GROUNDWATER MONITORING &

Mardie Salt and Potash Project
MANAGEMENT PLAN

DOCUMENT CONTROL

O	21-02 2025	Updated to respond to DWER comments	Mardie Minerals	Snyman Van Straaten	Shaun Meredith
N	15-01-2025	Updated after Pond 3 filling completed	Mardie Minerals	Snyman Van Straaten	Shaun Meredith
M	31-08-2024	Revised to respond to DCCEEW comments	Mardie Minerals	Karen Frehill	Shaun Meredith
L	30-04-2024	Revised to respond to DWER and DCCEEW comments	Mardie Minerals	Hamish Manzi	Shaun Meredith
K	19-03-2024	Revised to respond to DWER and DCCEEW comments	Mardie Minerals	Matt Spence	Shaun Meredith
J	21-12-2023	Revised to respond to DWER comments	Mardie Minerals	Matt Spence	Spencer Shute
I	21-11-2023	Revised to respond to DCCEEW comments	Mardie Minerals	Arron Minchin	David Boshoff
H	06-11-2023	Revised to respond to DCCEEW comments	Oscar Dalla Pria Bruce Harvey	Spencer Shute	Spencer Shute
G	25-8-2023	Revised with new data	Bruce Harvey	Gavin Edwards	Spencer Shute
F	22-03-2023	Revised per EPA comments	Bruce Harvey	Julie Mahony	Angela Glover
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PROJECT SUMMARY

Action: To construct and operate the Mardie salt and sulphate of potash project, 80 km south-west of Karratha, Pilbara region, Western Australia.

Mardie Project Approvals: Ministerial Statement (MS) 1211 (replaces the superseded 1175) & EPBC 2018/8236 (as varied)

Optimised Mardie Project Approval: MS 1211 & EPBC 2022/9169.

Proponent: Mardie Minerals Pty Ltd (ABN 50 152 574 457)

DECLARATION OF ACCURACY

In making this declaration, I am aware that sections 490 and 491 of the *Environment Protection and Biodiversity Conservation Act 1999* (Cth) (EPBC Act) make it an offence in certain circumstances to knowingly provide false or misleading information or documents. The offence is punishable on conviction by imprisonment or a fine, or both. I declare that all the information and documentation supporting this Monitoring Plan is true and correct in every particular. I am authorised to bind the approval holder to this declaration and that I have no knowledge of that authorisation being revoked at the time of making this declaration.

Signed:

Name:	Shaun Meredith
Position:	Head of Environment and Heritage
Organisation:	Mardie Minerals
ABN 50 152 574 457	

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LIST OF ACRONYMS AND ABBREVIATIONS

Term	Definition
°C	Degrees Celsius
µS/cm	Salinity measured as microsemens per centimeter
ANZG	Australian and New Zealand Guidelines
ARIMA	Auto Regressive Integrated Moving Average
BCH	Benthic Communities and Habitats
BCHMMP	Benthic Communities and Habitats Monitoring and Management Plan
BCI	BCI Minerals Limited; the Company
CAR	Compliance Assessment Report
cm	Centimetres
Company	BCI Minerals Limited; BCI
Contractor	Persons appointed by the Company to undertake the works as described in the contract.
DAA	Data Analytics Australia
DBCA	Department of Biodiversity Conservation and Attractions
DCCEEW	Department of Climate Change, Energy, the Environment and Water
DE	Development Envelope
DPLH	Department of Planning, Lands and Heritage
DTW	Dynamic Time Warping
DWER	Department of Water and Environmental Regulation
EC	Electrical Conductivity
ENSI	Ensemble Space Inversion
EPA	Environmental Protection Authority
EPBC Act	*Environment Protection and Biodiversity Conservation Act 1999* (Commonwealth)
GMMP	Groundwater Monitoring and Management Plan
GMRPF	Groundwater Management Response Plan Framework
HSU	Hydrostratigraphic units
kg/m^3	Kilogram per cubic metre
kL	Kilolitre
km	Kilometres

Term	Definition
L	Litre
M. tridens	*Minuria tridens*; “Minnie Daisy”
m	Meter
m^3	Cubic meter
mAHD	Metres Australian Heigh Datum
m-BACI	Modified Before-After Control-Impact
mm	Millimetres
mbgl	Meters below ground level
mg/L	Milligram per Litre
MNES	Matter of National Environmental Significance
mRL	Meters Relative Level
MS	Ministerial Statement
MRWA	Main Roads Western Australia
MSMMP	Migratory Shorebird Monitoring and Management Plan
NDVI	Normalised Difference Vegetation Index
OMP	Optimised Mardie Project
PMPL	Pastoral Management Pty Ltd
PPA	Pilbara Ports Authority
ppm	Part per million
Project	The Mardie Salt and Potash Project
PSWI	Primary Sea Water Intake
PSU	Particle Size Unit
RRKAC	Robe River Kuruma Aboriginal Corporation
SOP	Sulphate of potash
SSWI	Secondary Sea Water Intake
Sub-Contractor	Persons appointed to undertake the works as described in the Contract on behalf of the Contractor.
TDS	Total Dissolved Solids
WA	Western Australia
WAC	Wirrawandi Aboriginal Corporation

1. EXECUTIVE SUMMARY

This Groundwater Monitoring and Management Plan (GMMP) (Rev O) is submitted by Mardie Minerals Pty Ltd (Mardie Minerals) in support of the Mardie Project Ministerial Statement (MS) 1211, EPBC 2018/8236 (as varied) and the Optimised Mardie Project (EPBC 2022/9169). The GMMP has been developed to align with the Environmental Protection Authority (EPA) *Instructions and Templates for Part IV Environmental Management Plans* (EPA, 2021a) and the Commonwealth's *Environmental Management Plan Guidelines* (Commonwealth, 2014).

