criteria: • No Threatened Flora records are located within the Development Envelopes • No records of undescribed flora species are located only within the Development Envelopes	No residual impacts are considered to meet this criteria - no TECs were recorded within the Study Area	No residual impacts are considered to meet this criteria – all remaining vegetation will have 80% or more of their pre-European extent remaining	No residual impacts are considered to meet this criteria: • No wetlands or waterways that are protected by statute will be impacted • Mardie Pool will not be disturbed and mitigation measures have been proposed to ensure indirect impacts are not significant • Cumulative impacts are not considered to be at a critical level	No residual impacts are considered to meet this criteria: • Clearing of mangroves is not proposed within the Robe River Delta MMA • No other conservation areas are present • Indirect impacts to the mangroves within the Robe River Delta MMA are not considered to be significant	No residual impacts are considered to meet this criteria: • Mangroves, tidal creeks and Mardie Pool would be considered areas of high biological diversity – almost all of these areas have been avoided • Clearing of mangroves is not proposed within the Robe River Delta MMA	No residual impacts are considered to meet this criteria: • Clearing of mangroves is not proposed within the Robe River Delta MMA • The residual impact of direct and indirect disturbance of coastal habitat for listed Threatened or Migratory bird species is not considered to be significant given almost all of significant the local habitat has been avoided and will not be impacted by the Proposal • The residual impact of direct and indirect disturbance of marine habitat for listed Threatened or Migratory marine species is not considered to be significant given the Proposal occurs in habitat with low relative value and indirect impacts are able to be mitigated
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*	No residual impacts are considered to meet this criteria: • No Threatened Flora records are located within the Development Envelopes • No flora are likely to become Threatened as a result of the Proposal • No records of undescribed flora species are located within the Development Envelopes	No residual impacts are considered to meet this criteria - no TECs were recorded within the Study Area and impacts to the Horseflat Land System of the Roebourne Plains PEC are minor and unlikely to result in the PEC becoming a TEC	No residual impacts are considered to meet this criteria – refer above	No residual impacts are considered to meet this criteria: • The Proposal generally occurs downstream of ephemeral creek lines (i.e. at the point where the creeks discharge into the mudflats) • Mardie Pool will not be disturbed and mitigation measures have been proposed to ensure indirect impacts are not significant • Direct impacts to tidal creeks are limited to a seawater intake (approximately	No residual impacts are considered to meet this criteria – refer above	No residual impacts are considered to meet this criteria – refer above	Residual impacts to listed Migratory birds may be considered significant if the impacts are not mitigated appropriately or if outcomes vary from modelling predictions, i.e. if the direct and indirect disturbance of coastal habitat for listed Threatened or Migratory bird species leads to a reduction in usage of the remaining habitat

As described in Table 55, the Proposal will affect habitat utilised by Threatened Fauna and therefore the significance of the residual impacts on these habitats was assessed to determine whether these impacts would be considered 'significant residual impacts'. Direct impacts on fauna are necessarily generally based on assessment of impacts to habitat. Based on the findings of the EIA in this ERD, Mardie Minerals considers that the proposed disturbance of samphire communities (classed as 'samphire / samphire mudflats' when assessed as BCH or 'tidal samphire mudflats' when assessed as terrestrial fauna habitat) may be considered significant due to the impacts on habitat forming part of the MSSA, an important habitat for migratory shorebirds. While difficult to quantify the proposed disturbance is equivalent to a small portion of the significant coastal samphire habitats within the MSSA.

There is some uncertainty about whether this impact constitutes a significant residual impact that would require offsets. The WA Environmental Offsets Guidelines (Government of WA, 2014) notes that:

> "There may be cases where there is some uncertainty about whether a significant residual impact will occur, and/or the extent of the impact. An offset may apply in some cases based on an assessment of the risk using a normal risk-based approach, that is considering the 'likelihood' of the impact occurring and the 'consequences' of the impact if it did occur, based on the evidence and information available. Offsets would normally only be applied in cases where there was a significant risk that the impact was likely to occur and there was likely to be a significant consequence".

The uncertainty in this case is the assessment of consequence; Mardie Minerals considers that the consequence of the disturbance of low value samphire habitats and a small area of higher value samphire habitats within the MSSA would not be considered a significant residual impact due to the following:

- The development envelopes do not meet any of the criteria for an important migratory shorebird habitat (only the MSSA as a whole meets this criteria);
- The most favoured samphire habitats occurred along the western edge of this habitat type (Figure 75 - Figure 78), outside the development envelopes, therefore the impact assessment is likely to still be conservative ; and
- The salt ponds may provide additional habitat for migratory bird species which may compensate for the losses (Phoenix, 2020b; Appendix 9.1).

Based on the above, Mardie Minerals has committed to ongoing monitoring that will inform and ultimately verify the scale of the residual impact. The key monitoring is considered to be the annual migratory shorebird survey and the ongoing BCH monitoring programme.

The annual migratory shorebird survey (committed to in Section 10 and 13) will provide data trends regarding the use of the MSSA by migratory shorebirds and will investigate the potential use of the salt ponds by these species over time. Mardie Minerals will liaise with DBCA to ensure this information can inform broader research into migratory shorebirds in the Pilbara and WA.

The ongoing BCH monitoring program is committed to in this ERD in Sections 7, 8and 13. This program is designed to monitor BCH boundaries and health over the life of the Proposal and will allow information to be gathered regarding changes to BCH characteristics and composition associated with sea level rise.

If the surveys described above (in combination with others proposed in this ERD) determine that the Proposal may be having a more significant impact than predicted in this ERD then offset options can be considered in consultation with EPA Services, DBCA and DAWE.

Mardie Minerals has completed a WA Offsets Template as per the requirements of the WA Environmental Offsets Guideline (Government of WA, 2014), provided in Table 56.

12.1 WA OFFSETS POLICY TEMPLATE

Table 56: 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
Groundwater – mounding or quality impacts from seepage or spills from ponds	**Avoid**: Groundwater is not to be abstracted for the Proposal (desalination plant to be used) **Minimise**: • Ponds are located on low permeability soils • Compliance with Part V EP Act Works Approval and Licence • Pond wall stability and design to be regulated under the *Mining Act 1978*	Brine and salts to be removed	<u>Can the environmental values be rehabilitated / Evidence?</u> Yes, the potential for groundwater impacts will cease once brine and salts are removed. <u>Operator experience in undertaking rehabilitation?</u> None required, simple process. <u>What is the type of vegetation being rehabilitated?</u> N/A <u>Time lag?</u> Up to two years depending on rainfall events. <u>Credibility of the rehabilitation proposed (evidence of demonstrated success)</u> Credible, no vectors for impact will remain.	No					
Inland surface waters – alteration of surface water flow regime and potential quality impacts	**Avoid**: Development envelope was revised to allow Peter's Creek flows to intertidal zone **Minimise**: • Two significant drainage channels incorporated into the design • All inland drainage lines are to be diverted through channels or around ponds (up to 1:20 yr ARI event) • Compliance with Part V EP Act Works Approval and Licence • Pond wall stability and design to be regulated under the *Mining Act 1978*	• Drainage mechanisms to be removed and water will be allowed to flow back over pond footprint • Pond walls to be breached to allow flows • Brine and salts to be removed from ponds	<u>Can the environmental values be rehabilitated / Evidence?</u> Yes, the Proposal occurs at the low point of the drainage lines (where they report to the intertidal mudflats), therefore reinstatement is relatively simple <u>Operator experience in undertaking rehabilitation?</u> None required, simple process. <u>What is the type of vegetation being rehabilitated?</u> N/A <u>Time lag?</u> Up to two years to remove salts depending on rainfall events. <u>Credibility of the rehabilitation proposed (evidence of demonstrated success)</u> Credible, the Proposal occurs at the low point of the drainage lines (where they report to the intertidal mudflats), therefore reinstatement is relatively simple	No					
Intertidal zone surface water regime – alteration of tidal flow regimes and potential quality impacts	**Avoid**: • Development envelope was revised to allow Peter's Creek flows to intertidal zone • Development envelopes moved inland, outside of main intertidal flows • Floodways and culverts proposed to maintain intertidal flows **Minimise**: • Seawater intake located in large tidal creek with adequate capacity • Compliance with Part V EP Act Works Approval and Licence • Pond wall stability and design to be regulated under the *Mining Act 1978*	• Brine and salts to be removed from ponds • Pond walls to be breached to allow flows to re-enter the pond footprint	<u>Can the environmental values be rehabilitated / Evidence?</u> Yes, the Proposal occurs at the high point of the intertidal flow system, therefore reinstatement is relatively simple (breach walls and allow natural processes to resume). The base of the ponds will not be shaped therefore existing elevations will remain at closure <u>Operator experience in undertaking rehabilitation?</u> None required, simple process. <u>What is the type of vegetation being rehabilitated?</u> N/A <u>Time lag?</u> Up to two years to remove salts depending on rainfall events. <u>Credibility of the rehabilitation proposed (evidence of demonstrated success)</u> Credible, the Proposal occurs at the high point of the intertidal flow system, therefore reinstatement is relatively simple.	No					
General intertidal BCH –8,207 ha to be disturbed (5,789 ha is bare mudflat), with	**Avoid**: • Development envelopes were revised to avoid almost all of the high value BCH along the coastline	• Brine and salts to be removed from ponds • Pond walls to be breached to allow	<u>Can the environmental values be rehabilitated / Evidence?</u> Yes, 5,789 ha is bare mudflat and will remain at closure. Natural processes are expected to gradually reinstate the remaining BCH,	No					

Existing Environment / Impact	Mitigation: Avoid and Minimise	Mitigation: Rehabilitation Type	Mitigation: Likely Rehab Success	Significant Residual Impact	Offset Calculation Methodology: Type	Risk	Likely Offset Success	Time Lag	Offset Quantification
potential indirect impacts associated with changes to water quality and the risk of introducing marine pests.	• Development envelopes moved inland, outside of main intertidal flows • Floodways and culverts proposed along causeway to maintain intertidal flows **Minimise**: • Limit on mangrove disturbance, including on CC mangroves disturbance • Construct jetty using top-down approach where appropriate • Implement IMP requirements • Compliance with Part V EP Act Works Approval and Licence • Pond wall stability and design to be regulated under the *Mining Act 1978*	flows to re-enter the pond footprint, with consideration of BCH that has become established on the pond walls • Causeway and other infrastructure to be removed	although some boundaries may be altered due to sea level rise. BCH are relatively dynamic due to cyclone events. Operator experience in undertaking rehabilitation? None required, rehabilitation will occur via natural processes. Advice will be sought regarding BCH that has become established on pond walls and other disturbed areas. What is the type of vegetation being rehabilitated? Algal mat, samphire mudflat and some mangrove BCH Time lag? Up to two years to remove salts depending on rainfall events, then several decades for BCH to re-establish, although some BCH will established faster than others. Credibility of the rehabilitation proposed (evidence of demonstrated success) 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 Pilbara of mangroves growing on man-made structures.						
Mangrove BCH – 17 ha to be disturbed (17 ha of SC Mangroves and CC mangroves), with potential indirect impacts associated with changes to water quality and the risk of introducing marine pests.	**Avoid**: • Disturbance footprints were revised to avoid CC Mangroves and limit clearing to only 17 ha of SC Mangroves • Development envelopes moved inland, outside of main intertidal flows • Floodways and culverts proposed along causeway to maintain intertidal flows **Minimise**: • 35 ha limit on mangrove disturbance, including 1 ha limit on CC mangroves • Construct jetty using top-down approach where appropriate Implement IMP requirements • Compliance with Part V EP Act Works Approval and Licence • Pond wall stability and design to be regulated under the *Mining Act 1978*	• 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 mangroves that have become established on the pond walls • Causeway and other infrastructure to be removed	Can the environmental values be rehabilitated / Evidence? Yes, natural processes are expected to gradually reinstate mangroves, although some boundaries may be altered due to sea level rise. Mangrove habitats are relatively dynamic due to cyclone events. Operator experience in undertaking rehabilitation? None required, rehabilitation will occur via natural processes. Advice will be sought regarding BCH that has become established on pond walls and other disturbed areas. What is the type of vegetation being rehabilitated? Mangrove BCH Time lag? Up to two years to remove salts depending on rainfall events, then several decades for mangroves to re-establish. Credibility of the rehabilitation proposed (evidence of demonstrated success) Credible, intertidal processes are dynamic and will flush the area and allow mangroves to spread into the area over time. There is evidence in the Pilbara of mangroves growing on man-made structures.	No					
Algal Mat BCH –880 ha to be disturbed, with potential indirect impacts associated with changes to water quality and flow regimes.	**Avoid**: • Development envelopes were revised to avoid the majority of algal mat habitat • Development envelopes moved inland, outside of main intertidal flows • Trestle jetty proposed to maintain intertidal flows **Minimise**: • Compliance with Part V EP Act Works Approval and Licence • Pond wall stability and design to be regulated under the *Mining Act 1978*	• Brine and salts to be removed from ponds • Pond walls to be breached to allow flows to re-enter the pond footprint	Can the environmental values be rehabilitated / Evidence? Yes, natural processes are expected to gradually reinstate algal mats and other BCH, although some boundaries may be altered due to sea level rise. The base of the ponds will not be shaped therefore existing elevations will remain at closure. Operator experience in undertaking rehabilitation? None required, rehabilitation will occur via natural processes. What is the type of vegetation being rehabilitated? Algal Mat BCH Time lag? Up to two years to remove salts depending on rainfall events, then several decades for algal mat BCH to re-establish Credibility of the rehabilitation proposed (evidence of demonstrated success)	No					

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
			Credible, intertidal processes are dynamic and will flush the area and allow algal mat BCH to spread into the area over time.						
Samphire Mudflat BCH –954 ha to be disturbed, with potential indirect impacts associated with changes to water quality and flow regimes.	**Avoid**: • Development envelopes were revised to avoid almost all of high value samphire mudflat BCH • Development envelopes moved inland, outside of main intertidal flows • Floodways and culverts proposed along causeway to maintain intertidal flows **Minimise**: • Compliance with Part V EP Act Works Approval and Licence • Pond wall stability and design to be regulated under the *Mining Act 1978*	• Brine and salts to be removed from ponds • Pond walls to be breached to allow flows to re-enter the pond footprint	<u>Can the environmental values be rehabilitated / Evidence?</u> Yes, natural processes are expected to gradually reinstate BCH, although some boundaries may be altered due to sea level rise. The base of the ponds will not be shaped therefore existing elevations will remain at closure. <u>Operator experience in undertaking rehabilitation?</u> None required, rehabilitation will occur via natural processes. Advice will be sought regarding BCH that has become established on pond walls and other disturbed areas. <u>What is the type of vegetation being rehabilitated?</u> Samphire mudflat BCH <u>Time lag?</u> Up to two years to remove salts depending on rainfall events, then several decades for samphire mudflat 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 samphire species to spread into suitable habitat over time.	No					
Sub-tidal BCH – 79 ha of vegetated BCH to be lost, and 104 ha of bare substrate, with recoverable impacts associated with dredge sedimentation	**Avoid**: • Bitterns disposal to be located in dredged footprint **Minimise**: • Limit on dredging volumes and bitterns disposal • Implement Dredging and Soil Disposal Management Plan (DSDMP) • Implement Marine Environmental Quality Monitoring and Management Plan (MEQMMP) • Implement Oil Spill Response Plan • Implement IMP requirements • Compliance with Part V EP Act Works Approval and Licence	• Infrastructure to be removed if not required by PPA. • Dredged channel to be left to naturally fill if not required by PPA.	<u>Can the environmental values be rehabilitated / Evidence?</u> Yes, 63 ha is bare substrate and will remain at closure. Natural processes are expected to gradually reinstate the remaining BCH. 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> 9 broad habitat classes identified <u>Time lag?</u> Up to several decades for BCH to re-establish, although some BCH will established faster than others. <u>Credibility of the rehabilitation proposed (evidence of demonstrated success)</u> Credible, sub-tidal processes are dynamic and will allow BCH to spread across the area over time. There is evidence in the Pilbara of sub-tidal BCH such as coral growing on man-made structures or disturbed areas.	No					
Marine turtles – Loss of 79 ha of sub-tidal vegetated marine fauna habitat, disturbance of 50 m width of a low-quality turtle nesting beach, death or injury as a result of vessel strike, dredging or entrapment in seawater intakes, potential indirect impacts	**Avoid**: • Development envelopes were revised to avoid the majority of the low value turtle nesting beach • Impacts associated with significant dredging activities and ocean-going vessel movements close to shore have been avoided by the use of a transhipment loading method. • Impacts associated with the use of a cutter-suction dredge have been avoided by utilising a simpler back-hoe method. • Impacts associated with marine barriers have been avoided by the use of a trestle jetty instead of a causeway **Minimise**:	• Infrastructure to be removed if not required by PPA. • Dredged channel to be left to naturally fill if not required by PPA.	<u>Can the environmental values be rehabilitated / Evidence?</u> Yes, 63 ha is bare substrate and will remain at closure. Natural processes are expected to gradually reinstate the remaining BCH. BCH are relatively dynamic due to cyclone events. The sandy beach is able to be easily rehabilitated by removing the jetty pylons <u>Operator experience in undertaking rehabilitation?</u> None required, rehabilitation is relatively simple or will occur via natural processes. <u>What is the type of vegetation being rehabilitated?</u> Sandy beach and sub-tidal BCH <u>Time lag?</u> 6 - 12 months for the sandy beach to be rehabilitated, up to several decades for sub-tidal BCH to re-establish.	No					

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
	• Limit on dredging volumes and bitterns disposal • Implement DSDMP and MEQMMP • Implement marine noise controls • Implement vessel speed limits • Seawater intake maintained at less than 0.15 m/s at the screen • Develop illumination plan and ensure lighting aligns with DAWE (2019) recommendations • Implement Oil Spill Response Plan • Implement IMP requirements • Compliance with Part V EP Act Works Approval and Licence		<u>Credibility of the rehabilitation proposed (evidence of demonstrated success)</u> Credible, sub-tidal processes are dynamic and will allow BCH to spread across the area over time. There is evidence in the Pilbara of sub-tidal BCH such as coral growing on man-made structures or disturbed areas. The Sandy beach rehabilitation is relatively simple.						
Marine mammals –Loss of 79 ha of sub-tidal vegetated marine fauna habitat, death or injury as a result of vessel strike or dredging, potential indirect impacts.	**Avoid**: • Development envelopes were revised to avoid higher value BCH. • Impacts associated with significant dredging activities and ocean-going vessel movements close to shore has been avoided by the use of a transhipment loading method. • Impacts associated with the use of a cutter-suction dredge have been avoided by utilising a simpler back-hoe method. • Impacts associated with marine barriers have been avoided by the use of a trestle jetty instead of a causeway **Minimise**: • Limit on dredging volumes and bitterns disposal. • Implement DSDMP and MEQMMP. • Implement marine noise controls. • Implement 8 knot vessel speed limits. • Implement Oil Spill Response Plan. • Implement IMP requirements. • Compliance with Part V EP Act Works Approval and Licence.	• Infrastructure to be removed if not required by PPA. • Dredged channel to be left to naturally fill if not required by PPA.	<u>Can the environmental values be rehabilitated / Evidence?</u> Yes, 63 ha is bare substrate and will remain at closure. Natural processes are expected to gradually reinstate the remaining BCH. 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> Sub-tidal BCH <u>Time lag?</u> Up to several decades for sub-tidal BCH to re-establish. <u>Credibility of the rehabilitation proposed (evidence of demonstrated success)</u> Credible, sub-tidal processes are dynamic and will allow BCH to spread across the area over time. There is evidence in the Pilbara of sub-tidal BCH such as coral growing on man-made structures or disturbed areas.	No					
Sawfish – Loss of 79 ha of sub-tidal vegetated marine fauna habitat, death or injury as a result of vessel strike, dredging or entrapment in seawater intakes, potential indirect impacts, and potential indirect impacts.	**Avoid**: • Development envelopes were revised to avoid 13 of the 15 tidal creeks. • Impacts associated with significant dredging activities and ocean-going vessel movements close to shore has been avoided by the use of a transhipment loading method. • Impacts associated with the use of a cutter-suction dredge have been avoided by utilising a simpler back-hoe method. • Impacts associated with marine barriers have been avoided by the use of a trestle jetty instead of a causeway **Minimise**: • Limit on dredging volumes and bitterns disposal. • Implement DSDMP and MEQMMP. • Implement marine noise controls. • Implement vessel speed limits.	• Infrastructure to be removed if not required by PPA. • Dredged channel to be left to naturally fill if not required by PPA.	<u>Can the environmental values be rehabilitated / Evidence?</u> Yes, 104 ha is bare substrate and will remain at closure. Natural processes are expected to gradually reinstate the remaining BCH given their current low cover, although BCH types and boundaries may differ from current status. 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> Sub-tidal BCH and tidal creeks <u>Time lag?</u> Up to several decades for sub-tidal and tidal creek BCH to re-establish. <u>Credibility of the rehabilitation proposed (evidence of demonstrated success)</u> Credible, sub-tidal and intertidal processes are dynamic and will allow BCH to spread across the area over time. There is evidence in the Pilbara of BCH such as mangroves and coral growing on man-made structures and disturbed areas.	No					

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
	• Seawater intake maintained at less than 0.15 m/s at the screen. • Implement Oil Spill Response Plan. • Implement IMP requirements. • Compliance with Part V EP Act Works Approval and Licence.								
Short-nosed seasnake – Loss of 79 ha of sub-tidal vegetated marine fauna habitat, death or injury as a result of vessel strike, dredging or entrapment in seawater intakes, potential indirect impacts.	**Avoid**: • Impacts associated with significant dredging activities and ocean-going vessel movements close to shore has been avoided by the use of a transhipment loading method. • Impacts associated with the use of a cutter-suction dredge have been avoided by utilising a simpler back-hoe method. • Impacts associated with marine barriers have been avoided by the use of a trestle jetty instead of a causeway **Minimise**: • Limit on dredging volumes and bitterns disposal. • Implement DSDMP and MEQMMP. • Implement marine noise controls. • Seawater intake maintained at less than 0.15 m/s at the screen. Implement Oil Spill Response Plan. • Implement IMP requirements. • Compliance with Part V EP Act Works Approval and Licence.	• Infrastructure to be removed if not required by PPA. • Dredged channel to be left to naturally fill if not required by PPA.	<u>Can the environmental values be rehabilitated / Evidence?</u> Yes, 104 ha is bare substrate and will remain at closure. Natural processes are expected to gradually reinstate the remaining BCH although BCH types and boundaries may differ from current status. 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> Sub-tidal BCH <u>Time lag?</u> Up to several decades for sub-tidal BCH to re-establish. <u>Credibility of the rehabilitation proposed (evidence of demonstrated success)</u> Credible, sub-tidal processes are dynamic and will allow BCH to spread across the area over time. There is evidence in the Pilbara of BCH such as coral growing on man-made structures and disturbed areas.	No					
OPMF Nursery Area – Loss of 79 ha of sub-tidal vegetated marine fauna habitat, death or injury as a result of vessel strike, dredging or entrapment in seawater intakes, potential indirect impacts.	**Avoid**: • Impacts associated with significant dredging activities and ocean-going vessel movements close to shore has been avoided by the use of a transhipment loading method. • Impacts associated with the use of a cutter-suction dredge have been avoided by utilising a simpler back-hoe method. • Impacts associated with marine barriers have been avoided by the use of a trestle jetty instead of a causeway **Minimise**: • Limit on dredging volumes and bitterns disposal. • Implement DSDMP and MEQMMP. • Implement marine noise controls. • Seawater intake maintained at less than 0.15 m/s at the screen. • Implement Oil Spill Response Plan. • Implement IMP requirements. • Compliance with Part V EP Act Works Approval and Licence.	• Infrastructure to be removed if not required by PPA. • Dredged channel to be left to naturally fill if not required by PPA.	<u>Can the environmental values be rehabilitated / Evidence?</u> Yes, 63 ha is bare substrate and will remain at closure. Natural processes are expected to gradually reinstate the remaining BCH. 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> Sub-tidal BCH <u>Time lag?</u> Up to several decades for sub-tidal BCH to re-establish. <u>Credibility of the rehabilitation proposed (evidence of demonstrated success)</u> Credible, sub-tidal processes are dynamic and will allow BCH to spread across the area over time. There is evidence in the Pilbara of BCH such as coral growing on man-made structures and disturbed areas.	No					
General terrestrial flora and vegetation / fauna habitat – Disturbance of 5,3,772 ha of vegetation, as well as 862 ha of algal mats	**Avoid**: • Development envelopes were revised to avoid: • The majority of coastal vegetation as it was identified as having a higher ecological value;	• Terrestrial vegetation to be respread with topsoil and reseeded. • Intertidal zone vegetation to be	<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>	No					

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
and 6,580 ha of unvegetated clay pan surface, some potential indirect impacts	• All records of Threatened and Priority Flora; • All records of range extension Flora; • All records of undescribed or unidentified *Tecticornia* spp; and • The majority of the Horseflat Land System of the Roebourne Plain PEC (excluded from the development envelopes by relocating the southern-most pond). **Minimise**: • Manage mesquite in accordance with Mesquite Management Strategy. • Industry standard clearing controls • Compliance with Part V EP Act Works Approval and Licence, and *Mining Act 1978* approvals.	allowed to reinstate (refer above).	Mardie Minerals will source experienced rehabilitation operators at closure. What is the type of vegetation being rehabilitated? Intertidal and terrestrial vegetation Time lag? Up to several decades for vegetation to re-establish. Credibility of the rehabilitation proposed (evidence of demonstrated success) Credible, intertidal processes are dynamic and will allow BCH to spread across the area over time. 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.						
***Tecticornia* spp. shrubland vegetation and associated unidentified and undescribed species** – Disturbance of 1,109 ha, some potential indirect impacts	**Avoid**: Development envelopes were revised to avoid the majority of this vegetation type **Minimise**: • Manage mesquite in accordance with Mesquite Management Strategy. • Industry standard clearing controls. • Compliance with Part V EP Act Works Approval and Licence, and *Mining Act 1978* approvals.	• Terrestrial portions of this vegetation to be respread with topsoil and reseeded. • Intertidal portions of the vegetation to be allowed to reinstate (refer above).	Can the environmental values be rehabilitated / Evidence? 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. Operator experience in undertaking rehabilitation? Mardie Minerals will source experienced rehabilitation operators at closure. What is the type of vegetation being rehabilitated? *Tecticornia* spp. shrubland vegetation Time lag? Up to several decades for vegetation to fully re-establish. Credibility of the rehabilitation proposed (evidence of demonstrated success) Credible, intertidal processes are dynamic and will allow *Tecticornia* spp. to become re-established in the area over time. 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.	No					
Open woodland (riparian) habitat – Disturbance of 5 ha, some potential indirect impacts	**Avoid**: Development envelopes were revised to avoid the majority of this habitat type **Minimise**: • Minimise clearing within this habitat type • Manage mesquite in accordance with Mesquite Management Strategy. • Industry standard clearing controls. • Compliance with Part V EP Act Works Approval and Licence, and *Mining Act 1978* approvals.	Vegetation to be respread with topsoil and reseeded.	Can the environmental values be rehabilitated / Evidence? 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. Operator experience in undertaking rehabilitation? Mardie Minerals will source experienced rehabilitation operators at closure. What is the type of vegetation being rehabilitated? Riparian vegetation Time lag? Up to several decades for vegetation to fully re-establish. Credibility of the rehabilitation proposed (evidence of demonstrated success) 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.	No					
Migratory shorebird habitat – Disturbance of up to:	**Avoid**: Development envelopes were revised to avoid the majority of these habitat types	• Brine and salts to be removed from ponds	Can the environmental values be rehabilitated / Evidence? Yes, the majority of the disturbance is bare mudflat and will remain at closure. Natural processes are expected to gradually reinstate the	No					

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
• 17 ha of mangrove communities • 1,115 ha of the tidal samphire mudflats Some potential indirect impacts.	**Minimise**: • Minimise clearing within these habitat type • Mangrove disturbance limits Ensure low noise and light emissions • Verify inundation model • Industry standard clearing controls. • Compliance with Part V EP Act Works Approval and Licence, and *Mining Act 1978* approvals.	• 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	remaining BCH, although some boundaries may be altered due to sea level rise. BCH are relatively dynamic due to cyclone events. Operator experience in undertaking rehabilitation? None required, rehabilitation will occur via natural processes. What is the type of vegetation being rehabilitated? Algal mat, samphire mudflat and some mangrove BCH Time lag? Up to two years to remove salts depending on rainfall events, then several decades for BCH to re-establish Credibility of the rehabilitation proposed (evidence of demonstrated success) 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 Pilbara of mangroves growing on man-made structures.						

13 MATTERS OF NATIONAL ENVIRONMENTAL SIGNIFICANCE

13.1 CONTROLLED ACTION PROVISIONS

The Proposal was referred to the Minister for Environment and Energy under the EPBC Act on 12 September 2018. The Minister determined that the Proposal was a Controlled Action under Section 75 of the EPBC Act (EPBC 2018/8236), with an accredited assessment to be conducted.

The controlling provisions for the Proposal are:

- 'Listed threatened species and communities' (Sections 18 and 18A of the EPBC Act);
- Listed migratory species (Sections 20 & 20A); and
- Commonwealth marine areas (Sections 23 & 24A).

Based on the studies conducted and the information provided in Sections 7- 10 of this ERD, the species in Table 57 were considered to be potentially impacted by the Proposal and require assessment under the EPBC Act.

Table 57: Matters of National Environmental Significance that may be impacted by the Proposal

Common Name	Species Name	Conservation Status	Recorded
Mammals			
Pilbara Leaf-nosed Bat	*Rhinonicteris aurantia* (Pilbara)	Vulnerable	Yes
Australian Humpback Dolphin	*Sousa sahulensis*	Vulnerable, Migratory	No
Humpback Whale	*Megaptera novae*	Vulnerable, Migratory	No
Dugong	*Dugong dugon*	Migratory	Yes
Reptiles			
Pilbara Olive Python	*Liasis olivaceus barroni*	Vulnerable	No
Flatback Turtle	*Natator depressus*	Vulnerable, Migratory	Yes
Hawksbill Turtle	*Eretmochelys imbricate*	Vulnerable, Migratory	Yes
Green Turtle	*Chelonia mydas*	Vulnerable, Migratory	Yes
Loggerhead Turtle	*Caretta caretta)*	Endangered, Migratory	No
Short-nosed Seasnake	*Aipysurus apraefrontalis*	Critically Endangered	No
Elasmobranch			
Green Sawfish	*Pristis clavata*	Vulnerable, Migratory	No
Birds			
Red Knot	*Calidris canutus*	Endangered, Migratory	Yes
Curlew Sandpiper	*Calidris ferruginea*	Critically Endangered, Migratory	Yes
Great Knot	*Calidris tenuirostris*	Critically Endangered, Migratory	Yes

Common Name	Species Name	Conservation Status	Recorded
Greater Sand Plover	*Charadrius leschenaultii*	Vulnerable, Migratory	Yes
Lesser Sand Plover	*Charadrius mongolus*	Vulnerable, Migratory	Yes
Eastern Curlew	*Numenius madagascariensis*	Critically Endangered, Migratory	Yes
Common Sandpiper	*Actitis hypoleucos*	Migratory	Yes
Ruddy Turnstone	*Arenaria interpres*	Migratory	Yes
Sanderling	*Calidris alba*	Migratory	Yes
Red-necked Stint	*Calidris ruficollis*	Migratory	Yes
Oriental Plover	*Charadrius veredu*	Migratory	Yes
White-winged Black Tern	*Chlidonias leucopteru*	Migratory	Yes
Gull-billed Tern	*Gelochelidon nilotica*	Migratory	Yes
Oriental Pratincole	*Glareola maldivarum*	Migratory	Yes
Caspian Tern	*Hydroprogne caspia*	Migratory	Yes
Bar-tailed Godwit	*Limosa lapponica*	Migratory	Yes
Whimbrel	*Numenius phaeopus*	Migratory	Yes
Osprey	*Pandion cristatus (haliaetus)*	Migratory	Yes
Pacific Golden Plover	*Pluvialis fulva*	Migratory	Yes
Grey Plover	*Pluvialis squatarola*	Migratory	Yes
Crested Tern	*Sterna bergii*	Migratory	Yes
Common Tern	*Sterna hirundo*	Migratory	Yes
White-shafted Little Tern, Little Tern	*Sternula albifrons*	Migratory	Yes
Grey-tailed Tattler	*Tringa brevipes*	Migratory	Yes
Common Greenshank	*Tringa nebularia*	Migratory	Yes
Terek Sandpiper	*Xenus cinereus*	Migratory	Yes
Flora			
Minnie Daisy	*Minuria tridens*	Vulnerable	Yes

13.2 POLICY AND GUIDANCE

The relevant policy and guidance for MNES includes:

- Generic guidelines for the content of a draft EPBC Act PER/EIS (including the objects and principles of the EPBC Act, 1999) (DotEE, 2016);
- Other Minister of the Environment (Cth) approval decision making considerations;
- Environmental Management Plan Guidelines (DoTEE, 2018a);
- EPBC Act Condition Setting Policy (DotE, 2016a);
- EPBC Act Outcomes-based conditions policy (DotE, 2016b);
- EPBC Act Environmental Offsets Policy (DSEWPaC, 2012a) – including the Offset Assessment guide;

- *Environment Protection (Sea Dumping) Act 1981* – note this is not required as no sea dumping is proposed;
- Marine bioregional plan for the North-west Marine Region (DSEWPaC, 2012b);
- National Assessment Guidelines for Dredging (DEWHA, 2009b);
- Environmental best practice port development: an analysis of international approaches (GHD, 2013);
- Significant Impact Guidelines: 1.1 – Matters of National Environmental Significance (DotEE, 2013);
- Recovery Plan for Marine Turtles in Australia (DotEE, 2017);
- Sawfish and River Sharks Multispecies Recovery Plan (DoE, 2015);
- Approved Conservation Advice for *Dermochelys coriacea* (Leatherback Turtle) (DEWHA, 2008e);
- Approved Conservation Advice for *Liasis olivaceus barroni* (Olive Python – Pilbara subspecies) (Threatened Species Scientific Committee (TSSC), 2008);
- Approved Conservation Advice for Green Sawfish (DEWHA, 2008c);
- Conservation Advice *Numenius madagascariensis* Eastern Curlew (DoE, 2015b);
- Conservation Advice *Calidris ferruginea* Curlew Sandpiper (DoE, 2015c);
- Conservation Advice *Rhinonicteris aurantia* (Pilbara form) (Pilbara Leaf-nosed Bat) (TSSC, 2016a);
- Conservation Advice *Calidris canutus* Red Knot (TSSC, 2016b);
- Conservation Advice *Calidris tenuirostris* Great Knot (TSSC, 2016c);
- Conservation Advice *Charadrius mongolus* Lesser Sand Plover (TSSC, 2016d);
- Approved Conservation Advice *Charadrius leschenaultii* Greater sand plover (TSSC, 2016e);
- Approved Conservation Advice for *Sternula nereis nereis* (Fairy Tern) (DSEWPAC, 2011d);
- Conservation Advice *Megaptera novaeangliae* (Humpback Whale) (TSSC, 2015);
- Industry guidelines for avoiding, assessing and mitigating impacts on EPBC Act listed migratory shorebird species (DotEE, 2017b);
- Survey guidelines for Australia's threatened birds (DSEWPAC, 2010);
- Survey guidelines for Australia's threatened fish (DSEWPAC, 2011a);
- Survey guidelines for Australia's threatened mammals (DSEWPAC,2011b);
- Survey guidelines for Australia's threatened reptiles DSEWPAC,2011c);
- EPBC Act Policy Statement 2.1 – Interaction between offshore seismic exploration and whales (DEWHA, 2008g);
- National Strategy for Reducing Vessel Strike on Cetaceans and other Marine Megafauna (DotEE, 2017c).
- National Light Pollution Guidelines for Wildlife Including marine turtles, seabirds and migratory shorebirds (DAWE, 2019)
- Commonwealth Listing Advice on ten species of Bats (TSSC 2001);
- Threat abatement plan for predation by the European red fox (DEWHA 2008a); and
- Threat abatement plan for predation by feral cats (DoE, 2015d);
- Threat abatement plan to reduce the impacts of exotic rodents on biodiversity on Australian offshore islands of less than 100,000 hectares (DoE, 2009); and
- Threat Abatement Plan for the impacts of marine debris on the vertebrate wildlife of Australia's coasts and oceans (DotEE, 2018b).

13.3 DESCRIPTION OF THE ENVIRONMENT

A summary of surveys conducted to date and a detailed description of survey findings relevant to each of the MNES species and their respective habitats is provided in Section 8 (Marine MNES), Section 9 (*Minuria tridens*) and Section 10 (Terrestrial Fauna MNES). A summary of the findings is provided below.

13.3.1 SURVEY EFFORT

Marine Turtles

Mardie Minerals commissioned Phoenix to complete initial marine turtle reconnaissance surveys in 2017 (Phoenix, 2020a; Appendix 8.1). As a result of the presence of marine turtles being confirmed in the area, Pendoley Environmental (Pendoley) was then engaged to conduct field surveys of known and potential marine turtle habitat in proximity to the Proposal (Pendoley, 2019a; Appendix 9.1). The field surveys were designed to collect baseline data to meet the following objectives:

- Identify the species of turtles nesting on the beaches;
- Identify the abundance and distribution of adult tracks on the nesting beaches;
- Collect baseline data on the health of the nesting habitat;
- Collect baseline data on hatchling orientation; and
- Measure the intensity and extent of light sources visible from nesting beaches.

The surveys were conducted on suitable sections of sandy coastline in the vicinity of the Proposal as well as nearby offshore islands (Figure 92).

Two discrete field surveys were scheduled to capture the peak nesting and hatching periods (December 2018 and February 2019 respectively) for green and flatback turtles in this region. Each survey was conducted over 14 days to encompass one complete inter-nesting cycle. This duration was based on observations of the inter-nesting cycle at Mundabullangana (13 ± 3.3 days), Barrow Island (14.1 ± 2.2 days), and Cemetery Beach (12.2 ± 1.2 days) (Pendoley *et al*., 2014). This duration was also consistent with DBCA recommendations for providing the most reliable abundance estimates from the peak of the flatback and green turtle nesting season.

The survey dates were:

- Field Survey 1 (nesting): 1 - 15 December 2018 ('December survey'); and
- Field Survey 2 (hatching): 30 January - 12 February 2019 ('February survey').

Both surveys were scheduled during the new moon phase of the lunar cycle. The new moon fell on 6 December 2018 and 4 February 2019.

Data captured during the survey included (refer to Figure 93 for locations):

- **Nesting habitat assessment – track census**. This included marking a line on the beach at each survey location and conducting an aerial survey each morning to determine if there were any crossings overnight (i.e. fresh tracks). Marine turtle species and the resulting nesting activity category (false crawl, attempt or nest) were determined using track and nest characteristics, including track width, shape and orientation of flipper marks, tail drag marks, movement of sand, morphology and depth of nest pit and associated mound (Eckert et al., 1999). All identified tracks were marked to avoid being recounted on subsequent days. Predator activity was identified by tracks left in the vicinity of the turtle nesting activity. Categories of predation included digging at and around the nest site, or egg shells scattered at the sand surface;

- **Nesting habitat assessment – incubation success**. Firstly, the field personnel found new clutches clutch by digging into a fresh nest and locating the eggs at the top of the nest. A temperature logger was placed amongst the eggs at the top of the nest to record the temperature profile during incubation (every 30 minutes). Temperature loggers were also buried on each beach at 500 mm depth to collect control temperature data from the survey beaches. At the end of the survey period, previously identified clutches were excavated to determine hatchling success. Excavations of marked clutches were conducted with caution to avoid disturbance to live hatchlings within the clutch or to developing embryos that may not yet have hatched. The contents of the egg chamber were counted and sorted into live hatchlings, dead hatchlings, egg shells, undeveloped embryos or no discernible embryos (as per Shigenaka, 2003; Pendoley *et al.,* 2014);
- **Artificial light monitoring**. Light monitoring cameras were deployed on each monitored beach section during the December and February surveys. Images of night-time light emissions on a 360° horizon were captured automatically by the deployed camera at 15-minute intervals between sunset and sunrise; and
- **Hatchling orientation**. A nest fan was recorded if five or more hatchling tracks were sighted from a hatched clutch (defined by a depression in the sand from which the hatchling tracks were seen to emerge). A sighting compass was used to measure the bearing along the outside arms of emergent hatchling tracks. Bearings were taken at either the point where the track crossed the high tide line, or 5 m from the clutch emergence point (whichever distance was shortest).

Other Marine Fauna

A comprehensive desktop review was undertaken by O2 Marine (2020g; Appendix 9.2) to identify significant marine fauna species known or likely to occur in the Study Area. The results of the initial desktop review and likelihood of occurrence assessment identified that the Proposal posed a relatively low risk to marine fauna species other than Turtles. Therefore, specific surveys targeting other marine fauna species were not deemed to be warranted for this assessment. To supplement the desktop assessment, incidental observations of marine fauna were recorded by experienced marine scientists during extensive field surveys undertaken by O2 Marine and Stantec while delivering other work scopes. The details of these surveys (including observer hours) are summarised in Table 58 and Figure 94.

Table 58: Marine field surveys that included incidental observations of marine fauna

Field survey	Company	No. of surveys	Timeframe	Observer hours
Water Quality Maintenance	O2 Marine	11	March 2018 – March 2019	264 Hours (Vessel-based)
Bathymetry Surveys	O2 Marine	2	August – October 2018	60 Hours (Vessel-based)
Benthic Habitat Surveys	O2 Marine	5	March 2018 - March 2019	264 Hours (Vessel-based)
Sediment Sampling Surveys	O2 Marine	3	December 2018 – March 2019	108 Hours (Vessel-based)
Mangrove & Intertidal Surveys	Stantec	2	August & October 2017	24 Hours (Aerial)
	O2 Marine	2	March – December 2018	18 Hours (Vessel-based)

Minuria tridens

Phoenix was commissioned to conduct a detailed flora and vegetation survey for the Proposal, consistent with the commitments provided in the ESD. Extensive reconnaissance and detailed field surveys were conducted to verify and build on desktop reviews compiled using existing information of the Proposal and its surroundings. The field survey effort for the Proposal can be summarised as follows:

- A single day site reconnaissance by helicopter: 17 August 2017;
- Three day site reconnaissance by helicopter: 8 - 10 December 2017;
- Six day first phase detailed flora survey: 14 - 19 May 2018; and
- Nine day second phase detailed flora survey: 15 - 23 August 2018.

The surveys were completed over a defined 28,137 ha Study Area, which encompasses the entire Ponds and Terrestrial Infrastructure Development Envelope, and extends outside the development envelope in some areas (Figure 105).

The detailed survey of the Study Area was conducted over two seasons in accordance with the recommendations in the EPA's Technical Guidance (EPA, 2016f) for the Eremaean botanical province. The initial detailed survey was conducted in May 2018 by Dr Grant Wells and Alice Watt, six weeks post-wet season, with the second survey conducted in August 2018 by Dr Grant Wells, Alice Watt and Laurinda Timmins approximately six weeks following the highest winter rainfall. The detailed surveys assessed 51 permanent quadrats, 11 transects and 11 releves. Targeted searches for significant flora were also conducted, by searching for previous species records identified in the desktop review and in suitable habitat encountered while traversing the Study Area.

Stantec were commissioned to undertake a desktop assessment of mangal and algal communities in September 2017. This work included mapping of the mangroves, algal mats and *Tecticornia* spp. shrublands along the coast and was utilised by Mardie Minerals in their assessment of direct and indirect impacts to terrestrial vegetation.

Terrestrial Fauna MNES

A desktop review and numerous field surveys have been conducted over the disturbance areas proposed in this ERD.

Two study areas were defined:

1. The 'Terrestrial Fauna Study Area (TFSA)' which is 28,149.4 ha in size and is shown on Figure 119; and
2. The 'Migratory Shorebird Study Area (MSSA)' is 64,201.1 ha in size and is associated with the coast and coastal habitats. The MSSA covers an area that extends from 7.5 km west of the Fortescue River mouth, southwest to 41.5 km east of Onslow and is shown in Figure 120. The MSSA comprised two programs:
    a) The 'local program' – 18 aerial transects focused on habitats in proximity to the development envelopes; and
    b) The 'regional program' – Eight aerial transects focused on habitat south of the TFSA / development envelopes.

The MSSA has been determined to be a contiguous 'shorebird area' as per EPBC Act Policy Statement 3.21 - *Industry guidelines for avoiding, assessing and mitigating impacts on EPBC Act listed Migratory shorebird species* (DotEE, 2017), which is described as:

> "The geographic area used by the same group of shorebirds over the main non-breeding period, effectively the home range of the local population when present. Shorebird areas may include multiple roosting and feeding habitats. While most Migratory shorebird areas will represent contiguous habitat, non-contiguous habitats may be included as part of the same area where there is evidence of regular bird movement between them."

A desktop review of relevant databases, literature and spatial data preceded the field surveys to assess the potential for presence of conservation significant vertebrate fauna and Short-Range Endemic (SRE) species and habitats in the study areas.

The field survey effort can be summarised as follows:

- Migratory shorebird survey comprising –
  - Aerial surveys;
  - Ground counts;
- Marine turtle survey comprising –
  - Aerial-based survey to identify turtle nesting habitats and record opportunistic sightings of turtles;
  - Ground survey of potential nesting sites to identify tracks and any other evidence of turtles;
- Targeted Night Parrot (*Pezoporus occidentalis*) survey using autonomous recording units;
- Targeted Northern Coastal Free-tailed Bat (*Ozimops coborgianus*) survey, as well as a mangrove and terrestrial bat species inventory;
- A terrestrial vertebrate fauna observation survey comprising:
  - Fauna habitat assessment and mapping;
  - Active searches and opportunistic records;
  - Nocturnal searches;
  - Avifauna census using timed observation and call identification; and
- SRE invertebrate survey focusing primarily on salt flats and associated islands, comprising of active searches.

Initial habitat characterisation was undertaken using various remote geographical tools, including aerial photography, land system maps and topographic maps. Habitats with the potential to support conservation significant fauna and SRE invertebrates were then identified through these data sources, based on known habitats of such species within the Pilbara bioregion and previous survey reports. Tentative sites were selected for the terrestrial fauna surveys so that all habitat types were represented.

Site selection was aided by a site reconnaissance undertaken in August 2017. A helicopter was used to gain access to all habitats of the study areas, including tidal mangrove creeks, sandy / rocky beaches and tidal islands. At the broadest scale, site selection considered aspect, topography and land systems. At the finer scale, consideration was given to proximity to water bodies (drainage lines and creeks), vegetation complexes and condition and soil type. Sites were primarily chosen to represent the best example of distinct habitats within the broader habitat associations of the study areas. Consideration was also given to the potential Proposal footprint, as available at the time which predominantly occurred in the northern section for the Study Area.

The timing of the field survey work was as follows:

- Reconnaissance survey to ground truth desktop review in 17 August 2017;
- Migratory shorebird survey over three periods from 4 – 9 December 2017 (phase 1), 12 – 16 January 2018 (phase 2), 24 – 26 July 2018 (phase 3) and 21 – 25 February 2019 (Phase 4);
- Marine turtle survey in 5 December 2017 and 13 January 2018;
- Targeted North Coastal Free-tailed Bat survey from 4 – 9 December 2017;
- Targeted Night Parrot survey from December 2017 – March 2018; and
- Terrestrial fauna survey, including vertebrate fauna and SRE invertebrates from 14 – 21 March 2018.

Migratory Shorebirds

Migratory shorebird surveys were conducted over four phases by personnel from Phoenix and Ornithological Technical Services; a specialist avifauna consultancy. Phases 1-3 comprised a 'local program' focussed on shorebird habitats within and in proximity to the development envelopes, including an overwintering survey. Phase 4 expanded on the local program to include a 'regional program', which sampled areas south of the development envelopes within the MSSA. Similar habitats were sampled in the local and regional programs; these included tidal channels, beaches, mangrove areas and the extensive mudflat / saltflat areas to the east.

The Program for Regional and International Shorebird Monitoring (PRISM) (2018) details survey methods for monitoring non-breeding shorebirds. They recommend sampling be undertaken wherever possible within discrete, manageable spatial units, such that an instantaneous sample can be achieved, preferably within 2 - 3 hours, centred around tidal movements (as the area of available habitat changes with time and being aligned with peak tides means the most 'stable' area of habitat availability is surveyed) and thereby reducing the risk of observer fatigue.

The study area for both the local and regional programs was large and thus, the methodology was designed to achieve as close to an instantaneous survey as possible. The regional program was divided into two units of approximate equal area (Table 41), with each being similar in size to the local program area, so that they could reasonably be surveyed on each daily tide cycle. These units were surveyed consecutively and repeatedly during phase 4.

Aerial (helicopter) counts were necessary due to the inaccessible nature of the project site and were completed in conjunction with ground counts in areas of high density or activity. Aerial transects were typically three hours in duration, centred on the peak low and high tide each day. A total of 26 survey events were completed equating to a minimum 78 hours of aerial survey time.

The local program comprised 18 aerial transects focused on habitats in proximity to the development envelopes and the regional program comprised eight aerial transects throughout the southern two-thirds of the MSSA. The survey program methods therefore largely met the considerations detailed in PRISM (2018).

The relative area, percentage and extrapolation factor for each program is provided in Table 41. An extrapolation factor is given as it was necessary to apply this factor to each species to estimate the abundance of each species across the entire MSSA habitat, given that the entire area could not be surveyed in a single event (i.e. a single tide). The extrapolation assumed all species recorded were distributed evenly. This extrapolation in shorebird surveys is common practice e.g. PRISM; Revision of the East Asian-Australasian Flyway Population Estimates for 37 listed Migratory

Shorebird Species (Hansen *et al*, 2016); and Interim Recovery Plan for the Threatened Migratory Shorebirds visiting Western Australia (DBCA, 2018).

All sample events were undertaken using an R44 helicopter, which was considered the most effective method to access such a large area of inaccessible coastline and associated habitat. The alternative survey craft were boat or fixed-wing plane which were determined to be unviable. Boats were not considered suitable as:

- Survey by boat would have taken much longer in each phase to achieve coverage. This means that a 'snap-shot' could not be attained as significant numbers of birds could move in and out of the area during any survey period;
- Mangrove roosting birds are difficult to flush, identify and count (DotEE, 2017);
- Large parts of the MSSA were not accessible by boat, particularly landward roosting and feeding grounds which would not have even been identified without aerial support; and
- Flocks could not be reliably tracked and therefore the risk of double-counting was considered too high.

Therefore, using a boat would likely have resulted in a very limited and/or biased dataset. Fixed-wing planes were also not considered suitable due to the following reasons:

- The inability to rapidly respond to bird movements, slow down or stop, would have resulted in large numbers being missed or double-counted on return; and
- No ground counts could be achieved.

Survey from helicopter was therefore chosen as the most viable method, capable of overcoming the above limitations. It was particularly effective at detecting birds active in the extensive mangroves of the MSSA (a habitat unit where assessment is often inadequate; DotEE 2017) as the helicopter was able to fly along both seaward and landward faces, or over the top of mangroves, as necessary.

For each sample event 3 - 4 'transects' were flown; these commenced in the north and tracked south, then north and then south and north again. On high tides, they commenced on the landward side of the MSSA and on low tides they commenced on the coast over the exposed tidal mudflats, reefs and near-shore islands, finishing over the inland mudflats.

Where large congregations were encountered, the helicopter hovered or slowly circled so that the full complement of a flock could be identified and counted. Care was taken to track flocks so as to not double-count birds. The helicopter was also landed so that ground counts could be completed at certain areas, e.g. in areas of high foraging / roosting density / activity or where key Proposal infrastructure was to be sited. Care was always taken to avoid disturbance of feeding or roosting activity, primarily by flying low and slow toward any congregations identified. It was apparent that this typically resulted in the birds taking to the wing for short periods of time before landing back in the same location. As a result, some point recordings were made over a different habitat to that in which they were initially observed; pulling apart such records from the large dataset attained was not possible. There were no observed events of congregations departing an area permanently due to disturbance by the helicopter observations.

While conducting the surveys, a primary observer was positioned in the front of the helicopter who called out species names and numbers, these were recorded by a secondary observer who also made other observations, identified and tracked flocks, as required.

It was estimated during the surveys that identifications could reliably made on average 150 m either side of the helicopter. Based on this, an area of around 13,300 ha was typically, reliably surveyed on each tide in the MSSA (calculations from local and regional program 21 - 31 February 2019), which represents approximately 60% of the total MSSA.

A 'site' comprised both single and multiple species records, as required. In total, 1,948 site point locations were marked during the four survey phases in the 78 hours of aerial and ground count surveys.

Table 59: Area breakdown of the two MSSA programs

Name	Km^2	Relative % of contiguous shorebird area	Extrapolation factor
Local program	245.3	40.5%	2.6
Regional program (north)	157.4	26%	4.0
Regional program (south)	203.1	33.5%	3.1
Total	**641.9**	**100**	

While DAWE (DotEE, 2017) acknowledges that it may be impossible to achieve a complete ('instantaneous') shorebird survey, the approach and resources used in the Mardie MSSA survey program are considered to have more than adequate scope and reliability to ensure the DAWE survey objectives were still met.

<u>Data Analysis</u>

The data gathered on Migratory shorebirds was assessed against the criteria for determining nationally and internationally important habitats in Australia, including total abundance for each sample event and for individual species records against the most recent published EAAF population estimates for 37 species of shorebird (Hansen *et al.,* 2016), where the total abundance of a species in each of the 26 sample events was calculated.

To determine the estimated abundance for each species across the MSSA, it was necessary to multiply the maximum recorded abundance by the extrapolation factor for the survey component area, as detailed in Table 41. While shorebirds are highly mobile and not always evenly distributed, this was considered the most reliable and accurate method available for estimating the total abundance for a species within the MSSA, particularly given that the recorded abundance for a species in any given sample event is likely an underestimate of the actual resident numbers as the entire area could not be reliably surveyed. By applying a 300 m buffer to the helicopter transects in phase 4 (the maximum estimated distance for reliable spotting determined in the field), it is estimated that a total of 385 km^2 was reliably surveyed, equating to 60% of the MSSA.

The data was also analysed spatially at the scales of the MSSA (local and regional programs) and the development envelopes.

The analysis of total shorebird population considered only the 37 species listed under *EPBC Act Policy Statement 3.21* (DotEE, 2017) with the total abundance in each sample event again calculated. Other 'shorebird' species listed as Migratory, such as the Gull-billed Tern, where not considered in these calculations.

Night Parrot Survey Effort

One historic (unverified) record of the Night Parrot (*Pezoporus occidentalis*) (1967; DBCA, 2017c), occurs approximately 30 km south of the TFSA. Phoenix zoologists used a helicopter to visit the site of the 1967 record in order to assess the habitat and compare it to the habitats of the TFSA. The record was from the Robe Homestead, on the Robe River. Spinifex hummock size and age appeared much greater than seen anywhere in the TFSA and no creekline of the magnitude of the Robe River intersects the TFSA.

Automated Recording Units (ARUs) targeting Night Parrot were deployed at 21 sites within the TFSA using three SongMeter SM2 and three SM4 units in areas considered the most prospective nesting (i.e. mature *Triodia* grassland habitat) or foraging (i.e. samphire habitat) habitat, associated with islands on the salt flats, on the eastern boundary of the salt flats and in the spinifex grassland east of the salt flats (Figure 121).

Devices were initially deployed by Phoenix personnel in December 2017; BCI field staff recovered and re-deployed the devices in January - February 2018 and recovered them on 15 - 16 March 2018.

Additional sites were sampled on 21 August – 24 October 2018. Twenty-one sites were sampled in total. All but three of the sites recorded at least ten nights of audio recordings, above the minimum recommendation of six nights in DPaW (2017a), with a total of 283 recording nights obtained.

Acoustic data gathered to determine the presence of the Night Parrot was analysed using the software package Kaleidoscope®. The sequential analysis process was auto-detection followed by manual inspection, with any calls tagged for review.

13.3.2 Recorded or Likely Species

The MNES species identified in Table 57 have either been recorded during studies for the Proposal or they were considered likely to occur given the presence of suitable habitat in the development envelopes or surrounding areas. The location of the Threatened species that were recorded is shown in Figure 128 and Figure 129. The location of all Migratory Bird records is provided in Figure 75 to Figure 78.

The Short-nosed Seasnake was considered only moderately likely to occur by O2 Marine (2020g Appendix 7.2) however it was included on the list given its status as 'critically endangered' under the EPBC Act.

The following sections provide more detail on the species recorded.

Marine Mammals

An assessment was undertaken of the likelihood of occurrence for threatened marine mammal species identified through the desktop review. Threatened marine species are those listed under the EPBC Act, the *Biodiversity Conservation Act 2016* (BC Act) and the International Union for Conservation of Nature (IUCN) Red List of Threatened Species. The results for the fauna likelihood of occurrence assessment is presented in Table 60. Listed threatened marine mammals with high potential to occur in the area (on occasion) include the Humpback whale

(*Megaptera novaeangliae*), Dugong (*Dugong dugong*) and Australian humpback dolphin (*Sousa sahulensis*).

Table 60: Likelihood of occurrence for marine mammals (from O2 Marine, 2020g; Appendix 7.2)

Species	Range / habitat preference	Likelihood of occurrence
Dugong (*Dugong dugon*) Marine, Migratory EPBC Act, Specially Protected BC Act, Vulnerable IUCN	Dugongs undertake long-distance movements, which means Australia shares populations with other neighbouring countries. In Australia, dugongs occur in the shallow coastal waters of northern Australia from the Queensland / NSW border in the east to Shark Bay on the WA coast. They are also found in other parts of the Indian and Pacific Oceans in warm shallow seas in areas where seagrass is found.	High potential to occur. The species has been recorded in the region (desktop searches) and suitable habitat is present in the Study Area.
Australian Humpback Dolphin (*Sousa sahulensis*) Marine, Migratory EPBC Act, Priority 4 BC Act, Near threatened IUCN	Australian Humpback Dolphins are known to occur along the northern coastline, extending to Exmouth Gulf on the west coast (25°S), and the Queensland / NSW border region on the east coast (34°S). There are few records between the Gulf of Carpentaria in the north and Exmouth Gulf in the west, this is probably due to a lack of research effort and the remoteness of the area.	High potential to occur. The species has been recorded in the region (desktop searches) and suitable habitat is present in the Study Area.
Humpback Whale (*Megaptera novaeangliae)* Marine, Migratory, Vulnerable EPBC Act, conservation dependent BC Act, Least Concern IUCN	Humpback whales utilising Australian waters currently have tropical calving grounds along the mid and northern parts of the east and west coasts of Australia, with feeding grounds in the Southern Ocean. The majority of humpbacks in Australian waters migrate north to tropical calving grounds from June - August, and south to the Southern Ocean feeding areas from September - November. The migratory habitat around mainland Australia is primarily coastal waters less than 200 m in depth and generally within 20 km of the coast.	High potential to occur. The species has been recorded in the region (desktop searches). Typically occur further offshore (>35 km) during migratory routes, although some whales recorded in <10 m water during southern migration (i.e. September).
Blue Whale (*Balaenoptera musculus)* - Endangered, Marine, Migratory EPBC Act, Endangered BC Act, Endangered IUCN	The Blue Whale is a cosmopolitan species, found in all oceans except the Arctic, but absent from some regional seas such as the Mediterranean, Okhotsk and Bering seas. Blue whales feed almost exclusively on krill, with a variety of species being taken by different blue whale populations. They feed both at the surface and also at depth, following the diurnal vertical migrations of their prey to at least 100 m. The migration patterns of blue whales are not well understood, but appear to be highly diverse.	Moderate potential to occur. The species has not been recorded in the region (no records from desktop searches), however is known to occur in the area and in similar habitats to those found within the Study Area.
Indo-Pacific / Spotted Bottlenose Dolphin (*Tursiops aduncus*) - Marine, Migratory EPBC Act	Found in tropical and sub-tropical coastal and shallow offshore waters of the Indian Ocean, Indo-Pacific Region and the western Pacific Ocean. Bottlenose dolphins are distributed continuously around the Australian mainland, but the taxonomic status of many populations is unknown. Indo-Pacific Bottlenose Dolphins have been confirmed to occur in estuarine and coastal waters of eastern, western and northern Australia.	Moderate potential to occur. The species has not been recorded in the region (no records from desktop searches) however suitable habitat occurs within the Study Area.
Southern Right Whale (*Eubalaena australis*) – Endangered, Marine, Migratory EPBC, Vulnerable BC Act, Least Concern, IUCN	In Australian coastal waters, southern right whales occur along the southern coastline including Tasmania, generally as far north as Sydney on the east coast and Perth on the west coast. There are occasional occurrences further north, with the extremities of their range recorded as Hervey Bay and Exmouth.	Low potential to occur. The species has not been recorded in the region (no records from desktop searches) and the distribution for this species occurs significantly south of the Study Area.

Species	Range / habitat preference	Likelihood of occurrence
Australian Snubfin Dolphin (*Orcaella heinsohni*) – Marine, Migratory EPBC Act, Priority 4 BC Act, Vulnerable IUCN	Stranding and museum specimen records indicate that Australian Snubfin Dolphins occur only in waters off the northern half of Australia, from approximately Broome on the west coast to the Brisbane River on the east coast. Aerial and boat-based surveys indicate that Australian Snubfin Dolphins occur mostly in protected shallow waters close to the coast, and close to river and creek mouths.	Low potential to occur. The species has been recorded in the region (desktop searches), however suitable habitat is generally lacking in the Study Area.

Whales

Humpback whales migrate annually from Antarctic feeding grounds to the Kimberley coast for calving during the winter. The humpback whales predominantly occur further offshore, however some have been observed by O2 Marine in 2018 within 5 km of the Marine Development Envelope. The southern migration is the period when they are closest to shore at an average of 36 km although are often recorded in waters less than 10 m deep during the latter part of the migration (September - November) (O2 Marine, 2020g; Appendix 7.2).

Seven other species of toothed whale and three species of baleen whale have been recorded from the Montebello region. Further evidence from aerial surveys and acoustic surveys supports this, as sightings further offshore indicated a greater range of species existing in small numbers that included species of Brydes Whales, Minke Whales, Pygmy Blue Whales, Killer Whales, Southern Right Whales, Pilot Whales and Sperm Whales. However, these whales are believed to only transit through oceanic waters well offshore from the shallow waters of the Study Area (O2 Marine, 2020g; Appendix 7.2).

Dugong

Dugong (*Dugong dugong*) are found throughout the Pilbara region, particularly close to the coast or in the lee of reef-fringed islands and often in areas where seagrass has previously been recorded. Although Dugong have been previously recorded in the nearshore waters of the Mardie coastline, the nearest known Dugong aggregations have been recorded near Cape Preston in the North and Coolgra Point in the South, generally in areas that consistently support extensive seagrass meadows (O2 Marine, 2020g; Appendix 7.2).

Stantec (2018; Appendix 2.2) noted a potential Dugong sighting during aerial surveys in 2017 however the location of this sighting was not recorded. However, no Dugong were observed in the development envelopes during over 700 hours of vessel-based observations. O2 Marine (2020g; Appendix 7.2) concluded that this was most likely due to the lower value of the subtidal BCH in the development envelopes as suitable feeding or foraging habitat for Dugong.

Dolphins

The Australian humpback dolphin (*Sousa sahulensis*) and Indo-Pacific Bottlenose Dolphin (*Tursiops aduncus*) are likely to be the most abundant dolphin species in the area inside the 20 m isobath. The Australian Snubfin Dolphin (*Orcaella heinsohni*) has also previously been recorded in the region but is presumed to be an occasional visitor from the Kimberley region. These dolphin species occur throughout the region and are likely to be present in shallow and nearshore waters of the Mardie coastline at any time. Other species of dolphin most likely occur further offshore.

The abundance of dolphins in nearshore areas surrounding the Mardie coast is likely to be highest during winter and the distribution of dolphins is likely influenced by prey availability. Dolphins will move inshore or offshore dependant on prey availability. Oceanographic currents, areas of upwelling, eddies, and increased nutrients all affect the abundance of zooplankton and transport of larval recruitment of finfish, which therefore have a seasonal effect on dolphin distribution (O2 Marine, 2020g; Appendix 7.2).

Elasmobranch

An assessment was undertaken of the likelihood of occurrence for Threatened elasmobranch species identified through the desktop review. The results for the likelihood of occurrence assessment is presented in Table 61.

Table 61: Likelihood of occurrence for threatened elasmobranch (from O2 Marine, 2020g Appendix 7.2)

Species	Distribution / Habitat Preferences	Likelihood of Occurrence
Dwarf Sawfish (*Pristis clavata*) - Vulnerable EPBC Act, Priority 1 BC Act, Endangered IUCN	The species' Australian distribution has previously been considered to extend north from Cairns around the Cape York Peninsula in Queensland, across northern Australian waters to the Pilbara coast in Western Australia. The Dwarf Sawfish usually inhabits shallow (2 - 3 m) coastal waters and estuarine habitats.	Moderate potential to occur. The species has not been recorded in the region (no records from desktop searches). The western extent of this species range has not been fully resolved, however suitable habitat is present in the vicinity of the Proposal.
Green Sawfish (*Pristis zijsron*) - Vulnerable EPBC Act, Vulnerable BC Act, Critically Endangered IUCN	The green sawfish inhabit shallow coastal marine and estuarine waters of northern Australia, from about Eighty Mile Beach, WA, to the Cairns region. It has been occasionally been caught as far south as Sydney. Green sawfish are known to be pupped near the Ashburton River mouth and utilise the estuary and nearby mangrove creeks, before moving offshore to mature at a length of about 3 m.	High potential to occur. The species is known to occur in the region from recent scientific studies. Suitable habitat is present in the vicinity of the Proposal.
Grey Nurse Shark (*Carcharias taurus*) – Vulnerable EPBC Act, Vulnerable BC Act	The Grey Nurse Shark (west coast population) has a broad inshore distribution, primarily in sub-tropical to cool temperate waters. The population of Grey Nurse Shark (west coast population) is predominantly found in the south-west coastal waters of WA and has been recorded as far north as the North West Shelf.	Moderate potential to occur. The species has not been recorded in the region (no records from desktop searches). Predominantly found in cooler coastal waters further south, however, has been found at Muiron Islands and potential suitable habitat does exist in the vicinity of the Proposal.
Narrow Sawfish (*Anoxypristis cuspidate*) - Marine migratory EPBC Act, Endangered IUCN	The Narrow Sawfish is an Indo-West Pacific species occurring from the northern Persian (Arabian) Gulf to Australia and north to Japan. It is a bentho-pelagic species that occurs from inshore and estuarine areas to offshore habitats in depths of up to 100 m. Common in sheltered bays with sandy bottoms and feed on small fish and cuttlefish.	Moderate potential to occur. The species has not been recorded in the region (desktop searches) and the exact distribution is uncertain. Potential habitat is present in the vicinity of the Proposal.
Whale Shark (*Rhincodon typus*) - Vulnerable, Marine, Migratory EPBC Act, Specially protected BC Act, Endangered IUCN	Found worldwide in tropical and subtropical oceans. In Australia, the Whale Shark is most commonly seen in waters off northern Australia. Yearly Whale Shark numbers in Ningaloo Marine Park are estimated to vary between 300 - 500 individuals. Research conducted in 2003 on Whale Sharks aggregating at Ningaloo Reef found that this species routinely moved between the sea surface and depth. Sharks spent at least 40% of their time in the upper 15 m of the water column and at least 50% of their time at depths equal to or less than 30 m.	Low potential to occur. The species has not been recorded in the region (no records from desktop searches) and are generally found in waters deeper than present near the Proposal.

Species	Distribution / Habitat Preferences	Likelihood of Occurrence
Great White Shark (*Carcharodon carcharias*) - Vulnerable, Marine, Migratory EPBC Act, Vulnerable BC Act, Vulnerable IUCN	In Australia, Great White Sharks have been recorded from central Queensland around the south coast to north-west WA but may occur further north on both coasts. They inhabit inshore waters around rocky reefs, surf beaches and shallow coastal bays; waters on the outer continental shelf and slope; and the open ocean. These sharks most commonly live in depths above 100 m.	Low potential to occur. The species has not been recorded in the region (no records from desktop searches). Has been found at Muiron Islands although predominantly found in cooler coastal waters further south. Suitable habitat is lacking in the vicinity of the Proposal.
Giant Manta Ray (*Manta birostris*) - Marine, Migratory EPBC Act, Marine, Migratory BC Act, Vulnerable IUCN	The Manta Ray lives in tropical, marine waters worldwide, but is also found occasionally in temperate seas. In Australia it is recorded from south-western WA, around the tropical north of the country and south to the southern coast of NSW. The species is known to occur in the Ningaloo Marine Park, Muiron Islands Marine Management Area, Montebello Islands Marine Park, Eighty Mile Beach Marine Park, Lalang-garram / Camden Sound Marine Park and Rowley Shoals Marine Park.	Moderate potential to occur. The species has not been recorded in the region (no records from desktop searches). Potential habitat however does occur near the Proposal.
Reef Manta Ray (*Manta alfredi*) - Marine, Migratory EPBC Act, Marine, Migratory BC Act, Vulnerable IUCN	Reef manta rays are found primarily in the Indian and Pacific Oceans, including coastal waters surrounding Australia, Japan, South Africa, Thailand and Hawaii. This species is generally found in inshore habitats (within a few km of land) in tropical and subtropical latitudes. They are often sighted near coral and rocky reefs in atolls and bays, likely due to the high densities of zooplankton associated with these areas (O2 Marine, 2020g; Appendix 7.2).	Moderate potential to occur. The species has not been recorded in the region (no records from desktop searches). Potential habitat however does occur near the Proposal

Sharks

Sharks inhabit a wide range of coastal and offshore habitats and depths. During the Stantec (2018; Appendix 2.2) survey several sharks were observed along the nearshore ocean environment of their Study Area including: Whitetip Reef Shark, Blacktip Reef Shark, Grey Reef Shark, Bull Shark and Tiger Shark.

Rays

Stingray, Eagle Ray, Shovelnose Ray, Giant Manta Ray and Reef Manta Ray were observed during a survey by Stantec (2018; Appendix 2.2) in the Mardie coastal nearshore waters. Manta rays have been frequently sighted sparsely distributed in depths further offshore in depths of 50 - 150 m (O2 Marine, 2020g; Appendix 7.2).

Sawfish

Relatively little is known about the distribution and abundance of sawfish species in north WA. The North-west Marine Region is considered an important area for the species group because the region and adjacent inshore coastal waters and riverine environments contain nationally and globally significant populations of sawfish species. Two species of sawfish are considered likely to occur in the Study Area, including the Green Sawfish (*Pristis zijsron*) and the Narrow Sawfish (*Anoxypristis cuspidata*). In addition, the western extent of the dwarf sawfish's (*Pristis clavata*) range has not been fully resolved, and this species may therefore also occur. Green sawfish in particular are expected to be present in the creeks and rivers of the Mardie coastline, and in other areas of the Pilbara they are known to use the mouths of major rivers (i.e. Ashburton River) as pupping grounds. Sawfish then move into adjacent creeks at approximately 3 - 6 months old, before moving offshore to mature at a length of about 3 m (O2 Marine, 2020g; Appendix 7.2).

Marine Reptiles

An assessment was undertaken of the likelihood of occurrence for threatened marine reptile species identified through the desktop review. The results for the likelihood of occurrence assessment is presented in Table 62.

Table 62: Likelihood of occurrence for threatened marine reptiles (from O2 Marine, 2020g; Appendix 7.2)

Species	Habitat Preference	Likelihood of Occurrence
Loggerhead Turtle (*Caretta caretta*) - Endangered, Migratory, Marine EPBC Act, Endangered BC Act, Vulnerable IUCN	In Australia, Loggerhead Turtles nest on open, sandy beaches concentrated in southern Queensland and from Shark Bay to the North West Cape in WA. They live at or near the surface of the ocean and move with the ocean currents, choosing a wide variety of tidal and sub-tidal habitat as feeding areas and showing fidelity to both their foraging and breeding areas. (DotE, 2015). The Loggerhead Turtle occurs in the waters of coral and rocky reefs, seagrass beds and muddy bays throughout eastern, northern and western Australia.	High potential to occur. The species has been recorded in the region (desktop searches) and suitable habitat is present in the vicinity of the Proposal.
Leatherback Turtle (*Dermochelys coriace*) - Endangered, Migratory, Marine EPBC Act, Vulnerable BC Act, Vulnerable IUCN	The Leatherback Turtle is a pelagic feeder, found in tropical, subtropical and temperate waters throughout the world. Large body size, high metabolism, a thick adipose tissue layer and regulation of blood flow them to utilise cold water foraging areas unlike other sea turtle species. For this reason, this species is regularly found in the high latitudes of all oceans including the South Pacific Ocean in the waters offshore from NSW, Victoria, Tasmania and WA.	Low potential to occur. The species has not been recorded in the region (no records from desktop searches) with their desired habitat lacking in the vicinity of the Proposal.
Green Turtle (*Chelonia mydas*) - Vulnerable, Migratory, Marine EPBC Act, Vulnerable BC Act, Endangered IUCN	Green Turtles nest, forage and migrate across tropical northern Australia. They usually occur between the 20°C isotherms, although individuals can stray into temperate waters. In Australia, the key nesting and inter-nesting areas (where females live between laying successive clutches in the same season) occur on offshore islands off the Pilbara coast.	High potential to occur. The species has been recorded in the region (desktop searches) and suitable habitat is present in the vicinity of the Proposal.
Flatback Turtle (*Natator depressus*) - Vulnerable, Migratory, Marine EPBC Act, Vulnerable BC Act	The Flatback Turtle is found only in the tropical waters of northern Australia, Papua New Guinea and Irian Jaya, and is one of only two species of sea turtle without a global distribution. On the North-West Shelf, the major rookeries are on the mid-eastern coast of Barrow Island and at Mundabullangana Station near Cape Thouin on the mainland. These turtles are known to occur in the Pilbara region during all sensitive life-history phases (mating, nesting and inter-nesting).	High potential to occur. The species has been recorded in the region (desktop searches) and suitable habitat is present in the vicinity of the Proposal.
Hawksbill Turtle (*Eretmochelys imbricate*) - Vulnerable, Migratory, Marine EPBC Act, Vulnerable BC Act, Critically Endangered IUCN	Hawksbill Turtles are found in tropical, subtropical and temperate waters in all the oceans of the world. In Australia, the key nesting and inter-nesting areas (where females live between laying successive clutches in the same season) occur on offshore Islands off Onslow. Reefs from Cape Preston to Onslow are considered important feeding grounds.	Moderate potential to occur. The species has been recorded in the region (desktop searches) and suitable habitat is present in the vicinity of the Proposal.
Short-nosed Seasnake (*Aipysurus apraefrontalis*) - Critically Endangered EPBC Act, Critically	The Short-nosed Seasnake is endemic to WA, and has been recorded from Exmouth Gulf to the reefs of the Sahul Shelf, in the eastern Indian Ocean. The species prefers the reef flats or shallow waters along the outer reef edge in water depths to 10 m.	Moderate potential to occur. The species has not been recorded in the region (desktop searches) however, there is suitable

Species	Habitat Preference	Likelihood of Occurrence
Endangered BC Act, Critically Endangered IUCN		habitat in the vicinity of the Proposal, and the Proposal is within the known distribution of the species.

Turtles

The following information has been sourced from Pendoley (2019a; Appendix 7.1).

Only a small part of potential marine turtle nesting beach lies within the development envelopes, a narrow section of the beach labelled as 'Mardie Creek East' in Figure 92. The Pendoley (2019a; Appendix 7.1) survey identified only very minor nesting effort by Flatback turtles and a single hawksbill turtle, along the 15 km stretch of coastline to the east of the creek. These results indicated that the mainland beaches are not currently a regionally important rookery. The results of the temperature loggers also confirmed that mainland beaches were significantly warmer than the offshore islands, impacting the success rate of any marine turtle nests on these beaches.

With the exception of the single hawksbill nest recorded on the mainland in December, turtles nested most successfully on the offshore islands (Figure 92); 34 – 42% of Flatback and 36 – 50% of hawksbill nesting attempts on the islands resulted in a nest. None of the three Flatback nesting attempts on the mainland resulted in a nest. This variation in nesting success may be related to the varying nesting habitat characteristics between the island and mainland monitoring sites. For example, the island sites featured a wide supratidal zone, a well-defined primary dune, and fine-medium grained sand size that may have facilitated the successful deposition of a clutch, whereas the mainland sites featured a narrow supratidal zone, little or no primary dune development, and medium-coarse grained sand size that may have hindered successful clutch deposition.

The main species recorded on the offshore islands was Flatback turtles, with relatively less nesting effort seen for hawksbill and green turtles at the same locations. The snapshot monitoring data from Round, Middle, and Angle Islands confirmed similar species composition and abundance at these sites. These results are consistent with turtle activity throughout the Pilbara where Flatback and Hawksbill nesting is dominant on nearshore island habitat, and Flatback turtles are the most common mainland nesting species (Pendoley *et al.* 2016).

Baseline artificial light results found the overhead skies at the Proposal are typically very dark and representative of pristine, natural dark skies unaffected by artificial light. The only light source visible from all mainland and offshore light monitoring sites was the Sino Iron facilities located over 30 km away on the easterly horizon.

The hatchling orientation results indicate marine turtle hatchlings successfully oriented seaward, regardless of the orientation of the beach (e.g. Sholl Island north and south) or the visibility of the glow from the Sino Iron facilities. While hatchling orientation generally coincided with the direction of the horizon glow from the Sino Iron facilities, it is unlikely that the relatively small spatial extent of the sky glow visible from the nesting beach influenced hatchling orientation over the 30 km distance.

Sea Snakes

The North West Marine Region is considered a biodiversity hotspot for 'true' sea snakes within Australia and globally. The Short-nosed Seasnake (*Aipysurus apraefrontalis*), found in Pilbara waters, is currently considered Critically Endangered. As much of the Pilbara waters are quite turbid, sea snakes are infrequently encountered, and in many cases data deficient species are only known from a few specimens collected as fisheries bycatch and lack basic biological data.

Aipysurus sp. are typically found in coral reef habitats. All true sea snake species are strongly associated with benthic habitats, and occur in coastal, shallow water habitats (typically <100 m depth). Coral reefs are not found in coastal waters surrounding Mardie, but rather the highest diversity of benthic habitats and assemblages (coral, macroalgae, and non-coral benthic macroinvertebrates) are found around nearshore islands with fringing coral reefs and / or isolated reef patches. This species is considered moderately likely to occur near the Proposal but is more likely to be found in the vicinity of the offshore islands.

Stantec (2018; Appendix 2.2) recorded a sea snake during the mapping study however the species was unidentified.

Flora

The following information has been sourced from Phoenix (2020a; Appendix 8.1) unless noted otherwise.

A total of 250 flora taxa representing 41 families and 115 genera identified to species level were recorded in the Study Area during the field surveys. Phoenix reported that the level of floristic diversity present in the Study Area was lower than that indicated from the desktop assessment. This may have been due to the survey area containing extensive claypans that supported little to no vegetation, as well as the generally poor condition of the terrestrial vegetation communities as a result of grazing and heavy weed infestation.

Threatened Flora

One Threatened Flora species, *Eleocharis papillosa,* was identified in the desktop review as potentially occurring in the Study Area.

Targeted searches were undertaken for significant flora species identified in the desktop review. The searches focused on habitats considered likely to support significant flora, in addition to previously recorded locations of significant plants or populations in close proximity to the Study Area.

One Threatened Flora listed under the EPBC Act (*Minuria tridens*) was recorded during the field surveys. It was recorded at one location within the Study Area; a single plant was located on a sand dune in *Triodia epactia* and *Cenchrus ciliaris* grassland. This record lies outside any of the Proposal development envelopes (Figure 113). *M. tridens* was not identified through the desktop review as the only other previous record of this species in WA was from near Cue, located on the roadside of the Great Northern Highway in the Eastern Murchison subregion (over 800 km away). As a result of finding the single plant, the dune system on which it was located was searched extensively, including on neighbouring tenure, outside of the initial study area, but no other specimens were recorded.

Terrestrial Mammals

The Pilbara Leaf-nosed Bat (Rhinonicteris aurantia Pilbara) is listed as Vulnerable under the EPBC Act, and was recorded at two riparian open woodland habitats and a creek that was flowing due to recent rainfall (Figure 123). Pilbara Leaf-nosed bats roost in warm and humid caves. At night, individuals disperse outside of their caves to forage in the open, often over open water. In the

Pilbara, this habitat is almost exclusively present in large creek beds and gorges. Pilbara Leaf-nosed bats also forage over Triodia grasslands, usually flying close to the ground up to 3 m high. Mardie Pool (Figure 123) is likely to be regularly used for foraging by this species. No roosting habitat was present in the TFSA.

Terrestrial Reptiles

No terrestrial reptile species listed under the EPBC Act were recorded during the field surveys. One species was however identified as likely to occur within the TFSA; the Pilbara Olive Python (*Liasis olivaceus barroni*).

The Pilbara Olive Python (*Liasis olivaceus barroni*) is listed as Vulnerable under the EPBC Act and is commonly found in rocky areas in association with watercourses and pools and often associated with areas of permanent pooling water near rocky habitats, such as gullies, gorges and rocky ranges or boulder sites. This species was not recorded during two nocturnal searches but suitable habitat is present at Mardie Pool (Figure 123). The species may also be found on occasion on the southern creeklines.

Migratory Shorebirds

The East Asia-Australasian Flyway (EAAF) migratory shorebird survey recorded 20 of the 37 species listed under EPBC Act Policy Statement 3.21 (DotEE, 2017). All 20 species were recorded in the summer sampling events, and twelve were recorded overwintering; no new species were confined to the overwintering survey (phase 3). The average species richness of the three summer phases was 11.3 species per sample event, whereas species richness was lower during winter (phase 3), at 7.2 species per sample event. Average richness between tides in summer sample events were immaterial.

The recorded species are listed in Table 63 and the collated locations of Migratory bird records are shown on Figure 75 to Figure 78.

Table 63: Migratory bird species recorded within the MSSA

Species	EPBC Act	Records
Common Sandpiper (*Actitis hypoleucos*)	Migratory	154
Ruddy Turnstone (*Arenaria interpres*)	Migratory	1,113
Sanderling (*Calidris alba*)	Migratory	39
Red Knot (*Calidris canutus*)	Endangered , Migratory	461
Curlew Sandpiper (*Calidris ferruginea*)	Critically Endangered, Migratory	101
Red-necked Stint (*Calidris ruficollis*)	Migratory	2,040
Great Knot (*Calidris tenuirostris*)	Critically Endangered, Migratory	172
Greater Sand Plover (*Charadrius leschenaultii*)	Vulnerable, Migratory	233
Lesser Sand Plover (*Charadrius mongolus*)	Endangered, Migratory	27
Oriental Plover (*Charadrius veredus*)	Migratory	359
Oriental Pratincole (*Glareola maldivarum*)	Migratory	734
Bar-tailed Godwit (*Limosa lapponica*)	Migratory	4,399
Black-tailed Godwit (*Limosa limosa*)	Migratory	1
Eastern Curlew (*Numenius madagascariensis*)	Critically Endangered, Migratory	423

Species	EPBC Act	Records
Whimbrel (*Numenius phaeopus*)	Migratory	1,503
Pacific Golden Plover (*Pluvialis fulva*)	Migratory	122
Grey Plover (*Pluvialis squatarola*)	Migratory	6
Grey-tailed Tattler (*Tringa brevipes*)	Migratory	3,178
Common Greenshank (*Tringa nebularia*)	Migratory	433
Terek Sandpiper (*Xenus cinereus*)	Migratory	145

13.3.3 Habitat Suitability for MNES

Twelve terrestrial habitat types were recorded in the Phoenix (2020b; Appendix 9.1) Study Area:

- Mudflat or saltflat;
- Tidal samphire mudflats;
- Spinifex grassland;
- Tidal channel and ocean;
- Shrubland;
- Prosopis shrubland;
- Mangal community;
- Cleared;
- Samphire shrubland;
- Open woodland (riparian);
- Beach and dune: and
- Fresh water pool.

These are described in detail in Section 10 and shown on Figure 119.

Seven broad intertidal BCH habitat types were recorded across the Study Area surveyed by O2 Marine (2020a; Appendix 2.3):

- Algal mat;
- Foreshore mudflat/tidal creek;
- CC Mangroves;
- SC Mangroves;
- Rocky Shoreline;
- Samphire/samphire mudflat; and
- Mudflat/saltflat.

Three broad sub-tidal BCH classes (bare sand, filter feeder/macroalgae/seagrass and coral/macroalgae) were recorded within the sub-tidal portion of the Study Area, with eight BCH subclasses distinguished based on varying levels of benthic cover and dominant taxa. These are:

- **Bare silt/sand.** This habitat comprises 89% of the subtidal BCH within the sub-tidal portion of the Study Area and is also widely dispersed across the region;
- **Sand/ sparse (<5%) macroalgae** This habitat comprises 1% of the BCH within the sub-tidal portion of the Study Area;
- **Sand/sparse (<5%) filter feeders.** This habitat comprises 2% of the BCH within the sub-tidal portion of the Study Area and is widely dispersed throughout the region.

- **Low (5-10%) cover macroalgae/filter feeders.** This habitat comprises 6% of the BCH within the sub-tidal portion of the Study Area and follows a patchy distribution throughout the region;
- **Low (5-10%) cover coral.** This habitat comprises 1% of the BCH within the sub-tidal portion of the Study Area;
- **Moderate (10-25%) cover coral/macroalgae.** This habitat class comprises only 1% of the BCH within the sub-tidal portion of the Study Area. Dense (>25%) cover macroalgae/coral/ filter feeders;
- **Dense (>25%) cover macroalgae dominated:** This habitat class comprised <1% of the BCH in the sub-tidal portion of the Study Area; and
- **Dense (>25%) cover coral dominated.** This habitat class was only recorded at one location in the Study Area and, as such, comprises only <1% of the BCH within the sub-tidal portion of the Study Area.

Of the habitat types listed above, the following are considered to have elevated conservation significance:

- **Mangal community / SC Mangroves / CC Mangroves**, due to their importance in supporting roosting, loafing and foraging of Migratory and Threatened bird species. 3,608 ha of this habitat type were mapped within the Study Area, and 7,849 ha was mapped within the MSSA;
- **Tidal samphire mudflats**. This habitat type is well represented through the Study Area however it represents high-value habitat for a number of significant fauna species, including Threatened and Migratory birds. 5,993 ha of this habitat was mapped within the Study Area, and 13,111 ha was mapped within the MSSA;
- **Open woodland (riparian) / Fresh water pool** as it provides habitat for the Pilbara Leaf-nosed Bat and Pilbara Olive Python;
- **Sandy Beaches** as it provides nesting habitat for marine turtles, however the beach within the development envelopes was determined to be of low quality (Pendoley, 2019a; Appendix 7.1);
- **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. Overall, coral habitat was sparse covering less than 3% of the sub-tidal portion of the Study Area. Furthermore, high density corals (which are more significant in supporting marine life) were less than 1% of the sub-tidal portion of the Study Area; and
- **Seagrass**. Seagrasses are known to support marine fauna including turtles and dugong. However, their limited distribution and low cover in the vicinity of the Proposal suggests that their contribution to ecosystem services is limited. Whilst seagrasses were identified in the shallow (<5 m LAT) nearshore waters within the sub-tidal portion of the Study Area, they were generally in areas dominated by filter feeder and macroalgal BCH. Targeted multi-season surveys failed to identify any locations that recorded benthic cover of seagrass that was more than 1%.

A detailed description of the habitat types present in proximity to the Proposal has been provided in Section 6.3.

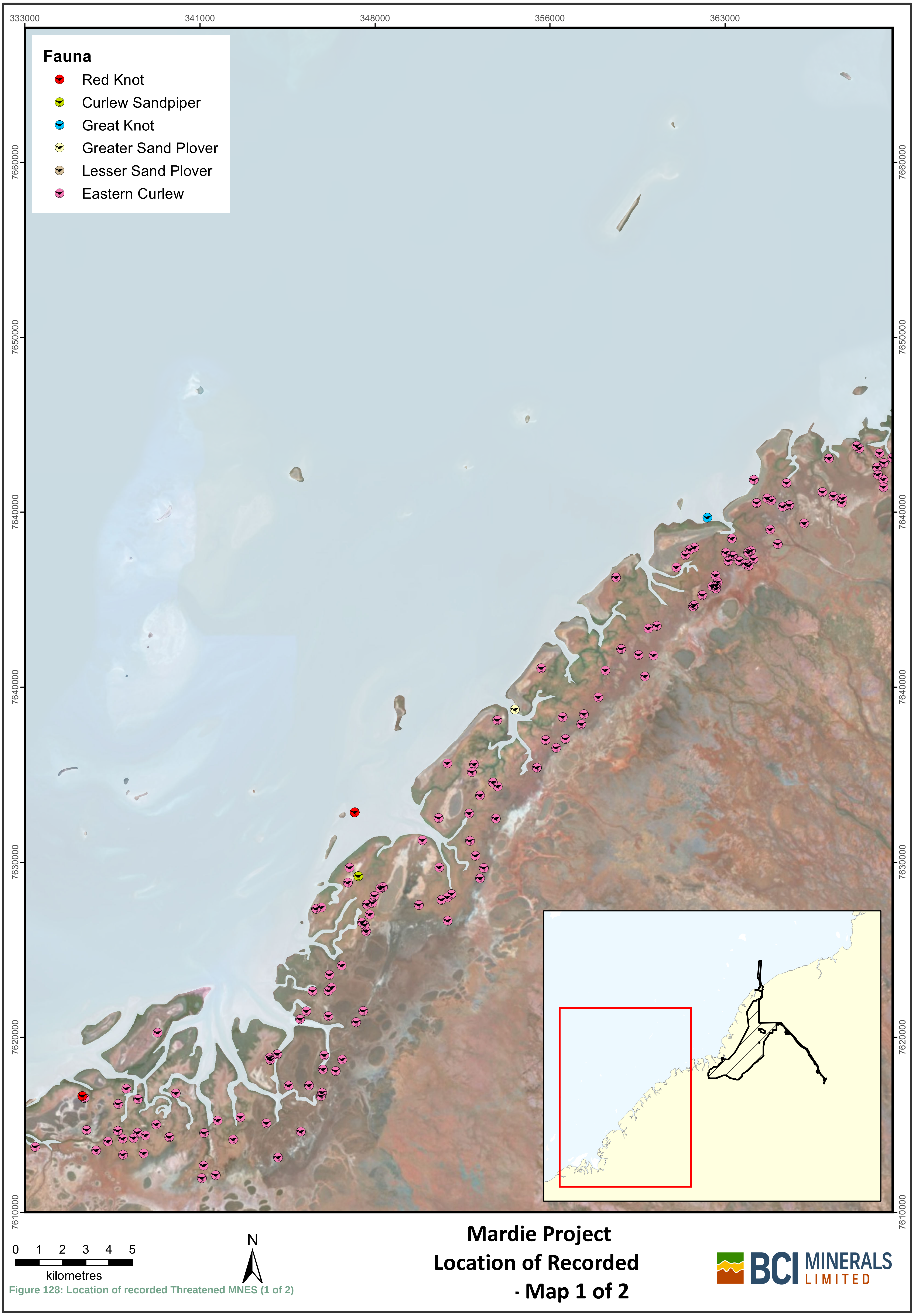


Figure 128: Location of recorded Threatened MNES (1 of 2)

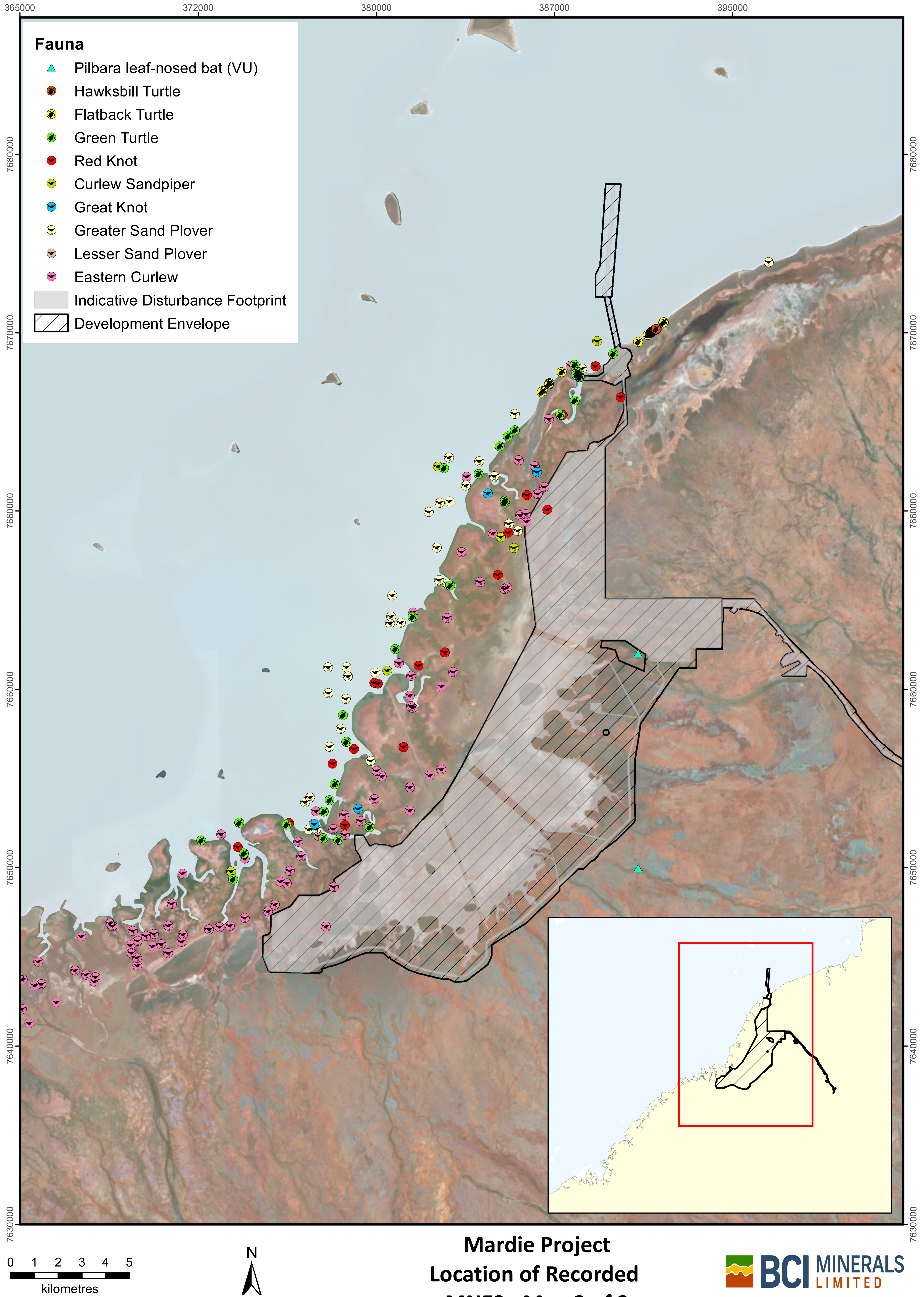


Figure 129: Location of recorded Threatened MNES (2 of 2)

Mardie Project
Location of Recorded
MNES - Map 2 of 2

BCI MINERALS LIMITED

13.4 RELEVANT IMPACTS

Sections 8 - 10 of this ERD have assessed the potential impacts on MNES in detail. To avoid repetition, Table 64 summarises the findings of those assessments as applicable to MNES.

Table 64: Potential Impacts to MNES

Potential Impact	Assessment of Impacts	Relevant MNES
Direct disturbance / loss of habitat		
Disturbance of up to 17 ha of mangrove habitat	**Nature and extent of impact:** 17 ha of SC Mangroves to allow the development of the seawater intake, trestle jetty and concentrator and crystalliser ponds. **Unknown, unpredictable or irreversible impacts**: 17 ha (<1%) of SC Mangroves is predicted to occur as a result of the Proposal. 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**: O2 Marine (2020a; Appendix 2.3) determined that the three mangrove species identified during the field surveys are known to have broader distributions across Asia-Pacific, are characteristic of the regional area and have no current conservation significance. Mangrove associations and functional groups identified are typical of mangrove communities within the regional Pilbara area along with the wider Pilbara and Canning coasts of North WA. All efforts have been made during the Proposal design and engineering stages to avoid mangrove disturbance with <1%, or 17 ha, identified for direct removal and no net predicted indirect effects. No losses of CC mangroves will occur. Therefore, the risk of impact to biological diversity and ecological integrity of mangrove communities is not considered significant. **Additional technical data:** • Section 6.3.7 provides detail regarding the mangrove communities identified within the Study Area • Section 6.5.2 provides further detail regarding the assessment of significance of the potential impacts • O2 Marine (2020a; Appendix 2.3) provides further technical information regarding the mangrove communities within the Study Area • O2 Marine (2020c; Appendix 2.1) provides further detail regarding the calculation of impacts to mangrove communities	Green Sawfish Red Knot Curlew Sandpiper Great Knot Greater Sand Plover Lesser Sand Plover Eastern Curlew Other migratory birds
Disturbance of up to 1,115 ha of tidal samphire mudflat habitat	This habitat type is well represented through the TFSA however it represents high-value habitat for a number of significant fauna species. A direct disturbance of 1,115 ha of tidal samphire mudflat habitat is not expected to be significant in a local context as the area of habitat to be disturbed avoids almost all of the higher value habitat along the coast, which is shown to be most heavily utilised by migratory shorebirds. The remaining extent of this habitat type within the TFSA lies within tenements held by Mardie Minerals and therefore is unlikely to be made	Pilbara Leaf-nosed Bat Red Knot Curlew Sandpiper Great Knot Greater Sand Plover Lesser Sand Plover Eastern Curlew Migratory birds

Potential Impact	Assessment of Impacts	Relevant MNES
	available for development by another proponent for the duration of the Proposal.	
An *irreversible loss* of 44 ha and *recoverable impact* of 69 ha of coral / macroalgae habitat	**Nature and extent of impact:** Loss of 44 ha of coral / macroalgae habitat, to allow dredging for the development of the export facility. A recoverable impact of 69 ha is predicted as a result of sedimentation from dredging activities. **Unknown, unpredictable or irreversible impacts**: Irreversible loss of 44 ha is predicted to occur as a result of the Proposal. No unknown or unpredictable impacts are predicted from this direct disturbance of habitat. **Significance of impacts**: O2 Marine (2020c; Appendix 2.4) determined that the coral / macroalgae BCH is well represented throughout the Study Area and more broadly, this BCH was previously mapped as occurring with the filter feeder / macroalgae / seagrass BCH from the Fortescue River mouth to the southern end of the Exmouth Gulf, thus indicating that it is extensively well represented throughout the region. Whilst this BCH provides suitable habitat for a variety of marine fauna species, the loss of 44 ha is not considered to pose a significant risk to ecological integrity and biological diversity of this BCH and therefore any direct impacts to this BCH are not deemed significant. **Additional technical data**: • Section 7.3.14 provides detail regarding macroalgae habitat identified within the Study Area • Section 7.3.17 provides detail regarding coral habitat identified within the Study Area • Section 7.5.5 provides further detail regarding the assessment of significance of the potential impacts • O2 Marine (2020c; Appendix 2.4) provides further technical information regarding coral / macroalgae habitat within the Study Area • O2 Marine (2020a; Appendix 2.1) provides further detail regarding the calculation of impacts to coral / macroalgae habitat	Flatback Turtle Hawksbill Turtle Green Turtle Loggerhead Turtle Australian Humpback Dolphin Short-nosed Seasnake
An *irreversible loss* of 35 ha and *recoverable impact* of 133 ha of filter feeder / microalgae / seagrass habitat	**Nature and extent of impact:** Loss of up to 35 ha of filter feeder / microalgae / seagrass habitat, to allow dredging for the development of the export facility. **Unknown, unpredictable or irreversible impacts**: Irreversible loss of up to 35 ha is predicted to occur as a result of the Proposal. No unknown or unpredictable impacts are predicted from this disturbance of habitat. **Significance of impacts**: BCH surveys of the region support findings that the development envelopes are comprised of relatively poor quality (i.e. low cover and dynamic) vegetated habitats for foraging compared to areas where dugongs and turtles typically congregate. Flatback, Loggerhead and Green Turtles are the most likely species to be found foraging on the low quality habitat within the Study Area. The habitat described is well represented along the Pilbara coast. Therefore, the portion	Flatback Turtle Hawksbill Turtle Green Turtle Loggerhead Turtle Australian Humpback Dolphin

Potential Impact	Assessment of Impacts	Relevant MNES
	of this habitat type within the Study Area is unlikely to represent critical habitat for marine fauna. The Proposal is situated in internesting habitat used by female Flatback Turtles nesting on Barrow Island (Whittock et al, 2014, 2016). Disturbance caused by the construction and operation of the facilities may cause Flatbacks to avoid the area however this is not expected to be permanent, and for seabed which has been dredged the utilisation by internesting flatbacks is expected to increase (Whittock et al, 2017). **Additional technical data**: • Section 7.3.16 provides detail regarding filter feeder habitat identified within the Study Area • Section 7.3.14 provides detail regarding macroalgae habitat identified within the Study Area • Section 7.3.15 provides detail regarding seagrass habitat identified within the Study Area • Section 7.5.5 provides further detail regarding the assessment of significance of the potential impacts • O2 Marine (2020b; Appendix 2.1) provides further technical information regarding filter feeder / microalgae / seagrass habitat within the Study Area • O2 Marine (2020c; Appendix 2.4) provides further detail regarding the calculation of impacts to filter feeder / microalgae / seagrass habitat	
Indirect Impacts		

Potential Impact	Assessment of Impacts	Relevant MNES
Light spill	**Nature and extent of impact:** The Proposal will require lighting, including on the trestle jetty and other infrastructure close to the coast. Lighting within these coastal areas will be limited to lighting of the port stockyard operational areas, navigation beacons on the trestle jetty and the export berth area (when operational). **Unknown, unpredictable or irreversible impacts**: The exact quantity and type of lighting is unknown at this point of the design process, therefore the exact light emissions are unpredictable. No irreversible impacts are predicted from this indirect impact. **Significance of impacts**: While exact light emissions are unable to be predicted, it is understood that the Proposal will require relatively low amounts of permanent lighting, particularly close to the coast. Most lighting will be able to be turned off when not require, which will reduce the extent of the lighting impact. Given the lack of turtle nesting activity on the mainland in the area the Proposal's light emissions are unlikely to significantly impact turtle hatchlings and populations. Nevertheless, lighting for coastal and jetty facilities will consider design recommendations provided in DotEE (2019) in order to ensure that lighting impacts are as low as practicable. **Additional technical data**: • Section 8.3.5 provides detail regarding marine turtles and their habitat identified within the Study Area • Section 8.5.2 provides further detail regarding the assessment of significance of the potential impacts. Pendoley (2019a; Appendix 7.1) provides further technical information regarding marine turtle species and use of the mainland coast within the Study Area	Flatback Turtle Hawksbill Turtle Green Turtle Loggerhead Turtle

Potential Impact	Assessment of Impacts	Relevant MNES
Vessel / propeller strike	**Nature and extent of impact:** The Proposal includes the movement of vessels, including a construction vessels, transhipment vessels (2 – 4 barge movements per day), export vessels (1 per week) and support vessels. 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 due to the small scale (i.e. spatial movements) of the operation and dredge vessel (i.e. slow-moving and small support vessels). Similarly, the risk of vessel strike on marine mammals during the operational stage is considered unlikely due to the slow speed of the transhipment barge (8 – 12 knots), the short journey length (approximately 50 km per return trip) and low frequency of vessel movements (1 - 2 return trips per day). Dolphins are quick moving and would react quickly to avoid potential impact to vessels. Whales are not expected to occur in the immediate dredge vicinity due their preference for deeper waters and therefore not expected to be impacted from vessel activity. Dugongs may be present however specific foraging habitats have been avoided (refer Section 8.5.3). Mitigation measures are proposed to reduce this risk to an acceptable level (Section 13.7). **Additional technical data**: • Section 8.3 provides detail regarding marine turtles and mammals and their habitat identified within the Study Area • Section 8.5.2 and 8.5.3 provides further detail regarding the assessment of significance of the potential impacts • Pendoley (2019a; Appendix 7.1) provides further technical information regarding marine turtle species and use of the mainland coast within the Study Area	Flatback Turtle Hawksbill Turtle Green Turtle Loggerhead Turtle Australian Humpback Dolphin Humpback Whale Dugong

Potential Impact	Assessment of Impacts	Relevant MNES
Marine Noise	**Nature and extent of impact:** The Proposal will produce marine noise, predominantly during the construction phase during dredging and pile driving activities during jetty and wharf construction. A long-reach excavator on a barge will be used for dredging. The use of a barge-mounted long-reach excavator is a lower noise alternative to other dredging techniques, as the majority of the noise sources are located on the dredge barge out of the water. As a result, only a small amount of acoustic energy though structure-borne noise is expected to be transferred into the water through the long-reach excavator and other ancillary equipment operating on the barge (Talis, 2019; Appendix 6.4). A SPL of 167 dB re 1 µPa is predicted during dredging activities. Pile driving involves hammering a pile into the seabed to the point of refusal. The noise emanating from a pile is a function of its material type, its size, the force applied to it and the characteristics of the substrate into which it is being driven. The action of driving a pile into the seabed excites bendy waves (a wave that comprises of a compression wave and a transverse wave) in the pile that propagate along the length of the pile and transfer into the sea and seabed. The transverse component of the wave propagates into the ocean, while the compression component propagates into the seabed. Once in the seabed, the energy will then propagate outwards as compression and shear waves. Piles can be driven using various methods such as vibration, gravity and hydraulic hammer. The method that is used is dependent on the size of the pile and the substrate into which the pile is being driven. It is planned that hydraulic impact hammers will be used for piling operations at the Proposal. The noise that is generated by an impact hammer hitting the top of the pile is short in duration lasting approximately 100 ms and can therefore be described as an impulsive noise. A SEL of 205 dB re 1 µPa.s @ 1m is predicted during piling activities. The model results determined that noise emissions from dredging and barging operations would not exceed the TTS threshold for any marine fauna. Behavioural impacts would be expected for marine mammals, at a distance of less than 1,500 m for Humpback Whales and Dugong, and less than 200 m for Australian Humpback Dolphins. For marine turtles, piling activities will result in an exceedance of the TTS threshold at mean and high tides at distances less than 100 m. The TTS threshold is never exceeded at low tide. Behavioural responses are predicted at distances less than 500 m during mean and high tides, with no impacts at low tide (Figure 101). For Humpback Whales and Dugong, piling activities will result in an exceedance of the TTS threshold at distances less than: • 500 m at high tide • 300 m at mean tide • Only at the pile at low tide Behavioural responses are predicted at distances less than 10 km during mean and high tides, with impacts limited to close to the pile at low tides (Figure 103). For the Australian Humpback Dolphin, piling activities will result in an exceedance of the TTS threshold only at the pile during mean and high tides. No exceedance will occur at	Flatback Turtle Hawksbill Turtle Green Turtle Loggerhead Turtle Australian Humpback Dolphin Green Sawfish Humpback Whale Dugong

Potential Impact	Assessment of Impacts	Relevant MNES
	low tide. Behavioural responses are predicted at distances less than 4- 5 km during mean and high tides, with impacts limited to close to the pile at low tides (Figure 104). **Unknown, unpredictable or irreversible impacts**: Marine noise impacts are known and were able to be predicted. No irreversible impacts are predicted from this indirect impact. **Significance of impacts**: Modelled marine noise from dredging activities is not significant, and marine noise mitigation measures are now well established within the marine construction industry for pile driving activities. Mardie Minerals has committed to measures that were applied as Ministerial conditions for the Balla Balla Export Facilities (Ministerial Statement 945) and it is expected that similar conditions will be applied to this Proposal. With the application of these measures it is expected that pile driving will be able to be conducted without significant impacts on marine fauna. **Additional technical data**: • Section 8.3 provides detail regarding marine turtles and mammals and their habitat identified within the Study Area • Section 8.5.1 provides more detail about the source and extent of the marine noise and risk pathways for marine fauna • Section 8.5.2 and 8.5.3 provides further detail regarding the assessment of significance of the potential impacts • Pendoley (2019a; Appendix 7.1) provides further technical information regarding marine turtle species and use of the mainland coast within the Study Area • Talis (2019; Appendix 6.4) provides further technical information regarding the noise model inputs, assumptions and results	
Entrapment in seawater intakes	**Nature and extent of impact:** Two seawater intakes are required for the Proposal. One is located in a tidal creek and used as an intake for the concentrator and crystalliser ponds (Figure 3), and the other is located on the trestle jetty to allow dilution of the bitterns prior to discharge (refer to Section 2.3.3). O2 Marine (2020g; Appendix 7.2) determined that turtles and fish species are likely to be present in the vicinity of the proposed seawater intakes and therefore there was the potential for marine fauna to become trapped within the intakes. An intake flow rate of less than 0.15 m/s is recommended by the US Environmental Protection Agency (2001) as it ensures the protection of 96% of fish species, and is lower than the swim speed of marine turtles (Bell & Richardson, 1978; Bustard & Limpus, 1970; Chung et al., 2009; de Silva, 1995; Frick, 1976; Hirth, 1971; Hughes, 1974; Papi et al., 1995; Prange, 1976; Salmon & Wyneken, 1987; Witherington, 1991, Wyneken 1997). This flow rate has been adopted at a number of seawater intakes in WA including Anketell Port, The Wheatstone Development and Adelaide Desalination Plant. The tidal creek intake pipes are to be located within a screened enclosure. Water within the enclosure rises and falls with the tide, and the intake pumps are to be operated	Flatback Turtle Hawksbill Turtle Green Turtle Loggerhead Turtle Green Sawfish

Potential Impact	Assessment of Impacts	Relevant MNES
	when water depths are greater than MSL. The intakes will draw in water through all sides of the perimeter screen, resulting in an even flow rate around the perimeter of less than 0.15 m/s. The offshore seawater intake (used for dilution of the bitterns) will draw in up to 20 GL of water per year. A similar screened enclosure (albeit a smaller size) will be installed at this location to again ensure an even flow rate of less than 0.15 m/s around the perimeter of the screen. This will ensure flow rates are low enough to allow marine turtles to swim against the current and not become trapped against the enclosure screens. Consequently the risk of entrapment of marine turtles at the seawater intakes is considered to be low. **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**: The Proposal will have two seawater intakes and both pose a risk of marine fauna entrapment if not designed and operated appropriately. Mardie Minerals has committed to two specific mitigation measures for these intakes; screens will be installed to prevent marine turtles from being drawn into the intake pipe, and the intake has been designed such that the intake velocity is maintained below 0.15 m/s at all times. This velocity is recommended by the US Environmental Protection Agency (2001) as it ensures the protection of 96% of fish species, and is lower than the swim speed of marine turtles (Bell & Richardson, 1978; Bustard & Limpus, 1970; Chung et al., 2009; de Silva, 1995; Frick, 1976; Hirth, 1971; Hughes, 1974; Papi et al., 1995; Prange, 1976; Salmon & Wyneken, 1987; Witherington, 1991, Wyneken 1997). With the implementation of these two controls the risk of marine turtle entrapment is expected to be lowered to an acceptable level. **Additional technical data**: • Section 8.3 provides detail regarding marine turtles and their habitat identified within the Study Area • Section 8.5.1, 8.5.2 and 8.7 provides further detail regarding the assessment of significance of the potential impacts • Pendoley (2019a; Appendix 7.1) provides further technical information regarding marine turtle species and use of the mainland coast within the Study Area	
Alteration of surface water regimes affecting downstream 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 Proposal will affect overland flows by directing them to corridors between the ponds, or diverting the flows around the southern end of the pond footprint. Section 5.5.2 provides detail about the nature and extent of these impacts. The Proposal will affect intertidal flows as the pond walls will prevent the inland movement of the tidal flow during high tidal events, and the seawater intake will abstract water from a tidal creek for use in the Proposal. The	Green Sawfish Red Knot Curlew Sandpiper Great Knot Greater Sand Plover Lesser Sand Plover Eastern Curlew Other migratory birds Pilbara Leaf-nosed Bat Pilbara Olive Python

Potential Impact	Assessment of Impacts	Relevant MNES
	causeway may also alter the flow characteristics of the intertidal zone along the northern coastline. Section 5.5.4 provides detail about the nature and extent of these impacts. **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 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 if mitigation measures are implemented. **Significance of impacts**: There are several ephemeral creekline systems that drain to the intertidal claypans where they spread across the intertidal zone and drain to the ocean via tidal creeks. The Proposal will require the diversions of these drainage systems either around the ponds or through dedicated channels. These diversions will be designed, constructed and maintained appropriately to ensure the Proposal infrastructure is protected, and as a result there is a high level of confidence that surface water diversions will allow adequate flows through to the intertidal zone without significant erosion of the pond walls, thereby maintaining the overall volume and timing of freshwater flows from the catchment into the intertidal zone, where the important mangrove and samphire communities are located. The Proposal will affect tidal exchange by: • Reducing the extent of the intertidal zone due to the construction of pond walls and the causeway; and • Abstracting seawater from a tidal creek, as feed for the concentrator and crystalliser ponds. The Proposal has been specifically designed to minimise impacts to the intertidal zone, by locating the pond walls a significant distance from the coast and away from the mangal and samphire communities. Extensive surveys and modelling demonstrate with a high degree of confidence that, because of the low topography, interconnected flow systems, and a highly dynamic intertidal environment and tidal regime, the effect of the pond walls on tidal exchange will be minimal. Additional monitoring will be conducted to verify the modelling outcomes. The installation of appropriately sized and spaced floodways and culverts as part of the causeway design is not predicted to significantly affect tidal inundation regimes. The impacts of the abstraction of up to 150 GL of seawater per year from a designated tidal creek is not expected to result in any discernible impact to environmental values of the creek, owing to the creek's size, interconnectivity with other creeks and the intertidal claypans, as well as the proximity of the draw point to the open water. As a precautionary measure, seawater will only be drawn when the tide is above MSL. **Additional technical data**: • Section 5.3 provides detail regarding the surface water regime of the Proposal • Section 7.3 and 10.3 provide detail regarding the MNES habitats that may be affected	

Potential Impact	Assessment of Impacts	Relevant MNES
	• Section 5.5.2, 5.5.4 and 5.7 provides further detail regarding the assessment of significance of the potential impacts to surface water regimes • Section 10.5.1, 10.5.3 and 10.7 provides further detail regarding the assessment of significance of the potential impacts to these species • Phoenix (2020b; Appendix 9.1) provides further technical information regarding these species and use of the Study Area • RPS (2020b; Appendix 1.1) provides technical information about the potential impacts on coastal inundation • RPS (2017 and 2020b) provides technical information regarding storm surge and flood flows from inland catchments • Baird (2020a; Appendix 6.1) provides a hydrodynamic nearshore model	
Alteration of water quality or volume within Mardie Pool	**Nature and extent of impact:** Habitat of value to these species within the Study Area is limited to foraging habitat and water sources. Mardie Pool is a freshwater pool that occurs on one of these creeks (Figure 123) and is likely to be regularly used as a water source or foraging by these species. Mardie Pool is outside the development envelopes and will not be directly impacted by the Proposal (refer to Section 10.5.4), however indirect impacts require consideration and mitigation. Mardie Pool may be impacted by changes to intertidal flows and seepage of hypersaline water from the eastern crystalliser ponds, which lie 250 m to the north. Section 5.5.3 provides a detailed assessment of the nature and extent of the potential indirect impacts to Mardie Pool. **Unknown, unpredictable or irreversible impacts**: No impacts would be considered unknown. The rate of seepage from the 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**: Habitat of value to these species within the Study Area is limited to foraging habitat and water sources. Mardie Pool occurs on one of these creeks (Figure 123) and is likely to be regularly used as a water source or foraging by these species, however Mardie Pool is outside the development envelopes and will not be significantly impacted by the Proposal (refer to Section 10.5.4). With the implementation of mitigation, no indirect impacts to Mardie Pool are expected, as modelling conducted for seepage and overland flows shows (refer to Section 5.5). Direct impacts to Mardie Pool have been avoided and therefore impacts to this species are likely to be low. **Additional technical data**: • Section 10.3 provides detail regarding these species and their habitat identified within the Study Area • Section 10.5.1, 10.5.3 and 10.7 provides further detail regarding the assessment of significance of the potential impacts to these species • Section 5.5.1, 5.5.2, 5.5.3 and 5.7 provides further detail regarding the assessment of significance of the potential impacts to these species	Pilbara Leaf-nosed Bat Pilbara Olive Python

<table>
<tr><th>Potential Impact</th><th>Assessment of Impacts</th><th>Relevant MNES</th></tr>
<tr><td></td><td>Phoenix (2020b; Appendix 9.1) provides further technical information regarding these species and use of the Study Area</td><td></td></tr>
<tr><td>Potential Movement of Hypersaline Groundwater as a Result of Hydrostatic Pressure of the Brine in the Ponds</td><td>Nature and extent of impact:
Modelling of the hydraulic influence of the proposed ponds on the underlying groundwater was conducted by SWG (2019a; Appendix 10.1). The pertinent findings from investigation are:
The groundwater system within the supratidal flats is effectively a closed system, which has experienced prolonged evaporative concentration of salts resulting in hypersaline conditions. This system is not connected to the marine environment or the underlying calcarenite aquifer;
The elevated 'natural' salinities within the supratidal flats restrict the landward extension of mangroves, and thus the impacts from the Proposal are expected to be minimal;
The seepage rates from the Concentrator Ponds due to the clay content of the Supratidal flats are very low. In addition, predicted process water quality, and hence potential seepage water quality, from the Concentrator Ponds, which represents the largest footprint area, is similar to the existing groundwater quality. Therefore, the combination of low seepage rates and process water quality results in expected negligible impacts on groundwater quality in the Supratidal Flats is expected;
Process water quality within the crystalliser ponds does exceed the surrounding natural environment, but the extent of seepage from these areas is significantly reduced by the precipitation of salts;
Based on the data presented, the Proposal is not expected to alter the local or regional groundwater quality;
Under realistic actual evaporation conditions, the spread of the groundwater mound under the concentrator ponds will not interact with the algal mats that occur downstream , and no change in soil water dynamics is expected in the top 2 cm of the soil profile, which is the depth of soil that the algal mats depend on (Paling, 1990); and
If evaporation rates are lower than expected, resulting in a greater spread of the groundwater mound, then modelling has shown that seepage capture bores or trenches could be effectively used, with potential extraction rates of up to 30 L/s/m^2 shown to significantly reduce any downstream impacts.
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.</td><td>Green Sawfish
Red Knot
Curlew Sandpiper
Great Knot
Greater Sand Plover
Lesser Sand Plover
Eastern Curlew
Other migratory birds
Pilbara Leaf-nosed Bat
Pilbara Olive Python</td></tr>
</table>

Potential Impact	Assessment of Impacts	Relevant MNES
	Significance of impacts: With the implementation of mitigation, no significant indirect impacts to down-gradient fauna habitats are expected, as modelling conducted for seepage shows (refer to Section 5.5). **Additional technical data**: • Section 10.3 provides detail regarding these species and their habitat identified within the Study Area • Section 10.5.1, 10.5.3 and 10.7 provides further detail regarding the assessment of significance of the potential impacts to these species • Section 5.5.1, 5.5.2, 5.5.3 and 5.7 provides further detail regarding the assessment of significance of the potential impacts to these species • Phoenix (2020b; Appendix 9.1) provides further technical information regarding these species and use of the Study Area	
Introduced Fauna	**Nature and extent of impact:** Several feral animals were recorded within the TFSA, including dogs, foxes and cats (Phoenix, 2020b; Appendix 9.1). 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. **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**: 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 13.7). **Additional technical data**: • Phoenix (2020b; Appendix 9.1) provides further technical information regarding introduced species and use of the Study Area	The Cat Threat Abatement Plan is listed as relevant for: • Hawksbill Turtle • Pilbara Olive Python The Pigs Threat Abatement Plan is listed as relevant for: • Hawksbill Turtle • Green Turtle • Flatback Turtle • Loggerhead Turtle The Fox Threat Abatement Plan is listed as relevant for: • Green Turtle • Flatback Turtle • Loggerhead Turtle • Lesser Sand Plover

13.5 ASSESSMENT AGAINST SIGNIFICANT IMPACT CRITERIA FOR LISTED THREATENED SPECIES AND ECOLOGICAL COMMUNITIES

Assessment against the significant impact criteria for each listed threatened species listed in Table 57 has been provided in the tables below. Where appropriate, some species have been assessed as a group if they share similar habitats and potential impacts.

Table 65: Pilbara Leaf-nosed Bat

Significant impact criteria (Vulnerable)	Assessment of impacts to Pilbara Leaf-nosed Bat
Lead to a long-term decrease in the size of an important population of a species	The approved conservation advice (TSSC, 2016b) for the Pilbara Leaf-nosed Bat defines critical habitat as including permanent and transitory diurnal and breeding roosts, and identifies priority foraging habitat as gorges with pools, gullies, rocky outcrops, major watercourses and grassland and woodland. No roosts were recorded during the surveys conducted for the Proposal. An 'important population' is defined by the Significant Impact Guidelines 1.1 (DotE), 2013) as a population that is necessary for a species' long-term survival and recovery. This may include populations identified as such in recovery plans, and/or that are: • Key source populations either for breeding or dispersal; • Populations that are necessary for maintaining genetic diversity, and/or • Populations that are near the limit of the species range. Given that only two records of this species were noted by Phoenix (2020b; Appendix 9.1) it is unclear as to whether there is a population in the area that would be classified as an 'important population' under the definition in the Significant Impact Guidelines 1.1 (DotE, 2013). Regardless of this, the Proposal avoids almost all of the habitat identified as being significant for this species (riparian woodland) and will not impact any fresh water pools. The Proposal is therefore unlikely to impact the survival of any individuals of this species, therefore it would be extremely unlikely to decrease the size of the population. A summary of each potential impact is provided below. **Clearing** It is unlikely the proposed clearing will lead to a long-term decrease in the size of the Pilbara Leaf-nosed Bat population. There are no caves in the development envelopes and therefore roost sites are unlikely to be present. Habitat of value to this species is therefore limited to foraging habitat and water sources. Mardie Pool occurs on one of these creeks and is likely to be regularly used as a water source of foraging by the species, however this pool is outside the development envelopes and will not be impacted by the Proposal. Western-flowing creekline habitats (open woodland (riparian)) also support foraging by Pilbara Leaf-nosed Bat (refer above). The other creeks within the development envelopes do not contain permanent water and are more likely to be used seasonally by the species when they are in flow or contain pools. Observations during the Phoenix (2019b; Appendix 9.1) surveys suggest pools persist in some creeks in the local area for several months following rainfall events inland. Only a small percentage of the open riparian woodland surveyed (15.9 ha of 74 ha) is located in the development envelope, and only 5.4 ha is expected to be disturbed (7.3% of mapped extent). No impact to such pools is expected. Direct impacts to this habitat are not considered significant and therefore impacts to this species are likely to be low. **Noise and Light Emissions** 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), and the Process Plant is small in size in comparison to mining operations in the Pilbara. 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 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. **Brine Seepage and Spills** A spill or leak of brine from the ponds or pipelines could result in impacts to the health of the surrounding fauna habitat. Of interest to this species is a potential spill in the vicinity of the riparian habitat or Mardie Pool. 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

Significant impact criteria (Vulnerable)	Assessment of impacts to Pilbara Leaf-nosed Bat
	minimise the chance of leaks, and mitigation will be implemented to reduce this risk further (refer to Section 10.6). Ponds have been designed with adequate freeboard and overflow features to minimise the risk of unplanned overflows and wall breaches. The crystalliser ponds adjacent to Mardie Pool will be lined to prevent seepage. If a spill was to occur, it may cause a reduction in the health of the downslope fauna habitat, however the spill would be limited to an area that is adapted to saline conditions and is regularly inundated with seawater. Brine would be expected to dilute and wash away over a period of several months. **Vehicle Strike** Pilbara Leaf-nosed Bats are known to be attracted to light and fly low, resulting in the potential for vehicle collisions. However, the Proposal will have a relatively small workforce with minimal requirements for night work (when Pilbara Leaf-nosed Bats are most active foraging).
Reduce the area of occupancy of an important population	The area of occupancy of the Pilbara Leaf-nosed Bat is limited by the availability of suitable diurnal roosts (TSSC, 2016a). No diurnal roosts have been recorded at the Proposal and individuals recorded are considered likely to originate from a roost remote from the development envelopes. The Proposal is therefore unlikely to reduce the area of occupancy of an important population of this species.
Fragment an existing important population into two or more populations	The proposed disturbance is unlikely to fragment a population, given that no roosts have been recorded in the TFSA and the wide ranging nature of this species.
Adversely affect habitat critical to the survival of a species	No diurnal roosts have been identified within the TFSA and the foraging habitat recorded within the development envelopes would not be considered 'critical to the survival' of this species.
Disrupt the breeding cycle of an important population	No diurnal roosts have been identified within the TFSA, and none are expected close enough to the Proposal such that noise or light could influence the breeding cycle of this species.
Modify, destroy, remove or isolate or decrease the availability or quality of habitat to the extent that the species is likely to decline	Only a small percentage of the open riparian woodland surveyed (15.9 ha of 74 ha) is located in the development envelope, but only 5.4 ha is expected to be disturbed (7.3% of mapped extent). No impact to fresh water pools is proposed or expected. The disturbance of 3% of the riparian foraging habitat with the TFSA (which is smaller than the foraging range of this species) is unlikely to 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	The TSSC (2016a) notes that the Pilbara Leaf-nosed Bat has been exposed to the degradation and modification of natural habitats caused by introduced species such as invasive weeds, domestic herbivores and other larger feral ungulates since the arrival of Europeans, however these invasive species are unlikely to have a significant effect overall. Nevertheless the Proposal includes strict control measures to prevent the spread of Mesquite, which will in turn minimise the likelihood of other invasive species becoming established. Feral animals will be controlled on site to minimise their introduction or spread (refer to Section 13.7).
Introduce disease that may cause the species to decline	There are no known diseases threatening the Pilbara Leaf-nosed Bat (TSSC, 2016a).
Interfere substantially with the recovery of the species	The primary objective for preventing the decline of the Pilbara Leaf-nosed Bat is to protect known and suspected diurnal roost sites and to avoid activities within close proximity to these roosts that could cause roost abandonment and fatalities of individuals (TSSC, 2016a). Given that the Proposal will not impact any known or suspected Pilbara Leaf-nosed Bat roosts and that proposed disturbance will impact only a small proportion of available foraging habitat, the Proposal is unlikely to interfere with the recovery of the Pilbara Leaf-nosed Bat.

Table 66: Australian Humpback Dolphin

Significant impact criteria (Vulnerable)	Assessment of impacts to Australian Humpback Dolphin
Lead to a long-term decrease in the size of an important population of a species	Australian Humpback Dolphins are known to occur along the northern coastline, extending to Exmouth Gulf on the west coast (25° S), and the Queensland/NSW border region on the east coast (34°S). There are few records between the Gulf of Carpentaria in the north and Exmouth Gulf in the west, this is probably due to a lack of research effort and the remoteness of the area (O2 Marine, 2020g; Appendix 7.2). No incidental recordings of Australian Humpback Dolphin were recorded during field studies for the Proposal undertaken by O2 Marine. An 'important population' is defined by the Significant Impact Guidelines 1.1 (DotE, 2013) as a population that is necessary for a species' long-term survival and recovery. This may include populations identified as such in recovery plans, and/or that are: • Key source populations either for breeding or dispersal; • Populations that are necessary for maintaining genetic diversity, and/or • Populations that are near the limit of the species range. Given that no individuals of this species were recorded by O2 Marine (2020g) it is unclear as to whether there is a population in the area that would be classified as an 'important population' under the definition in the Significant Impact Guidelines 1.1 (Department of the Environment, 2013). Regardless of this, the Proposal will only have minor disturbance to the habitat of this species and indirect impacts are able to be easily mitigated with well-established controls. The Proposal is therefore unlikely to impact the survival of any individuals of this species, therefore it would be extremely unlikely to decrease the size of the population. A summary of each potential impact is provided below. **Vessel Strike** The likelihood of a vessel strike during dredging and construction from proposed vessel movements is considered low due to the small scale (i.e. spatial movements) of the operation and dredge vessel (i.e. slow-moving and small support vessels). Similarly, the risk of vessel strike on marine mammals during the operational stage is considered unlikely due to the slow speed of the transhipment barge and relatively low vessel movements (2 - 4 barge movements per day) in comparison to other ports or boat ramps in WA. The consequence of vessel strike on marine mammals may result in injury or mortality, although these events are expected to be rare. Dolphins are quick moving and would react quickly to avoid potential impact to vessels. Mitigation measures outlined in Section 13.7 are proposed to reduce this risk to an acceptable level. **Marine Noise** A Marine Noise Assessment (Talis, 2019; Appendix 6.4) was undertaken to predict impacts to marine mammals, specifically the Humpback Whale, Dugong and Australian Humpback Dolphin. The results of the model show that marine mammals could be impacted by dredging, barging and piling activities, however mitigation measures are well established for dredging and piling operations and these will be implemented to ensure that these potential impacts are minimised. Further detail on these mitigation measures is provided in Section 13.7. **Other indirect Impacts** Marine mammals or their habitat may be indirectly impacted by the Proposal as a result of: • Disposal of bitterns impacting water quality and/or marine fauna habitats; • Increased turbidity due to activities such as dredging; • Leaks or spillages of hypersaline brine; and • Leaks or spillages of hydrocarbons or chemicals.

Significant impact criteria (Vulnerable)	Assessment of impacts to Australian Humpback Dolphin
	Bitterns disposal will result in a defined LEPA with reduced water quality within the LEPA. There will be no BCH within the LEPA and as it has been located within the proposed dredging footprint to reduce habitat impacts. Marine mammals that pass through the LEPA are unlikely to be significantly affected given the relatively small size of the area and the lack of habitat (located within a dredged area - i.e. no significant BCH). A spill or leak of brine from the ponds or pipelines is unlikely to impacts the health of subtidal BCH. 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 10.6). Ponds have been designed with adequate freeboard and overflow features to minimise the risk of unplanned overflows and wall breaches. If a spill were to occur, the high tidal action in the region would dilute and disperse the brine. Indirect impacts to subtidal BCH may be caused due to increased suspended sediment concentration (SSC), resulting in increased turbidity, a reduction in available benthic light and localised increases in sedimentation. Baird (2020b; Append 6.3) determined that the sedimentation thresholds were not exceeded beyond the ZoHI for either best or worst-case model scenarios (refer to Section 6.5.1). Therefore, no irreversible indirect impacts to BCH were predicted outside the ZoHI as a result of sedimentation. Refuelling of vessels is proposed to occur at the Mardie Export Facility, and therefore there is a risk of hydrocarbon spill from vessels during construction and operation as a result of vessel collisions or hydraulic hose leaks. With the exception of vessels used in jetty construction, the majority of these vessels would be located several kilometres offshore as refuelling will occur at the end of the trestle jetty. Construction vessels are also small in size and therefore would not contain significant volumes of hydrocarbons. All ocean-going vessels will be located offshore in deeper water. Any spills at the offshore locations are expected to dissipate without reaching the shore based on the high levels of evaporation in the region and strong tidal currents.
Reduce the area of occupancy of an important population	In Australia, humpback dolphins are thought to be widely distributed along the northern Australian coastline from approximately the Queensland–NSW border to western Shark Bay, WA (Parra & Cagnazzi, 2016). The Proposal will directly impact only a small proportion of the Study Area, which are smaller than the extent of any local populations if they were present, therefore the Proposal is unlikely to reduce the occupancy of the Australian Humpback dolphin population.
Fragment an existing important population into two or more populations	The Proposal is unlikely to fragment a population, given that the marine infrastructure proposed (jetty, berth pocket, dredge channel) will not form barriers to the movement of this species.
Adversely affect habitat critical to the survival of a species	No critical habitat for this species has been identified within the study area and the BCH recorded within the development envelopes would not be considered 'critical to the survival' of this species as it is well represented in the region and has no notable environmental significance.
Disrupt the breeding cycle of an important population	Life history data are almost non-existent for Australian humpback dolphins, however life history of this species is thought to be similar to that of Indo-Pacific humpback dolphins (*S. chinensis*), which has been studied in detail in Hong Kong and the Pearl River Estuary of China (Jefferson et al., 2012, cited in Parra & Cagnazzi,, 2016). The gestation period of Indo-Pacific humpback dolphins lasts 10 - 12 months, lactation may last more than 2 years, female sexual maturity is reached at 9 - 10 years of age and male maturity at 12 - 14 years. Length at birth was estimated at 101 cm, and age at physical maturity is estimated at around 14 - 17 years of age (Jefferson et al., 2012, cited in Parra & Cagnazzi, 2016). The generation length is estimated to be 25 years (Moore, in press) and they are expected to live to ages of over 40 years (Taylor et al., 2007, cited in Parra & Cagnazzi, 2016). There were no important habitats for the Australian humpback dolphin located within the marine areas surveyed for the Proposal, and therefore any individuals that would be present would be passing through the area. During construction of the trestle jetty the piling operations have the potential to disturb individuals of this species that may be in proximity to the piling operations. The area affected by the marine noise however is much smaller than the

Significant impact criteria (Vulnerable)	Assessment of impacts to Australian Humpback Dolphin
	range of individuals, and the application of controls will reduce this risk to an acceptable level. It is therefore unlikely that the breeding cycle of any local populations would be disrupted during construction. The Proposal includes a relatively small export operation, with only 2 – 4 barge movements per day and small export tonnages (4 Mtpa). The operation of the Proposal is therefore unlikely to disturb individuals to an extent that the breeding cycle of this species would be disrupted.
Modify, destroy, remove or isolate or decrease the availability or quality of habitat to the extent that the species is likely to decline	BCH surveys of the region support findings that the development envelopes are comprised of relatively poor quality (i.e. low cover and dynamic) habitats for marine mammals. The loss of 79 ha of the vegetated subtidal BCH within the Study Area (which is much smaller than the range of this species) is unlikely to 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	The Proposal has the potential to introduce marine pests, however with the application of regulated controls, the Proposal was identified as being of 'low risk' of introducing marine pests to Mardie marine waters. Standard industry controls (enforced by DAWR) relating to ballast water and vessel hygiene provide a level of confidence that IMPs will not be introduced. The Proposal is therefore considered unlikely to introduce invasive species that are harmful to this species.
Introduce disease that may cause the species to decline	The Proposal does not include any known vectors for disease.
Interfere substantially with the recovery of the species	The area of BCH within the development envelopes does not represent significant local or regional habitat. This, combined with the relatively small-scale habitat disturbance required and the low scale of the export operations, means that the Proposal is not expected to interfere substantially with the recovery of the Australian Humpback Dolphin.

Table 67: Humpback Whale

Significant impact criteria (Vulnerable)	Assessment of impacts to Humpback Whale
Lead to a long-term decrease in the size of an important population of a species	Humpback whales utilising Australian waters currently have tropical calving grounds along the mid and northern parts of the east and west coasts of Australia, with feeding grounds in the Southern Ocean. The majority of humpbacks in Australian waters migrate north to tropical calving grounds from June - August, and south to the Southern Ocean feeding areas from September - November. The migratory habitat around mainland Australia is primarily coastal waters less than 200 m in depth and generally within 20 km of the coast (O2 Marine, 2020g; Appendix 7.2). No incidental recordings of the Humpback Whale were recorded during field studies undertaken. Conservation advice for this species lists whaling, climate change, overharvesting of prey, noise interference, habitat degradation, vessel strike and entanglement as potential threats. An 'important population' is defined by the Significant Impact Guidelines 1.1 (DotE, 2013) as a population that is necessary for a species' long-term survival and recovery. This may include populations identified as such in recovery plans, and/or that are: • Key source populations either for breeding or dispersal; • Populations that are necessary for maintaining genetic diversity, and/or • Populations that are near the limit of the species range. The population of this species that migrates along the west coast of Australia would be considered an 'important population' under this definition. The Proposal will only have minor disturbance to the habitat of this species and indirect impacts are able to be easily mitigated with well-established controls. The Proposal is therefore unlikely to impact the survival of any individuals of this species, therefore it would be extremely unlikely to decrease the size of the population. A summary of each potential impact is provided below. **Vessel Strike** The likelihood of a vessel strike during dredging and construction from proposed vessel movements is considered low due to the small scale (i.e. spatial movements) of the operation and dredge vessel (i.e. slow-moving and small support vessels). Similarly, the risk of vessel strike on marine mammals during the operational stage is considered unlikely due to the slow speed of the transhipment barge and relatively low vessel movements (2 - 4 barge movements per day) in comparison to other ports or boat ramps in WA. Whales are not expected to occur in the immediate dredge vicinity due their preference for deeper waters and therefore not expected to be impacted from vessel activity. The consequence of vessel strike on marine mammals may result in injury or mortality, although these events are expected to be extremely unlikely. Mitigation measures outlined in Section 13.7 are proposed to reduce this risk further. **Marine Noise** A Marine Noise Assessment was undertaken by Talis (2019; Appendix 6.4) to predict impacts to marine mammals, including a specific assessment for the Humpback Whale. The results of the Talis (2019) model show that Humpback Whale individuals could be impacted by dredging, barging and piling activities if they were present in close proximity to these activities. Mitigation measures will be implemented (Section 13.7) to ensure that these potential impacts are minimised. **Other indirect Impacts** Marine mammals or their habitat may be indirectly impacted by the Proposal as a result of: • Disposal of bitterns impacting water quality and/or marine fauna habitats;

Significant impact criteria (Vulnerable)	Assessment of impacts to Humpback Whale
	• Increased turbidity due to activities such as dredging; • Leaks or spillages of hypersaline brine; and • Leaks or spillages of hydrocarbons or chemicals. Bitterns disposal will result in a defined LEPA with reduced water quality within the LEPA. There will be no BCH within the LEPA however as it has been located within the proposed dredging footprint to reduce habitat impacts. Marine mammals that pass through the LEPA are unlikely to be significantly affected given the small size of the area and the lack of habitat (located within a dredged area - i.e. no significant BCH). A spill or leak of brine from the ponds or pipelines is unlikely to impacts the health of subtidal BCH. 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 10.6). Ponds have been designed with adequate freeboard and overflow features to minimise the risk of unplanned overflows and wall breaches. The crystalliser ponds adjacent to Mardie Pool will be lined to prevent seepage. If a spill were to occur, the high tidal action in the region would dilute and disperse the brine. Indirect impacts to subtidal BCH may be caused due to increased suspended sediment concentration (SSC), resulting in increased turbidity, a reduction in available benthic light and localised increases in sedimentation. Baird (2020b; Appendix 6.3) determined that the sedimentation thresholds were not exceeded beyond the ZoHI for either best or worst-case model scenarios (refer to Section 6.5.1). Therefore, no indirect impacts to BCH were predicted outside this buffer as a result of sedimentation. Refuelling of vessels is proposed to occur at the Mardie Export Facility, and therefore there is a risk of hydrocarbon spill from vessels during construction and operation as a result of vessel collisions or hydraulic hose leaks. With the exception of vessels used in jetty construction, the majority of these vessels would be located several kilometres offshore as refuelling will occur at the end of the trestle jetty. Construction vessels are also small in size and therefore would not contain significant volumes of hydrocarbons. All ocean-going vessels will be located offshore in deeper water. Any spills at the offshore locations will be contained and cleaned up, and any residual oil is expected to dissipate without reaching the shore based on the high levels of evaporation in the region and strong tidal currents.
Reduce the area of occupancy of an important population	Given the wide range of this species, and the small scale of direct and indirect impacts, the Proposal will not reduce the occupancy of the Humpback Whale population.
Fragment an existing important population into two or more populations	The proposed disturbance is unlikely to fragment a population, given the wide ranging nature of this species and the small scale of direct and indirect impacts.
Adversely affect habitat critical to the survival of a species	No critical BCH has been identified within the Study Area and the BCH recorded within the development envelopes would not be considered 'critical to the survival' of this species.
Disrupt the breeding cycle of an important population	Sexual maturity is reached at 4 – 8 years (average 5 years). Breeding peaks in the winter and the gestation period is 11 - 12 months. Lactation extends over 10 - 12 months although calves have been seen independently feeding at 6 months of age (Clapham, 2000). The mean calving interval is 2.4 years (Barlow & Clapham, 1997) although it ranges from 1 year to more than 5 years. There is a temporal separation of individuals on their migration route related to sex and reproductive status (Brown et al., 1995; Chittleborough, 1965; Dawbin, 1966, 1997; Vang, 2002). On the northern migration, lactating females accompanied by weaning yearlings are first to migrate, followed by immature males and females, followed by mature males together with resting females and then pregnant females. On the southern migration, mixed

Significant impact criteria (Vulnerable)	Assessment of impacts to Humpback Whale
	females (including those in early pregnancy) and immature males and females are first to migrate, followed by mature males and then females with calves in early lactation (Paton 2006, pers. comm.). There were no important habitats for the Humpback whale located within the Study Area surveyed for the Proposal, and therefore any individuals present would be passing through the area. The Proposal has the potential to alter the behaviour of these individuals that may be in close proximity to vessels, dredging and piling operations however there are standard mitigation measures proposed, and the scale of these potential impacts would not be significant enough to disrupt the breeding cycle of this species.
Modify, destroy, remove or isolate or decrease the availability or quality of habitat to the extent that the species is likely to decline	BCH surveys of the region support findings that the development envelopes are comprised of relatively poor quality (i.e. low cover and dynamic) habitats for marine mammals. The loss of 79 ha of the vegetated sub-tidal BCH within the Study Area (which is extremely small in comparison to the range of this species) is unlikely to 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	The Proposal has the potential to introduce marine pests, however with the application of regulated controls, the Proposal was identified as being of 'low risk' of introducing marine pests to Mardie marine waters. Standard industry controls (enforced by DoA) relating to ballast water and vessel hygiene provide a level of confidence that IMPs will not be introduced. The Proposal is therefore considered unlikely to introduce invasive species that are harmful to this species.
Introduce disease that may cause the species to decline	The Proposal is not considered to provide any vectors for disease.
Interfere substantially with the recovery of the species	The area of BCH within the development envelopes does not represent significant local or regional habitat. This, combined with the relatively small-scale habitat disturbance required, the low scale of the export operations, and the wide-ranging nature of this species, means that the Proposal is not expected to interfere substantially with the recovery of the Humpback Whale.

Table 68: Pilbara Olive Python

Significant impact criteria (Vulnerable)	Assessment of impacts to Pilbara Olive Python
Lead to a long-term decrease in the size of an important population of a species	There are currently no defined criteria for habitat critical for the survival of the Pilbara Olive Python or identified important populations. The approved conservation advice describes preferred habitat for the Pilbara Olive Python as including deep gorges and water holes. Estimating population size for the Pilbara Olive Python is difficult due to the cryptic nature of the species, lack of reliable trapping methods or census techniques and the narrow range of reliable surveys (DEWHA, 2008b). This species was not recorded during two nocturnal searches but suitable habitat is present at the permanent pool (Mardie Pool). The species may also be found on occasion on the southern creeklines. An 'important population' is defined by the Significant Impact Guidelines 1.1 (Department of the Environment, 2013) as a population that is necessary for a species' long-term survival and recovery. This may include populations identified as such in recovery plans, and/or that are: • Key source populations either for breeding or dispersal; • Populations that are necessary for maintaining genetic diversity; and/or • Populations that are near the limit of the species range. Given that no individuals of this species were recorded by Phoenix (2020b; Appendix 9.1) it is unclear as to whether there is a population in the area that would be classified as an 'important population' under the definition in the Significant Impact Guidelines 1.1 (DotE, 2013). Regardless of this, the Proposal avoids almost all of the habitat identified as being significant for this species (riparian woodland) and will not impact any freshwater pools. The Proposal is therefore unlikely to impact the survival of any individuals of this species, therefore it would be extremely unlikely to decrease the size of the population. A summary of each potential impact is provided below. **Clearing** It is unlikely the proposed clearing will lead to a long-term decrease in the size of the Pilbara Olive Python population. Habitat of value to this species is therefore limited to creek lines and water sources. Mardie Pool occurs in the TFSA and could be used as a water source by the species if present, however this pool is outside the development envelopes and will not be impacted by the Proposal. The other creeks within the development envelopes do not contain permanent water. Observations during the Phoenix (2020b) surveys suggest pools persist in some creeks in the local area for several months following rainfall events inland. Only a small percentage of the open riparian woodland surveyed (15.9 ha of 74 ha) is located in the development envelopes, but only 5.4 ha is expected to be disturbed (7.3% of mapped extent). Direct impacts to this habitat are not considered significant and therefore impacts to this species are likely to be low. **Brine Seepage and Spills** A spill or leak of brine from the ponds or pipelines could result in impacts to the health of the surrounding fauna habitat. Of interest to this species is a potential spill in the vicinity of the riparian habitat or Mardie Pool. 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 10.6). Ponds have been designed with adequate freeboard and overflow features to minimise the risk of unplanned overflows and wall breaches. The crystalliser ponds adjacent to Mardie Pool will be lined to prevent seepage. If a spill was to occur, it may cause a reduction in the health of the downslope fauna habitat, however the spill would be limited to an area that is adapted to saline conditions and is regularly inundated with seawater. Brine would be expected to dilute and wash away over a period of several months. **Vehicle Strike**

Significant impact criteria (Vulnerable)	Assessment of impacts to Pilbara Olive Python
	The Proposal will have very few roads that intersect with Pilbara Olive Python habitat. The Proposal also has a relatively small workforce (particularly during operations), with limited vehicle movements.
Reduce the area of occupancy of an important population	Given that no individuals of this species were recorded by Phoenix (2020b; Appendix 9.1) it is unclear as to whether there is a population in the area that would be classified as an 'important population' under the definition in the Significant Impact Guidelines 1.1 (Department of the Environment, 2013). Regardless of this, the Proposal avoids almost all of the habitat (92.7% of what was mapped within the TFSA) identified as being significant for this species (riparian woodland) and will not impact any freshwater pools. The Proposal is therefore unlikely to reduce the area of occupancy of an important population of this species.
Fragment an existing important population into two or more populations	The Proposal avoids almost all of the habitat (92.7% of what was mapped within the TFSA) identified as being significant for this species (riparian woodland) and will not impact any fresh water pools. The Proposal will very few roads that intersect with Pilbara Olive Python habitat and these roads will be able to be traversed by this species. The Proposal is therefore unlikely to fragment an existing important population into two or more populations.
Adversely affect habitat critical to the survival of a species	The Significant Impact Guidelines 1.1 (Department of the Environment, 2013) state that 'habitat critical to the survival of a species' refers to areas that are necessary: • For activities such as foraging, breeding, roosting, or dispersal; • For the long-term maintenance of the species or ecological community (including the maintenance of species essential to the survival of the species, such as pollinators); • To maintain genetic diversity and long-term evolutionary development, or • For the reintroduction of populations or recovery of the species or ecological community. The Proposal has completely avoided Mardie Pool and will result in the disturbance of only 15.4 ha of riparian habitat, which may be utilised by the Pilbara Olive Python. This habitat is not expected to be 'critical to the survival of the species' as it represents only 7.3% of the habitat mapped within the TFSA. Based on the above, the Proposal is not expected to adversely affect habitat critical to the survival of the Pilbara Olive Python
Disrupt the breeding cycle of an important population	Given that no individuals of this species were recorded by Phoenix (2020b; Appendix 9.1) it is unclear as to whether there is a population in the area that would be classified as an 'important population' under the definition in the Significant Impact Guidelines 1.1 (DotE, 2013). Regardless of this, the Proposal avoids almost all of the habitat (92.7% of what was mapped within the TFSA) identified as being significant for this species (riparian woodland) and will not impact any freshwater pools. The Proposal is therefore unlikely to 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	The Proposal will result in the disturbance of some areas of riparian habitat that may be utilised by the Pilbara Olive Python. This disturbance however constitutes only 7.3% of the habitat within the TFSA and therefore it is unlikely that this disturbance would case a decline in the species.
Result in invasive species that are harmful to a vulnerable species becoming established in the vulnerable species' habitat	The Proposal includes strict control measures to prevent the spread of Mesquite, which will in turn minimise the likelihood of other invasive weed species becoming established. Feral animals will also be controlled on site to minimise their introduction or spread (refer to Section 13.7).

Significant impact criteria (Vulnerable)	Assessment of impacts to Pilbara Olive Python
Introduce disease that may cause the species to decline	TSSC (2016b) does not list disease as a threat to the Pilbara Olive Python. Nevertheless the Proposal is not expected to provide a vector for any disease.
Interfere substantially with the recovery of the species	The Proposal will result in the disturbance of some areas of riparian habitat that may be utilised by the Pilbara Olive Python. This disturbance however constitutes only 7.3% of the habitat within the TFSA and indirect impacts on this habitat or this species are not expected to be significant. It is unlikely that the Proposal would interfere substantially with the recovery of the species.

Table 69: Flatback, Hawksbill and Green Turtle

<table>
<tr><th>Significant impact criteria (Vulnerable)</th><th>Assessment of impacts to Flatback, Hawksbill and Green Turtle</th></tr>
<tr><td>Lead to a long-term decrease in the size of an important population of a species</td><td>
There is no approved conservation advice for the Flatback Turtle, Hawksbill Turtle or Green Turtle. The major rookeries for Flatback Turtles on the North-West Shelf are on the mid-eastern coast of Barrow Island and at Mundabullangana Station near Cape Thouin on the mainland.
For Hawksbill Turtle, the key nesting and inter-nesting areas in Australia (where females live between laying successive clutches in the same season) occur on offshore islands off Onslow. Reefs from Cape Preston to Onslow are considered important feeding grounds.
For Green Turtles, the key nesting and inter-nesting areas (where females live between laying successive clutches in the same season) occur on offshore islands off the Pilbara coast.
An ‘important population’ is defined by the Significant Impact Guidelines 1.1 (DotE, 2013) as a population that is necessary for a species’ long-term survival and recovery. This may include populations identified as such in recovery plans, and/or that are:

Key source populations either for breeding or dispersal;
Populations that are necessary for maintaining genetic diversity, and/or
Populations that are near the limit of the species range.

Given that individuals of these species were recorded by O2 Marine (2020g; Appendix 7.2) Mardie Minerals has taken a conservative position which is to assume that these individuals form part of an important regional population. A summary of each potential impact is provided below.
Habitat Disturbance
Seagrasses and algae BCH provide important feeding habitats for significant marine fauna species such as turtles, so removal can have substantial effects on survival, distribution and feeding habits (Gales et al., 2004). Pendoley found that the nearshore islands and tidal creeks represent the most important feeding areas for turtles. BCH surveys of the region support findings that the development envelopes are comprised of relatively poor quality (i.e. low cover and dynamic) vegetated habitats for foraging compared to areas where turtles typically congregate. Therefore, the development envelopes are unlikely to represent critical habitat for marine turtles.
Surveys conducted on the sandy beach to the north of the Proposal (Pendoley, 2019a; Appendix 7.1) indicated that the mainland beaches are not currently a regionally important turtle rookery. The proposed disturbance of this beach is limited to a narrow section (less than 50 m) to install the trestle jetty structure. Given the above, the direct impacts to this beach is not expected to be significant to local marine turtle populations.
There is no evidence that nesting has always been low on these mainland beaches, however it is known that other sections of the WA mainland coastline do currently support moderate to high turtle nesting, e.g. Port Hedland, Onslow Back Beach to Ashburton Delta, Mundabullangana Station and Cape Dommett. There is no historical evidence to suggest the Proposal location has been subject to human or predator pressures at levels greater than these other mainland nesting locations, in fact the remoteness of the Proposal would suggest the beaches are less affected than Port Hedland, Onslow and Mundabullangana where human pressures have been present for over 100 years. So it is considered highly unlikely a nesting population might suddenly appear at the Proposal (Pendoley, 2019a).
This coastline has been subjected to low level survey effort over the past 10 - 20 years by DBCA and environmental consultant surveys (Pendoley et al, 2016). While limited, the survey data has confirmed this section of the coastline is a poorly used nesting habitat. Direct impacts to marine turtle habitat is therefore considered unlikely to decrease the size of an important population of any of these species.
Vessel Strike
The likelihood of a vessel strike during dredging and construction from proposed vessel movements is considered low due to the small scale (i.e. spatial movements) of the operation and dredge vessel (i.e. slow-moving and small support vessels). Similarly, the risk of vessel strike on marine turtles during the
</td></tr>
</table>

Significant impact criteria (Vulnerable)	Assessment of impacts to Flatback, Hawksbill and Green Turtle
	operational stage is considered unlikely due to the slow speed of the transhipment barge and relatively low vessel movements (2 - 4 barge movements per day) in comparison to other ports or boat ramps in WA. The consequence of vessel strike on marine turtles may result in injury or mortality, although these events are expected to be rare. Mitigation measures outlined in Section 13.7 are proposed to reduce this risk further. **Marine Noise** A Marine Noise Assessment was undertaken by Talis (2019; Appendix 6.4) to predict impacts to marine fauna, including a specific assessment for marine turtles. The results of the Talis (2019) model show that marine turtle individuals could be impacted by dredging, barging and piling activities if they were present in close proximity to these activities. Mitigation measures will be implemented (Section 13.7) to ensure that these potential impacts are minimised. With the implementation of controls (refer to Section 13.7) the noise emissions from the Proposal are unlikely to lead to a long-term decrease in the size of an important population of a species. **Light Emissions** A survey conducted by Pendoley (2019a; Appendix 7.1) identified that marine turtles nested most successfully on the offshore islands (Figure 93). These offshore islands lie more than 8 km from the closest potential Proposal light source, which exceeds the 1.5 km ‘darkness zone’ recommended by EPA (2010). Turtle hatchlings and nesting on these beaches are therefore unlikely to be significantly impacted by the Proposal given this large distance, and the fact that minimal lighting is required for the Proposal. Light associated with the trestle jetty could have an impact on hatchlings leaving the mainland beaches (should any successful nests be laid there) or during sea finding on or leaving the nesting beaches on the nearby coastal islands. The low level of turtle nesting on the mainland beach and the implementation of controls (refer to Section 13.7) means that light emissions from the Proposal is unlikely to lead to a long-term decrease in the size of an important population of a species. **Dredging – Marine Turtle Injury or Death** The dredging will occur during daylight hours over a 12-hour shift, with actual dredge operation times expected for 10 hours per day. Dredging activities for the Proposal are low impact in comparison to common dredging operations such as cutter suction dredge programs. Dredging will instead involve the use of a barge-mounted long-reach excavator to excavate sediment from high points along the dredge channel. The sediment will be loaded into the barge for transport to shore as required. This form of dredging greatly reduces the potential for injury or death to marine turtles when compared to cutter suction dredging, as it is unlikely that a marine turtle would be captured within the loader shovel, and the loader operator would be likely to notice a marine turtle in the vicinity of the dredging operations. The noise and sea bed disturbance associated with a bucket dredge is likely to cause a startle response in turtles and drive them from the immediate area. Depending on the design, a bucket dredge may also have better visibility of the material being picked up from the bottom, making it easier for a fauna observer to see if any wildlife has been picked up. In addition, tickler chains will be utilised to further reduce the risk of entrainment. Pendoley’s (2019a) experience from Barrow Island was that they found little or no impact on turtles from dredging. **Entrapment in Seawater Intakes** Two seawater intakes are required for the Proposal. One is located in a tidal creek and used as an intake for the concentrator and crystalliser ponds and the other is located on the trestle jetty to allow dilution of the bitterns prior to discharge. O2 Marine (2020g; Appendix 7.2) determined that turtles are likely to be present in the vicinity of the proposed seawater intakes and therefore there was the potential for marine turtles (juveniles) to become trapped within the intakes. The intakes have therefore been designed with large intake pipes to ensure flow rates are low enough (less than 0.15 m/s) to allow marine turtles to swim against the current and escape. Recent work with flatback hatchlings found swim speeds of 0.5 m/s for hatchlings leaving a rookery beach at Thevenard Island (Wilson et al 2018). However, when an artificial light was present, hatchlings were able to swim against low velocity currents (up to 0.3 m/s) to reach a light source (Wilson et al. 2018). Green turtle hatchlings have also been tracked in Western Australia, as they dispersed through nearshore waters near Ningaloo, and were found to move directly away from the shoreline at speeds of 0.5 m.s-1 (Thums et al., 2016).

Significant impact criteria (Vulnerable)	Assessment of impacts to Flatback, Hawksbill and Green Turtle
	In addition screens will be installed on the intakes to prevent marine turtles from entering the intake pipelines. Assuming these mitigation measures are implemented, the risk of entrapment of marine turtles at the seawater intakes is considered to be very low. **Summary** The Proposal may have some impacts on marine turtles however the scale of these impacts are low and relatively localised. The implementation of mitigation controls will ensure that the potential impacts are minimised such that the Proposal would be unlikely to 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	The area of occupancy of the Flatback Turtle, Hawksbill Turtle and Green Turtle is limited by the availability of suitable habitat. Seagrasses and algae BCH provide important feeding habitats for significant marine fauna species such as turtles, so removal can have substantial effects on survival, distribution and feeding habits (Gales et al., 2004). Pendoley found that the nearshore islands and tidal creeks represent the most important feeding areas for turtles. BCH surveys of the region support findings that the development envelopes are comprised of relatively poor quality (i.e. low cover and dynamic) vegetated habitats for foraging compared to areas where turtles typically congregate. Therefore, the development envelopes are unlikely to represent critical habitat for marine turtles. Marine turtles will also be able to traverse across the marine structures as no solid structures (such as rock causeways) are proposed. Surveys conducted on the sandy beach to the north of the Proposal (Pendoley, 2019a; Appendix 7.1) indicated that the mainland beaches are not currently a regionally important turtle rookery. The proposed disturbance of this beach is limited to a narrow section (less than 50 m) to install the trestle jetty structure. Given the above, the direct impacts to this beach is not expected to be significant to local marine turtle populations. Pendoley Environmental (Pendoley, 2019a) has advised that the possibility of the mainland beaches being more heavily utilised by nesting turtles in the future is unlikely as these beaches are already hot and are only expected to get hotter with the progress of climate change. Climate change is expected to drive nesting turtles further south to nest on cooler beaches during the summer. A switch to winter nesting associated with climate change is another possibility however has not been reported anywhere globally to date and so is considered unlikely. Direct impacts to marine turtle habitat is therefore considered unlikely to reduce the area of occupancy of an important population.
Fragment an existing important population into two or more populations	There are no physical barriers associated with an open pile trestle jetty. The presence of the trestle jetty structure is not expected to have any impact on population fragmentation since the trestle will not obstruct animal movement though the area. Equally the presence of the open pile trestle jetty in not expected to interrupt nesting behaviour or success (beach or nest site selection, sea finding etc.) even if nesting females were present (Pendoley, 2019a; Appendix 7.1). The trestle jetty legs may creation artificial habitat and a refuge for fish which could predate on the hatchlings swimming off the adjacent nesting beach. However the lack of evidence of nesting on the mainland beaches, monitored for an entire internesting period at the peak of the nesting season for flatback and green turtles, and the associated lack of hatchlings leaving these beaches means the risk of hatchlings being predated by fish is negligible. Green hatchlings leaving the more densely utilised nesting beaches on the nearshore islands are unlikely to swim inshore and instead will disperse into deep offshore waters, while flatback hatchlings are likely to be carried on coastal currents and tides and dispersed along entire Pilbara coast. Personal observations during manual tracking of flatback hatchlings dispersing from Barrow Island indicated that the hatchlings will orient into waves, are carried along by nearshore currents and will crawl onto and rest on seaweed within an hour or two of leaving the beach (Pendoley, 2019a).
Adversely affect habitat critical to the survival of a species	The Recovery Plan for Marine Turtles in Australia 2017 – 2027 (Commonwealth of Australia, 2017) defines 'habitat critical to the survival of a species' as habitat that meets the following criteria: • Nesting habitat critical to the survival of green, flatback and hawksbill turtles includes at least 70 per cent of nesting for the stock; and • Where relevant, nesting habitat determined to be critical to the survival of marine turtles includes areas that are: geographically dispersed; major and minor rookeries; mainland and island beaches; and winter or summer nesting.

Significant impact criteria (Vulnerable)	Assessment of impacts to Flatback, Hawksbill and Green Turtle
	In the north west of WA the following nesting locations are considered critical to the survival of the species: • Flatback Turtle - Montebello Islands, Mundabullangana Beach, Barrow Island, Cemetery Beach, Dampier Archipelago (including Delambre Island and Huay Island), coastal islands from Cape Preston to Locker Island; • Hawksbill Turtle - Dampier Archipelago (including Rosemary Island and Delambre Island), Montebello Islands (including Ah Chong Island, South East Island and Trimouille Island), Lowendal Islands (including Varanus Island, Beacon Island and Bridled Island), Sholl Island; and • Green Turtle - Adele Island, Maret Island, Cassini Island, Lacepede Islands, Barrow Island, Montebello Islands (all with sandy beaches), Serrurier Island, Dampier Archipelago, Thevenard Island, Northwest Cape, Ningaloo coast. As listed above, offshore islands in the Pilbara are often noted as important habitat, and the islands off the Mardie coast were identified by Pendoley (2019a; Appendix 7.1) as containing suitable nesting habitat. No impacts to these beaches are expected, they are more than 8 km from the development envelopes and therefore the minimum 1.5 km 'dark zone' recommended by EPA (EPA, 2010) will be maintained for these beaches. Surveys conducted on the sandy mainland beach to the north of the Proposal (Pendoley, 2019a) indicated that the mainland beaches are not currently a regionally important turtle rookery. The proposed disturbance of this beach is limited to a narrow section (less than 50 m) to install the trestle jetty structure. Given the above, the Proposal is considered unlikely to adversely affect habitat critical to the survival of a species.
Disrupt the breeding cycle of an important population	**Breeding Cycle** Flatback Turtle In the Pilbara region, peak nesting occurs in the summer months (Prince, 1994). Females lay a mean of 2.8 clutches per season at an inter-nesting interval of 15 days. The sex ratio of the hatchlings is determined by the temperature of the sand, with males produced below 29°C and females produced above this temperature (Limpus, 1995a). Flatback Turtles breed at intervals between 1 - 5 years (i.e. remigration interval) with a mean of 2.7 years (Limpus et al., 1983). Clutches of eggs are susceptible to a number of natural disturbances, including nest disturbance by other nesting female turtles; flooding; or erosion of nests in storm events (Limpus, 2007). Egg and hatchling survivorship averages around 80% (Limpus, 1971) though the success of incubation and emergence of hatchlings is high in those rookeries free from disruption (Limpus, 2007). Eggs incubate for around 6 weeks before hatchlings emerge from the nest and enter the sea. Predation of hatchlings as they cross the beach to the sea by birds, small crocodiles and crabs can be significant. Post-hatchlings are surface-water dwelling, feeding on macroplankton. The duration of the post-hatchling life stage is unknown (Limpus, 2007). Unlike other sea turtle species, Flatback Turtles lack an oceanic phase and remain in the surface waters of the continental shelf (Limpus et al., 1994; Walker, 1994). Once the pelagic stage of its life is completed, the Flatback Turtle moves to sub-tidal soft bottomed habitats inshore, feeding on benthic organisms. Little is known about their foraging habits and habitat. Survivorship data is lacking for the majority of the life history of the Flatback Turtle. Survivorship from hatchling emergent to maturity is estimated at less than 0.0026 (Parmenter & Limpus, 1995). Annual survivorship of adult females on nesting beaches is greater than 0.99 (unpublished data in Limpus, 2007). Breeding rates for adult females are not known for any population. As with all marine turtles, seasonal breeding in Flatback Turtles is tied to incubation conditions (in particular sand temperatures need to be between 25 - 32°C), hatchling dispersal and courtship (Hamann et al., 2002). The female Flatback Turtle displays a high degree of fidelity to her chosen nesting beach, with most females returning to the same beach within a nesting season and in successive nesting seasons (Limpus 2007). Flatback Turtles show a preference for nesting in sand dunes or the steep seaward slope of beaches and rarely come ashore to nest on beaches fronted by intertidal coral reef flats. Successful incubation of eggs require temperatures within the nest of between 25 - 32°C, good ventilation, low salinity, high humidity and no disturbance (such as rotation) of the egg.

Significant impact criteria (Vulnerable)	Assessment of impacts to Flatback, Hawksbill and Green Turtle
	Disruptions to nests include flooding and erosion, predation by feral and native animals and disturbance by other nesting turtles. Emergent hatchlings make their way to the ocean by orienting themselves to the low elevation light horizon. The strong nest site fidelity shown by the Flatback Turtle makes this species susceptible to the hazards of nest site disturbance, particularly considering that a first-time nesting turtle may be returning to her "pre-determined" nest site some 20 years after her own emergence from the nest, during which time the suitability of the nest site may have decreased. For instance, predators may have been introduced or increased (pigs, foxes or dogs), human interference may have increased (infrastructure, access and light pollution) or beach morphology changed. <u>Hawksbill Turtle</u> Hawksbill turtles grow very slowly. Growth and timing of sexual maturity vary between populations (Chaloupka & Limpus, 1997). Sexual maturity is not reached until after 31 years of age (Limpus, 1992). To develop successfully, marine turtle eggs must be buried in sand that is aerated (but not exposed), low in salt, high in humidity (but not flooded), and between 25 - 33° C (DEH, 2005). Breeding male and female Hawksbills move from their feeding grounds to areas near nesting beaches for mating. The males then return to their feeding grounds and the females come up onto the beach to lay their eggs, usually on several different nights (Robins et al., 2002). Nesting occurs in WA all year with a peak between October and January (Robinson, 1990, cited in Limpus, 1995a). The inter-nesting interval (the time between successive clutches) is 14.5 days. Individual females reproduce every 2 - 4 years (Dobbs et al., 1999). The sex of the hatchlings is determined by the temperature of the nest; warmer nests (above 29°C) produce more females than males (Mrosovsky et al., 1992). <u>Green Turtle</u> Female Green Turtles vary in their age at maturity depending on the different foraging grounds they occupy. Females may reach sexual maturity at between 25 - 50 years of age (Chaloupka et al., 2001). In one study, 88% of eggs laid hatched successfully (IPSTCG, 2003). However, mortality of hatchlings may be high. To develop successfully, marine turtle eggs must be buried in sand that is aerated (but not exposed), low in salt, high in humidity (but not flooded), and between 25 - 33°C (DEH, 2005). The sex of the hatchlings is determined by the temperature of the nest, with nests at or below 26°C producing all male hatchlings, and nests at or above 29°C producing all female hatchlings (Miller & Limpus, 1981). Nests with intermediate temperatures produce mixed sex hatchlings, depending on the position, and therefore, temperature of individual eggs. Breeding male and female Green Turtles move from their feeding grounds to areas near nesting beaches for mating. The males then return to their feeding grounds, and the females come up onto the beach to lay their eggs, usually on several different nights (Robins et al., 2002). In WA, nesting is between November and March (DEH, 2005). Females lay an average of five clutches of around 115 eggs per season. The inter-nesting interval (time between successive clutches) is 14 days (DEH, 2005). The incubation period is 64 days (Limpus, 1995). Female Green Turtles breed every 1 - 9 years. The number of females breeding each year is correlated with the Southern Oscillation Index, which determines sea surface temperatures (Limpus et al., 1994; Limpus, 1995; Limpus & Nicholls, 1988; Limpus & Walter, 1980). **Potential to Disrupt Breeding Cycle** There were no important habitats for marine turtles located within the Study Area surveyed for the Proposal, and therefore the Proposal only has the potential to indirectly impact any individuals of a population that would be present within or in proximity to the development envelopes. These potential impacts are discussed above.

Significant impact criteria (Vulnerable)	Assessment of impacts to Flatback, Hawksbill and Green Turtle
	The Proposal has the potential to disrupt the behaviour of marine turtle individuals that may be in close proximity to vessels, dredging and piling operations however there are standard mitigation measures proposed, and the scale of these potential impacts would not be significant enough to disrupt the breeding cycle of an important population of these species.
Modify, destroy, remove or isolate or decrease the availability or quality of habitat to the extent that the species is likely to decline	BCH surveys of the region support findings that the development envelopes are comprised of relatively poor quality (i.e. low cover and dynamic) vegetated habitats for foraging compared to areas where turtles typically congregate. Therefore, the development envelopes are unlikely to represent critical habitat for marine turtles. Surveys conducted on the sandy beach to the north of the Proposal (Pendoley, 2019a; Appendix 7.1) indicated that the mainland beaches are not currently a regionally important turtle rookery. The proposed disturbance of this beach is limited to a narrow section (less than 50 m) to install the trestle jetty structure. Given the above, the direct impacts to this beach is not expected to be significant to local marine turtle populations. Dredging and bitterns disposal activities were shown to have indirect habitat impacts over a relatively small area that was noted to contain no significant habitat for marine turtles. The Proposal is therefore considered unlikely to modify, destroy, remove or isolate or decrease the availability or quality of habitat to the extent that these species are likely to decline.
Result in invasive species that are harmful to a vulnerable species becoming established in the vulnerable species' habitat	Turtle hatchlings can be predated by introduced species such as pigs, foxes, cats and dogs. Several feral animals were recorded within the TFSA, including dogs, foxes and cats (Phoenix, 2020b; Appendix 9.1). 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. Mardie Minerals notes that while the mainland beach would be unlikely to be considered important habitat, mitigation measures to control introduced species would benefit the success rate of hatchlings on this beach. These mitigation measures are listed in Section 13.7. The Proposal has the potential to introduce marine pests, however with the application of regulated controls, the Proposal was identified as being of 'low risk' of introducing marine pests to Mardie marine waters. Standard industry controls (enforced by DAWR) relating to ballast water and vessel hygiene provide a level of confidence that IMPs will not be introduced. The Proposal is therefore considered unlikely to introduce invasive species that are harmful to these species.
Introduce disease that may cause the species to decline	To date, there are no recorded occurrences of diseases and pathogens affecting the viability of a marine turtle stock in Australia (DotEE, 2017). Nevertheless the Proposal is not expected to provide a vector for any disease.
Interfere substantially with the recovery of the species	The Proposal will not impact any important nesting beaches or have a significant impact on BCH. Marine noise and lighting controls will be implemented to minimise indirect impacts such that local individuals and populations are not significantly impacted. These controls are well-established for marine projects. Based on the above, the Proposal is considered unlikely to interfere substantially with the recovery of these species.

Table 70: Loggerhead Turtle

Significant impact criteria (Endangered)	Assessment of impacts to Loggerhead Turtle
Lead to a long-term decrease in the size of a population	There is no approved conservation advice for the Loggerhead Turtle. In Australia, Loggerhead Turtles nest on open, sandy beaches concentrated in southern Queensland and from Shark Bay to the North West Cape in WA. They live at or near the surface of the ocean and move with the ocean currents, choosing a wide variety of tidal and sub-tidal habitat as feeding areas and showing fidelity to both their foraging and breeding areas. (DotE, 2015). The Loggerhead Turtle was not recorded during field surveys however it was considered likely to occur based on suitable habitat. **Habitat Disturbance** Seagrasses and algae BCH provide important feeding habitats for significant marine fauna species such as turtles, so removal can have substantial effects on survival, distribution and feeding habits (Gales et al., 2004). Pendoley found that the nearshore islands and tidal creeks represent the most important feeding areas for turtles. BCH surveys of the region support findings that the development envelopes are comprised of relatively poor quality (i.e. low cover and dynamic) vegetated habitats for foraging compared to areas where turtles typically congregate. Therefore, the development envelopes are unlikely to represent critical habitat for marine turtles. Surveys conducted on the sandy beach to the north of the Proposal (Pendoley, 2019a; Appendix 7.1) indicated that the mainland beaches are not currently a regionally important turtle rookery, and no evidence of Loggerhead Turtle nesting was recorded. The proposed disturbance of this beach is limited to a narrow section (less than 50 m) to install the trestle jetty structure. Given the above, the direct impacts to this beach is not expected to be significant to local marine turtle populations. Direct impacts to marine turtle habitat is therefore considered unlikely to decrease the size of a population of this species. **Vessel Strike** The likelihood of a vessel strike during dredging and construction from proposed vessel movements is considered low due to the small scale (i.e. spatial movements) of the operation and dredge vessel (i.e. slow-moving and small support vessels). Similarly, the risk of vessel strike on marine turtles during the operational stage is considered unlikely due to the slow speed of the transhipment barge and relatively low vessel movements (2 - 4 barge movements per day) in comparison to other ports or boat ramps in WA. The consequence of vessel strike on the Loggerhead Turtle may result in injury or mortality, although these events are expected to be rare. Mitigation measures outlined in Section 13.7 are proposed to reduce this risk further. **Marine Noise** A Marine Noise Assessment was undertaken by Talis (2019; Appendix 6.4) to predict impacts to marine fauna, including a specific assessment for marine turtles. The results of the Talis (2019) model show that marine turtle individuals could be impacted by dredging, barging and piling activities if they were present in close proximity to these activities. Mitigation measures will be implemented (Section 13.7) to ensure that these potential impacts are minimised. With the implementation of controls (refer to Section 13.7) the noise emissions from the Proposal are unlikely to lead to a long-term decrease in the size of a population of this species. **Light Emissions** A survey conducted by Pendoley (2019a) identified that marine turtles nested most successfully on the offshore islands (Figure 93), however evidence of Loggerhead Turtle nesting was not recorded. These offshore islands lie more than 8 km from the closest potential Proposal light source, which exceeds the 1.5 km 'darkness zone' recommended by EPA (2010). Turtle hatchlings and nesting on these beaches are therefore unlikely to be significantly impacted by the Proposal given this large distance, and the fact that minimal lighting is required for the Proposal. Light associated with the trestle jetty could have an impact on hatchlings leaving the mainland beaches (should any successful nests be laid there) or during sea finding on or leaving the nesting beaches on the nearby

Significant impact criteria (Endangered)	Assessment of impacts to Loggerhead Turtle
	coastal islands. The low level of turtle nesting on the mainland beach and the implementation of controls (refer to Section 13.7) means that light emissions from the Proposal is unlikely to lead to a long-term decrease in the size of a population of this species. **Dredging – Marine Turtle Injury or Death** The dredging will occur during daylight hours over a 12-hour shift, with actual dredge operation times expected for 10 hours per day. Dredging activities for the Proposal are low impact in comparison to common dredging operations such as cutter suction dredge programs. Dredging will instead involve the use of a barge-mounted long-reach excavator to excavate sediment from high points along the dredge channel. The sediment will be loaded into the barge for transport to shore as required. This form of dredging greatly reduces the potential for injury or death to marine turtles when compared to cutter suction dredging, as it is unlikely that a marine turtle would be captured within the loader shovel, and the loader operator would be likely to notice a marine turtle in the vicinity of the dredging operations. The noise and sea bed disturbance associated with a bucket dredge is likely to cause a startle response in turtles and drive them from the immediate area. Depending on the design, a bucket dredge may also have better visibility of the material being picked up from the bottom, making it easier for a fauna observer to see if any wildlife has been picked up. In addition, tickler chains will be utilised to further reduce the risk of entrainment. Pendoley's (2019a; Appendix 7.1) experience from Barrow Island was that they found little or no impact on turtles from dredging. **Entrapment in Seawater Intakes** Two seawater intakes are required for the Proposal. One is located in a tidal creek and used as an intake for the concentrator and crystalliser ponds and the other is located on the trestle jetty to allow dilution of the bitterns prior to discharge. O2 Marine (2020g; Appendix 7.2) determined that turtles are likely to be present in the vicinity of the proposed seawater intakes and therefore there was the potential for marine turtles (juveniles) to become trapped within the intakes. The intakes have therefore been designed with large intake pipes to ensure flow rates are low enough to allow marine turtles to swim against the current and escape. Recent work with flatback hatchlings found swim speeds of 0.5 m/s for hatchlings leaving a rookery beach at Thevenard Island (Wilson et al 2018). However, when an artificial light was present, hatchlings were able to swim against low velocity currents (up to 0.3 m/s) to reach a light source (Wilson et al. 2018). Green turtle hatchlings have also been tracked in Western Australia, as they dispersed through nearshore waters near Ningaloo, and were found to move directly away from the shoreline at speeds of 0.5 m/s (Thums et al., 2016). In addition screens will be installed on the intakes to prevent marine turtles from entering the intake pipelines. Assuming these mitigation measures are implemented, the risk of entrapment of marine turtles at the seawater intakes is considered to be very low. **Summary** The Proposal may have some impacts on the Loggerhead Turtle (if present) however the scale of these impacts are low and relatively localised. The implementation of mitigation controls will ensure that the potential impacts are minimised such that the Proposal would be unlikely to lead to a long-term decrease in the size of an important population of a species.
Reduce the area of occupancy of the species	The area of occupancy of the Loggerhead Turtle is limited by the availability of suitable habitat. Seagrasses and algae BCH provide important feeding habitats for significant marine fauna species such as turtles, so removal can have substantial effects on survival, distribution and feeding habits (Gales et al., 2004). Pendoley found that the nearshore islands and tidal creeks represent the most important feeding areas for turtles. BCH surveys of the region support findings that the development envelopes are comprised of relatively poor quality (i.e. low cover and dynamic) vegetated habitats for foraging compared to areas where turtles typically congregate. Therefore, the development envelopes are unlikely to represent critical habitat for marine turtles. Loggerhead turtles will also be able to traverse across the marine structures as no solid structures (such as rock causeways) are proposed. Surveys conducted on the sandy beach to the north of the Proposal (Pendoley, 2019a; Appendix 7.1) indicated that the mainland beaches are not currently a regionally important turtle rookery. The proposed disturbance of this beach is limited to a narrow section (less than 50 m) to install the trestle jetty structure. Given the above, the direct impacts to this beach is not expected to be significant to local Loggerhead turtle populations. Pendoley Environmental (Pendoley,

Significant impact criteria (Endangered)	Assessment of impacts to Loggerhead Turtle
	2019a) has advised that the possibility of the mainland beaches being more heavily utilised by nesting turtles in the future is unlikely as these beaches are already hot and are only expected to get hotter with the progress of climate change. Climate change is expected to drive nesting turtles further south to nest on cooler beaches during the summer. A switch to winter nesting associated with climate change is another possibility however has not been reported anywhere globally to date and so is considered unlikely. Direct impacts to Loggerhead turtle habitat is therefore considered unlikely to reduce the area of occupancy of an important population.
Fragment an existing population into two or more populations	There are no physical barriers associated with an open pile trestle jetty. The presence of the trestle jetty structure is not expected to have any impact on population fragmentation since the trestle will not obstruct animal movement though the area. Equally the presence of the open pile trestle jetty in not expected to interrupt nesting behaviour or success (beach or nest site selection, sea finding etc.) even if nesting females were present (Pendoley, 2019a; Appendix 7.1). The trestle jetty legs may creation artificial habitat and a refuge for fish which could predate on the hatchlings swimming off the adjacent nesting beach. However the lack of evidence of nesting on the mainland beaches, monitored for an entire internesting period at the peak of the nesting season, and the associated lack of hatchlings leaving these beaches means the risk of hatchlings being predated by fish is negligible. (Pendoley, 2019a).
Adversely affect habitat critical to the survival of a species	The Recovery Plan for Marine Turtles in Australia 2017 – 2027 (Commonwealth of Australia, 2017) defines 'habitat critical to the survival of a species' as habitat that meets the following criteria: • Nesting habitat critical to the survival of green, loggerhead, flatback and hawksbill turtles includes at least 70 per cent of nesting for the stock; and • Where relevant, nesting habitat determined to be critical to the survival of marine turtles includes areas that are: geographically dispersed; major and minor rookeries; mainland and island beaches; and winter or summer nesting. In the north west of WA the following nesting locations are considered critical to the survival of the species: • Dirk Hartog Island; • Muiron Islands; • Gnaraloo Bay; and • Ningaloo coast. As listed above, offshore islands in the Pilbara are often noted as important habitat, and the islands off the Mardie coast were identified by Pendoley (2019a; Appendix 7.1) as containing suitable nesting habitat. No impacts to these beaches are expected, they are more than 8 km from the development envelopes and therefore the minimum 1.5 km 'dark zone' recommended by EPA (EPA, 2010) will be maintained for these beaches. Surveys conducted on the sandy mainland beach to the north of the Proposal (Pendoley, 2019a) indicated that the mainland beaches are not currently a regionally important turtle rookery. The proposed disturbance of this beach is limited to a narrow section (less than 50 m) to install the trestle jetty structure. Given the above, the Proposal is considered unlikely to adversely affect habitat critical to the survival of this species.
Disrupt the breeding cycle of a population	**Breeding Cycle** Data for the eastern Australian genetic stock indicate that sexual maturity is reached at between 22 - 27 years of age (Chaloupka, 2003). Breeding life has been estimated from overseas stocks at 32 years (Frazer, 1995). While it is not clear how long a juvenile Loggerhead Turtle will stay in the open ocean, once it moves to its chosen feeding area, it will be a further 13 years or so before it is ready to breed. Some movement between the chosen feeding areas to the open ocean during the juvenile period has been demonstrated off the coast of North America (McClellan & Read 2007) but fidelity to the feeding area is strong. Once it has reached breeding age, it will move between its chosen feeding area and its chosen breeding area for the rest of its life (Limpus 2008a). Survivorship varies with age class:

Significant impact criteria (Endangered)	Assessment of impacts to Loggerhead Turtle
	• Eggs - average emergence success is between 70 - 90% (Limpus, 1985) • Hatchlings - average mortality was estimated at between 16 - 65% at Heron Reef (Gyuris, 1994) • Immature turtles - annual survivorship is calculated to be between 58% (males) and 84% (females) (Chaloupka & Limpus, 2002) • Adult turtles - annual survivorship is calculated to be 87% (Chaloupka & Limpus, 2002) Loggerhead Turtles in Australia breed from November to March with a peak in late December / early January (Limpus, 1985). Breeding rates for adult females vary annually from 0 - 70%. Seasonal breeding in Loggerhead Turtles, as is the case for all species, is tied to incubation conditions (in particular, sand temperatures need to be between 25 - 32°C), hatchling dispersal and courtship (Hamann et al., 2002). **Potential to Disrupt Breeding Cycle** There were no important habitats for marine turtles located within the Study Area surveyed for the Proposal, and therefore the Proposal only has the potential to indirectly impact any individuals of a population that would be present within or in proximity to the development envelopes. These potential impacts are discussed above. The Proposal has the potential to disrupt the behaviour of marine turtle individuals that may be in close proximity to vessels, dredging and piling operations however there are standard mitigation measures proposed, and the scale of these potential impacts would not be significant enough to disrupt the breeding cycle of a population of this species.
Modify, destroy, remove, isolate or decrease the availability or quality of habitat to the extent that the species is likely to decline	It is unlikely the Proposal will lead to decline of the Loggerhead Turtle. The development envelopes are unlikely to represent critical foraging BCH for marine turtles. Surveys conducted on the sandy beach to the north of the Proposal (Pendoley, 2019a; Appendix 7.1) indicated that the mainland beaches are not currently a regionally important turtle rookery. Additionally, Loggerhead Turtle nests were recorded on the mainland beaches. The proposed disturbance of this beach is limited to a narrow section (less than 50 m) to install the trestle jetty structure. None of the potential direct or indirect impacts are likely to result in a significant impact to the availability or quality of the foraging or nesting habitat for this species. The proposed habitat loss is therefore not expected to affect the survival of this species locally or regionally.
Result in invasive species that are harmful to a critically endangered or endangered species becoming established in the endangered or critically endangered species' habitat	Turtle hatchlings can be predated by introduced species such as pigs, foxes, cats and dogs. Several feral animals were recorded within the TFSA, including dogs, foxes and cats (Phoenix, 2020b; Appendix 9.1). 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. Mardie Minerals notes that while the mainland beach would be unlikely to be considered important habitat, mitigation measures to control introduced species would benefit the success rate of hatchlings on this beach. These mitigation measures are listed in Section 13.7. The Proposal has the potential to introduce marine pests, however with the application of regulated controls, the Proposal was identified as being of 'low risk' of introducing marine pests to Mardie marine waters. Standard industry controls (enforced by DAWR) relating to ballast water and vessel hygiene provide a level of confidence that IMPs will not be introduced. The Proposal is therefore considered unlikely to introduce invasive species that are harmful to this species.
Introduce disease that may cause the species to decline	To date, there are no recorded occurrences of diseases and pathogens affecting the viability of a marine turtle stock in Australia (DotEE, 2017). Nevertheless the Proposal is not expected to provide a vector for any disease.
Interfere with the recovery of the species	The Proposal will not impact any important nesting beaches for this species or have a significant impact on BCH. Marine noise and lighting controls will be implemented to minimise indirect impacts such that local individuals and populations are not significantly impacted. These controls are well-established for marine projects. Based on the above, the Proposal is considered unlikely to interfere with the recovery of this species.

Table 71: Short-nosed Seasnake

Significant impact criteria (Critically Endangered)	Assessment of impacts to Short-nosed Seasnake
Lead to a long-term decrease in the size of a population	The Short-nosed Seasnake is endemic to WA, and has been recorded from Exmouth Gulf to the reefs of the Sahul Shelf, in the eastern Indian Ocean. The species prefers the reef flats or shallow waters along the outer reef edge in water depths to 10 m. The main threat to the species appears to be degradation of reef habitat, primarily as a result of coral bleaching. There have been some records of the species occurring in the Exmouth Gulf and along the Pilbara coast. While a population has not been confirmed in this area, any sea snakes that do occur in this region are likely to be impacted by trawl fishing (DotEE, 201). No sightings of Short-nosed Seasnake have been recorded in the area and none were recorded during field studies undertaken for the Proposal. All true sea snake species are strongly associated with benthic habitats, and occur in coastal, shallow water habitats (typically <100m depth). The Short-nosed sea snake (*Aipysurus apraefrontalis*) is typically found in reef flats or shallow waters along the outer reef edge in water depths to 10 m (Cogger, 2000; Guinea, 1993, 1995; McCosker, 1975). The species has been observed during daylight hours, resting beneath small coral overhangs or coral heads in 1 - 2 m of water (McCosker, 1975). Guinea and Whiting (2005) reported that "very few Short-nosed Seasnakes moved even as far as 50 m away from the reef flat." In studies done in the nearby Exmouth Gulf and Onslow region, a total of 17 sea snakes were captured via trawl net from three surveys between March and November 2004 (Kangas et al., 2006). Thirteen sea snakes were captured from sites located in the southern part of Exmouth Gulf, and a further three sea snakes were caught in the central area of Exmouth Gulf. These included five different species of sea snake, which included the Critically Endangered short-nosed sea snake (*Aipysurus apraefrontalis*) and listed marine species dubois' sea snake (*Aipysurus duboisii*), olive sea snake (*Aipysurus laevis*), olive-headed sea snake (*Disteira major*) and stoke's sea snake (*Disteira stokesii*). No sea snakes were caught from the OPMF area during surveys undertaken in 2004 (Kangas et al. 2006), thus indicating that the Onslow region does not have the same importance for sea snakes as the Exmouth Gulf (O2 Marine, 2020g; Appendix 7.2). **Habitat Disturbance** The Short-nosed Seasnake is typically found in coral reef habitats. Based on the above habitat description and the mapped subtidal BCH types within the Study Area, suitable habitat for this species does not occur in proximity to the development envelopes. The nearest suitable habitat is located more than 5 km away from the Proposal. Given the Short-nosed Sea Snake is predicted to remain within 50 m of the reef flat, it is considered unlikely that it would be observed on a low-profile reef system more than 5 km away that provides little to no refuge. It is noted that whilst coral species are present in the Study Area, they do not form a complex reef system with a reef edge, reef flat and lagoon. Rather sediment-tolerant coral species are present in low abundance in areas where low profile limestone is exposed. This species was considered likely to occur near the Proposal but this reference was in the context that it would be likely to be found in the vicinity of the offshore islands. The Proposal will result in the loss of 44 ha of coral/macroalgae BCH. This habitat is of low value to the Short-nosed Seasnake due to the sparse nature of the coral cover and the presence of much higher quality coral at the fringing islands. Corals are mapped to cover only 1% of the sub-tidal portion of the Study Area which highlights that the Study Area is not significant habitat for this species. The Proposal is therefore unlikely to disturb any significant habitat for this species. **Dredging – Injury or Death** Dredging activities for the Proposal are low impact in comparison to common dredging operations such as cutter suction dredge programs. Dredging will instead involve the use of a barge-mounted long-reach excavator to excavate sediment from high points along the dredge channel. The sediment will be loaded into the barge for transport to shore as required. This form of dredging greatly reduces the potential for injury or death to sea snakes when compared to cutter suction dredging, as it is unlikely that a sea snake would be captured within the loader shovel.

Significant impact criteria (Critically Endangered)	Assessment of impacts to Short-nosed Seasnake
	Entrapment in Seawater Intakes Two seawater intakes are required for the Proposal. One is located in a tidal creek and used as an intake for the concentrator and crystalliser ponds, and the other is located on the trestle jetty to allow dilution of the bitterns prior to discharge. O2 Marine (2020g; Appendix 7.2) determined that the Short-nosed seasnake is unlikely to be present in the vicinity of the proposed seawater intakes (in particular the pond intake) and therefore it is unlikely that this species would become trapped within the intakes. Nevertheless the intakes have been designed with large intake pipes to ensure flow rates are low enough to allow sea snakes (and other marine fauna) to swim against the current and escape. In addition screens will be installed on the intakes to prevent sea snakes from entering the pipelines (committed to in Section 8.6.2). Assuming this mitigation measure is implemented, the risk of entrapment of the Short-nosed seasnake at the seawater intakes is considered to be very low. **Increased Predation** Artificial structures installed in the marine environment often result in aggregations of marine fauna species, which can cause increases in prey for the Short-nosed Seasnake, however in turn there may be increased predation risks from other species. The seawater intakes, trestle jetty and loading wharf are the only structures that will be installed in the marine environment. Marine fauna may aggregate around these items to some degree, however they are relatively small in scale and any increased predation is likely to be localised and unlikely to significantly alter the behaviour of this species. **Summary** The Proposal will have some direct impacts on BCH however the BCH to be impacted is of low quality for this species, and the scale of these impacts are low and localised. No impacts to offshore habitats are predicted. The implementation of mitigation controls will ensure that the potential impacts are minimised such that the Proposal would be unlikely to lead to a long-term decrease in the size of a population of this species.
Reduce the area of occupancy of the species	The area of occupancy of the Short-nosed seasnake is limited by the availability of suitable habitat. The Short-nosed seasnake is typically found in coral reef habitats which were not found in the Study Area and therefore the development envelopes are unlikely to represent critical habitat for this species. Short-nosed seasnakes will also be able to traverse across the marine structures as no solid structures (such as rock causeways) are proposed. Direct impacts to Short-nosed seasnake habitat is therefore considered unlikely to reduce the area of occupancy of an important population.
Fragment an existing population into two or more populations	The Proposal will not create physical barriers to sea snake movement and therefore will not fragment the existing population into two or more populations.
Adversely affect habitat critical to the survival of a species	The Short-nosed seasnake is typically found in coral reef habitats, which were not found in the Study Area. The Proposal will result in the loss of 44 ha of coral/macroalgae BCH, however this habitat is of low value to the Short-nosed seasnake due to the sparse nature of the coral cover and the presence of much higher quality coral at the fringing islands. Based on this assessment the Proposal will not affect habitat critical to the survival of this species.
Disrupt the breeding cycle of a population	All phases of the reproductive cycle of seasnakes takes place in the sea and reproductive seasonality varies among the species (DEWHA, 2008). The Proposal is unlikely to disrupt the breeding cycle of the Short-nosed seasnake given the low quality habitat present in the development envelopes and the low scale of indirect impacts.
Modify, destroy, remove, isolate or decrease the availability or quality of habitat to the extent that the species is likely to decline	It is unlikely the Proposal will lead to decline of the Short-nosed seasnake. The habitat within the development envelopes (and LAU 5) is of low value to the Short-nosed seasnake due to the sparse nature of the coral cover and the presence of much higher quality coral at the fringing islands. Sparse corals are mapped to cover only 1% of the subtidal portion of the Study Area. Additionally, the BCH identified within the Study Area were identified as widely occurring within the Pilbara and were not regionally significant.

Significant impact criteria (Critically Endangered)	Assessment of impacts to Short-nosed Seasnake
	None of the potential direct or indirect impacts are likely to result in a significant impact to the availability or quality of habitat for this species. The proposed habitat loss is therefore not expected to affect the survival of this species.
Result in invasive species that are harmful to a critically endangered or endangered species becoming established in the endangered or critically endangered species' habitat	The Proposal has the potential to introduce marine pests, however with the application of regulated controls, the Proposal was identified as being of 'low risk' of introducing marine pests to Mardie marine waters. Standard industry controls (enforced by DAWR) relating to ballast water and vessel hygiene provide a level of confidence that IMPs will not be introduced. The Proposal is therefore considered unlikely to introduce invasive species that are harmful to this species.
Introduce disease that may cause the species to decline	The Proposal is not expected to provide a vector for any disease that may impact this species.
Interfere with the recovery of the species	The area of potential Short-nosed Seasnake habitat within the development envelopes does not represent significant local or regional habitat. This, combined with the relatively small-scale habitat disturbance required, and the low scale of indirect impacts, means that the Proposal is not expected to interfere substantially with the recovery of this species if it was present in the area.

Table 72: Green Sawfish

Significant impact criteria (Vulnerable)	Assessment of impacts to Green Sawfish
Lead to a long-term decrease in the size of an important population of a species	The Green sawfish inhabit shallow coastal marine and estuarine waters of northern Australia, from about Eighty Mile Beach, WA, to the Cairns region. It has been occasionally been caught as far south as Sydney. Green sawfish are known to be pupped near the Ashburton River mouth and utilise the estuary and nearby mangrove creeks, before moving offshore to mature at a length of about 3 m (O2 Marine, 2020g; Appendix 7.2). The main potential threats to Green Sawfish include incidental capture as bycatch and by-product in gillnet and trawl fisheries, illegal capture for fins and rostra and habitat degradation through coastal development. No incidental recordings of the Green sawfish were recorded during field studies undertaken. An 'important population' is defined by the Significant Impact Guidelines 1.1 (DotE, 2013) as a population that is necessary for a species' long-term survival and recovery. This may include populations identified as such in recovery plans, and/or that are: • Key source populations either for breeding or dispersal; • Populations that are necessary for maintaining genetic diversity, and/or • Populations that are near the limit of the species range. A summary of each potential impact is provided below. **Habitat Disturbance** Of the BCH impacted, tidal creeks (specifically the creek mouths) are considered to be of most significance to sawfish species. The tidal creeks are considered to be important nursery areas for Green Sawfish, however the Proposal only includes minor works within two of the tidal creeks in the area (limited to a seawater intake and a boat ramp), which are both out of the usual range of this species as they are located more than 700 m inland from the creek mouth. In addition this minor disturbance is not resulting in any modification to sawfish nursery areas which are confined to the <1 m depth range around the mouth of the tidal creeks (O2 Marine, 2020g). Given the number of similar tidal creeks, and the minimal direct disturbance, the Proposal is not expected to have a significant impact on tidal creek habitat for sawfish. **Vessel Strike** The likelihood of a vessel strike during dredging and construction from proposed vessel movements is considered low due to the small scale (i.e. spatial movements) of the operation and dredge vessel (i.e. slow-moving and small support vessels) and the bottom-dwelling nature of the species. Similarly, the risk of vessel strike on sawfish during the operational stage is considered unlikely due to the slow speed of the transhipment barge and relatively low vessel movements (2 - 4 barge movements per day) in comparison to other ports or boat ramps in WA. Maintaining speed limits of 12 knots within coastal waters is a suitable measure to significantly reduce the potential to cause impacts to Sawfish from vessel strike (Vanderlaan and Taggart, 2007). In addition, marine fauna observers are to be present at all times during vessel operation and inform the skipper to slow down should marine fauna such as sawfish approach the vessels. The consequence of vessel strike on sawfish may result in injury or mortality, although these events are expected to be extremely rare. Mitigation measures are proposed to reduce this risk further (Section 13.7). **Dredging – Sawfish Injury or Death** Dredging activities for the Proposal are low impact in comparison to common dredging operations such as cutter suction dredge programs. Dredging will instead involve the use of a barge-mounted long-reach excavator to excavate sediment from high points along the dredge channel. The sediment will be loaded into the

Significant impact criteria (Vulnerable)	Assessment of impacts to Green Sawfish
	barge for transport to shore as required. This form of dredging greatly reduces the potential for injury or death to sawfish when compared to cutter suction dredging, as it is unlikely that a sawfish would be captured within the loader shovel, and the loader operator would be more likely to notice a sawfish in the vicinity of the dredging operations. **Entrapment in Seawater Intakes** Two seawater intakes are required for the Proposal. One is located in a tidal creek and used as an intake for the concentrator and crystalliser ponds (Figure 3), and the other is located on the trestle jetty to allow dilution of the bitterns prior to discharge. O2 Marine (2019i) determined that sawfish are unlikely to be present in the vicinity of the proposed seawater intakes due to them being located more than 700 m from the creek mouths and therefore there was minimal potential for sawfish to become trapped within the intakes. The intakes have therefore been designed with flow rates that are low enough to allow sawfish to swim against the current and escape. In addition screens will be installed on the intakes to prevent sawfish from entering the pipelines (committed to in Section 13.7). Assuming this mitigation measure is implemented, the risk of entrapment of sawfish at the seawater intakes is considered to be very low. **Marine Noise** This section applies the findings of the marine noise assessment described in Section 8.5.1 to sawfish, in particular the Green Sawfish. The model results determined that noise emissions from dredging and barging operations would not exceed any Green Sawfish noise criteria, meaning that behavioural impacts would not be expected, even if Green Sawfish were in close proximity to the dredging or barging activities. Piling activities will result in an exceedance of the Green Sawfish TTS threshold at mean and high tides at distances less than 100 m. The TTS threshold is never exceeded at low tide. Behavioural responses are predicted at distances less than 500 m during mean and high tides, with no impacts at low tide. The results of the Talis (2019; Appendix 6.4) model show that sawfish (in particular the Green Sawfish) could be impacted by piling activities during the construction of the trestle jetty and loading wharf. Mitigation measures will be implemented to ensure that these potential impacts are reduced to an acceptable level (Section 13.7). **Other Indirect Impacts** Green sawfish or their habitat may be indirectly impacted by the Proposal as a result of: • Disposal of bitterns impacting water quality and/or marine fauna habitats; • Increased turbidity due to activities such as dredging; • Leaks or spillages of hypersaline brine; and • Leaks or spillages of hydrocarbons or chemicals. Bitterns disposal will result in reduced water quality within the LEPA. There will be no BCH within the LEPA however as it has been located within the proposed dredging footprint to reduce habitat impacts. Green sawfish that pass through the LEPA are unlikely to be significantly affected given the small size of the area and the lack of habitat (located within a dredged area - i.e. no significant BCH). A spill or leak of brine from the ponds or pipelines is unlikely to impacts the health of subtidal BCH. 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 10.6). Ponds have been designed with adequate freeboard and overflow features to minimise the risk of unplanned overflows and wall breaches. The crystalliser ponds adjacent to Mardie Pool will be lined to prevent seepage. If a spill were to occur, the high tidal action in the region would dilute and disperse the brine. Indirect impacts to subtidal BCH can be caused due to increased suspended sediment concentration (SSC), resulting increased turbidity, reduction in available benthic light and localised increase in sedimentation. Baird (2020b; Appendix 6.3) determined that the sedimentation thresholds were not exceeded beyond the

Significant impact criteria (Vulnerable)	Assessment of impacts to Green Sawfish
	ZoHI for either best or worst-case model scenarios. Dredging and this associated sedimentation is predicted to result in a total loss of 79 ha of vegetated subtidal BCH. Refuelling of vessels is proposed to occur at the Mardie Export Facility, and therefore there is a risk of hydrocarbon spill from vessels during construction and operation as a result of vessel collisions or hydraulic hose leaks. With the exception of vessels used in jetty construction, the majority of these vessels would be located several kilometres offshore as refuelling will occur at the end of the trestle jetty. Construction vessels are also small in size and therefore would not contain significant volumes of hydrocarbons. All ocean-going vessels will be located offshore in deeper water. Any spills at the offshore locations will be contained and cleaned up and any residual spills are expected to dissipate without reaching the shore based on the high levels of evaporation in the region and strong tidal currents. **Summary** The Proposal may have some impacts on the Green sawfish (if present) however the scale of these impacts are low and relatively localised. The implementation of mitigation controls will ensure that the potential impacts are minimised such that the Proposal would be unlikely to lead to a long-term decrease in the size of an important population of this species.
Reduce the area of occupancy of an important population	The tidal creeks are considered to be important nursery areas for Green Sawfish, however the Proposal only includes minor works within two of the tidal creeks in the area (limited to a seawater intake and a boat ramp). In addition this minor disturbance is not resulting in any modification to sawfish nursery areas which are confined to the <1 m depth range around the mouth of the tidal creeks (O2 Marine, 2020g; Appendix 7.2). The Proposal has a limited marine footprint with infrastructure and activities that have a low impact on sawfish species (trestle jetty, shallow dredge channel, low vessel movements). The species will be able to traverse the Proposal infrastructure. Based on the above, the Proposal is not expected to reduce the area of occupancy of an important population of this species (if present).
Fragment an existing important population into two or more populations	The Proposal will not create physical barriers to movement for marine fauna and therefore will not fragment any potential population of this species.
Adversely affect habitat critical to the survival of a species	The Green Sawfish inhabits muddy bottom habitats and enters estuaries (Allen, 1997; Stead, 1963). It has been recorded in inshore marine waters, estuaries, river mouths, embankments and along sandy and muddy beaches (Peverell et al., 2004; Stevens et al., 2005; Thorburn et al., 2004). Stead (1963) reported that this species was frequently found in shallow water. Its habitat is heavily fished and often subject to pollution, habitat loss and degradation from coastal, riverine and catchment developments. Green Sawfish have been recorded in very shallow water (<1 m) to offshore trawl grounds in over 70 m of water (Stevens et al., 2005). Smaller specimens (<2.5 m in length) are more common in foreshore and offshore coastal waters (Thorburn et al. 2004), as well as estuaries and river mouths at slightly reduced salinities, but do not venture into freshwater. Larger individuals (>2.5 m in length) are found in both inshore and offshore waters. Their apparent preference for shallow inshore waters as nursery areas increases the likelihood of interaction with inshore gillnets (Stevens et al., 2005). Information on the short term habitat usage of a 3.5 m female Green Sawfish tracked in Port Musgrave, Queensland was obtained by Peverell and Pillans (2004). Over 27 hours, the sawfish moved 28.7 km at an average speed of 28.4 m/min and was at all times within 200 m of the shoreline in very shallow water (average water depth was 0.69 m). During the day, the sawfish was in slightly deeper water (0.84 m) compared to the night (0.48 m) indicating a diurnal shift in water depth. The preference for shallow water shown by the sawfish in this study and the fact that it moved parallel to the shoreline suggests they may occupy a relatively small area of available habitat that is concentrated in a narrow strip of water adjacent to the shoreline (Stevens et al., 2005). No incidental recordings of the Green sawfish were recorded during field studies undertaken for the Proposal (O2 Marine, 2020g; Appendix 7.2).

Significant impact criteria (Vulnerable)	Assessment of impacts to Green Sawfish
	The mouths of the tidal creeks (less than 1 m depth) are considered to be important nursery areas for Green Sawfish, however the Proposal avoids disturbance within these areas and is unlikely to have any indirect impacts. Given the number of similar tidal creeks, and the minimal direct disturbance, the Proposal is not expected to adversely affect habitat critical to the survival of this species.
Disrupt the breeding cycle of an important population	**Breeding Cycle** While limited data is available on the life history of Green Sawfish, it is likely that they are long-lived, produce few pups and mature late in life (Stevens et al., 2005; Walker, 1998). The Green sawfish appears to reach 95% of its maximum length (508 cm) at approximately 24 years of age and size at maturity (from direct observation) in 9 years (Peverell, James Cook University, unpublished MSc thesis, cited in Stevens et al., 2005). Based on these estimates of age, generation length is likely to be about 16 years (Stevens et al., 2005). The low fecundity and late maturation of Green sawfish render the species highly susceptible to anthropogenic mortality and limits the ability of the species to recover from threats such as overfishing (Stevens et al., 2005; Stobutzki et al., 2002). Sawfish return seasonally to inshore coastal waters adjacent to the northern Australian region to breed and pup. The Commonwealth Scientific Industrial Research Organisation and Fisheries agencies in WA, Northern Territory and Queensland have recorded pupping in January (R. McAuley, 2003, pers. comm., cited in Peverell, 2005). This very scant dataset suggests pupping may occur during the wet season (Peverell, 2005). Little is known about reproduction in Green sawfish. As in other pristids, the reproductive mode is aplacental viviparity with lecithotropic nutrition of the embryos (energy reserves come from the egg). Litter size in other pristids is up to 20. The sex ratio of male to female is 1:1 (Peverell 2005). **Potential to Disrupt Breeding Cycle** The assessment of potential impacts discussed above would also apply to this criteria. The mouths of the tidal creeks (less than 1 m depth) are considered to be important nursery areas for Green Sawfish, however the Proposal avoids disturbance within these areas and is unlikely to have any indirect impacts. Given the number of similar tidal creeks, and the minimal direct disturbance, the Proposal is not expected to disrupt the breeding cycle of Green sawfish.
Modify, destroy, remove or isolate or decrease the availability or quality of habitat to the extent that the species is likely to decline	The tidal creeks are considered to be important nursery areas for Green Sawfish, however the Proposal only includes minor works within two of the tidal creeks in the area (limited to a seawater intake and a boat ramp). In addition this minor disturbance is not resulting in any modification to sawfish nursery areas which are confined to the <1 m depth range around the mouth of the tidal creeks (O2 Marine, 2020g; Appendix 7.2). The Proposal has a limited marine footprint with infrastructure and activities that have a low impact on sawfish species (trestle jetty, shallow dredge channel, low vessel movements). Based on the above, the Proposal is not expected to 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	The Proposal has the potential to introduce marine pests, however with the application of regulated controls, the Proposal was identified as being of 'low risk' of introducing marine pests to Mardie marine waters. Standard industry controls (enforced by DoA) relating to ballast water and vessel hygiene provide a level of confidence that IMPs will not be introduced. The Proposal is therefore considered unlikely to introduce invasive species that are harmful to this species.
Introduce disease that may cause the species to decline	The Proposal is not expected to provide a vector for any disease that may impact this species.

Significant impact criteria (Vulnerable)	Assessment of impacts to Green Sawfish
Interfere substantially with the recovery of the species	The potential habitat within the development envelopes does not represent significant local or regional habitat for the Green sawfish. This, combined with the relatively small-scale habitat disturbance required, and the low scale of indirect impacts, means that the Proposal is not expected to interfere substantially with the recovery of this species if it was present in the area.

Table 73: Red Knot, Curlew Sandpiper, Great Knot and Eastern Curlew

Significant impact criteria (Endangered and Critically Endangered)	Assessment of impacts to Red Knot, Curlew Sandpiper, Great Knot and Eastern Curlew
Lead to a long-term decrease in the size of a population	When assessing significant shorebirds, it was found that the species recorded utilised similar habitats and therefore for the purposes of the MNES assessment, the Red Knot, Curlew Sandpiper, Great Knot, and Eastern Curlew have been grouped together. **Red Knot** 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. It was recorded across mangal community, tidal channel or ocean, mudflat / saltflat and tidal samphire mudflat habitats within the MSSA. **Curlew Sandpiper** 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; Appendix 9.1). 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). Based on habitat preferences reported, they are likely to forage on tidal mudflats, channels and beaches in the MSSA and may roost on beaches, sand-spits, tidal samphire mudflats and mangroves in the MSSA. **Great Knot** 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 Based on habitat preferences reported, they are likely to forage on tidal mudflats, channels and beaches in the MSSA and may roost on beaches, sand-spits, tidal samphire mudflats and mangroves in the MSSA. **Eastern Curlew** 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 saltflats and in saltmarsh, rockpools 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. This species was recorded almost exclusively within the tidal samphire mudflats. Whilst important habitats for the species occur in the MSSA, there is limited important habitat for the species in the development envelopes and only five individuals were recorded within the development envelopes. **Clearing**

Significant impact criteria (Endangered and Critically Endangered)	Assessment of impacts to Red Knot, Curlew Sandpiper, Great Knot and Eastern Curlew
	The majority of Proposal disturbance is to occur within bare mudflat or saltflat habitat, the habitat that was the least important for shorebirds/waterbirds within the MSSA (Phoenix, 2020b). However the development envelopes do contain portions of the three migratory shorebird habitats identified and mapped by Phoenix (2020b) within the TFSA: • Tidal samphire mudflats; • Tidal channel and ocean; and • Mangal communities. Tidal Samphire Mudflats This habitat type is the most widespread habitat recorded within the MSSA. The habitat within the TFSA was not noted as being of any greater significance than elsewhere in the MSSA. The Phoenix (2020b) surveys reported the great majority of the bird observations in the tidal samphires to the west of the development envelope - the tidal samphires lower on the shore, closer to the mangroves and tidal creek margins had high numbers of birds relative to areas of the same habitat type higher on the shore. This likely to be a consequence of lower soil salinities closer to the mangroves and tidal creeks due to more regular and longer inundation of the substrate with a corresponding increase in invertebrate infauna (O2 Marine, 2020a; Appendix 2.3). In terms of likely impact on ecological functions, the samphire mudflats habitat to be impacted by the Proposal is unlikely to make a significant difference to the maintenance of ecological functions and diversity across the MSSA (O2 Marine, 2020a). There have been numerous design revisions in order to minimise disturbance to this habitat type and keep indirect impacts as low as practicable. The Proposal is able to be implemented while retaining almost all of the higher value coastal tidal samphire mudflats habitat within the MSSA. The Proposal is therefore considered unlikely to significantly impact this habitat type such that its use by significant shorebirds would be affected. Further detail about this assessment is provided in Sections 7.5.4, 9.5.6 and 10.5.2. Tidal Channel and Ocean 71.7 ha of this habitat is predicted to be disturbed by the Proposal, which equates to 2.6% of the mapped extent within the TFSA. When extrapolated across the MSSA the Proposal is considered unlikely to significantly impact this habitat type such that its use by significant shorebirds would be affected. Mangal Communities The TFSA lies in the northern section of the MSSA, within a larger area (tens of km) that that was noted as being dominated by mangal communities. Mangrove community habitat was found to be less important for migratory birds than the tidal samphire mudflats and tidal channel and ocean mudflats/sandbars discussed above (Phoenix, 2020b). There have been numerous design revisions in order to minimise disturbance to this habitat type and keep indirect impacts as low as practicable. The Proposal is able to be implemented while retaining more than 99% of the available mangrove community habitat within the MSSA. The Proposal is therefore considered unlikely to significantly impact this habitat type such that its use by migratory shorebirds would be affected. **Introduced Fauna** Several feral animals were recorded within the TFSA, including dogs, foxes and cats (Phoenix, 2020b). 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.

Significant impact criteria (Endangered and Critically Endangered)	Assessment of impacts to Red Knot, Curlew Sandpiper, Great Knot and Eastern Curlew
	Pond Fauna Attraction 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 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, the Port Hedland Dampier Saltworks are listed as IBAs (Birdlife Australia, 2005–2007), and Houston et al. (2012) concluded after studying two salt fields associated with the Fitzroy River estuary, Queensland, that saltfields are “an integral component of the ecology of the landscape, providing complementary resources to that of the natural wetlands.” **Sedimentation of Habitat** The majority of the disturbance for the Proposal is associated with the flooding of an existing landscape. Any sediment would be captured within the ponds during this activity. Sediment may be released during construction of the pond walls, however these walls are generally low and contain relatively low volumes of fill material. The wall material is generally high in clay content and will be compacted in place, which means the walls will consolidate quickly and therefore sediment losses will be minimal. Mardie Minerals have committed to mitigation measures to reduce the risk of sedimentation (refer to Section 13.7). **Brine Spills** 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 10.6. 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 the spill would be limited to an area that is adapted to saline conditions and is regularly inundated with seawater. Brine would be expected to dilute and wash away over a period of several months. **Summary** The Proposal will have a direct impacts on areas of generally low value habitat utilised by the Red Knot, Curlew Sandpiper, Great Knot, and Eastern Curlew. This disturbance however equates to a small percentage of available habitats (<1% of mangroves and estimated <1% of tidal channel and ocean, and <5% of the coastal tidal samphire mudflats) within the MSSA as the Proposal has been designed to minimise clearing within these areas. Indirect impacts are expected to be minimal or able to be mitigated apart from pond fauna attraction, which may result in increases in shorebird numbers within the MSSA. In summary, the Proposal is unlikely to lead to a long-term decrease in the size of a population of these species.
Reduce the area of occupancy of the species	The Red Knot, Curlew Sandpiper, Great Knot and Eastern Curlew all have wide distributions. The Proposal will impact only a small proportion of their habitat within the MSSA, which in turn represents only a portion of the area of occupancy of these species. The Proposal is therefore unlikely to reduce the area of occupancy of the species.
Fragment an existing population into two or more populations	These species have a large range and the construction of the Proposal will not fragment an existing population.

Significant impact criteria (Endangered and Critically Endangered)	Assessment of impacts to Red Knot, Curlew Sandpiper, Great Knot and Eastern Curlew
Adversely affect habitat critical to the survival of a species	The habitat assessment shows that Proposal avoids direct impacts to the majority of migratory shorebird habitats, and how habitats identified for migratory shorebirds in the MSSA were almost entirely outside the development envelopes. All habitats were well represented regionally and were not considered significant, therefore the Proposal will not adversely affect habitat critical to the survival of these species.
Disrupt the breeding cycle of a population	None of these species breed in Australia, therefore the Proposal is unlikely to disrupt the breeding cycle of these species.
Modify, destroy, remove, isolate or decrease the availability or quality of habitat to the extent that the species is likely to decline	The habitat assessment shows that Proposal avoids direct impacts to the majority of migratory shorebird habitats, and how habitats identified for migratory shorebirds in the MSSA were almost entirely outside the development envelopes. All habitats were well represented regionally and were not considered significant, therefore the Proposal is unlikely to decrease the availability or quality of habitat to the extent that these species are 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	Feral animals are already present in the area and Mardie Minerals will implement feral fauna control in areas where it operates. The Proposal is therefore unlikely to result in invasive species that are harmful to the Red Knot, Curlew Sandpiper, Great Knot, and Eastern Curlew becoming further established in their habitat.
Introduce disease that may cause the species to decline	The Proposal is not considered to provide any vector for disease that affect the Red Knot, Curlew Sandpiper, Great Knot, or Eastern Curlew.
Interfere with the recovery of the species	The Proposal will have a direct impact on habitat utilised by the Red Knot, Curlew Sandpiper, Great Knot, and Eastern Curlew. This disturbance however equates to less than 5% of any habitat of value within the MSSA as the Proposal has been designed to minimise clearing within these areas. Indirect impacts are expected to be minimal apart from pond fauna attraction, which may result in increases in shorebird numbers within the MSSA. In summary, the Proposal is unlikely to lead to interfere with the recovery of these species.

Table 74: Greater Sand Plover and Lesser Sand Plover

Significant impact criteria (Vulnerable)	Assessment of impacts to the Greater Sand Plover and Lesser Sand Plover
Lead to a long-term decrease in the size of an important population of a species	When assessing significant shorebirds, it was found that these two species utilised similar habitats and had the same listing (Vulnerable) therefore for the purposes of the MNES assessment, the Greater Sand Plover and Lesser Sand Plover have been grouped together. 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). The majority of records were in the northern half of the MSSA, on low tides, on coastal samphire mudflats and sand bars in upper reaches of tidal creeks. 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 (Phoenix, 2020b; Appendix 9.1). Lesser Sand Plover was not recorded in nationally significant numbers and was also not extrapolated at nationally significant numbers. It was rare within the MSSA with only 27 individuals recorded across 26 sample events, all of which were outside of the development envelopes. **Clearing** The majority of Proposal disturbance is to occur within bare mudflat or saltflat habitat, the habitat that was the least important for shorebirds/waterbirds within the MSSA (Phoenix, 2020b). However the development envelopes do contain portions of the three migratory shorebird habitats identified and mapped by Phoenix (2020b) within the TFSA: • Tidal samphire mudflats; • Tidal channel and ocean; and • Mangal communities. <u>Tidal Samphire Mudflats</u> The samphire intertidal zone habitat is the most widespread habitat recorded within the MSSA. The habitat within the TFSA was not noted as being of any greater significance than elsewhere in the MSSA. The Phoenix (2020b) surveys reported the great majority of the bird observations in the tidal samphires to the west of the development envelope - the tidal samphires lower on the shore, closer to the mangroves and tidal creek margins had high numbers of birds relative to areas of the same habitat type higher on the shore. This likely to be a consequence of lower soil salinities closer to the mangroves and tidal creeks due to more regular and longer inundation of the substrate with a corresponding increase in invertebrate infauna (O2 Marine, 2020a). In terms of likely impact on ecological functions, the samphire mudflats habitat to be impacted by the Proposal is unlikely to make a significant difference to the maintenance of ecological functions and diversity across the MSSA (O2 Marine, 2020a). There have been numerous design revisions in order to minimise disturbance to this habitat type and keep indirect impacts as low as practicable. The Proposal is able to be implemented while retaining almost all of the higher value coastal tidal samphire mudflats habitat within the MSSA. The Proposal is therefore

Significant impact criteria (Vulnerable)	Assessment of impacts to the Greater Sand Plover and Lesser Sand Plover
	considered unlikely to significantly impact this habitat type such that its use by significant shorebirds would be affected. Further detail about this assessment is provided in Sections 7.5.4, 9.5.6 and 10.5.2. <u>Tidal Channel and Ocean</u> 71.7 ha of this habitat is predicted to be disturbed by the Proposal, which equates to 2.6% of the mapped extent within the TFSA. When extrapolated across the MSSA the Proposal is considered unlikely to significantly impact this habitat type such that its use by significant shorebirds would be affected. <u>Mangal Communities</u> The TFSA lies in the northern section of the MSSA, within a larger area (tens of km) that that was noted as being dominated by mangal communities. Mangrove community habitat was found to be less important for migratory birds than the tidal samphire mudflats and tidal channel and ocean mudflats/sandbars discussed above (Phoenix, 2020b). There have been numerous design revisions in order to minimise disturbance to this habitat type and keep indirect impacts as low as practicable. The Proposal is able to be implemented while retaining more than 99% of the available mangrove community habitat within the MSSA. The Proposal is therefore considered unlikely to significantly impact this habitat type such that its use by migratory shorebirds would be affected. **Introduced Fauna** Several feral animals were recorded within the TFSA, including dogs, foxes and cats (Phoenix, 2020b). 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. **Pond Fauna Attraction** 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 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, the Port Hedland Dampier Saltworks are listed as IBAs (Birdlife Australia, 2005–2007), and Houston et al. (2012) concluded after studying two salt fields associated with the Fitzroy River estuary, Queensland, that saltfields are "an integral component of the ecology of the landscape, providing complementary resources to that of the natural wetlands." **Sedimentation of Habitat** The majority of the disturbance for the Proposal is associated with the flooding of an existing landscape. Any sediment would be captured within the ponds during this activity. Sediment may be released during construction of the pond walls, however these walls are generally low and contain relatively low volumes of fill material. The wall material is generally high in clay content and will be compacted in place, which means the walls will consolidate quickly and therefore sediment losses will be minimal. Mardie Minerals have committed to mitigation measures to reduce the risk of sedimentation (Section 10.6.2). **Brine Spills** 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 10.6. Ponds have been designed with adequate freeboard and overflow features to minimise the risk of unplanned overflows and wall breaches. If a

Significant impact criteria (Vulnerable)	Assessment of impacts to the Greater Sand Plover and Lesser Sand Plover
	spill was to occur, it may cause a reduction in the health of the downslope fauna habitat, however the spill would be limited to an area that is adapted to saline conditions and is regularly inundated with seawater. Brine would be expected to dilute and wash away over a period of several months. **Summary** The Proposal will have a direct impacts on areas of generally low value habitat utilised by the Greater Sand Plover and Lesser Sand Plover. . This disturbance however equates to a small percentage of available habitats (<1% of mangroves and estimated <1% of tidal channel and ocean, and <5% of the coastal tidal samphire mudflats) within the MSSA as the Proposal has been designed to minimise clearing within these areas. Indirect impacts are expected to be minimal or able to be mitigated apart from pond fauna attraction, which may result in increases in shorebird numbers within the MSSA. In summary, the Proposal is unlikely to lead to a long-term decrease in the size of a population of these species.
Reduce the area of occupancy of an important population	The Great Sand Plover and Lesser Sand Plover all have wide distributions. The Proposal will impact only a small proportion of their habitat within the MSSA, which in turn represents only a portion of the area of occupancy of these species.
Fragment an existing important population into two or more populations	These species have a large range and the construction of the Proposal will not fragment an existing population.
Adversely affect habitat critical to the survival of a species	The habitat assessment shows that Proposal avoids direct impacts to the majority of migratory shorebird habitats, and how habitats identified for migratory shorebirds in the MSSA were almost entirely outside the development envelopes. All habitats were well represented regionally and were not considered significant, therefore the Proposal will not adversely affect habitat critical to the survival of these species.
Disrupt the breeding cycle of an important population	Neither of these species breed in Australia, therefore the Proposal is unlikely to disrupt the breeding cycle of these species.
Modify, destroy, remove or isolate or decrease the availability or quality of habitat to the extent that the species is likely to decline	The habitat assessment shows that Proposal avoids direct impacts to the majority of migratory shorebird habitats, and how habitats identified for migratory shorebirds in the MSSA were almost entirely outside the development envelopes. All habitats were well represented regionally and were not considered significant, therefore the Proposal is unlikely to decrease the availability or quality of habitat to the extent that these species are likely to decline.
Result in invasive species that are harmful to a vulnerable species becoming established in the vulnerable species' habitat	Feral animals are already present in the area and Mardie Minerals will implement feral fauna control in areas where it operates. The Proposal is therefore unlikely to result in invasive species that are harmful to these species becoming further established in their habitat.
Introduce disease that may cause the species to decline	The Proposal is not considered to provide any vector for disease that affect the Greater Sand Plover and Lesser Sand Plover.

Significant impact criteria (Vulnerable)	Assessment of impacts to the Greater Sand Plover and Lesser Sand Plover
Interfere substantially with the recovery of the species	The Proposal will have a direct impact on habitat utilised by the Greater Sand Plover and Lesser Sand Plover. This disturbance however equates to less than 5% of any habitat of value within the MSSA as the Proposal has been designed to minimise clearing within these areas. Indirect impacts are expected to be minimal apart from pond fauna attraction, which may result in increases in shorebird numbers within the MSSA. In summary, the Proposal is unlikely to lead to interfere with the recovery of these species.

Table 75: *Minuria tridens*

Significant impact criteria (Vulnerable)	**Assessment of impacts to *Minuria tridens***
Lead to a long-term decrease in the size of an important population of a species	Only one record of this species was found during flora and vegetation surveys by Phoenix (2020a; Appendix 8.1). An 'important population' is defined by the Significant Impact Guidelines 1.1 (DotE, 2013) as a population that is necessary for a species' long-term survival and recovery. This may include populations identified as such in recovery plans, and/or that are: • Key source populations either for breeding or dispersal; • Populations that are necessary for maintaining genetic diversity, and/or • Populations that are near the limit of the species range. Mardie Minerals was unable to determine whether the record was a sole outlier individual or part of a population located within the Study Area. For the purposes of this assessment a conservative position was taken where the record was assumed to be part of a local population. *Minuria tridens* was recorded well outside the development envelopes (Figure 106) and no records were found within the development envelopes despite targeted searches. The AcAjTe vegetation type was identified to be potential habitat for this species however this vegetation type covered a large area, with more than 559 ha occurring outside the development envelopes. The continuous portion of habitat where the *Minuria tridens* record was found lies completely outside the development envelopes and will not be disturbed by the Proposal (Figure 113). Based on the above, direct impacts to this species are not expected to be significant. As described in Section 9.5.2, there is the potential for some indirect impacts, however these are not expected to have a significant impact on the AcAjTe vegetation type and will not impact the recorded specimen. The Proposal is therefore considered unlikely to lead to a long-term decrease in the size of an important population of this species.
Reduce the area of occupancy of an important population	*Minuria tridens* was recorded well outside the development envelopes (Figure 106) and no records were found within the development envelopes despite targeted searches. The AcAjTe vegetation type was identified to be potential habitat for this species however the continuous portion of habitat where the *Minuria tridens* record was found lies completely outside the development envelopes and will not be disturbed by the Proposal (Figure 113). The Proposal is therefore considered unlikely to reduce the area of occupancy of an important population.
Fragment an existing important population into two or more populations	The AcAjTe vegetation type was identified to be potential habitat for this species however the continuous portion of habitat where the *Minuria tridens* record was found lies completely outside the development envelopes and will not be disturbed by the Proposal (Figure 113). No other records were found within the Study Area despite targeted searches. The Proposal is therefore considered unlikely to fragment an existing important population of this species into two or more populations.
Adversely affect habitat critical to the survival of a species	Only one specimen of *Minuria tridens* has previously been recorded in WA, and subsequent surveys have been unable to locate the specimen. There is therefore no information regarding what constitutes 'critical habitat' in WA (Nano & Pavey, 2008). In the Northern Territory, this species typically occurs on south facing slopes or steep rocky cliffs in low shrubland on dolomite, limestone and calcrete-impregnated sandstone hills and ranges (Cooke 1986; Nano & Pavey 2008). Associated shrubland is mixed with Rock Fuchsia Bush (*Eremophila freelingii*), Witchetty Bush (*Acacia kempeana*), Silver Cassia (*Senna artemisioides*) and White Indigo (*Indigofera leucotricha*) (Nano et al. 2012; Nano & Pavey, 2008) with spinifex (*Triodia* spp.) largely absent and Buffel Grass (*Cenchrus ciliaris*) in more disturbed areas (Nano et al. 2012).

Significant impact criteria (Vulnerable)	**Assessment of impacts to *Minuria tridens***
	In the absence of habitat information Mardie Minerals has assumed that the vegetation type AcAjTe could form potential habitat. This vegetation type covered a large area, with more than 1,291 ha occurring within the Study Area with more than 559 ha located outside the development envelopes. The continuous portion of habitat where the *Minuria tridens* record was found lies completely outside the development envelopes and will not be disturbed by the Proposal (Figure 113). The Proposal is therefore considered unlikely to adversely affect habitat critical to the survival of this species.
Disrupt the breeding cycle of an important population	The AcAjTe vegetation type was identified to be potential habitat for this species however this vegetation type covered a large area, with more than 540 ha occurring outside the development envelopes. The continuous portion of habitat where the *Minuria tridens* record was found lies completely outside the development envelopes and will not be disturbed by the Proposal (Figure 113). Extensive habitat is therefore expected to be retained such that the breeding cycle of this species would not be disrupted. The Proposal is therefore considered unlikely to disrupt the breeding cycle of an important population of this species.
Modify, destroy, remove or isolate or decrease the availability or quality of habitat to the extent that the species is likely to decline	The AcAjTe vegetation type was identified to be potential habitat for this species however this vegetation type covered a large area, with more than 540 ha occurring outside the development envelopes. The continuous portion of habitat where the *Minuria tridens* record was found lies completely outside the development envelopes and will not be disturbed by the Proposal (Figure 113). The Proposal is therefore considered unlikely to 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	The Proposal includes strict control measures to prevent the spread of Mesquite, which will in turn minimise the likelihood of other invasive weed species becoming established. Feral animals will also be controlled on site to minimise their introduction or spread (refer to Section 13.7).
Introduce disease that may cause the species to decline	The Proposal is not considered to provide any vector for disease that affect this species.
Interfere substantially with the recovery of the species	The Proposal will not disturb the known record of this species or the continuous habitat surrounding the record. Significant areas of potential habitat will be retained within the Study Area and surrounds. The Proposal is unlikely to interfere substantially with the recovery of this species.

13.6 Assessment against Significant Impact Criteria for Listed Migratory Species

A total of 34 species listed as migratory under the EPBC Act have been recorded or are considered likely to occur in the vicinity of the Proposal based on an assessment of habitat requirements (Section 13.3.2). Detailed information about these species, their distribution and potential impacts from the Proposal is provided in Section 8 and Section 10.

Mardie Minerals notes that the migratory species significant impact criteria are relevant to migratory species that are not threatened (DotEE, 2013). Threatened species are therefore not assessed again in this section. An assessment of the significance of impacts to those Migratory species that are not also Threatened is provided in the tables below.

Table 76: Dugong

Significant impact criteria	Assessment of impacts to Dugong
Potential to 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.	**Important Habitat** Seagrass meadows are considered important habitat for Dugong. 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. Seagrass habitats in tropical and sub-tropical Australia are characterised by low nutrient concentrations and high disturbance, and are spatially and temporally dynamic (ephemeral (short-lived); Carruthers et al. 2002). The majority of seagrasses are found in shallow inshore and intertidal zone areas to water depths of around 25 m. Dugong feeding aggregations tend to occur in large seagrass meadows within wide, shallow protected bays (e.g. Hervey and Moreton Bays); wide, shallow mangrove channels (e.g. Hinchinbrook Channel); and in the lee of large inshore islands (Marsh et al. 2011a). Dugongs also feed in offshore seagrass habitats in areas where the continental shelf is wide, shallow and protected. **Potential Habitat within the Study Area** Historic Dugong surveys of the region indicate that Coolgra Point and Cape Preston represent the closest areas with potential to be considered important foraging habitat for dugongs. BCH surveys conducted by O2 Marine (2020a; Appendix 2.3, 2020b; Appendix 2.4) support findings that the Study Area is comprised of relatively poor quality (i.e. low cover and dynamic) vegetated habitats, with minimal seagrass for grazing compared to areas where dugong typically graze. Therefore, the Study Area is unlikely to represent important habitat for Dugong.
Potential to result in an invasive species that is harmful to the migratory species becoming established in an area of important habitat for the migratory species.	*The Action Plan for Australian Mammals 2012* (Woinarski et al., 2014) did not identify invasive species as a threat to Dugong.
Potential to seriously disrupt the lifecycle (breeding, feeding, migration or resting behaviour) of an ecologically significant proportion of the population of a migratory species.	**Life Cycle** Dugongs are long-lived and slow breeding. The oldest wild dugong whose age has been estimated was a female from WA estimated to be more than 70 years old (Marsh, 1995). Neither mature males nor mature females are continuously in breeding condition. Dugongs are diffusely seasonal breeders and the seasonality of breeding is more marked in the sub-tropics (mostly spring, early summer calving) than in the tropics. Usually a single calf is born after a gestation period of about 14 months and nursed for 18 months or more. Twins are rare. Like many other long-lived species, dugongs delay breeding in adverse environmental conditions. Marked fluctuations have been documented in the pregnancy rate, the age at first reproduction in both sexes (7 - 17 years in females), the body size at which sexual maturity is

Significant impact criteria	Assessment of impacts to Dugong
	reached (Marsh and Kwan, 2008) and the incidence of reproductively active males (Marsh, 1995, Burgess et al., 2012). These fluctuations apparently track major changes in the status of the dugong's food supply, which is subject to episodic (a series of separate events) diebacks that are often associated with extreme climatic events, including exceptionally high rainfall and cyclones (Johannes and MacFarlane, 1991; Preen and Marsh, 1995; Poiner and Peterkin, 1996; Marsh and Kwan, 2008; Marsh et al., 2011; Sobtzick et al., 2012). This life history limits the reproductive potential of dugongs and high survival of immature animals, especially adults, is required for population growth or stability (Marsh et al., 2011). **Vessel Strike** The likelihood of a vessel strike during dredging and construction from proposed vessel movements is considered low due to the low abundance of this species in the area, and the small scale (i.e. spatial movements) of the operation and dredge vessel (i.e. slow-moving and small support vessels). Similarly, the risk of vessel strike on Dugong during the operational stage is considered unlikely due to the slow speed of the transhipment barge and relatively low vessel movements (2 - 4 barge movements per day) in comparison to other ports or boat ramps in WA. The consequence of vessel strike on Dugong may result in injury or mortality, although these events are expected to be rare. Mitigation measures outlined in Section 13.7 are proposed to reduce this risk to an acceptable level. **Marine Noise** A Marine Noise Assessment (Talis, 2019; Appendix 6.4) was undertaken to predict impacts to marine mammals, including a specific assessment for Dugong. The results of the model show that Dugong could be impacted by noise from dredging and piling activities, however mitigation measures are well established for dredging and piling operations and these will be implemented to ensure that these potential impacts are minimised. Further detail on these mitigation measures is provided in Section 13.7. **Potential to Disrupt Life Cycle** There were no important habitats for Dugong located within the marine areas surveyed for the Proposal, and therefore any individuals that would be present would be passing through the area. The Proposal has the potential to disrupt the lifecycle of these Dugong individuals that may be in close proximity to vessels, dredging and piling operations however there are standard mitigation measures proposed, and the scale of these potential impacts would not be significant enough to affect "an ecologically significant proportion of the population".

Table 77: Migratory Birds

Significant impact criteria	Assessment of impacts to Migratory Birds

Potential to 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.	Two study areas (Figure 119 and Figure 120) are relevant to this assessment;
	• MSSA refers to a regional-scale, 64,201 ha area mapped by Phoenix mapped by Phoenix as a contiguous 'shorebird area'; and
	• TFSA refers to the local-scale 28,150 ha study area surrounding the Proposal, which occurs within the broader MSSA but provides more context about the Proposal impacts.
	Important Habitat
	Under the EPBC Act, 'important habitat' is a key concept for migratory species (DotEE, 2017b). Important habitats in Australia for migratory shorebirds under the EPBC Act include those recognised as nationally or internationally important. The accepted and applied approach to identifying internationally important shorebird habitat has been through the use of criteria adopted under the Ramsar Convention on Wetlands (DotEE, 2017b).
	According to that approach:
	• Internationally important habitat may regularly support:
	  ○ 1% of the individuals in a population of one species or sub-species of waterbird; or
	  ○ A total abundance of at least 20,000 waterbirds.
	• Nationally important habitat may regularly support:
	  ○ 0.1% of the flyway population of a single species of Migratory shorebird;
	  ○ A total abundance of at least 2,000 Migratory shorebirds; or
	  ○ At least 15 Migratory shorebird species.

Significant impact criteria	Assessment of impacts to Migratory Birds
	26 Migratory bird species were recorded within the MSSA. Using the criteria above, the MSSA was deemed to represent or contain important habitat for 14 of these species (Phoenix, 2020b; Appendix 9.1): • Bar-tailed Godwit • Common Greenshank • Curlew Sandpiper • Eastern Curlew • Greater Sand Plover • Grey-tailed Tattler • Oriental Plover • Pacific Golden Plover • Red Knot • Red-necked Stint • Ruddy Turnstone • Sanderling • Terek Sandpiper • Whimbrel However, when the data is analysed at the scale of the development envelopes, no criteria are met at either the national or international scales for either assemblage or individual species abundance (Phoenix, 2020b). Three migratory shorebird habitat types were identified and mapped by Phoenix (2019b) within the TFSA: • Tidal samphire mudflats; • Tidal channel and ocean; and • Mangal communities. The saline unvegetated mudflats on which the concentrator and crystalliser ponds predominantly occur, support few Migratory bird species (Phoenix, 2020b). **Direct Impacts** When the Phoenix (2020b) survey results are considered with respect to the development envelopes, not a single species was recorded at nationally or internationally significant numbers. This is because the majority of Proposal disturbance is to occur within bare mudflat or saltflat habitat, the habitat that was the least important for shorebirds / waterbirds within the MSSA. The development envelopes do contain portions of the three migratory shorebird habitat types identified and mapped by Phoenix (2020b) within the MSSA. Potential impacts to these migratory shorebird habitats are discussed below (noting that none were identified as important habitat when considered at the scale of the development envelopes). Tidal Samphire Mudflats This habitat is the most widespread habitat recorded within the MSSA. The habitat within the TFSA was not noted as being of any greater significance than elsewhere in the MSSA. As a comparison in the far south of the MSSA there is a large delta where four large creeks converge, which feed an expansive and highly productive area of samphire wetland up to 7 km wide. Potential impacts to samphire intertidal zone habitat within the TFSA have been discussed in detail in Section 10.5.2 and the outcome is summarised below. The Phoenix (2020b) surveys reported the great majority of the bird observations in the tidal samphires to the west of the development envelope - the tidal samphires lower on the shore, closer to the mangroves and tidal creek margins had high numbers of birds relative to areas of the same habitat type higher on the shore. This likely to be a consequence of lower soil salinities closer to the mangroves and tidal creeks due to more regular and longer inundation of the substrate with a corresponding increase in invertebrate infauna (O2 Marine, 2020a). In terms of likely impact on ecological functions, the samphire mudflats habitat to be impacted by the Proposal is unlikely to make a significant difference to the maintenance of ecological functions and diversity across the MSSA (O2 Marine, 2020a). The avoidance measures implemented during the Proposal design have resulted in 90.8% of the broader tidal samphire mudflats habitat being avoided within the TFSA and unlikely to be indirectly impacted by the Proposal. In addition, the Proposal will avoid almost all of the higher-value coastal portion of this habitat. The boundaries of this higher value portion of this

Significant impact criteria	Assessment of impacts to Migratory Birds
	habitat type are not able to be accurately mapped given the scale of the MSSA, however none of the areas surveyed within the development envelopes were identified as having high-cover samphire species (i.e. all were less than 40% cover).When impacts are considered in the context of the MSSA the area of habitat to be directly or indirectly impacted by the Proposal represents only a small percentage of the higher value portion of this habitat type within the MSSA. There have been numerous design revisions in order to minimise disturbance to this habitat type and keep indirect impacts as low as practicable. The Proposal is able to be implemented while retaining almost all of the higher value coastal portion of tidal samphire mudflat habitat (where the vast majority of the records were found) within the MSSA. The Proposal is therefore considered unlikely to significantly impact this habitat type such that its use by migratory shorebirds would be affected. <u>Tidal Channel and Ocean</u> This habitat type is shown on Figure 119 and contains numerous small sand bars/spits, mudflats and rocky reefs. This habitat type overlaps with the BCH mapping conducted by O2 Marine (refer to Section 6 – BCH), however it was determined to be appropriate to migratory shorebirds as they are assessed as 'Terrestrial Fauna'. The TFSA also does not contain any areas of tidal channel and ocean habitat that is more concentrated within the TFSA than elsewhere within the MSSA. This habitat type is utilised by migratory shorebirds mainly for foraging. The Proposal will require 71.7 ha of disturbance within this habitat type for the following purposes (refer to Figure 3): • Seawater intake within a large tidal creek; • Trestle jetty; and • Small boat launching facility. The TFSA contains 2,780.6 ha of this habitat type. When extrapolated across the MSSA the Proposal is considered unlikely to significantly impact this habitat type such that its use by migratory shorebirds would be affected. <u>Mangal Communities</u> The TFSA lies in the northern section of the MSSA, within a larger area (tens of km) that that was noted as being dominated by mangal communities. Mangrove community habitat was found to be less important for migratory birds than the tidal samphire mudflats and tidal channel and ocean mudflats/sandbars discussed above (Phoenix, 2020b). Potential impacts to mangal communities have been discussed in detail in Section 6 (BCH; discussed as mangrove communities in the BCH section) and the outcome of this assessment is summarised below. O2 Marine (2020a) identified mangroves as being the highest ecologically important BCH within the LAUs, particularly CC mangroves, due to the range of ecological services in which they provide to adjacent BCH and coastal waters. All efforts have been made during the Proposal design phase to maintain maximum mangrove biomass, with all CC Mangroves to be avoided, and 17 ha of SC Mangroves (<1% of TFSA extent) identified for direct removal and no net predicted indirect effects. It is therefore anticipated that any risk or impact to biological diversity and ecological integrity of mangrove communities is not considered to pose a significant risk to ecological integrity and biological diversity of this BCH. While 17 ha of SC Mangroves will be lost, this in addition to the 4 ha of loss associated with the existing gas pipeline still represent less than 1% of this assemblage that is present across the TFSA and will not impact on the integrity of this assemblage in terms of contributions to local and regional ecological function and connectivity. The Proposal is not predicted to impact either of the two regionally significant mangrove areas that lie either side of the Proposal. There have been numerous design revisions in order to minimise disturbance to this habitat type and keep indirect impacts as low as practicable. The Proposal is able to be implemented while retaining more than 99% of the available mangrove community habitat within the MSSA. The Proposal is therefore considered unlikely to significantly impact this habitat type such that its use by migratory shorebirds would be affected. **Potential Modification of Habitat** A detailed assessment of the potential modifications of habitat is provided in Section 6, and has been summarised below. <u>Increased sedimentation resulting in settlement and smothering of habitat</u>

Significant impact criteria	Assessment of impacts to Migratory Birds
	The majority of the Proposal disturbance is associated with the flooding of an existing landscape. Any sediment would be captured within the ponds during this activity. Sediment may be released during construction of the pond walls, however these walls are generally low and contain relatively low volumes of fill material. The wall material is generally high in clay content and will be compacted in place, which means the walls will consolidate quickly and therefore sediment losses will be minimal. Mardie Minerals have committed to mitigation measures to reduce the risk of sedimentation (refer to Section 13.7) which are expected to ensure impacts to migratory shorebird habitats are minimal. <u>Alteration to surface water regimes</u> An extensive tidal inundation study conducted by RPS (2019; Appendix 1.1) confirms that, during highest tides, the pond walls would affect the landward movement of seawater at the northern and southern ends of the Pond and Terrestrial Infrastructure Development Envelope, where the walls are closest to the ocean. The modelled period coincided with the annual king tide, so inundation depths and predicted changes would be lower if modelled over an annual period. As a worse-case, during spring high tides (2.2 m MSL), water levels in those areas closest to the northern and southern pond walls would increase by up to 20 cm but only for very short periods of time (Figure 54). The study also confirmed that, due to the multiple flow paths available to the tidal waters, no areas currently flooded would be left dry as a result of the Proposal, although some areas close to tidal creeks would drain quicker due to the reduced catchment area. Overall, the construction of the pond walls will result in a shift in the timing of the tidally-driven inundation cycle, with the largest effects where the walls are closest to the sea. The magnitude of this shift is well within the natural variability of the existing regime. Therefore impacts to surface water regimes are not considered significant for migratory shorebird habitats. Modelling of overland flows has identified that there will be some portions of migratory shorebird habitat will experience less or more freshwater inflows that they currently experience. Section 13.4 provides some detail of this impact, and Section 5.5.2 and 10.5.2 provide more technical detail. It is predicted that 50.5 ha of tidal samphire mudflats habitat may be impacted by a reduction in freshwater inflows. Monitoring and mitigation is proposed to avoid or minimise this impact from occurring (refer to Section 13.7). If this impact is not able to be mitigated it may affect the health of 0.4% of the extent of tidal samphire mudflats habitat within the MSSA. <u>Changes to the dynamics of nutrient flows and budgets</u> Key points regarding nutrient budgets are outlined below: • CC Mangroves and their related ecosystems (especially cyanobacterial communities) are the single most important contributor to the nutrient budget; • A significant trend is identified with respect to decreasing biomass and productivity with respect to tidal elevation. Seaward mangrove communities with the highest associated biomass are the most productive with biomass reducing with each BCH type until the saltflats, which are represented by no biomass (the least productive intertidal BCH); and • Nutrient productivity from Algal Mat BCH, whilst potentially high, have not been identified as a significant source within the system due to a lack of connectivity with adjacent BCH. The key points regarding nutrient flows are outlined below: • Tidal inundation is the single most important mechanism with regards to connectivity for nutrient transportation between BCH and coastal waters; • Freshwater inputs, though potentially significant, are highly sporadic and therefore associated nutrient inputs are considered supplementary, not essential; and • Groundwater flows through the site are considerably static and therefore considered negligible in contribution to nutrient flows within the system. The Proposal footprint and design has purposely been designed to minimise any direct, or indirect losses of the structurally complex, higher biomass and primary productivity BCH. By avoiding direct loss of these BCH, the impacts upon primary productivity and nutrient budgets has been minimised. A minor alteration to the tidal cycle is predicted (i.e. a time delay from current regime), with no predicted alteration to tidal inundation frequency or tidal heights. This maintains the single most aspect related to nutrient flows between BCH and coastal waters. Alterations to surface water flows have also been minimised and engineered to ensure surface water continues to flow to the same destination, albeit through different pathways. As surface water flows are considered unessential to the function of arid zone BCH, and every attempt

Significant impact criteria	Assessment of impacts to Migratory Birds
	has been made to ensure the ultimate source (tidal creek and coastal waters) still receive any supplementary nutrients, minimal indirect impacts to migratory shorebird habitats are predicted from alterations to surface water flows from the development of the Proposal. Leaks or spills of hydrocarbons or chemicals There will be limited storage of hydrocarbons or chemical in the vicinity of migratory shorebird habitat. The pond seawater intake is located within a tidal creek and will contain high-volume pumps that run on diesel fuel. These pumps will be located either within a bunded area on an intake barge, or within a bunded area on the shore. Any spills from these pumps will be captured by the bund and will not reach the surrounding habitat. A small boat launching facility will be located within the main northern tidal creek (adjacent to the jetty). The facility will be used to launch small vessels used in the construction and operation of the export facility. Refuelling of vessels will occur while the vessels are moored at the boat ramp. Fuel will be stored within self-bunded tanks onshore. Based on the above, the risk of oil spills impacting migratory shorebird habitat is not expected to be significant. Leaks or spillages of hypersaline brine Seepage of brine from the ponds is not expected to impact migratory shorebird habitat as only small amounts of seepage is predicted through groundwater, at concentrations at or below that of the existing groundwater, (refer to Section 5 – Inland Waters for more detail). A spill or leak of brine from the ponds or pipelines could result in impacts to migratory shorebird habitat if sufficiently large. 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 13.7). 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, depending on the size of the spill it is most likely to spread across the mudflat area. Brine would be expected to dilute and wash away over a period of several weeks, depending on the tidal regime at the time. Note that the saltflats already contain extensive areas of crystallised salt. 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. Based on the above, the risk of leaks or spills of hypersaline brine impacting migratory shorebird habitat is not expected to be significant. Potential Movement of Hypersaline Groundwater as a Result of Hydrostatic Pressure of the Brine in the Salt Ponds Modelling of the hydraulic influence of the proposed ponds on the underlying groundwater was conducted by SWG (2019a; Appendix 10.1). The pertinent findings from the SWG (2019a) investigation are: • The groundwater system within the supratidal flats is effectively a closed system, which has experienced prolonged evaporative concentration of salts resulting in hypersaline conditions. This system is not connected to the marine environment or the underlying calcarenite aquifer; • The elevated 'natural' salinities within the supratidal flats restrict the landward extension of mangroves, and thus the impacts from the Proposal are expected to be minimal; • The seepage rates from the Concentrator Ponds due to the clay content of the Supratidal flats are very low. In addition, predicted process water quality, and hence potential seepage water quality, from the Concentrator Ponds, which represents the largest footprint area, is similar to the existing groundwater quality. Therefore, the combination of low seepage rates and process water quality results in expected negligible impacts on groundwater quality in the Supratidal Flats is expected; • Process water quality within the crystalliser ponds does exceed the surrounding natural environment, but the extent of seepage from these areas is significantly reduced by the precipitation of salts; • Based on the data presented, the Proposal is not expected to alter the local or regional groundwater quality; • Under realistic actual evaporation conditions, the spread of the groundwater mound under the concentrator ponds will not interact with the algal mats that occur

<table>
<tr><th>Significant impact criteria</th><th>Assessment of impacts to Migratory Birds</th></tr>
<tr><td></td><td>downstream , and no change in soil water dynamics is expected in the top 2 cm of the soil profile, which is the depth of soil that the algal mats depend on (Paling, 1990); and
• If evaporation rates are lower than expected, resulting in a greater spread of the groundwater mound, then modelling has shown that seepage capture bores or trenches could be effectively used, with potential extraction rates of up to 30 L/s/m^2 shown to significantly reduce any downstream impacts.
Summary
The Proposal has been designed to avoid the majority of migratory bird habitat within the MSSA and potential indirect impacts are either not expected to pose a significant risk, or they are able to be mitigated such that they do not substantially modify migratory bird habitat. Monitoring is proposed to ensure that the mitigation measures are successful.
With the implementation of mitigation controls and monitoring listed in Section 13.7 the Proposal is considered unlikely to substantially modify, destroy or isolate an area of important habitat for migratory birds.</td></tr>
<tr><td>Potential to result in an invasive species that is harmful to the migratory species becoming established in an area of important habitat for the migratory species.</td><td>Several feral animals were recorded within the TFSA, including dogs, foxes and cats (Phoenix, 2020b; Appendix 9.1). 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 13.7).
The Proposal is therefore considered unlikely to result in an invasive species that is harmful to migratory birds becoming established in an area of important habitat for migratory birds.</td></tr>
<tr><td>Potential to seriously disrupt the lifecycle (breeding, feeding, migration or resting behaviour) of an ecologically significant proportion of the population of a migratory species.</td><td>14 migratory bird species were recorded or extrapolated as having a significant proportion (>0.1% of the flyway population) present within the MSSA (Phoenix, 2020b; Appendix 9.1):
Life Cycle
None of these species breed in Australia. The MSSA is therefore used for feeding and resting.
Potential to Disrupt Life Cycle
<u>Reduction in Habitat</u>
The development envelopes do not contain an ecologically significant proportion of the population of any of the migratory birds recorded during the Phoenix (2020b) survey.
The Proposal has been designed to avoid the majority of migratory bird habitat within the MSSA. This is evident when reviewing bird records in Figure 75 to Figure 78, where almost all records were outside the development envelopes.
The disturbance of a small percentage of mostly low value habitat within the MSSA is not expected to seriously disrupt the life cycle of an ecologically significant proportion of any of the migratory species.
<u>Introduced Fauna</u>
Several feral animals were recorded within the TFSA, including dogs, foxes and cats (Phoenix, 2020b). 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 13.7).
<u>Pond Fauna Attraction</u>
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, migratory birds may be attracted and utilise the concentrator 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, the Port Hedland Dampier Saltworks are listed as Important Bird and Biodiversity Areas (IBAs) (Birdlife Australia, 2005 - 2007), and Houston et al. (2012) concluded after studying two salt fields associated with the Fitzroy River estuary, Queensland, that saltfields are “an integral component of the ecology of the landscape, providing complementary resources to that of the natural wetlands.”</td></tr>
</table>

Significant impact criteria	Assessment of impacts to Migratory Birds
	Noise and Light Emissions Construction of the Proposal will result in relatively low levels of noise, particularly in proximity to migratory bird habitat. Most of the works will be conducted in narrow strips on soft mudflats (for the pond walls), and the Process Plant is small in size in comparison to mining operations in the Pilbara. 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 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 migratory bird species. Processing and export operations at the Proposal are limited in capacity and will produce low levels of light and noise emissions. The main source of noise and light emissions will be the Process Plant, which covers only several hectares and is located away from the coastline. The Port is a simple narrow jetty structure that will export low volumes of product and not require significant lighting, apart from navigational aids. **Summary** The development envelopes did not contain an ecologically significant proportion of the population of any of the migratory birds recorded during the Phoenix (2020b) survey. A small proportion of the larger MSSA habitat will be disturbed however this is considered unlikely to seriously disrupt the lifecycle of any of the migratory birds as almost all of the disturbance will occur in the lower value portions of the habitat away from the coast, where very few bird records were noted. The scale of noise, light and feral animal risks would not be significant enough to affect an ecologically significant proportion of the population. The concentrator ponds may provide new habitat in areas that are not currently utilised (bare clay pans, algal mats). The utilisation of these ponds may alter the feeding or resting behaviour for some migratory birds however this is not expected to seriously disrupt the life cycle of an ecologically significant proportion of the population of these migratory species. Annual migratory shorebird monitoring across the MSSA will be conducted to verify the assessment above, with results to be made publicly available to inform other programs.

13.7 Proposed Safeguards and Mitigation Measures

The proposed safeguards and mitigation measures are outlined in Table 78.

Table 78: Proposed safeguards and mitigation measures

Mitigation / Safeguard Number	Key Mitigation / Safeguard	Detail	Species Affected	Timing	Location	Residual Impact
Hydrological / Water Quality						
1.	Monitor, where present, groundwater levels and quality down-gradient of the concentrator and crystalliser ponds	One or more monitoring bore will be installed down-gradient of each bank of crystalliser ponds, and at a minimum three locations along the concentrator pond walls. Other bores will be installed between the crystalliser ponds and Mardie Pool. The monitoring information will be used to determine whether any impacts to groundwater are occurring. Suitable reference bores will also be monitored to allow an appropriate comparison	Terrestrial and intertidal species	Operation	Ponds	N/A – refer to Mitigation 2.
2.	Install cut-off bores, sumps and / or trenches and pump the water to the appropriate salinity pond	Install cut-off bores, sumps and / or trenches and pump the water to the appropriate salinity pond if the monitoring described in Mitigation 1 either: a. Identifies sustained mounding that is encroaching on mangrove or algal mat habitat or is leaching water on the surface; or b. Identifies seepage of high salinity brine that is above the natural groundwater range and likely to significantly impact on environmental values.	Terrestrial and intertidal species	Operation	Ponds	No significant residual impact expected. The efficacy of cut-off bores has been modelled (Section 5.5.1) as being effective in mitigating associated impacts.
3.	Prepare and implement a Mardie Pool Monitoring and Management Plan (MPMMP)	The MPMMP will include the following details: a. Locations of the monitoring bore network down-gradient of the crystalliser ponds; b. Monitoring parameters and timing; c. Triggers for the installation and operation of cut-off bores; d. Ongoing monitoring and maintenance; e. Life of Mine performance indicators;	Pilbara Leaf-nosed Bat Pilbara Olive Python	Operation Closure	Eastern Crystalliser Ponds	No significant residual impact expected. The efficacy of cut-off bores has been modelled (Section 5.5.1) as being effective in mitigating associated impacts.
4.	Install a combination of engineered floodways and culverts along the causeway alignment to ensure intertidal flow regimes are maintained either side of the causeway	a. The inundation model will be re-run during the detailed design phase of the Proposal just prior to construction to ensure the outcomes presented in this ERD are able to be achieved; b. Once the above is confirmed, floodways and culverts are to be installed at appropriate locations in the landscape to maintain intertidal flow regimes; c. Visual monitoring will be conducted immediately after construction of the floodways and culverts to ensure that there is no ponding or other flow restrictions that do not align with the modelled predictions. If significant flow restrictions are noted that do not align with the modelled predictions then the following actions will be taken: i. Additional field monitoring will be conducted to define the quantitative extent of the flow restriction; ii. The model will be re-run with this updated site specific data to determine if the restriction will alter the targeted outcomes of the model (no significant change to baseline tidal movement); iii. If the target outcomes are unlikely to be achieved then the relevant floodway or culvert(s) will be revised, reinstalled or redesigned to ensure the target outcomes are achieved d. Ongoing monitoring is proposed after construction to ensure the results align with modelling predictions	Terrestrial and intertidal species	Construction Operation	Causeway	No significant residual impact expected. The efficacy of the floodways and culverts has been modelled (Section 5.5.4) as being effective in mitigating associated impact.
5.	Incorporate and install two major drainage channels in the concentrator pond design.	The channels are to be: a. A minimum width of 250 m; b. Fitted with sediment control structures; c. Fitted with erosion control at entry and exit points; d. Fitted with spreader mechanisms at the exit points to allow surface water to spread across the intertidal zone;	Terrestrial and intertidal species	Construction Operation	Concentrator Ponds	No significant residual impact expected. The efficacy of the drainage system has been modelled (Section 5.5.2) as being effective in mitigating associated impact.

Mitigation / Safeguard Number	Key Mitigation / Safeguard	Detail	Species Affected	Timing	Location	Residual Impact
		e. Appropriately designed and armoured to handle a predicted 1 in 100 year ARI flow event				
6.	All existing inland drainage lines are to be diverted around the ponds or through one of the drainage channels described above	The drainage system will include overflow structures to safely direct surface water flow from rainfall events greater than 1 in 50 ARI into the concentrator ponds	Intertidal species	Construction	Concentrator Ponds	No significant residual impact expected. The efficacy of the drainage system has been modelled (Section 5.5.2) as being effective in mitigating associated impact.
7.	Implement off-take drainage to Open Woodland (Riparian) habitat if required	Implement off take drainage to this habitat if required to provide surface water flows to this habitat where it may have been cut-off from upslope flows	Terrestrial species	Construction	Drainage Channels	No significant residual impact expected. The efficacy of the floodways and culverts has been modelled (Section 5.5.4), and an off-take from this drainage system is expected to be effective in mitigating associated impacts to this habitat.
8.	Prepare and implement an Erosion and Sediment Control Plan (ESCP)	The ESCP will ensure that erosion and sediment control strategies and measures are implemented consistent with industry best practice guidelines	Intertidal species	Construction	Concentrator Ponds	No significant residual impact expected. Sediment controls are predicted to contain sedimentation and prevent impacts to downslope habitats.
9.	Verify inundation modelling results after construction to ensure potential indirect impacts to the tidal regimes of the intertidal zone are within predicted outcomes.	The verification monitoring will collect data from several points within the intertidal zone, including: a. Water levels; b. Inundation periods; c. Flow rates (if relevant to the monitoring location).	Intertidal species	Construction	Ponds, Causeway	No significant residual impact expected. This mitigation is to verify that the impacts of the ponds and causeway are within modelled predictions (Section 5.5.4) as not having a significant residual impact.
10.	Concentrator and crystalliser ponds will be designed and constructed to be safe and stable	Concentrator and crystalliser ponds will be designed and constructed to be safe and stable according to DMIRS (WA) requirements and in accordance with an approved Mining Proposal issued under the *Mining Act 1978* (WA)	Terrestrial and intertidal species	Construction	Ponds	No significant residual impact expected. DMIRS regulation of pond construction will ensure this mitigation measure is suitable.
11.	Routinely inspect the condition and performance of pond walls, pipelines, containment systems and internal drainage structures	Routinely inspect the condition and performance of pond walls, pipelines, containment systems and internal drainage structures, to ensure they are in acceptable condition and / or operating appropriately	Terrestrial and intertidal species	Operation	Ponds	No significant residual impact expected. Regular inspections are expected to ensure structures do not pose a risk of significant impact.
12.	Additional controls will be used to further reduce the risk of impact from unintentional brine pipeline spills	a. Pipelines will be fitted with leak detection; b. Water flows will be shut off if leaks are detected; c. Pipelines will be inspected regularly, especially during extreme heat or fire events; d. Pipelines will be located off access road surfaces; e. If pipelines have to cross access roads then they will be buried; f. Investigations will be conducted into the cause of any spills, and remedial actions will be taken to minimise the chance of reoccurrence; and g. Spills response training to mitigate damage for site-based personnel.	Terrestrial and intertidal species	Construction Operation	Ponds Process Plants Causeway Port Stockyard	Spill prevention measures are considered appropriate to ensure that there are no significant residual impacts.
13.	Ensure product infrastructure wash down water is captured and not released to the surrounding environment	Product wash-down water will be captured within catchment basins and not released to the surrounding environment.	Intertidal species	Operation	Process Plants Port Stockyard	Containment measures are considered appropriate to ensure that there are no significant residual impacts.
14.	Monitor erosion at the outlets of the surface water corridors after each significant flow event.	If erosion is noted then install additional erosion controls to minimise further erosion	Intertidal species	Construction Operation	Pond drainage channels	Corrective measures are considered appropriate to ensure that there are no significant residual impacts.

Mitigation / Safeguard Number	Key Mitigation / Safeguard	Detail	Species Affected	Timing	Location	Residual Impact
15.	Comply with WA Water Quality Protection Guidelines and guidance notes	Particularly in relation to the storage and use of hydrocarbons and other harmful chemicals, the design and operation of vehicle maintenance areas and facilities, the siting and operation of wastewater treatment systems, and the handling and storage of other waste materials, including contaminated soils	All species	Construction Operation Closure	All infrastructure	Containment, clean-up and corrective measures are considered appropriate to ensure that there are no significant residual impacts.
16.	Collect and assess additional soil samples regularly for ASS during construction of the pond walls and causeway, and during dredging	To ensure the ongoing reliability of the original assessments. Conduct detailed assessment and treat soils in accordance with an ASS Management Plan if ASS are detected	All species	Construction	Ponds Dredging Causeway	Corrective measures are considered appropriate to ensure that there are no significant residual impacts.
17.	Limit seawater abstraction to 150 GL/yr	DAWE is expected to include this limit in the approval decision	Marine species	Operations	Seawater Intake	No significant residual impact expected. The impacts of this abstraction rate has been modelled (Section 5.5.4) and a limit is effective in mitigating associated impacts.
18.	Abstract seawater from the designated tidal creek only when tides are above MSL	This will ensure that sufficient water volumes are available in the creek to minimise abstraction impacts.	Marine species	Operations	Seawater intake	No significant residual impact expected. The impacts of this abstraction timing has been modelled (Section 5.5.4) and a limit is effective in mitigating associated impacts.
19.	Limit bitterns discharge and dilute prior to discharge	Bitterns discharge will be limited to 3.6 GL/yr (prior to dilution). Bitterns is to be diluted with seawater prior to discharge.	Marine species	Operations	Bitterns diffuser	This mitigation measure (in connection with the MEQMMP) will ensure that significant reduction in water quality is restricted to within the LEPA with some impacts within the boundary of the MEPA
20.	Limit total dredging volumes	Dredging will be limited to 850,000 m^3.	Marine species	Operations	Dredge corridor	This mitigation measure (in connection with the DSDMP) will ensure that losses of sub-tidal BCH is limited to 183 ha (including 60 ha of vegetated BCH)
21.	Implement the MEQMMP (Appendix 3)	The MEQMMP contains detailed information about the discharges, proposed management and monitoring, and contingency actions, including: a. Baseline monitoring requirements; b. Implementation of a Marine Environmental Quality Monitoring Program; c. WET testing of initial bitterns and comparison against initial modelling input and outputs. Conduct remodelling if required to verify LEP boundaries; d. Model verification monitoring e. Detailed design of the outfall diffuser; f. Ongoing bitterns quality monitoring g. Develop and implement procedures and plans, including a Chemical Storage and Handling Procedure, Bunkering Procedure, Port Facility Oil Spill Response Plan, Shipboard Oil Pollution Emergency Plan; h. Reporting requirements; and i. Contingency actions	Marine species	Operations	Port Bitterns outfall	This mitigation measure will ensure that significant reduction in water quality is restricted to within the LEPA with some impacts within the boundary of the MEPA
22.	Implement the DSDMP (Appendix 4)	The DSDMP includes key management actions to minimise impacts to marine environmental quality including: a. Dredged material is not to be dumped offshore. Dredged material will be brought onshore to be used in pond construction;	Marine species	Construction	Dredge Corridor	This mitigation measure will ensure that losses of sub-tidal BCH is limited to 183 ha (including 60 ha of vegetated BCH)

Mitigation / Safeguard Number	Key Mitigation / Safeguard	Detail	Species Affected	Timing	Location	Residual Impact
		b. Dredging will be conducted using a barge-mounted long-reach excavator instead of a cutter-suction vessel; c. Measures proposed to ensure the ZoMI remains within modelling predictions; d. No detectable impact on subtidal BCH within the ZoI; e. Plume modelling and monitoring; f. Contingency measures.				
23.	Dredge material is to be placed into a container to allow a crane to transfer the container to trucks via the trestle jetty	The container is to be lifted above the barge to ensure any spills are captured within the barge	Marine species	Construction	Berth Pocket	Containment measures are considered appropriate to ensure that there are no significant residual impacts.
24.	Ensure fuel is stored with secondary containment	Ensure fuel is stored within self-bunded tanks or within a bunded area onshore	Terrestrial species	Construction Operation	Fuel storage facilities	Containment measures are considered appropriate to ensure that there are no significant residual impacts.
25.	Visually monitor sediment plumes during the construction of the seawater intake and small boat launching facility	If plumes are evident that are not dissipating quickly then install silt curtains if suitable.	Marine species	Construction	Seawater intake Small boat launching facility	Impact will be short-term and containment measures (if required) are considered appropriate to ensure that there are no significant residual impacts.
26.	Develop and implement an Oil Spill Response Plan	This Plan will be developed in consultation with PPA and will include: a. Refuelling procedures b. Response equipment requirements c. Response procedures and action plans for various spill scenarios d. Reporting and responsibilities	Marine and intertidal species	Construction Operation	All intertidal or marine facilities	Containment, clean-up and corrective measures are considered appropriate to ensure that there are no significant residual impacts.
Benthic Communities and Habitats						
1.	Limit disturbance of mangroves	Mangrove disturbance will be limited to 17 ha of SC Mangroves, and no CC Mangroves	Intertidal species	Construction	Southern Concentrator Ponds	This mitigation measure will ensure that no more than 17 ha of SC Mangroves are disturbed by the Proposal
2.	Minimise disturbance within mangrove, algal mat and samphire communities	Disturbance of these habitats will be considered during detailed design to ensure the disturbance is the minimum practicable.	Intertidal species	Construction	Ponds	This mitigation measure will ensure that the disturbance of these habitats is less than predicted in this ERD.
3.	Construct the jetty using a top-down approach where appropriate	This minimises the requirement for a cleared corridor through intertidal BCH and therefore minimises BCH disturbance	Marine and intertidal species	Construction	Trestle jetty	This mitigation measure is effective to ensure disturbance from the construction of the trestle jetty is limited to the pile locations.
4.	Minimise the risk of introducing marine pests by implementing the following measures	a. All vessels should comply with Commonwealth Department of Agriculture– Biosecurity Requirements as well as all State legislation relating to management of introduced marine organisms; b. Any vessels visiting the Port of Mardie from international or interstate waters are required to complete the WA DoF 'Vessel Check' risk assessment (https://www.vessel-check.com)	Marine species	Construction Operations Closure	Offshore activities	IMP mitigation measures are well-established and are considered appropriate to ensure that there are no significant residual impacts.
5.	Develop and implement a BCH Monitoring Plan	This Plan will be designed to monitor the health and distribution of mangrove, algal mat, samphire mudflat and sub-tidal BCH and will include: a. Annual health assessment and comparison with baseline surveys; b. Annual BCH boundary mapping; and	Marine and intertidal species	Construction Operation Closure	Intertidal zone	This mitigation measure will ensure that the impacts to these habitats is aligned with the prediction in this ERD.

Mitigation / Safeguard Number	Key Mitigation / Safeguard	Detail	Species Affected	Timing	Location	Residual Impact
		c. Long-term sea level monitoring to determine if the intertidal communities are migrating inland as the sea level rises d. Commitments to investigate and implement corrective actions if any unexpected results are recorded that are attributed to the Proposal				
6.	Develop and implement a *Tecticornia* (Samphire) Monitoring and Management Plan	This Plan will be designed to monitor the health and distribution of samphire habitats and will include: a. Targeted pre-construction samphire surveys within areas that may be directly or indirectly impacted; b. Installation and survey of baseline monitoring sites; c. Annual health assessment and comparison with baseline surveys; d. Annual boundary mapping; e. Long-term sea level monitoring to determine if this habitat type is migrating inland as the sea level rises; f. Potential corrective actions, such as artificial inundation, will be investigated, and will include consultation with *Tecticornia* experts (i.e. Dr Kelly Shepherd or Bindy Datsun)	Shorebirds	Construction Operation Closure	Intertidal zone	This mitigation measure will ensure that the impacts to samphire habitats is aligned with the prediction in this ERD.
Fauna						
1.	Utilise a barge-mounted long-reach excavator for dredging activities	Impacts associated with the use of a cutter-suction dredge have been avoided by utilising a simpler barge-mounted long-reach excavator method	Marine species	Construction	Dredge Corridor	This mitigation measure will ensure that losses of sub-tidal BCH is limited to 183 ha (including 60 ha of vegetated BCH).
2.	Vessels will not be permitted to venture or operate outside of port operational waters unless conducting monitoring or rescue operations	Restricting vessels to port operational waters is proposed to limit the spatial extent of vessel strike risks	Marine species	Operation	Port	This mitigation measure (in connection with other vessel strike measures) is predicted to be effective in minimising the likelihood of a vessel strike that results in injury or death of marine fauna
3.	Minimise the risk of fatal vessel strikes to marine fauna	Consistent with the DoE guidelines for reducing vessel strikes, Mardie Minerals will ensure that all Proposal vessel operators will be trained to observe and report the location of any sightings of large marine fauna (in particular marine turtles, mammals and sawfish) to other vessel operators in the area to allow them to be tracked (if visible) and avoided. In addition, implementing a 12-knot speed limit for large vessels within Proposal waters will act to reduce marine mammal injury from vessel strike.	Marine species	Construction Operation Closure	Port	While the probability of vessel strike is already low, reducing vessel speed from 15 knots to 12 knots has been shown to decrease the likelihood of fatal injury (to large whales) by 30% (Vanderlaan and Taggart, 2007)
4.	Report any sightings of large marine fauna (i.e. mammals, turtles, sawfish) to all Mardie Minerals vessels in order to minimise vessel strike incidents	All sightings of marine fauna that occur within the operational areas of the Mardie Port to be reported to operational vessels to minimise vessel strike incidents	Marine species	Construction Operation Closure	Port	This mitigation measure (in connection with other vessel strike measures) is predicted to be effective in minimising the likelihood of a vessel strike that results in injury or death of marine fauna
5.	Minimise potential noise impacts to marine fauna for the duration of the marine pile-driving operations by implementing the following controls	a. Deployment of a MFO on each vessel undertaking marine pile driving operations and ensure they are trained in marine fauna observations and mitigation measures, including the requirements of the Wildlife Conservation (Closed Season Marine Mammals) Notice 1998. The MFO will keep a log of cetaceans, dugongs, sawfish and marine turtles observed; b. No marine pile driving activities shall commence until the MFO has verified that no cetaceans or dugongs have been observed within a radius of 1,000 m or marine turtles or sawfish within a radius of 300 m from any marine pile driving operations during the 20 minute period immediately prior to commencement of marine pile driving operation;	Marine species	Construction Operation Closure	Offshore	This mitigation measure has shown to be effective in minimising the impacts of marine noise to marine fauna such that there are no predicted residual impacts.

Mitigation / Safeguard Number	Key Mitigation / Safeguard	Detail	Species Affected	Timing	Location	Residual Impact
		c. If the MFO, or any other person, observes a marine turtle or sawfish enter within 100 m of marine pile driving operations, or cetacean or dugong within 500 m of marine pile driving operations, that marine pile driving operation is to be suspended; d. Marine pile driving that has been suspended in accordance with condition will not recommence until the cetacean, or dugong has moved beyond 1,000 m from the suspended marine piling operation or the marine turtle or sawfish beyond 300 m of their own accord, or the cetacean, dugong, sawfish or marine turtle has not been observed within 500 m of the marine pile driving operations for a period of 20 minutes. Marine pile driving that has been suspended for more than 15 minutes shall recommence with soft start-up procedures as required; e. Prior to commencement of full power marine pile driving, Mardie Minerals shall implement soft start-up procedures that slowly increase the intensity of noise emissions over a period of no less than 15 minutes. f. Marine pile driving commenced prior to sunset can continue between the hours of sunset and sunrise, unless marine pile driving is suspended for more than 15 minutes.				
6.	Seawater intakes are to be fitted with intake screens designed to prevent marine fauna from being drawn into the intake, and designed such that intake speeds are limited to a maximum of 0.15 m/s	This speed has been defined as slow enough to allow marine fauna to escape entrapment. Specially designed intake screen enclosures are proposed to be installed around intakes to ensure flow rates at the screen do not exceed 0.15 m/s	Marine species	Operation	Seawater intakes	This mitigation measure is expected to prevent any significant residual impacts to marine fauna. An intake flow rate of less than 0.15 m/s is recommended by the US Environmental Protection Agency (2001) as it ensures the protection of 96% of fish species, and is lower than the swim speed of marine turtles (Bell & Richardson, 1978; Bustard & Limpus, 1970; Chung et al., 2009; de Silva, 1995; Frick, 1976; Hirth, 1971; Hughes, 1974; Papi et al., 1995; Prange, 1976; Salmon & Wyneken, 1987; Witherington, 1991, Wyneken 1997). This flow rate has been adopted at a number of seawater intakes in Australia including Anketell Port, The Wheatstone Development and Adelaide Desalination Plant.
7.	Develop an 'illumination plan' for coastal and marine infrastructure.	The plan will be developed at the detailed design stage of the Proposal. Each light source will be described in terms of its purpose, location, footprint, intensity and spectral composition. The plan will ensure that appropriate lighting is installed that minimises impacts to marine turtles. Marine and coastal construction and operational activities will be conducted in accordance with design recommendations provided in EPA (2010) and DotEE (2019). Key mitigation includes: a. Lighting will be the minimum number and intensity required for safe operation; b. The trestle jetty will not be illuminated along its length; c. Light emitting diodes will be used where practicable, specifically PC amber, 2000 CCT or filtered 2700 -3000 CCT will be used wherever practicable	Marine turtles	Construction Operation	Port Stockyard Trestle Jetty	The application of measures within EPA (2010) and DotEE (2019) are shown to be successful in minimising light impacts on marine turtles. Some light spill will be unavoidable however this will not affect any high-quality nesting beaches that are well-utilised, such as those on the offshore islands.

Mitigation / Safeguard Number	Key Mitigation / Safeguard	Detail	Species Affected	Timing	Location	Residual Impact
		d. Long wavelength (550 – 700 nm; yellow to red) lights will be used wherever practicable. Use of short wavelength (400 – 500 nm; blue) lights will be avoided / minimised wherever practicable; e. If high pressure sodium lights are required to be used then amber filters will be fitted; f. White lights that emit ultraviolet light will not be used; g. Facilities will be designed to avoid light spill onto the beach and sea surface; h. Natural topography shielding will be considered when positioning lighting; i. Night construction will be minimised during turtle nesting season; j. Light fixtures will be mounted in low positions, directed downwards, shielded and aligned to direct light on the target area only; k. Lights will be turned on only when required; l. Long-period flashing lights will be used for navigation beacons or safety markings; m. Personnel will be educated on the need to minimise light spill and the controls to be implemented; n. An as-built audit will be conducted to verify that lighting impacts on the turtle nesting beach are minimal. Further actions will be taken to reduce lighting impacts if the audit determines that the Proposal lights are illuminating the nesting beach; o. A marine turtle hatchling survey will be conducted within 12 months of the completion of construction to determine if there is any evidence of mis-orientation or disorientation of turtle hatchlings that could be attributed to the Proposal. If evidence is found then review lighting to reduce impacts further;				
8.	Ensure key environmental windows (Section 8.3.12) are considered when planning construction activities.	Where practicable Mardie Minerals will align the timing of relevant construction activities to avoid these environmental windows	Marine species	Construction	Port Stockyard Trestle Jetty	This mitigation measure (in connection with others in this table) is expected to prevent any significant residual impacts to marine fauna.
9.	Implement the following management measures for fauna:	a. Vegetation clearing will be managed through internal ground disturbance procedures; b. Boundaries of areas to be cleared or disturbed will be identified by GPS coordinates and maps of boundaries will be provided to dozer operator; c. Progressive clearing will be undertaken; d. Raised blade disturbance will be conducted where practicable on tracks to minimise vegetation removal; e. The disturbance footprint will be developed to the minimum required to ensure safe and adequate construction and operation; f. Water or dust suppressants will be applied to disturbed areas and product transfer / storage areas as required to minimise dust generation; g. Emergency response capabilities will be maintained to prevent fire outbreaks where possible; h. 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 (mesquite controls discussed further below);	Terrestrial and intertidal species	Construction Operation Closure	All onshore areas	These mitigation measures (in connection with others in this table) are expected to prevent any significant residual impacts to terrestrial and intertidal fauna.

Mitigation / Safeguard Number	Key Mitigation / Safeguard	Detail	Species Affected	Timing	Location	Residual Impact
		i. Feral animal controls will be implemented; j. Pets will not be brought to site; k. Utilise low noise equipment where available and suitable; l. Pipeline trenches (if required) will be progressively opened and closed; m. Fauna egress mechanisms will be installed at all trenches, turkeys nests or concentrator and crystalliser ponds; n. The open portions of pipeline trenches will be inspected less than two hours after sunrise for the presence of trapped fauna; o. 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; p. Food wastes will be stored in bins that are not easily accessible to fauna; q. Low noise equipment will be used where practicable; r. All incidents resulting in fauna injury or death will be reported internally; and s. Vehicle speed limits will be set and enforced, with lower limits imposed within Northern Quoll foraging habitat				
10.	Conduct annual migratory shorebird surveys within the MSSA.	The annual surveys will be conducted in a similar manner to the targeted survey conducted by Phoenix (2020b; Appendix 9.1) and will provide information regarding long-term changes in the numbers, species and distributions of migratory shorebirds utilising the MSSA Record the usage of the concentrator and crystalliser ponds by fauna species and incorporate these areas into the annual migratory shorebird survey if shorebird species are noted to utilise the ponds	Shorebird species	Construction Operations Closure	Ponds MSSA	N/A – monitoring only
11.	Investigate and implement measures to improve the prospectivity of shorebird habitat within the concentrator ponds	Investigate and implement measures to improve the prospectivity of shorebird habitat within the lower salinity concentrator ponds (such as introducing food sources and minimising lighting and works during peak shorebird seasons)	Shorebird species	Construction Operations Closure	Ponds	The presence of the lower salinity concentrator ponds may result in increased shorebird numbers in the MSSA. Shorebirds are known to inhabit salt ponds; in the Pilbara, the Port Hedland Dampier Saltworks are listed as IBAs (Birdlife Australia, 2005–2007), and Houston et al. (2012) concluded after studying two salt fields associated with the Fitzroy River estuary, Queensland, that saltfields are "an integral component of the ecology of the landscape, providing complementary resources to that of the natural wetlands."
Flora						
1.	Manage mesquite in accordance with the Mesquite Management Strategy developed by PMMC. Develop/implement a Mesquite Management Plan in conjunction or consultation with PMMC and Mardie Station	Management measures will be developed and implemented in accordance with the management strategy devised by the PMMC. A number of eradication studies have been undertaken by the PMMC on Mardie Station and Mardie Minerals will utilise the eradication and management techniques resulting from these studies. Management actions will include the following: a. Weed mapping; b. Wash-down bays located in different areas of site; c. Cleaning of vehicles moving between weed infestation areas, cleared areas and areas with no weeds;	*Minuria tridens*, terrestrial fauna	Construction Operation Closure	All areas	The Mesquite Management Strategy is the best-available measure to prevent the spread of Mesquite at the Proposal. These mitigation measures are expected to prevent any significant residual impacts to *Minuria tridens* or terrestrial fauna habitat.

Mitigation / Safeguard Number	Key Mitigation / Safeguard	Detail	Species Affected	Timing	Location	Residual Impact
		d. Restrictions on soil movement between infestation areas, cleared areas and areas with no weeds; e. The use of a Holman Plough or other agreed method to ensure the effective removal of Mesquite when clearing land required for the Proposal; f. Development of control measures for cleared areas; and g. Liaison with PMMC to develop and implement eradication program.				
2.	Avoid all known records of *Minuria tridens*	All known records have been excluded from the development envelopes and therefore will not be disturbed	*Minuria tridens*	Construction	All terrestrial areas	No residual impacts to this species.
3.	Conduct pre-clearance targeted Threatened Flora surveys	Conduct pre-clearance targeted Threatened Flora surveys within areas of potential habitat that is to be disturbed, and avoid any new records of Threatened Flora identified where practicable	*Minuria tridens* and any other potential Threatened Flora species	Construction	All terrestrial areas	These mitigation measures (in connection with others in this table) are expected to prevent any significant residual impacts to Threatened Flora.
Rehabilitation						
1.	Salts will be harvested from each pond prior to closure	Seawater will cease being pumped into Pond 1, and then the remaining saline water will be pumped out to each subsequent pond until a final product is created. There will be some remaining water left in each pond and this water will be left to evaporate, leaving residual salts. These salts will be harvested prior to closure. Refer to the MCP in Appendix 3 for more information.	Marine and intertidal species	Closure	Ponds	This mitigation measure is expected to result in no residual impacts once the salts have been removed and the pond footprint flushed with tidal waters (refer below).
2.	Concentrator pond walls will be flattened or opened up to allow tidal flows to enter the ponds	The pond walls will either be flatted or opened up to all intertidal regimes to become reinstated within the ponds. The ponds will be rehabilitated and closed in accordance with a MCP approved under the *Mining Act 1978*. An interim MCP has been developed and provided in Appendix 3 which contains detail about the proposed rehabilitation of the Proposal. The MCP will be submitted to DMIRS for assessment and approval prior to the construction of the Proposal, and will be reviewed and revised every three years.	Marine and intertidal species	Closure	Ponds	This mitigation measure is expected to result in no residual impacts once the pond footprint has been flushed with tidal waters.
3.	All infrastructure, including the causeway, will be removed if not retained by Mardie Station or PPA	Mardie Minerals will liaise with PPA regarding the port infrastructure, as it may be of value for ongoing use by PPA. If not, the marine components of the Proposal are relatively easy to rehabilitate. All marine infrastructure including the jetty, wharf, seawater intakes, boat ramp and navigation infrastructure will be removed and the dredge channel will be left to gradually fill with sediment. The causeway material will be removed back to ground level to ensure tidal flows are maintained after closure.	All species	Closure	All areas	This mitigation measure is expected to result in no residual impacts once the pond infrastructure has been removed and the dredge channel has filled with sediment.
4.	All terrestrial disturbance areas to be revegetated will be respread with topsoil (or ripped and seeded if suitable topsoil is not available e.g. infested with Mesquite) and rehabilitated	Terrestrial disturbance areas will be rehabilitated and closed in accordance with a MCP approved under the *Mining Act 1978*. An interim MCP has been developed and provided in Appendix 3 which contains detail about the proposed rehabilitation of the Proposal. The MCP will be submitted to DMIRS for assessment and approval prior to the construction of the Proposal, and will be reviewed and revised every three years.	Terrestrial species	Closure	All terrestrial areas	This mitigation measure is expected to result in no residual impacts as adequate rehabilitation will be required under the *Mining Act 1978*.
5.	Key surface water drainage systems will be reinstated.	The pond drainage system will be reshaped to reinstate key drainage systems (i.e. those listed in Section 5.3.4).	Terrestrial and intertidal species	Closure	Pond drainage infrastructure	This mitigation measure is expected to result in no residual impacts as key drainage lines will be fully reinstated.

13.8 SUMMARY OF MNES IMPACTS

Table 79 summarises the key impacts to MNES.

Table 79: Summary of MNES impacts

Listed threatened species and communities (sections 18 & 18A)	Recovery Plan[1]	Threat Abatement Plan[1]	Approved Conservation Advice (ACA)[1, 3]	Listing advice[3]	Bioregional Plan [2]	Survey Guidelines[2]	Other references [2]	References	Adequate survey / abundance	Impact	Avoidance	Mitigation	Residual	Offset
Pilbara Leaf-nosed bat (*Rhinonicteris aurantia* (Pilbara form))	None	None	TSSC (2016a)	TSSC (2011b)	N/A	DEWHA (2010a)	Environment Australia (1999)	Phoenix (2020b; Appendix 9.1)	Survey conducted accordance with guidelines. Recorded at two riparian open woodland habitats and a creek that was flowing due to recent rainfall (Figure 123)	5.4 ha of open woodland (riparian) habitat (foraging habitat) to be disturbed (7.3% of mapped extent within TFSA)	Mardie Pool has been avoided The majority of mapped open woodland (riparian) habitat (92.7%) was avoided	Implement MPMMP Monitor groundwater levels and quality down-gradient and install cut-off bores, sumps and / or trenches if required Implement off-take drainage to Open Woodland (Riparian) habitat if required Routinely inspect the condition and performance of pond walls Ponds will be constructed in accordance with DMIRS requirements	5.4 ha of open woodland (riparian) habitat (foraging habitat) to be disturbed (7.3% of mapped extent within TFSA)	None Proposed
Pilbara Olive Python (*Liasis olivaceus barroni*) - Vulnerable	None	Cats	TSSC 2008 - OP	Within ACA	N/A	DSEWPAC, 2011d - Reptiles	-	Phoenix (2020b; Appendix 9.1)	This species was not recorded during two nocturnal searches but suitable habitat is present at Mardie Pool (Figure 123). The species may also be found on occasion on the southern creeklines.					
Australian Humpback Dolphin (*Sousa sahulensis*) - Cetacean, Migratory	None	None	None	None	DSEWPAC, 2012b - NW Marine	None	-	O2 Marine (2020g; Appendix 7.2)	Not recorded during various marine surveys but high potential to occur. The species has been recorded in the region (desktop searches) and suitable habitat is present in the Study Area.	*Irreversible loss* of 183 ha of sub-tidal habitat (79 ha vegetated) and *recoverable impact* of 797 ha of sub-tidal habitat (202 ha vegetated) Marine noise Vessel strike Bitterns disposal	Impacts associated with significant dredging activities avoided by the use of transhipment loading method Impacts associated with cutter-suction dredge avoided by utilising a simpler barge-mounted long-reach excavator method Impacts associated with marine barriers avoided by the use of trestle jetty instead of marine causeway Bitterns disposal to be contained within ZoHI boundary	Limit bitterns discharge and dilute prior to discharge Limit total dredging volumes Implement MEQMMP, DSDMP and Oil Spill Response Plan Minimise the risk of fatal vessel strikes to marine fauna Report large marine fauna sightings to vessels Implement pile-driving noise controls	*Irreversible loss* of 183 ha of sub-tidal habitat (79 ha vegetated)	None Proposed
Humpback Whale (*Megaptera novaeangliae*) – Vulnerable, Migratory	None	Marine debris	TSSC, 2015 - HW	Within ACA	DSEWPAC, 2012b - NW Marine	DEWHA, 2008 - 2.1 - Seismic	-	O2 Marine (2020g; Appendix 7.2)	Not recorded during various marine surveys but high potential to occur. The species has been recorded in the region (desktop searches). Typically occur further offshore (>35 km) during migratory routes, although some whales recorded in <10 m water during southern migration (i.e. September).					
Olive Python (*Liasis*	None	Cats	TSSC 2008 - OP	Within ACA	N/A	DSEWPAC,	-	269, 338	Not recorded during	Mardie Pool	Mardie Pool and	Implement mesquite		None

Listed threatened species and communities (sections 18 & 18A)	Recovery Plan[1]	Threat Abatement Plan[1]	Approved Conservation Advice (ACA)[1, 3]	Listing advice[3]	Bioregional Plan [2]	Survey Guidelines[2]	Other references [2]	References	Adequate survey / abundance	Impact	Avoidance	Mitigation	Residual	Offset
olivaceus barroni) - Vulnerable						2011d - Reptiles			field survey but likely to occur. Species does not always occupy permanent freshwater so intermittent creeks are important.	Southern Creeklines	the majority of mapped open woodland (riparian) habitat has been avoided	and feral animal controls		Proposed
Dugong (*Dugong dugon*) - Marine, Migratory	None	Marine debris	None	None	DSEWPAC, 2012b - NW Marine	None	-	O2 Marine (2020g; Appendix 7.2)	Not recorded during various marine surveys but high potential to occur.	As above	As above	As above	As above	None Proposed
Hawksbill Turtle (*Eretmochelys imbricata*) – Vulnerable, Migratory **Green Turtle** (*Chelonia mydas*) – Vulnerable, Migratory **Flatback Turtle** (*Natator depressus*) – Vulnerable, Migratory **Loggerhead Turtle** *(Caretta caretta*) – Endangered, Migratory **Green Turtle** (*Chelonia mydas*) – Vulnerable, Migratory **Flatback Turtle** (*Natator depressus*) – Vulnerable, Migratory **Loggerhead Turtle** *(Caretta caretta*) – Endangered, Migratory	DoEE, 2017b DoEE, 2017b DoEE, 2017b DoEE, 2017b	Cats (Hawksbill only), Pigs, Marine debris, Fox (apart from Hawksbill), Pigs, Marine debris Fox, Pigs, Marine debris Fox, Pigs, Marine debris	None None None None	None None None None	DSEWPAC, 2012b - NW Marine DSEWPAC, 2012b - NW Marine DSEWPAC, 2012b - NW Marine DSEWPAC, 2012b - NW Marine	- 01 - -	Wilson *et al*, 2018 Wilson *et al*, 2018 Wilson *et al*, 2018 Wilson *et al*, 2018	321, 328 7B pp 21Pendoley (2019a; Appendix 7.1) 321, 328, 344 7B pp 21 321, 328, 344 7B pp 21 321, 328, 344, 350 7B pp 21	Surveys Dec/Feb 2018/19 in accordance with guidelines. The Pendoley (2019a) survey identified only very minor nesting effort by Flatback turtles and a single hawksbill turtle, along the 15 km stretch of coastline to the east of the creek. Opportunistic sightings Mar and Jul 2018 but spp and abundance not recorded. Suitable habitat is present in the vicinity of the Proposal. Opportunistic sightings Mar and Jul 2018 but spp and abundance not recorded. Opportunistic sightings Mar and Jul 2018 but spp and abundance not recorded. Opportunistic sightings Mar and Jul 2018 but spp and abundance not recorded.	Not assessed in marine fauna review (7B) *Irreversible loss* of 183 ha of sub-tidal habitat (79 ha vegetated) and *recoverable impact* of 797 ha of sub-tidal habitat (202 ha vegetated) Disturbance of low quality nesting beach Disturbance within two tidal creeks Marine noise Vessel strike Bitterns disposal *Irreversible loss* of <1 ha (<1%) and *recoverable impact* of 17 ha of coral /macroalgae habitat ERD Table 30 *Irreversible loss* of <1 ha (<1%) and *recoverable impact* of 17 ha of coral /macroalgae habitat ERD Table 30 Not assessed in marine fauna review (7B) *Irreversible loss* of <1 ha (<1%) and *recoverable impact* of 17 ha of coral /macroalgae habitat ERD Table 30 *Irreversible loss* of	As above. The majority of the sandy beach at the north of the Proposal has been avoided The majority of mangrove and tidal creek habitats. Impacts associated with marine barriers have been avoided by the use of a trestle jetty instead of a marine causeway	As above. Implement DSDMP Implement marine pile-driving noise controls Implement IMP measures Implement vessel speed limits Report any sightings of large marine fauna Implement MEQMMP (Appendix 3.1) Seawater intake speeds limited to <0.15 m/s Seawater intakes to be fitted with intake screens Develop an 'illumination plan' Consider key environmental windows when planning construction activities	*Irreversible loss* of 183 ha of sub-tidal habitat (79 ha vegetated) Disturbance of low quality nesting beach Disturbance within two tidal creeks Likely near jetty and mainland beaches. FAD of jetty. Some impacts	None proposed None proposed None proposed None proposed

Listed threatened species and communities (sections 18 & 18A)	Recovery Plan[1]	Threat Abatement Plan[1]	Approved Conservation Advice (ACA)[1, 3]	Listing advice[3]	Bioregional Plan [2]	Survey Guidelines[2]	Other references [2]	References	Adequate survey / abundance	Impact	Avoidance	Mitigation	Residual	Offset
										<1 ha (<1%) and *recoverable impact* of 17 ha of coral /macroalgae habitat ERD Table 30				
Short-nosed Seasnake (*Aipysurus apraefrontalis*) – Critically Endangered, Marine	None	None	DSEWPaC (2011)	TSSC (2011a)	DSEWPAC, 2012b - NW Marine	None	-	O2 Marine (2020g; Appendix 7.2)	Not recorded during various marine surveys but no suitable habitat present within 5 km of the Proposal.	*Irreversible loss* of 44 ha of low value coral / macroalgae habitat and *recoverable impact* of 69 ha	Impacts associated with significant dredging activities avoided by the use of transhipment loading method Impacts associated with cutter-suction dredge avoided by utilising a simpler barge-mounted long-reach excavator method Impacts associated with marine barriers avoided by the use of trestle jetty instead of marine causeway Bitterns disposal to be contained within ZoHI boundary	Limit bitterns discharge and dilute prior to discharge Limit total dredging volumes Implement MEQMMP, DSDMP and Oil Spill Response Plan Seawater intake speeds limited to <0.15 m/s Seawater intakes to be fitted with intake screens	Loss of 44 ha of low value coral / macroalgae habitat	None Proposed
Green Sawfish (*Pristis zijsron*) – Vulnerable, Migratory	DoE, 2015b - sawfish and river sharks	None	DEWHA, 2008 - GS	TSSC, 2008 - GS	DSEWPAC, 2012b - NW Marine	Kyne 2014 DSEWPAC, 2011 - Threatened fish	-	177	High potential to occur.	No distribution or abundance information so the importance of impacts on the seawater intake creek compared to other creeks cannot be known.	An area of coral communities BCH by shortening the length of the Marine Development Envelope (refer to Section 6) The majority of	Implement DSDMP Implement marine pile-driving noise controls Implement IMP measures Implement vessel speed limits Report any sightings		None Proposed

Listed threatened species and communities (sections 18 & 18A)	Recovery Plan[1]	Threat Abatement Plan[1]	Approved Conservation Advice (ACA)[1, 3]	Listing advice[3]	Bioregional Plan [2]	Survey Guidelines[2]	Other references [2]	References	Adequate survey / abundance	Impact	Avoidance	Mitigation	Residual	Offset
											mangrove and tidal creek habitats. Impacts associated with significant dredging activities and ocean-going vessel movements close to shore has been avoided by the use of a transhipment loading method; Impacts associated with the use of a cutter-suction dredge have been avoided by utilising a simpler barge-mounted long-reach excavator method; and Impacts associated with marine barriers have been avoided by the use of a trestle jetty for the export facility instead of a marine causeway	of large marine fauna Implement MEQMMP (Appendix 3.1) Seawater intake speeds limited to <0.15 m/s Seawater intakes to be fitted with intake screens Develop an 'illumination plan' Consider key environmental windows when planning construction activities		
Green Sawfish (*Pristis zijsron*) – Vulnerable, Migratory	DoE, 2015b - sawfish and river sharks	None	DEWHA, 2008 - GS	TSSC, 2008 - GS	DSEWPAC, 2012b - NW Marine	Kyne 2014 DSEWPAC, 2011 - Threatened fish	-	O2 Marine (2020g; Appendix 7.2)	Not recorded during various marine surveys but high potential to occur. The species is known to occur in the region from recent scientific studies. Suitable habitat is present in the vicinity of the Proposal.	*Irreversible loss* of 183 ha of sub-tidal habitat (79 ha vegetated) and *recoverable impact* of 797 ha of sub-tidal habitat (202 ha vegetated) Disturbance within upper portion of two tidal creeks Marine noise Vessel strike Bitterns disposal	As above	Limit bitterns discharge and dilute prior to discharge Limit total dredging volumes Implement MEQMMP, DSDMP and Oil Spill Response Plan Minimise the risk of fatal vessel strikes to marine fauna Report large marine fauna sightings to vessels Implement pile-driving noise controls	*Irreversible loss* of 183 ha of sub-tidal habitat (79 ha vegetated) Disturbance within upper portion of two tidal creeks	None Proposed
Red Knot (Calidris canutus) – Endangered, Migratory	See ACA	None	TSSC, 2016 - RK	Within ACA	DSEWPAC, 2012b - NW Marine	*DoEE, 2017a - 3.21 - Shorebirds*	*Bamford 2008* *Hansen 2016* DotE, 2015d	Phoenix (2020b; Appendix 9)	Surveys conducted in accordance with guidelines.	Disturbance of up to 1,115 ha of tidal samphire mudflat	Extensive habitat will remain within the MSSA	Monitor groundwater levels and quality down-	Disturbance of up to 1,115 ha of tidal	None Proposed

Listed threatened species and communities (sections 18 & 18A)	Recovery Plan[1]	Threat Abatement Plan[1]	Approved Conservation Advice (ACA)[1, 3]	Listing advice[3]	Bioregional Plan [2]	Survey Guidelines[2]	Other references [2]	References	Adequate survey / abundance	Impact	Avoidance	Mitigation	Residual	Offset
									Recorded 461 times within MSAA Expected to meet national criteria: 0.1% of flyway population once extrapolated	habitat (although the majority is lower value inland habitats) Disturbance of up to 17 ha of mangrove habitat and 71.7 ha of tidal channel and ocean habitat Changes to surface water flows	The majority of coastal habitats were avoided (identified as having a higher ecological value) The location of the concentrator ponds has targeted areas of bare clay pan which is considered lower value fauna habitat	gradient and install cut-off bores, sumps and / or trenches if required Routinely inspect the condition and performance of pond walls Ponds will be constructed in accordance with DMIRS requirements Install floodways and culverts along the causeway Incorporate and install two major drainage channels Verify inundation modelling results Limit seawater abstraction to 150 GL/yr Limit disturbance of mangroves to 17 ha Implement a *Tecticornia* (Samphire) Monitoring and Management Plan Annual migratory shorebird surveys Implement measures to improve the prospectivity of shorebird habitat within concentrator ponds	samphire mudflat habitat (although the majority is lower value inland habitats) Disturbance of up to 17 ha of mangrove habitat and 71.7 ha of tidal channel and ocean habitat	
Curlew Sandpiper (Calidris ferruginea) – Critically Endangered, Migratory	None	None	DoE, 2015 - CS	Within ACA	DSEWPAC, 2012b - NW Marine	*DoEE, 2017a - 3.21 - Shorebirds*	*Bamford 2008* *Hansen 2016*	Phoenix (2020b; Appendix 9.1)	Recorded 101 times within MSAA Expected to meet national criteria: 0.1% of flyway population once extrapolated					None Proposed
Great Knot (Calidris tenuirostris) – Critically Endangered, Migratory	See ACA	None	TSSC, 2016 - GK	Within ACA	DSEWPAC, 2012b - NW Marine	*DoEE, 2017a - 3.21 - Shorebirds*	*Bamford 2008* *Hansen 2016* DotE, 2015d	Phoenix (2020b; Appendix 9.1)	Recorded 172 times within MSAA					None Proposed
Eastern Curlew (Numenius madagascariensis) – Critically Endangered, Migratory	None	None	DOE, 2015 - EC	Within ACA	None	*DoEE, 2017a - 3.21 - Shorebirds*	*Bamford 2008* *Hansen 2016* DotE, 2015d	Phoenix (2020b; Appendix 9.1)	Recorded 423 times within MSAA Meets national criteria: 0.1% of flyway population					None Proposed
Greater Sand Plover (Charadrius leschenaultii) – Vulnerable, Migratory	See ACA	None	TSSC, 2016 - GSP	Within ACA	DSEWPAC, 2012b - NW Marine	*DoEE, 2017a - 3.21 - Shorebirds*	*Bamford 2008* *Hansen 2016* DotE, 2015d	Phoenix (2020b; Appendix 9.1)	Recorded 233 times within MSAA Expected to meet national criteria: 0.1% of flyway population once extrapolated					None Proposed
Lesser Sand Plover (Charadrius mongolus) – Endangered, Migratory	See ACA	Fox	TSSC, 2016 - LSP	Within ACA	None	*DoEE, 2017a - 3.21 - Shorebirds*	*Bamford 2008* *Hansen 2016* DotE, 2015d	Phoenix (2020b; Appendix 9.1)	Recorded 27 times within MSAA					None Proposed

Listed threatened species and communities (sections 18 & 18A)	Recovery Plan[1]	Threat Abatement Plan[1]	Approved Conservation Advice (ACA)[1, 3]	Listing advice[3]	Bioregional Plan [2]	Survey Guidelines[2]	Other references [2]	References	Adequate survey / abundance	Impact	Avoidance	Mitigation	Residual	Offset
Other Migratory Birds 26 Migratory bird species were recorded within the MSSA (Section 13.3.2).	See ACA	None	TSSC, 2016	None	DSEWPAC, 2012b - NW Marine	*DoEE, 2017a - 3.21 - Shorebirds*	DotE, 2015d	Phoenix (2020b; Appendix 9.1)	Recorded within MSAA The MSSA was deemed to represent or contain important habitat for 14 species (Phoenix, 2020b): • Bar-tailed Godwit • Common Greenshank • Curlew Sandpiper • Eastern Curlew • Greater Sand Plover • Grey-tailed Tattler • Oriental Plover • Pacific Golden Plover • Red Knot • Red-necked Stint • Ruddy Turnstone • Sanderling • Terek Sandpiper • Whimbrel	As above	As above	As above	As above	None Proposed
Minnie Daisy (*Minuria tridens*) – Vulnerable	None	Rabbit	None	TSSC (2012)	None	None	-	Phoenix (2020a; Appendix 8.1) 366	Yes. Species identified but could not be re-discovered Recorded in one location outside the development envelopes.	Indirect – Outside of project envelope but may be impacted long-term by changes to surface or groundwater impacts	All known records will be avoided	Manage mesquite in accordance with the Mesquite Management Strategy developed by PMMC. Conduct pre-clearance targeted Threatened Flora surveys within areas of potential habitat and avoid that is to be disturbed Avoid any new records of Threatened Flora identified where practicable Minimise clearing within AcAjTe vegetation type which may provide habitat for *Minuria Tridens* Monitor the potential changes to tidal inundation regimes	No predicted impacts to species	None Proposed

Listed threatened species and communities (sections 18 & 18A)	Recovery Plan[1]	Threat Abatement Plan[1]	Approved Conservation Advice (ACA)[1, 3]	Listing advice[3]	Bioregional Plan [2]	Survey Guidelines[2]	Other references [2]	References	Adequate survey / abundance	Impact	Avoidance	Mitigation	Residual	Offset
Bar-tailed Godwit (*Limosa lapponica*) – Vulnerable, Migratory.	See ACA	None	None	None	DSEWPAC, 2012b - NW Marine	*DoEE, 2017a - 3.21 - Shorebirds*	DotE, 2015d	**270**	Recorded within MSAA Up to 86 individuals Meets national criteria: 0.1% of flyway population *Sub-species not distinguished*	No records were observed within the development envelopes, and impacts to its preferred habitat have been minimised such that extensive habitat (>95% of all habitat types) will remain within the MSSA. The potential impacts to this species are therefore not considered to be significant.	Extensive habitat (>95% of all habitat types) will remain within the MSSA The majority of coastal habitats were avoided (identified as having a higher ecological value) The location of the concentrator ponds has targeted areas of bare clay pan which is considered lower value fauna habitat	Limit total mangrove disturbance to 35 ha Verify inundation modelling Monitor erosion at the outlets of the surface water corridors Conduct annual migratory shorebird surveys Record the usage of the concentrator and crystalliser ponds by fauna species Ponds will be constructed according to DMIRS requirements Implement controls to reduce the risk from brine pipeline spills		None Proposed
Pilbara Leaf-nosed bat *(Rhinonicteris aurantia)*								285	Recorded at two riparian open woodland habitats and a creek	Recorded at Mardie Pool and east of development envelope. Approximately 1,650 ha of disturbance of *Triodia* grasslands foraging habitat.	Mardie Pool has been avoided The majority of mapped open woodland (riparian) habitat was avoided The location of the concentrator ponds has targeted areas of bare clay pan which is considered lower value habitat	Limit total mangrove disturbance to 35 ha Verify inundation modelling results to ensure potential indirect impacts are within predicted outcomes Ponds will be constructed in accordance with DMIRS requirements		None Proposed

14 HOLISTIC IMPACT ASSESSMENT

The Proposal relies on solar evaporation to produce product and as such the large-scale inundation of habitats is unavoidable. Given the location of the Proposal, Mardie Minerals identified that environmental constraints should be the primary input into the design and commissioned initial BCH surveys to map the boundaries of significant BCH such as mangroves and algal mats. The Proposal design was then revised significantly to avoid almost all mangrove habitat, and the majority of algal mat and coastal samphire habitat. This exercise resulted in the initial Proposal design that was referred to the EPA.

Mardie Minerals has since commissioned significant additional environmental survey work and studies, which were used to further revise and refine the Proposal design and operational requirements to avoid and minimise environmental impacts. These revisions and refinements included:

- Reshaping the western pond walls to target lower-value BCH using detailed BCH mapping;
- Significantly reducing the scale of the southern-most pond to avoid hydrological impacts to Peter's Creek drainage;
- Siting PPA infrastructure and the causeway crossing outside areas of significant BCH;
- The use of a trestle jetty to avoid impacts to offshore coastal processes and intertidal flows;
- The incorporation of a top-down jetty construction approach to reduce direct disturbance;
- The incorporation of a specific seawater intake design to reduce intake rates and avoid associated fauna entrapment;
- The incorporation of a multi-port bitterns outfall diffuser with pre-dilution to minimise water quality impacts, and locating the diffuser within the ZoHI for the dredging activities to avoid BCH impacts;
- Using a desalination plant instead of groundwater bores;
- Using a transhipment method to minimise dredging volumes;
- Using a simple mechanical excavation dredging method instead of a typical cutter-suction dredge;
- Using dredged material for construction instead of dumping offshore; and
- Excluding Mardie Pool from the development envelopes.

With the implementation of avoidance measures the Proposal disturbance is now almost completely located within a large area of low value BCH and terrestrial habitat, including bare mudflats and low biomass BCH.

There are some potential impacts that require management and monitoring to ensure that the impacts are not significant. Many of these potential impacts are adequately regulated under other legislation:

- Bitterns discharge, product loss during export, brine spills and leaks, and sewage will be regulated under Part V of the EP Act;
- General environmental management will be regulated through a Mining Proposal assessed under the *Mining Act 1978* or a Development Application and Construction Approval under the *Port Authorities Act 1999*;
- Closure and rehabilitation on *Mining Act 1978* tenure will be regulated through a Mine Closure Plan assessed under the *Mining Act 1978*;

There are some potential impacts however that are expected to require limits or conditions in the Ministerial Statement, including:

- Limits on total disturbance within each development envelope;
- Limits on total seawater abstraction, bitterns discharge and dredging volumes;
- The development and implementation of a DSDMP to regulate dredging;
- Marine noise conditions during jetty construction;
- The development and implementation of a MEQMMP to outline marine environmental quality boundaries, and management and monitoring requirements for bitterns discharge and port operations; and
- Monitoring of impact predictions to ensure that they are not significant and trigger contingency actions if required

With the application of the avoidance mechanisms in Proposal design and operations, and the limits and regulation of potential impacts discussed above, Mardie Minerals considers that potential impacts to key environmental values have been reduced to an acceptable level.

Mardie Minerals understands that this conclusion is in part based on studies and modelling. While the findings of these studies were based on best-available information, monitoring has been committed to in order to verify the study and model outputs, in order to ensure the outcomes presented in this ERD are accurate.

Mardie Minerals has completed a WA Offsets Template as per the requirements of the WA Environmental Offsets Guideline (Government of WA, 2014), provided in Section 12.

Based on the above, and the assessment provided in Sections 5 – 11, the Proposal is expected to be able to meet the EPA's objectives for Inland Waters, BCH, Marine Fauna, Marine Environmental Quality, Flora and Vegetation, Terrestrial Fauna and Social Surroundings.

GLOSSARY

Term	Meaning
AGB	Above ground biomass
AH Act	*Aboriginal Heritage Act 1972*
AHIS	Aboriginal Heritage Inquiry System
Am1	*A. marina* (Seaward edge) mangroves
Am2	*A. marina* closed canopy (Landward edge) mangroves
Am3	*A. marina* scattered mangroves
ANZECC	Australian and New Zealand Environment and Conservation Council
ANZG	Australian and New Zealand Guidelines for Fresh and Marine Water Quality
ARI	Average rainfall intensity
ARMCANZ	Agriculture and Resource Management Council of Australia and New Zealand
ASS	Acid Sulphate Soil
BC Act	*Biodiversity Conservation Act 2016* (WA)
BCH	Benthic Communities and Habitats
BCI	BCIM Pty Limited (parent company of Mardie Minerals)
BoM	Bureau of Meteorology
BTEXN	Benzene, toluene, ethylbenzene, xylenes and Naphthalene
CATAMI	Collaborative and Automated Tools for Analysis of Marine Imager
CC Mangroves	Closed canopy mangroves
CEO	Chief Executive Officer
CLA	Cumulative Loss Assessment
CSIRO	Commonwealth Scientific and Industrial Research Organisation
DAWE	Department of Agriculture, Water and the Environment (Commonwealth)
DAWR	Department of Agriculture and Water Resources
DBCA	Department of Biodiversity, Conservation and Attractions
DEC	Department of Environmental Conservation (now DBCA)
DEH	Department of Environmental Heritage
DEWHA	Department of Environment, Water, Heritage and the Arts (now DotEE)
DGV	Default guideline values
DIIS	Department of Industry Innovation and Science (Commonwealth)
DJTSI	Department of Jobs, Tourism, Science and Innovation (WA)
DLI	Daily Light Integral
DMIRS	Department of Mines, Industry Regulation and Safety (WA)
DMP	Department of Mines and Petroleum (now DMIRS)
DotEE	Department of the Environment and Energy (Commonwealth)
DoW	Department of Water (WA), now DWER
DPLH	Department of Planning, Lands and Heritage (WA)
DPIRD	Department of Primary Industries and Regional Development (WA)
DSDMP	Dredging and Spoil Disposal Management Plan

Term	Meaning
DSEWPaC	Department of Sustainability, Environment, Water, Population and Communities (Commonwealth), now DotEE
DWER	Department of Water and Environmental Regulation
EAAF	East Asia-Australasian Flyway
EIA	Environmental Impact Assessment
EIS	Environmental Impact Statement
EPA	Environmental Protection Authority (WA)
EP Act	*Environmental Protection Act 1986* (WA)
EPBC Act	*Environment Protection and Biodiversity Conservation Act 1999* (Cth)
EQMF	Environmental Quality Management Framework
EQC	Environmental Quality Criteria
EQO	Environmental Quality Objectives
ERD	Environmental Review Document
ESD	Environmental Scoping Document
EV	Environmental Values
GL	Gigalitre
GL/yr	Gigalitres per annum
ha	hectares
HAT	Highest Astronomical Tide
HEPA	High Ecological Protection Area
IBRA	Interim Biogeographic Regionalisation for Australia
IFD	Intensity-Frequency-Duration
IMS	Introduced Marine Species
IMP	Introduced Marine Pests
IUCN	International Union for Conservation of Nature
km	kilometres
KM	Kuruma Mardudhunera
KM People	Kuruma Marthudunera People
Ktpa	Kilotonne per annum
LAT	Lowest Astronomical Tide
LAU	Local Assessment Unit
LEP	Level of ecological protection
LEPA	Low Ecological Protection Area
LOSA	Large ovate seed aggregate
m	Metres
mAHD	Australian Height Datum
Mardie Minerals	Mardie Minerals Pty Ltd
MCP	Mine Closure Plan
MEPA	Moderate Ecological Protection Area
MEQMMP	Marine Environmental Quality Plan
MFO	Marine Fauna Observer

Term	Meaning
mbgl	Metres below ground level
mg/L	Milligrams per litre
MNES	Matters of National Environmental Significance
Mtpa	Million tonnes per annum
m/s	Metres per second
MSL	Mean sea level
MSSA	Migratory Shorebird Study Area
NaCl	Sodium Chloride
NATA	National Association of Testing Authorities
NIMPCG	National Introduced Marine Pests Coordination Group
NSW	New South Wales
NT	Northern Territory
NTC	National Tide Centre
NW	North-west
NNW	North-north-west
NTU	Nephelometric Turbidity Units
OCP	Organochlorine
OPMF	Onslow Prawn Managed Fishery
OPP	Organophosphate pesticides
PAR	Photosynthetically Active Radiation
PASS	potentially acid sulphate soils
PAH	Polycyclic aromatic hydrocarbons
PEC	Priority Ecological Communities – plant communities listed as being potentially threatened under the *Biodiversity Conservation Act 2016*
PER	Public Environment Report
pH_F	Field pH
pH_{FOX}	Field pH peroxide test
PMMC	Pilbara Mesquite Management Committee
PMP	Probable maximum flood
PMPL	Pastoral Management Pty Ltd
PoW	Programme of works
PPA	Pilbara Ports Authority
PSA	Particle size analysis
PTS	Permanent Threshold Shift
QAQC	Quality Assurance/Quality Control
RMS	Root Mean Square
RPS	RPS Group
Rs	*R. stylosa* (behind Am) mangroves
Rs/AM	*R. stylosa / A. marina* closed canopy mixed mangroves
SC Mangroves	Scattered mangroves
SEL	Sound Exposure Level

Term	Meaning
SI	International System of Units
SKM	SKM Consultants
SoP	Sulphate of Potash
SPL	Species Protection Level
SPL	Sound Pressure Level
SRE	Short-range Endemic
SSC	Suspended sediment concentration
TBT	Tributyltin
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*
TFSA	Terrestrial Fauna Study Area
TOC	Total organic carbon
TPH	Total petroleum hydrocarbons
TRH	Total Recoverable Hydrocarbons
TSSC	Threatened Species Scientific Committee
TTS	Temporary Threshold Shift
UCL	Upper confidence limits
URS	URS Australia Pty Ltd
USA	United Stated of America
WA	Western Australia
WAMSI	Western Australia Marine Science Institute
WET	Whole Effluent Toxicity
YM	Yaburara Mardudhunera
YM People	Yaburara Mardudhunera People
yr	Year
ZoHI	Zone of High Impact
ZoI	Zone of Influence
ZoMI	Zone of Moderate Impact

REFERENCES

Abdul Wahab MA, Fromont J, Pineda MC, Strehlow B, Duckworth A, Jones R, Webster N. (2019). *Defining thresholds and indicators of filter feeder responses to dredging-related pressures - final synthesis report.* Report of Theme 6 – prepared for the Dredging Science Node, Western Australian Marine Science Institution, Perth, Western Australia 26 pp.

actis Environmental (2016). *Independent Review, Wiluna Extension Proposal: Assessment of Potential Impacts on Samphire Vegetation Communities*. Report for Toro Energy.

Allen, G.R. (1982). *A Field Guide to Inland Fishes of Western Australia.*

Allen, G.R. (1997). *Marine Fishes of Tropical Australia and South-East Asia - A field guide for anglers and divers*.

Alongi, D.M., (2009a). *Paradigm shifts in Mangrove Biology: Coastal Wetlands and Integrated Ecosystem Approach*. Elsevier Science, Ch 22: 615-640.

Alongi, D.M., (2009b). *The Energetics of Mangrove Forests*. Springer Science and Business Media

ANZECC & ARMCANZ (2000). *Australian and New Zealand Guidelines for Fresh and Marine Water Quality*. Canberra, ACT.

ANZG 2018. *Australian and New Zealand Guidelines for Fresh and Marine Water Quality*. Australian and New Zealand Governments and Australian state and territory governments, Canberra, ACT, Australia. Viewed [23/04/2019], [http://www.waterquality.gov.au/anz-guidelines].

ASRIS (2014). *Australian Soil Resource Information System*. Department of Agriculture, Forestry and Fisheries Australia, and CSIRO Land and Water. Data available at: http://www.asris.csiro.au/.

Ayling, A.M., and Ayling A.L. (2005). *The dynamics of Cairns and Central Section Fringing Reefs.* Unpublished report submitted to the Great Barrier Reef Marine Park Authority.

Baird (2020a). *Mardie Project Hydrodynamic Modelling*. Report Prepared for Mardie Minerals Pty Ltd.

Baird (2020b). *Mardie Project Dredge Plume Modelli*ng. Report Prepared for Mardie Minerals Pty Ltd.

Baird (2020c). *Mardie Project Bitterns Plume Dispersion Modelling*. Report Prepared for Mardie Minerals Pty Ltd.

Bamford M, Watkins D, Bancroft W, Tischler G and J Wahl. (2008). *Migratory Shorebirds of the East Asian - Australasian Flyway; Population Estimates and Internationally Important Sites*. Wetlands International - Oceania.

Barnett *et al.* (2012). *Australian Groundwater Modelling Guidelines.* Waterlines Report. National Water Commission.

Bell, R. and Richardson, J. I. (1978). *An analysis of tag recoveries from loggerhead sea turtles (Caretta caretta) nesting on Little Cumberland Island, Georgia.* Florida Marine Research Publications. 33: 20-24.

Biota Environmental Services, (2005). *Yannarie Salt Project Mangrove and Coastal Ecosystem Study: Baseline Ecological Assessment.* Prepared for Straits Salt Pty Ltd.

Birdlife Australia. no date. *Internationally significant sites for migratory shorebirds in Australia.*

Boto K.G., Bunt J.S., (1981). *Tidal export of particulate organic matter from a northern Australian mangrove system.* Estuary, Coastal and Shelf Science 13:247–255.

Boto K.G., Bunt J.S., (1982). Carbon export from mangroves. In: *Galbally IE, Freney JR (eds) The cycling of carbon, nitrogen, sulfur and phosphorus in terrestrial and aquatic systems*. Australian Academy of Science, Canberra, pp 105–110

Brown, M., P.J. Corkeron, P.T. Hale, K.W. Schultz & M.M. Bryden (1995). *Evidence for a sex-segregated migration in the humpback whale (Megaptera novaeangliae).* Proceedings of the Royal Society of London B. 259:229-234.

Bulleri, F. & Chapman, M.G. (2004). *Intertidal assemblages on artificial and natural habitats in marinas on the north-west coast of Italy.* Marine Biology, 145: 381– 391.

Bulleri, F. & Chapman, M.G. (2010). *The introduction of coastal infrastructure as a driver of change in marine environments.* Journal of Applied Ecology. 47:26-35.

Bulleri, F. (2005a). T*he introduction of artificial structures on marine soft- and hard-bottoms: ecological implications of epibiota.* Environmental Conservation, 32: 101– 102.

Bulleri, F. (2005b). *Role of recruitment in causing differences between intertidal assemblages on seawalls and rocky shores.* Marine Ecology Progress Series, 287:53– 65.

Bulleri, F. (2006). *Is it time for urban ecology to include the marine realm?* Trends in Ecology and Evolution, 21: 658– 659.

Bureau of Meteorology (2018). *Climate Statistics for Australian Locations – Summary Statistics for Mardie.* Available at www.bom.gov.au/climate/averages/tables/cw_005008.shtml, last accessed 10 November 2018.

Burgess, E.A., J.M. Lanyon & T. Keeley (2012). *Testosterone and tusks: maturation and seasonal reproductive patterns of live, free-ranging male dugongs (Dugong dugon) in a subtropical population.* Reproduction. 14:683-697.

Bustard, H. R. and Limpus, C. (1970). *The first international recapture of an Australian tagged loggerhead turtle*. Herpetologica. 26: 358-359.

CALM (2005). *Indicative Management Plan for the proposed Dampier Archipelago Marine Park and Cape Preston Marine Management Area*.

Carrillo, M. & Ritter, F. (2010). *Increasing numbers of ship strikes in the Canary Islands: Proposals for immediate action to reduce risk of vessel-whale collisions.* Journal of Cetacean Research and Management 11(2):131-138.

Castalanelli, M. A., Teale, R., Rix, M. G., Kennington, J. & Harvey, M. S. 2014. *Barcoding of mygalomorph spiders (Araneae: Mygalomorphae) in the Pilbara region of Western Australia.* Invertebrate Systematics 28: 375–385.

Chaloupka, M. & C. Limpus (2001). *Trends in the abundance of sea turtles resident in southern Great Barrier Reef waters.* Biological Conservation. 102:235-249.

Chaloupka, M. & C.J. Limpus (2002). *Survival probability estimates for the endangered loggerhead sea turtle resident in souther Great Barrier Reef waters.* Marine Biology. 140:267-277.

Chaloupka, M., C. Limpus & J. Miller (2001). *Green Turtle somatic growth dynamics in a spatially disjunct Great Barrier Reef metapopulation.* Coral Reefs. 23:325-335.

Chapman, M.G. (2003) *Paucity of mobile species on constructed seawalls: effects of urbanization on biodiversity.* Marine Ecology Progress Series 264: 21–29.

Chevron. (2010a). *Draft Protected Marine Fauna Management Plan. Wheatstone Project Draft EIS/ERMP*

Chevron. (2010b). *Seagrass Dynamics and the Consequence of Seagrass Loss on Marine Megafauna: A Briefing Note. Final EIS/ Response to the ERMP for the Wheatstone Project*

Chevron. (2014). *Gorgon Project: Offshore Domestic Gas Pipeline Installation Management Plan: Summary.* Document No: G1-NT-PLNX0001302.

Chevron. (2015a). *Wheatstone Project Mid-term State of the Marine Environment Report.*

Chevron. (2015b). *Gorgon Gas Development and Jansz Feed Gas Pipeline – Coastal and Marine Baseline State and Environmental Impact Report: Domestic Gas Pipeline*

Chittleborough, R.G. (1965). *Dynamics of two populations of the Humpback Whale, Megaptera novaeangliae (Borowski)*. Australian Journal of Marine and Freshwater Research. 16:33-128.

Chung, F. C., Pilcher, N. J., Salmon, M. and Wyneken, J. (2009). *Offshore Migratory Activity of Hawksbill Turtle (Eretmochelys imbricata) Hatchlings, I. Quantitative Analysis of Activity, with Comparisons to Green Turtles (Chelonia mydas)*. Chelonian Conservation and Biology, 8(1): 28–34.

Clapham, P.J. (2000). *The humpback whale*. In: Mann, J.C., R.C. Connor, P.L. Tyack & H. Whitehead, eds. Cetacean Societies.

Clynick, B.G., Chapman, M.G. & Underwood, A.J. (2008). *Fish assemblages associated with urban structures and natural reefs in Sydney, Australia.* Austral Ecology, 33: 140– 150.

Commander, D. P. (1994a). *Hydrogeology of the Fortescue River alluvium, Ashburton Plain, Carnarvon Basin.* Geological Survey of Western Australia Professional Papers 37.

Commander, D. P. (1994b). *Hydrology of the Robe River alluvium, Ashburton Plain, Carnarvon Basin*. Geological Survey of Western Australia Professional Papers 37: 75–100.

Cooke, D.A. (1986). Two new species of *Olearia* Moench (Compositae: Astereae) from Central Australia. *Muelleria*. 6(3,4):181-184.

CWR. (2010). *A Description of Mega Fauna Distribution and Abundance in the SW Pilbara Using Aerial and Acoustic Surveys –Final Report 2010.* Wheatstone Project Final Technical Appendices FD. Centre for Whale Research. .

Dawbin, W.H. (1966). *The Seasonal Migratory Cycle of Humpback Whales*. In: Norris, K.R., ed. Whales, Dolphins and Porpoises.:145-170. Berkeley and Los Angeles: University of California Press.

Dawbin, W.H. (1997). *Temporal segregation of humpback whales during migration in Southern Hemisphere waters.* Memoirs of the Queensland Museum. 42:105-138.

de Silva, G. S. 1995. *The status of sea turtle populations in east Malaysia and the South China Sea. In: Biology and Conservation of Sea Turtles, Bjorndal, K. A (Ed)*. Smithsonian Institution Press.

Department of Aboriginal Affairs & Department of the Premier and Cabinet (2013). *Aboriginal Heritage – Due Diligence Guidelines (Version 3.0).*

Department of Agriculutre, Water and the Enviroment (2020). *EPBC Act Condition Setting Policy*

Department of Environmental Regulation (2015a). *Identification and investigation of acid sulphate soils and acidic landscapes.*

Department of Environmental Regulation (2015b). *Treatment and management of soil and water in acid sulphate soil landscapes*.

Department of Mines, Industry Regulation and Safety (2020). *Statutory Guidelines for Mine Closure Plans*

Department of Parks and Wildlife (2017). *Interim guideline for preliminary surveys of night parrot (Pezoporus occidentalis) in Western Australia*.

Department of Parks and Wildlife (2017). *Interim guideline for preliminary surveys of Night Parrot (Pezoporus occidentalis) in Western Australia Parrot (Pezoporus occidentalis) in Western Australia.*

Department of Planning Lands and Heritage (2013) *Geology, Geomorphology and Vulnerability of the Pilbara Coast, in the Shires of Ashburton, East Pilbara and Roebourne, and the Town of Port Hedland, Western Australia*. Available at www.dplh.wa.gov.au; accessed 20 May 2019.

Department of Planning, Lands and Heritage (2013). *Geology, Geomorphology and Vulnerability of the Pilbara Coast, in the Shires of Ashburton, East Pilbara and Roebourne, and the Town of Port Hedland, Western Australia.*

Department of Primary Industries and Regional Development (2007). *Biosecurity and Agriculture Management Act.*

Department of Sustainability, Environment, Water, Population and Communities (2011a). *Survey guidelines for Australia's threatened fish.*

Department of Sustainability, Environment, Water, Population and Communities (2011b). *Survey guidelines for Australia's threatened mammals: Guidelines for detecting mammals listed as threatened under the EPBC Act.*

Department of Sustainability, Environment, Water, Population and Communities (2011c). *Survey guidelines for Australia's threatened reptiles.*

Department of Sustainability, Environment, Water, Population and Communities (2011d). *Approved Conservation Advice for Sternula nereis nereis (Fairy Tern)*

Department of Sustainability, Environment, Water, Population and Communities (2012a). *Environment Protection and Biodiversity Conservation Act 1999 Environmental Offsets Policy.*

Department of Sustainability, Environment, Water, Population and Communities (2012b). Marine bioregional plan for the North-west Marine Region.

Department of Sustainability, Environment, Water, Population and Communities (2011). *Approved Conservation Advice for Aipysurus apraefrontalis (Short-nosed Sea Snake).*

Department of the Environment (2006) Pilbara *Coastal Water Quality Consultation Outcomes – Environmental Values and Environmental Quality Objectives.* Marine Series Report No. 1.

Department of the Environment (2009). *Threat abatement plan to reduce the impacts of exotic rodents on biodiversity on Australian offshore islands of less than 100 000 hectares.*

Department of the Environment (2010). *Environmental Management Plan Guidelines.*

Department of the Environment (2010). *Recovery Plan for Marine Turtles in Australia.*

Department of the Environment (2015a). *Sawfish and River Sharks: Multispecies Recovery Plan.*

Department of the Environment (2015b). *Conservation Advice Numenius madagascariensis Eastern Curlew.*

Department of the Environment (2015c). *Conservation Advice Calidris ferruginea Curlew Sandpiper*

Department of the Environment (2015d). *Threat abatement plan for predation by feral cats.*

Department of the Environment (2016). *EPBC Act Outcomes-based conditions policy.*

Department of the Environment and Energy (2013). *Sawfish and River Sharks Multispecies Recovery Plan.*

Department of the Environment and Energy (2013). *Significant Impact Guidelines: 1.1 – Matters of National Environmental Significance.*

Department of the Environment and Energy (2016a). *Generic guidelines for the content of a draft EPBC Act PER/EIS (including the objects and principles of the EPBC Act, 1999.*

Department of the Environment and Energy (2016b). *Threat abatement plan for competition and land degradation by rabbits.*

Department of the Environment and Energy (2017a). *Recovery Plan for Marine Turtles in Australia.* Canberra, Australia.

Department of the Environment and Energy (2017b). *EPBC Act Policy Statement 3.21—Industry guidelines for avoiding, assessing and mitigating impacts on EPBC Act listed migratory shorebird species*.

Department of the Environment and Energy (2017c). *National Strategy for Reducing Vessel Strike on Cetaceans and other Marine Megafauna.*

Department of the Environment and Energy (2018a). *Environmental Management Plan Guidelines.*

Department of the Environment and Energy (2018b). *Threat Abatement Plan for the impacts of marine debris on the vertebrate wildlife of Australia's coasts and oceans.*

Department of the Environment and Energy (2020). *National Light Pollution Guidelines for Wildlife Including Marine Turtles, Seabirds and Migratory Shorebirds*

Department of the Environment, Water, Heritage and the Arts (2008a). *Threat Abatement Plan for Predation by the European Red Fox*.

Department of the Environment, Water, Heritage and the Arts (2008b). *North-West Marine Bioregional Plan: Bioregional Profile: A Description of the Ecosystems, Conservation Values and Uses of the North-West Marine Region.*

Department of the Environment, Water, Heritage and the Arts (2008c). *Approved Conservation Advice for Green Sawfish*.

Department of the Environment, Water, Heritage and the Arts (2008d). *Approve Conservation Advice for Liasis olivaceus barroni (Olive Python – Pilbara Species).*

Department of the Environment, Water, Heritage and the Arts (2008e). *Approved Conservation Advice for Dermochelys coriacea (Leatherback Turtle).*

Department of the Environment, Water, Heritage and the Arts (2008f). Approved Conservation Advice for *Ctenotus angusticeps* (Airlie Island Ctenotus).

Department of the Environment, Water, Heritage and the Arts (2008g). *EPBC Act Policy Statement 2.1 – Interaction between offshore seismic exploration and whales.*

Department of the Environment, Water, Heritage and the Arts (2008g). *EPBC Act Policy Statement 2.1 – Interaction between offshore seismic exploration and whales.*

Department of the Environment, Water, Heritage and the Arts (2009a). *Threat Abatement Plan for the Impacts of Marine Debris on Vertebrate Marine Life*.

Department of the Environment, Water, Heritage and the Arts (2009b). *National Assessment Guidelines for Dredging.*

Department of the Environment, Water, Heritage and the Arts (2009c). *Threat abatement plan to reduce the impacts of exotic rodents on biodiversity on Australian offshore islands of less than 100 000 hectares 2009.*

Department of the Environment, Water, Heritage and the Arts (2010a). *Survey Guidelines for Australia's threatened bat species.*

Department of the Environment, Water, Heritage and the Arts (2010b). *Survey Guidelines for Australia's threatened birds.*

Department of Water (2009). *Operational Policy 5.12 – Hydrogeological reporting associated with a groundwater well licence*.

Department of Water (2013). *Water quality protection note 27: Liners for containing pollutants, using engineered soils.*

English JP, Colmer TD. (2013). *Tolerance of extreme salinity in two stem-succulent halophytes (Tecticornia species)*. Functional Plant Biology 40: 897–912.

English, J. (2001). *The ecophysiology of Halosarcia*. Salt Lake Workshop, 6th September 2001, Perth, Western Australia, Centre for Land Rehabilitation, UWA.

English, J. P. (2004). *Ecophysiology of salt and waterlogging tolerance in selected species of Halosarcia.* School of Plant Biology. Perth, Western Australia, University of Western Australia: 331.

Environment Australia (1999). *The Action Plan for Australia Bats.*

Environmental Protection Authority & Department of Parks and Wildlife (2015). *Technical Guide – Flora and Vegetation Surveys for EIA.*

Environmental Protection Authority (2001). *Guidance Statement No. 1. Protection of Tropical Arid Zone Mangroves along the Pilbara Coastline.*

Environmental Protection Authority (2004). *Guidance Statement No. 41 – Assessment of Aboriginal Heritage.*

Environmental Protection Authority (2006). *Guidance Statement No. 6 – Rehabilitation of Terrestrial Ecosystems.*

Environmental Protection Authority (2010). *Environmental Assessment Guideline No. 5 – Protecting Marine Turtles from Light Impacts.*

Environmental Protection Authority (2011). *WA Environmental Offsets Policy*.

Environmental Protection Authority (2013). *Environmental Protection Bulletin 20 – Protection of naturally vegetated areas through planning and development.*

Environmental Protection Authority (2014). *WA Environmental Offsets Guidelines*.

Environmental Protection Authority (2016a). *Statement of Environmental Principles, Factors and Objectives 2016.*

Environmental Protection Authority (2016b). *Environmental Factor Guideline: Benthic Communities and Habitats.*

Environmental Protection Authority (2016c). *Technical Guidance – Protection of Benthic Communities and Habitats*.

Environmental Protection Authority (2016d). *Technical Guidance – Protecting the Quality of WA's Marine Environment.*

Environmental Protection Authority (2016e). *Technical Guidance – Environmental Impact Assessment of Marine Dredging Proposals.*

Environmental Protection Authority (2016f). *Environmental Factor Guideline: Marine Environmental Quality.*

Environmental Protection Authority (2016g). *Environmental Factor Guideline: Marine Fauna.*

Environmental Protection Authority (2016h). *Environmental Factor Guideline. Flora and Vegetation*.

Environmental Protection Authority (2016i). *Technical Guidance. Flora and Vegetation Surveys for Environmental Impact Assessment.*

Environmental Protection Authority (2016j). *Checklist for documents submitted for EIA of proposals that have the potential to significantly impact on Sea and Land factors.*

Environmental Protection Authority (2016k). *Environmental Factor Guideline: Terrestrial Environmental Quality.*

Environmental Protection Authority (2016l). *Environmental Factor Guideline. Terrestrial Fauna.*

Environmental Protection Authority (2016m). *Technical Guidance. Sampling Methods for Terrestrial Vertebrate Fauna.*

Environmental Protection Authority (2016n). *Technical Guidance. Terrestrial Fauna Surveys.*

Environmental Protection Authority (2016o). *Technical Guidance. Sampling of Short Range Endemic Invertebrate Fauna.*

Environmental Protection Authority (2016q). *Environmental Factor Guideline: Air Quality.*

Environmental Protection Authority (2016q). *Environmental Factor Guideline: Social Surroundings.*

Environmental Protection Authority (2016r). *Environmental Impact Assessment (Part IV Divisions 1 and 2) Administrative Procedures 2016*.

Environmental Protection Authority (2016s). *EIA (Part IV Divisions 1 and 2) Procedures Manual 2016.*

Environmental Protection Authority (2017). *Instructions on how to define the key characteristics of a proposal.*

Environmental Protection Authority (2018a). *Environmental Impact Assessment (Part IV Divisions 1 and 2) Procedures Manual.*

Environmental Protection Authority (2018b). *Statement of Environmental Principles, Factors and Objectives.*

Environmental Protection Authority (2018c). Environmental Protection Authority. *Instructions on how to prepare an Environmental Review Document.*

Environmental Protection Authority (2018d). *Environmental Factor Guideline. Inland Waters.*

Frazer, N. (1995). L*oggerhead Sea Turtle, Caretta caretta.* In: Plotkin, P., ed. National Marine Fisheries Service and US Fish and Wildlife Service Status Reviews for Sea Turtles Listed under the Endangered Species Act of 1973.

Frick, J. 1976. *Orientation and behaviour of hatchling green turtles (Chelonia mydas) in the sea.* Animal Behaviour 24: 849-857.

Gales, N. M. (2004). *Change in abundance of Dugongs in Shark Bay, Ningaloo & Exmouth Gulf, Western Australia; evidence for large-scale migration.* Wildlife Research 31: 283-290.

GHD (2013). *Environmental best practice port development: An analysis of international approaches.*

Glasby, T.M. (1999)*. Interactive effects of shading and proximity to the seafloor on the development of subtidal epibiotic assemblages.* Marine Ecology Progress Series, 19: 113– 124.

Gordon, D.M., (1988)*. Disturbance to mangroves in tropical-arid Western Australia: hypersalinity and restricted tidal exchange as factors leading to mortality.* Journal of Arid Environments 15: 117-145.

Hadwen, WL, Capon, SJ, Kobashi D, Poloczanska, ES, Rochester, W, Martin, TG, Bay, LK, Pratchett, MS, Green, J, Cook, BD, Berry, A, Lalonde, A, Hall, A & Fahey, S 2011, *Climate change responses and adaptation pathways in Australian coastal ecosystems: Synthesis report*. National Climate Change Adaptation Research Facility, Gold Coast, 359 pp.

Haig, T. (2009). *The Pilbara coast water study.* Department of Water

Hamann, M., C. Limpus & M. Read (2007). Vu*lnerability of marine reptiles to climate change in the Great Barrier Reef.*

Hamann, M., D. Owens & C.J. Limpus (2002). *Reproductive cycles in male and female sea turtles.* In: Lutz, P.L., J. A. Musick & J. Wyneken, eds. Biology of sea turtles. 2.

Hansen, B.D., Fuller, R.A., Watkins, D., Rogers, D.I., Clemens, R.S., Newman, M., Woehler, E.J. and Weller, D.R. (2016). *Revision of the East Asian-Australasian Flyway Population Estimates for 37 listed Migratory Shorebird Species*.

Hazel, J., I. R. Lawler, et al. (2007). *Vessel speed increases collision risk for the green turtle Chelonia mydas*. Endangered Species Research 3(2): 105-113.

Hirth, H. F. 1971. *Synopsis of biological data on the green turtle Chelonia mydas (Linnaeaeus).* 1758 FAO Fish. Symposium, 85.

Hodge, W., Limpus, C. J. and Smissen, P. (2007). *Queensland Turtle Conservation Project: Hummock Hill Island Turtle Survey, 2006*. Conservation technical and data report 2006: 1-6.

Holguin, G., Vazquez, P., and Bashan, Y., (2001). *The role of sediment microorganisms in the productivity, conservation, and rehabilitation of mangrove ecosystems: an overview*. Biology and Fertility of Soils 33:265–278.

Houston, W., Black, R., Elder, R., Black, L. & Segal, R. (2012). *Conservation value of solar salt ponds in coastal tropical eastern Australia to waterbirds and migratory shorebirds.* Pacific Conservation Biology 18: 100-122.

Hughes, D. A. 1974. *The sea turtles of South-East Africa. 2. The biology of Tongaland loggerhead turtle Caretta caretta L. with comments on the leatherback turtle Dermochelys coriacea L. and the green turtle Chelonia mydas in the study region.* Investigational Report of the Oceanographic Research Institute, Durban, South Africa. 36: 1-96.

Huisman JM, Jones DS, Wells FE, Burton T, (2008). *Introduced marine biota in Western Australian waters.* Records of the Western Australian Museum 25: 1–44.

JDA (2012). *Karratha Coastal Vulnerability Study.* Report prepared by JDA Consulting Hydrologists Pty Ltd. Subiaco Western Australia.

Jensen, A.S. & Silber, G.K. (2003). *Large Whale Ship Strike Database. For: U.S. Department of Commerce, NOAA Technical Memorandum*. NMFS-OPR, pp. 37.

Johannes, R.E. & J.W. MacFarlane (1991). *Traditional Fishing in the Torres Strait Islands.*

Johnstone, R. E., Burbidge, A. H. & Darnell, J. C. (2013). *Birds of the Pilbara region, including seas and offshore islands, Western Australia: distribution, status and historical changes.* Records of the Western Australian Museum, Supplement 78: 343–441.

Jones R, Fisher R, Bessell-Brown P, Negri A, Duckworth A (2019). *Theme 4 | Synthesis Report: Defining thresholds and indicators of coral response to dredging-related pressures*. Western Australian Marine Science Institution (WAMSI). Perth, Western Australia pp. 36.

Jones R, Fisher R, Stark C & Ridd P (2015). *Temporal Patterns in Seawater Quality from Dredging in Tropical Environments.* PLoS ONE 10(10): e0137112. doi:10.1371/journal.pone.0137112.

Jones, R. (2016). *Corals of the north west of Western Australia: biogeography and considerations for dredging-related research.* Report of Theme 4 – Project 4.5, prepared for the Dredging Science Node, Western Australian Marine Science Institution (WAMSI).

Kangas, M. S. (2015). *Exmouth Gulf Prawn Managed Fishery.* Western Australian Marine Stewardship Council Report Series No. 1, 2015.

Kendrick, G and Olsen, Y. (2017). *Characterising macroalgal communities of the Pilbara. Macrophyte interactions.* CSIRO.

Kendrick, P & McKenzie, N. (2001). *Pilbara 1 (PIL1 Chichester Subregion).* Western Australian Department of Conservation and Land Management.

Kendrick, P. & Stanley, F. (2001). *Pilbara 4 (PIL4 Roebourne synopsis)*. Western Australian Department of Conservation and Land Management.

Kirk, M., Esler, D. & Boyd, W.S. (2007). *Morphology and density of mussels on natural and aquaculture structure habitats: implications for sea duck predators.* Marine Ecology Progress Series, 346: 179– 187.

Kyne, P.M. and Pillans, R.D. (2014). *Protocols for Surveying and Tagging Sawfishes and River Sharks.*

Laist, D.W., Knowlton, A.R., Mead, J.G., Collet, A.S. & Podesta, M. (2001). *Collisions between ships and whales.* Marine Mammal Science 17(1): 35-75.

Lam, N.W.Y., Huang, R. & Chan, B.K.K. (2009) Variations in intertidal assemblages and zonation patterns between vertical artificial seawalls and natural rocky shores: a case study from Victoria Harbour, Hong Kong. Zoological Studies 48: 184–195.

Lee, R. Y. and Joye, S. B., (2006). *Seasonal patterns of nitrogen fixation and dentrification in oceanic mangrove habitats*. Marine Ecology Progress Series 307: 127-141.

Leighton, K. A. (2004). "Climate". In: van Vreeswyk, A. M. E., Payne, A. L., Leighton, K. A. & Hennig, P. (eds) *Technical Bulletin 9. An inventory and condition survey of the Pilbara region, Western Australia*.

LeProvost Environmental Consulting, (1991). *Intertidal Habitats of Onslow to Turbridgi Point and Locker Island*. Prepared for West Australian Petroleum Pty Ltd, March 1991.

Limpus D.J., &. L. (2000). *Mangroves in the Diet of Chelonia mydas in Queensland.* Australia Marine Turtle Newsletter 89:13-15.

Limpus, C. J. (1973). *Avian predators of sea turtles in southeast Queensland rookeries*. The Sunbird. 4:45-41.

Limpus, C., Gyuris, E., Miller, J.D,. (1988). *Reassessment of the taxonomic status of the sea turtle genus Natator.* Transactions of the Royal Society of South Australia. 112:1-9.

Limpus, C.J. & D.J. Limpus (2003). *Loggerhead turtles in the equatorial and southern Pacific Ocean: A species in decline.* In: Bolten, A. and B. Witherington, eds. Loggerhead Sea Turtles. Page(s) 199-210. Washington, D. C: Smithsonian Institution Press.

Limpus, C.J. (1971). *The flatback turtle, Chelonia depressa garman in southeast Queensland, Australia.* Herpetologica. 27:431-446.

Limpus, C.J. (1995a). *Conservation of marine turtles in the Indo-Pacific region.* Brisbane: Queensland Department of Environment and Heritage.

Limpus, C.J. (2007). *A biological review of Australian marine turtle species*. 5. Flatback turtle, Natator depressus (Garman). Queensland Environmental Protection Agency.

Limpus, C.J., C.J. Parmenter, R. Parker & N. Ford (1981). *The flatback turtle Chelonia depressa in Queensland: the Peak Island rookery.* Herpetofauna. 13(1):14-18.

Limpus, C.J., C.J. Parmenter, V. Baker & A. Fleay (1983a). *The Crab Island sea turtle rookery in north-eastern Gulf of Carpentaria.* Australian Wildlife Research. 10:173-184.

Limpus, C.J., C.J. Parmenter, V. Baker & A. Fleay (1983b). *The flatback turtle, Chelonia depressa, in Queensland: post-nesting migration and feeding ground distribution*. Australian Wildlife Research. 10:557-561.

Limpus, C.J., D. Zeller, D. Kwan & W. Macfarlane (1989). *Sea-turtle rookeries in northwestern Torres Strait (Australia)*. Australian Wildlife Research. 16(5):517-526.

Limpus, C.J., P.J. Couper & K.L.D. Couper (1993). *Crab Island revisited: reassessment of the world's largest flatback turtle rookery after twelve years.* Memoirs of the Queensland Museum. 33(1):277-289.

Limpus, C.J., T.A. Walker & J. West (1994e). P*ost-hatchling sea turtle specimens and records from the Australian region*. In: James, R., ed. Proceedings of the Australian Marine Turtle Conservation Workshop, Gold Coast 14-17 November 1990. Page(s) 95-100. Canberra, ANCA.

Loneragan, N., Hodgson, A., Bejder, L and Allen, S. (2012). *Coastal dolphins in north-western Australia: The need for re-evaluation of species listings and short-comings in the Environmental Impact Assessment Process.* Pacific Conservation Biology 18(1): 22 -25.

Loneragan, N., Hodgson, A., Bejder, L and Allen, S. (2012). *Coastal dolphins in north-western Australia: The need for re-evaluation of species listings and short-comings in the Environmental Impact Assessment Process.* Pacific Conservation Biology 18(1): 22 -25.

Lorne, J. K. and Salmon, M. (2007). *Effects of exposure to artificial lighting on orientation of hatchling sea turtles on the beach and in the ocean.* Endangered Species Research 3:23-30.

Manson, F. L. (2005). *An evaluation for linkages in between mangroves and fisheries: A Synthesis of the Literature and Identification for Research Directions.* Oceanography and Marine Biology 43: 485-515.

Marsh, H., & D. Kwan (2008). *Temporal variability in the life history and reproductive biology of female dugongs in Torres Strait: The likely role of sea grass dieback.* Continental Shelf Research. 28:2152-2159.

Marsh, H., A. Grech & R. Hagihara (2011). *Aerial survey of Torres Strait to evaluate the efficacy of an enforced and possibly extended Dugong Sanctuary as one of the tools for managing the dugong fishery.* Report to the Australian Marine Mammal Centre and the Torres Strait Regional Authority.

Masero, J. A. & Pérez-Hurtado, A. (2001). *Importance of the supratidal habitats for maintaining overwintering shorebird populations: how redshanks use tidal mudflats and adjacent saltworks in southern Europe.* Condor 103: 21-30.

Mattison, C., Burney, C. and Fisher, L. (1993). *Trends in the spatial distribution of sea turtle activity on an urban beach (1981-1992).* in Schroeder, B. and Witherington, B. (eds) Proceedings of the Thirteenth Annual Symposium on Sea Turtle Biology and Conservation. NOAA Technical Memorandum NMFS-SEFC-341.

McCauley, R.D., Fewtrell, J., Duncan, A.J., Jenner, C., Jenner, M.-N., Penrose, J.D., Prince, R.I.T., Adhitya, A., Murdoch, J., McCabe, C. (2000) *Marine seismic surveys: analysis and propagation of air gun signals; and effects of air gun exposure on humpback whales, sea turtles, fishes and squid. Report on research conducted for The Australian Petroleum Production and Exploration Association*. CMST Report 99-15: 185.

McClellan, C.M & A.J Read (2007). *Complexity and variation in loggerhead sea turtle life history.* Biology Letters. 3:592-594.

McDonald J, (2008). *A likelihood analysis of non-indigenous marine species introduction to fifteen ports in Western Australia*. Department of Fisheries, Western Australia, Fisheries Research Report 182: 1–36 .

McDonald. J, Bridgwood. S, Hourston. M. (2015). *Likelihood of Marine Pest introduction to the Indian Ocean Territories*. Fisheries Research Report No. 264. 40pp.

McKenzie, L.J., Erftemeijer, P and Coles, R. (2006). *Seagrass ecosystems of Papua.The Ecology of Papua (Volume I & II),* Chapter:5.3 (Voll II). Periplus Editions (Singapore), pp. 800-823. Research Gate, https://www. reaserchgate.net/publication/283043957.

McKenzie, N. L., van Leeuwen, S. & Pinder, A. M. 2009. I*ntroduction to the Pilbara Biodiversity Survey, 2002–2007*. Records of the Western Australian Museum, Supplement 78: 3–89.

McMahon K, Statton J and Lavery P. (2017). *Seagrasses of the north west of Western Australia: biogeography and considerations for dredging-related research.* Report of Theme 5 - Project 5.1.2 prepared for the Dredging Science Node, Western Australian Marine Science Institution, Perth.

Miller, J.D. & C.J. Limpus (1981). *Incubation period and sexual differentiation in the Green Turtle Chelonia mydas L.* In: Banks, C. B. & A. A. Martin, eds. Proceedings of the Melbourne Herpetological Symposium. Page(s) 66-73. Melbourne, The Zoological Board of Victoria.

Moreira, J., Chapman, M.G. & Underwood, A.J. (2006). S*eawalls do not sustain viable populations of limpets. Marine Ecology Progress Series,* 322:179– 188.

Mortimer, J. A. 1979. Ascension Island: British jeopardize 45 years of conservation. Marine Turtle Newsletter 10 7-8. Mortimer, J. A. (1982). *Factors affecting beach selection by nesting sea turtles. in Bjorndal, K. A. (ed.) Biology and Conservation of Sea Turtles.* Revised Edition. Smithsonian Institution Press, Washington DC.

Moschella, P.S., Abbiati, M., Aberg, P., Airoldi, L., Anderson, J.M., Bacchiocchi, F., Bulleri, F., Dinesen, G.E., Frost, M., Gacia, E., Granhag, L., Jonsson, P.R., Satta, M.P., Sundelo f, A., Thompson, R.C. & Hawkins, S.J. (2005). *Low-crested coastal defence structures as artificial habitats for marine life: using ecological criteria in design.* Coastal Engineering 52: 1053–1071.

MScience (2009). *Wheatstone LNG Development: Baseline Water Quality Assessment Report.* Report to URS Australia Pty Ltd.

Nano, C. & Pavey, C. (2008). *National Recovery Plan for Olearia macdonnellensis, Minuria tridens (Minnie Daisy) and Actinotus schwarzii (Desert Flannel Flower)*.

Nano, C., R. Kerrigan & D. Albrecht (2012). *Threatened Species of the Northern Territory - Minuria tridens.*

National Oceanic and Atmospheric Administration (2016). *Technical Guidance for Assessing the Effects of Anthropogenic Sound on Marine Mammal Hearing*.

National Research Cnetre (2005). *Marine Mammal Populations and Ocean Noise, Determining When Noise Causes Biologically Significant Effect.* Washington, DC: The National Academies Press.

Nedwell J. R., Parvin S.J., Edwards B., Workman R., Brooker A.G., and Kynoch J.E., (2007). *Measurement and interpretation of underwater noise during construction and operation of offshore windfarms in UK waters.* Subacoustech Report No. 544R0738 to COWRIE Ltd.

Nedwell, J. and Howell, D. (2004). *A review of offshore windfarm related underwater noise sources.* Subacoustec Report No. 544 R0308.

NIMPCG (2009a). *Marine pests monitoring manual: Version 1c. National Introduced Marine Pests Coordination Group.*

NIMPCG (2009b). *Australian marine pests monitoring guidelines:Version 1c. National Introduced Marine Pests Coordination Group*.

NSW Office of the Environment and Heritage (2015). *Floodplain Risk Management Guide.*

O2 Marine (2019a). *Mardie Project Sediment Quality Assessment.* Report Prepared for Mardie Minerals Pty Ltd.

O2 Marine (2019b). *Mardie Project Whole Effluent Toxicity Assessment.* Report Prepared for Mardie Minerals Pty Ltd.

O2 Marine (2020a). *Mardie Project Intertidal Benthic Communities and Habitat.* Report Prepared for Mardie Minerals Pty Ltd.

O2 Marine (2020b). *Mardie Project Subtidal Benthic Communities and Habitat.* Report prepared for Mardie Minerals Pty Ltd.

O2 Marine (2020c). *Mardie Project Benthic Communities & Habitat Cumulative Loss Assessment.* Report Prepared for Mardie Minerals Pty Ltd.

O2 Marine (2020d). *Mardie Project Expert Advice On The Significance Of The BCH Impacted By The Proposal From A Local And Regional Perspective.* Report Prepared for Mardie Minerals Pty Ltd.

O2 Marine (2020e). *Marine Environmental Quality Monitoring and Management Plan*. Report Prepared for Mardie Minerals Pty Ltd.

O2 Marine (2020f). *Mardie Project Marine Water Quality Baselin*e. Report Prepared for Mardie Minerals Pty Ltd.

O2 Marine (2020g). *Mardie Project Marine Fauna Review.* Report Prepared for Mardie Minerals Pty Ltd.

O2 Marine (2020h). *Mardie Project: Introduced Marine Pest Risk Assessment*. Report Prepared for Mardie Minerals Pty Ltd.

O2 Marine (2020i). *Dredge and Spoil Disposal Management Plan*. Report Prepared for Mardie Minerals Pty Ltd.

Paling, E.I. and A.J. McComb, (1994). *Cyanobacterial Mats: A Possible Nitrogen Source for Arid-Coast Mangroves*. International Journal of Ecology and Environmental Sciences, 20: 47-54.

Paling, E.I., (1990). *Report on the Biological Environments near Onslow, Western Australia*. Report prepared for Gulf Holdings Pty Ltd, April 1990.

Paling, E.I., Humphreys, G., and McCardle, I. (2003). *The effect of a harbour development onmangroves in northwestern Australia. Wetlands Ecology Management, Vol 54:, 281-290.*

Paling, EI, McComb, AJ & Pate, JS (1989). *Nitrogen Fixation (Acetylene Reduction) in Nonheterocystous Cyanobacterial Mats from the Dampier Archipelago, Western Australia*. Australian Journal of Marine and Freshwater Research. 40: 147-153.

Papi, F., Liew, H. C., Luschi, P. and Chan, E. H. 1995. Long-range migratory travel of a green turtle tracked by satellite: evidence for navigational ability in the open sea. Marine Biology. 122, 171-175.

Parmenter, C.J. and Limpus, C.J (1995). *Female recruitment, reproductive longevity and inferred survivorship for the flatback turtle (Natator depressus) at a major eastern Australian rookery.* Copeia. 1995:474-477.

Parra, G.J., & D. Cagnazzi (2016). *Conservation Status of the Australian Humpback Dolphin (Sousa sahulensis) Using the IUCN Red List Criteria.* Advances in Marine Biology. 73:157-192.

Paton, D. (2006). *Personal Communication.* Southern Cross University.

Paton, D.A., & E. Kniest (2011). Po*pulation growth of Australian East coast humpback whales, observed from Cape Byron, 1998 to 2004.* Journal of Cetacean Research Management. Sp Iss 3:261-268.

Paton, D.A., L. Brooks, D. Burns, T. Franklin, W. Franklin, P. Harrison & P. Baverstock (2011). *Abundance of East coast Australian humpback whales (Megaptera novaeangliae) in 2005 estimated using multi-point sampling and capture-recapture analysis.* Journal of Cetacean Research Management. Sp Iss 3:253-259

Pendoley Environmental (2019a). *Mardie Salt Project Marine Turtle Monitoring Program 2018/19.* Report Prepared for Mardie Minerals Pty Ltd.

Pendoley Environmental (2019b) *Pump Station Work Platform Lighting: Advisory Memo*. Prepared for Mardie Minerals Pty Ltd

Pendoley, K.L., Bell, C.D., Mccracken, R., Ball, K.R., Sherborne, J., Oates, J.E., Becker, P., Vitenbergs, A. & Whittock, P.A. (2014). *Reproductive biology of the flatback turtle Natator depressus in Western Australia.* Endangered Species Research, 23(2): 115-123.

Pendoley, K.L., Whittock, P.A., Vitenbergs, A. & Bell, C. (2016). *Twenty years of turtle tracks: marine turtle nesting activity at remote locations in the Pilbara, Western Australia.* Australian Journal of Zoology, 64(3): 217-226.

Perkol-Finkel, S. & Benayahu, Y. (2004) C*ommunity structure of stony and soft corals on vertical unplanned artificial reefs in Eilat (Red Sea): comparison to natural reefs.* Coral Reefs. 23: 195–205.

Peverell, S. (2005). *Distribution of Sawfishes (Pristidae) in the Queensland Gulf of Carpentaria, Australia - with notes on sawfish ecology.* Environmental Biology of Fishes. 73:391-402.

Peverell, S., N. Gribble & H. Larson (2004). *'Sawfish'. In: National Oceans Office, Description of Key Species Groups in the Northern Planning Area.*

Peverell, S.C. & R.D. Pillans (2004). D*etermining feasibility of acoustic tag attachment and documenting short-term movement in Pristis zijsron Bleeker, 1851*. Report for the National Oceans Office.

Phoenix (2020a). *Detailed Flora and Vegetation Survey for the Mardie Project.* Report prepared for Mardie Minerals Pty Ltd.

Phoenix (2020b). *Level 2 Targeted Terrestrial Fauna Survey for the Mardie Salt Project.* Report prepared for Mardie Minerals Pty Ltd.

Poiner, I.R & C. Peterkin (1996). Seagrasses. In: Zann, L.P., & P. Kailola, eds. *The State of the Marine Environment Report for Australia.* Technical Annex: 1. Page(s) 40-45.

Prange, H. D. and Jackson, D. C. 1976(*Ventilation, gas exchange, and metabolic scaling of a sea turtle.* Respiration Physiology 27: 369-377.

Preen, A.R. & H. Marsh (1995). R*esponse of Dugongs to large-scale loss of seagrass from Hervey Bay, Queensland, Australia.* Wildlife Research. 22:507-519.

Preston (2017). *Mardie Solar Salt Project Gap Analysis of Environmental Studies.* Unpublished report prepared for Mardie Minerals Pty Ltd.

Preston (2018). *Mardie Project Environmental Scoping Document.* Report prepared for Mardie Minerals Pty Ltd.

Purvis, J.E., Datson, B., Meney, K., McComb, J. (2009). *Effect of salt on germination of samphire species.* Natural Resources and ENviromentla Issues 15 (1).

Raymond, P. W. (1984). *Sea turtle hatchling disorientation and artificial beachfront lighting.* Centre for Environmental Education, Washington DC.

Rich, C. and Longcore, T. (eds) (2006). *Ecological Consequences of Artificial Night Lighting.* Island Press, Washington.

Richardson WJ, Greene CRJ, Malme CI, Thomson DH, (1995). *Marine mammals and noise.* Academic Press, San Diego, 576 pp.

Robins, C.M., A.M. Goodspeed, I. Poiner & B.D. Harch (2002). *Monitoring the catch of turtles in the Northern Prawn Fishery.* Fisheries Research and Development Corporation. Department of Agriculture, Fisheries & Forestry: Canberra.

Robins, J.B. (1995). *Estimated catch and mortality of sea turtles from the East Coast Otter Trawl Fishery of Queensland, Australia*. Biological Conservation. 74:157-167.

RPS (2017b). *Mardie Salt Project Preliminary Storm Surge Study.* Unpublished report prepared for BCI Minerals Pty Ltd.

RPS (2017c). *Mardie Salt Project - Pre-Feasibility Hydraulic Assessment: Preliminary Results*. Unpublished report prepared for BCI Minerals Pty Ltd.

RPS (2017d). *Mardie Salt Project - Pre-Feasibility Hydraulic Assessment: Preliminary Results (II).* Unpublished report prepared for BCI Minerals Pty Ltd.

RPS (2018). *Mardie Salt Project Pre-Feasibility Surface Water Assessment (Updated).* Unpublished report prepared for BCI Minerals Pty Ltd.

RPS (2019a). *BCI Mardie Development Coastal Inundation Studies.* Unpublished report prepared for BCI Minerals Pty Ltd.

RPS (2019b). *Mardie Salt Project - Pre-Feasibility Surface Water Assessment.* Unpublished report prepared for BCI Minerals Pty Ltd.

RPS (2020). *Mardie Project - Comparison Of Inundation Over The North-Eastern Floodway With Construction Of A Road Causeway.* Unpublished report prepared for BCI Minerals Pty Ltd.

RPS. (2010a). *Marine Mammals Technical Report*. Wheatstone Project Draft EIS/ERM.

RPS. (2010b). *Dugong Aerial Survey Report.* Final EIS/ Response to ERMP for the Wheatstone Project.

RPS. (2010c). Identification and Risk Assessment of Marine Matters of National Environmental Significance. Final EIS/ Response to ERMP for the Wheatstone Project Appendix FF.

Rufino, R., A. Araujo, J. P. Pina and P. Miranda. (1984). *The use of salinas by waders in the Algarve, south Portugal.* Wader Studies Group Bulletin 42: 41-42.

Ryan, D. A., Heap, A. D., Radke, L., and Heggie, D. T., (2003). *Conceptual models of Australia's estuaries and coastal waterways: applications for coastal resource management.* Geoscience Australia, Record 2003/09, 136 pp.

Sadoul, N., J. Walmsley, and B. Charpentier. (1998). *Salinas and nature conservation.* Conservation of Mediterranean Wetlands.

Salmon, M. and Wyneken, J. (1987). *Orientation during the swimming frenzy period in loggerhead sea turtles*. Journal of Experimental Marine Biology 109: 137-153.

Sampath, K. & Krishnamurthy, K. (1989). *Shorebirds of the salt ponds at the Great Vedaranyam Salt Swamp, Tamil Nadu, India.* Stilt 15: 20-30.

Sanchez *et al.* (2016). *Functional Role of Native and Invasive Filter-Feeders, and the effect of Parasites: Learning from Hypersaline Ecosystems.* Public Library of Science. Doi:10.1371/journal.pone.0161478

Semeniuk, V. (1993). *The Pilbara Coast: a riverine coastal plain in a tropical arid setting, northwestern Australia*. Sedimentary Geology 83: 235-356.

Shepherd, D. P., Beeston, G. R. & Hopkins, A. J. M. (2002). *Native vegetation in Western Australia. Extent, type and status.*Technical Report 249.

Shigenaka, G. (2003). *Oils and sea turtle: biology, planning, and response*. Office of Response and Restoration, NOAA Ocean Service, Seattle, USA.

Sinclair Knight Merz (2011). *Port Hedland Outer Harbour* Development. Benthic Primary Producer Assessment: Intertidal. Appendix 13, Port Hedland Outer Harbour Development Project Referral to the EPA. Report prepared for BHP Billiton, October 2011.

SKM (2013). *Iron Ore Holdings Buckland Project: Marine Geotechnical Investigations.* Unpublished report prepared for Iron Ore Holdings Pty Ltd.

Sobtzick, S., H. Marsh & M. Brown (2015). *Developing an integrated publicly-accessible online database for the 30 year time series of dugong aerial survey data.* Final report to the Australian Marine Mammal Centre, Project 13/26. May 2015.

Soilwater Group (2019a). *Mardie Project Seepage Model Results and Potential Environmental Impacts*. Unpublished memo prepared for BCI Minerals Pty Ltd.

Soilwater Group (2019b). *Summary of laboratory results, Mardie Project.* Unpublished memo to CMW Geosciences, prepared on behalf of Mardie Minerals Pty Ltd.

Soilwater Group (2020) *Results of ASS screen testing carried out on floodway samples*. Unpublished memo prepared for BCI Minerals Pty Ltd

Southall BL, Bowles AE, Ellison WT, Finneran JJ, Gentry RL, (2007). *Criteria for Behavioural Disturbance.* Aquatic Mammals, 33 (4): 446.

Stantec (2017a). *Stage A: Acid Sulfate Soils Investigation Mardie Salt Project.* Unpublished report prepared for BC Iron Pty Ltd.

Stantec (2017b). *Mardie Solar Salt Project – Project Layout Advice*. Unpublished report prepared for BC Iron Pty Ltd.

Stantec (2018). *Assessment of Mangal and Algal Communities for the Mardie Solar Project.* Unpublished report prepared for Mardie Minerals Pty Ltd.

Stead, D.G. (1963). *Sharks and rays of Australian seas*.

Stevens, J.D., R.D. Pillans & J. Salini (2005). C*onservation Assessment of Glyphis sp. A (Speartooth Shark), Glyphis sp. C (Northern River Shark), Pristis microdon (Freshwater Sawfish) and Pristis zijsron (Green Sawfish).*

Takekawa, J. T., Lu, C. T. & Pratt, R. T. (2001). *Avian communities in baylands and artificial salt evaporation pondsof the San Francisco Bay estuary.* Hydrobiologia 466: 317-328

Talis (2019). *Mardie Salt Project Underwater Noise Assessment .* Unpublished report prepared for Mardie Minerals Pty Ltd.

Thorburn, D.C., S. Peverell, S. Stevens, J.D. Last & A.J. Rowland (2004). *Status of Freshwater and Estuarine Elasmobranches in Northern Australia.* Report to Natural Heritage Trust.

Threatened Species Scientific Committee (2011a). *Approved Conservation Advice for Aipysurus apraefrontalis (Short-nosed Sea Snake).*

Threatened Species Scientific Committee (2011b). *Commonwealth Listing Advice on ten species of Bats.*

Threatened Species Scientific Committee (2012). *Commonwealth Listing Advice on Minuria tridens (Minnie Daisy).*

Threatened Species Scientific Committee (2015). *Conservation Advice Megaptera novaeangliae humpback whale.*

Threatened Species Scientific Committee (2016a). *Conservation Advice Rhinonicteris aurantia (Pilbara form) (Pilbara Leaf-nosed Bat)*.

Threatened Species Scientific Committee (2016b). *Conservation Advice Calidris canutus Red knot*.

Threatened Species Scientific Committee (2016c). *Conservation Advice Calidris tenuirostris Great knot.*

Threatened Species Scientific Committee (2016d). *Conservation Advice Charadrius mongolus Lesser sand plover.*

Threatened Species Scientific Committee (2016e). *Approved Conservation Advice Charadrius leschenaultii Greater sand plover.*

Tuxbury, S. and Salmon, M. (2005). *Competitive interactions between artificial lighting and natural cues during seafinding by hatchling marine turtles.* Biol. Conserv. 121:311-316.

URS, (2010a). *Report: Wheatstone Project Intertidal Habitats of the Onslow Coastline*. Prepared for Chevron Australia Pty Ltd, May 2010.

URS. (2010b). *Wheatstone Project Draft EIS/ERMP Technical Appendices N11 Survey of Intertidal Habitats off Onslow, WA .*

URS. (2010c). *Biota of subtidal habitats in the Pilbara Mangroves, with particular reference to the Ashburton Delta and Hooley Creek. Wheatstone Project Draft EIS/ERMP.*

URS. (2010d). *Wheatstone Project Literature Review of Listed Marine Fauna.* Wheatstone Project Draft EIS/ERMP.

URS. (2010e). *Possible Effects of Underwater Noise on Marine Fauna and Fish in the Wheatstone Project Area.* Wheatstone Project Draft EIS/ERMP

URS. (2011). *Potential Interactions with the Onslow Prawn Managed Fishery. Final EIS/Response* To Submissions on the ERMP for the Wheatstone Project.

van Waerebeek, K., Baker, A.N., Felix, F., Gedamke, J., Iniguez, M., Sanino, G.P., Secchi, E., Sutaria, D., van Helden, A. & Wang, Y.(2007) *Vessel collisions with small cetaceans worldwide and large whales in the Southern Hemisphere, An initial assessment.* Latin American Journal of Aquatic Mammals 6(1):43-69.

Vanderlaan, A. S. M. and Taggart, C. T. (2006). *Vessel Collisions With Whales: The Probability Of Lethal Injury Based On Vessel Speed*. Marine Mammal Science, 23 (1): 144-156.

Vang, L. (2002). *Distribution, abundance and biology of Group V humpback whales* Megaptera novaeangliae*: A review*. Report to the Queensland Government.

Vaselli, S., Bulleri, F. & Benedetti-Cecchi, L. (2008). *Hard coastal-defence structures as habitats for native and exotic rocky-bottom species*. Marine Environmental Research, 66: 395– 403.

Velasquez, C. (1992). *Managing artificial saltpans as a waterbird habitat: species' response to water level manipulation.* Colonial Waterbirds 15: 43-55.

Velasquez, C. (1993). *The ecology and management of waterbirds at commercial saltpans in South Africa. Ph.D. Dissertation thesis.* University of Capetown, South Africa.

Warnock, N. & PRBO Conservation Science. *Synthesis Of Scientific Knowledge For Managing Salt Ponds To Protect Bird Populations: South Bay Salt Pond Restoration Projec*t.

Weinrich, M. (2004). *A review of worldwide collisions between whales and fast ferries*. Report to the Scientific Committee of the International Whaling Commission, SC/56/BC9.

Wells, F.E. (2018). *A low number of invasive marine species in the tropics: a case study from Pilbara (Western Australia)* Management of Biological Invasions (2018) Volume 9, Issue 3: 227–237.

Western Australian Herbarium (1998). *Cassytha aurea J.Z.Weber var. aurea .FloraBase*—the Western Australian Flora. Department of Biodiversity, Conservation and Attractions. https://florabase.dpaw.wa.gov.au/

Wilson P et al (2018). *Artificial light disrupts the nearshore dispersal of neonate flatback turtles Natator depressus*. Marine Ecology Progress Series, MEPS 600: 179-192.

Witherington, B. E. (1991). *Orientation of hatchling loggerhead turtles at sea off artificially lighted and dark beaches*. Journal of Experimental Marine Biology and Ecology, 149: 1-11.

Witherington, B. E. and Martin, R. E. (2000). *Understanding, Assessing and Resolving Light-Pollution Problems on Sea Turtle Nesting Beaches.* Florida Fish and Wildlife Conservation Commission FMRI Technical Report TR-2, Second Edition, Revised.

Wyneken, J. (1997). *Sea turtle locomotion: Mechanism, Behaviour and Energetics.* CRC Press (edt. by Lutz, P.L. and Musick, J.A.) 165-198.