This GMMP has been prepared to address the specific approval condition requirements (Table 2-3) and to address comments from DWER, DCCEEW and several independent reviewers received over multiple revisions of this plan.

The purpose of the GMMP is to ensure that:

- Changes to the health, diversity, and extent of benthic communities and habitat (BCH) (including subtidal macroalgae) as a result of changes to surface water, groundwater quality, groundwater regimes, and marine environmental quality associated with the proposal are detected as early as possible (MS 1211, Condition B1-3);
- The GMMP works together with the BCH Monitoring and Management Plan (BCHMMP) to ensure overlapping and holistic impacts are managed and monitored (MS 1211, Condition B1-4);
- There are no adverse impact to water levels or water quality in Mardie Pool as a result of changes to groundwater regimes or groundwater quality (MS 1211, Condition B3-1);
- There are no changes to the health, extent or diversity of intertidal benthic communities and habitat, including mangrove, coastal samphire and algal mat as a result of changes to groundwater regimes or groundwater quality associated with the proposal (MS 1211, Condition B3-1); and
- Impacts to protected matters are minimised from changes to groundwater (EPBC 2018/8236 (as varied) and EPBC 2022/9169).

Precautionary Approach

A key focus of the GMMP is to prevent unauthorized impacts on environmental matters. It outlines how this goal will be achieved through a precautionary approach to risk and adaptive management principles, particularly in relation to mitigation and management actions, where some residual uncertainty may exist. Section 2.7 of this report details the key potential impact pathways associated with Matters of National Environmental Significance (MNES).

As part of this precautionary approach, Mardie Minerals have implemented a staged filling process for Ponds 1, 2, and 3. This process includes a one-week pause between each 300mm increment in fill levels, with a heightened focus on monitoring pond integrity and groundwater conditions. The GMMP has been updated with data collected during the first stage of filling and is now submitted for assessment and approval by both State and Commonwealth regulators before proceeding with the filling of Ponds 4 to 9. This progressive approach ensures that mitigation and management measures can be promptly implemented if any changes to groundwater conditions are detected during the filling process.

Groundwater Monitoring Rationale at Mardie

Because of the size of the project and its proximity to the coast, groundwater characteristics vary widely across the development envelope. Salinities range from near fresh (approx. 1000 EC units) on the eastern edge of the project to hypersaline (up to 220,000 EC) in the coastal sabkha and reducing again to sea water salinities (50,000 EC) along the western edge of the project area. Groundwater depth and stability are similarly variable, being quite stable and relatively deep (typically 4-8m) on the eastern edge of the project, becoming shallower (at or very near the ground surface in some instances) and increasingly variable in depth across multiple timescales due to tidal influence as you move westward towards the coast.

Because of this large variability in groundwater and the similarly diverse range of biota (incorporating terrestrial, intertidal and marine flora and fauna) that are present at the site, it is not appropriate (or indeed possible) to apply a singularly effective method for determining biological tolerance-based management triggers and thresholds across the whole project footprint. Instead, the approach taken in this GMMP is one where hourly telemetered monitoring of groundwater across the site is assessed daily to identify changes (exceedances) to groundwater level and/or salinity. Where threshold changes to either groundwater level or salinity are detected, an investigation is undertaken to determine if any Matters of National Environmental Significance (MNES) or their habitats (ranging from mangroves and samphires to algal mats to *Triodia*) are likely to be impacted by that exceedance, and if so, to determine and implement appropriate management actions that must be undertaken to avoid, mitigate or (in the worst case scenario) offset those impacts.

To determine whether there have been changes to groundwater level and/or salinity, a 'coastal' network of 56 groundwater bores that provides telemetered data (approximately hourly) to a central data collected website has been established to enable characterisation and monitoring of the highly saline and variable coastal groundwater environment. A similarly telemetered 'terrestrial' bore network of 18 bores provides the same for the more stable, less saline inland portion of the project around the crystallisers. These two bore networks combine with 66 additional bores from within the pipeline corridor serve as the basis for the modelling, monitoring and management of groundwater that underpins this GMMP.

Groundwater Modelling

A regional three-dimensional density-dependent flow and transport model has been developed for the project aligned with the requirements of State and Commonwealth regulators to estimate and incorporate uncertainty of the modelling into the predictions. The objective of this modelling was to predict the water level and salinity impacts of any seepage from the ponds related to the operation of the Mardie Project on the underlying groundwater system.

The modelling approach adopted included a manual calibration exercise followed by the use of Ensemble Space Inversion (ENSI) implemented through the PEST _HP suite (Doherty, 2024) to obtain an initial set of parameters (prior parameter probability distribution) and realisations (alternate calibrations) were generated using PESTPP-IES. The model was calibrated or history matched by replicating pre- development groundwater conditions since early 2022 and the measured aquifer response to the filling of Ponds 1, 2 and 3 that has been underway since September 2024.

Model predictions for the 60 years life of the project show:

- Short term changes in water levels in the area of ponds during initial operation and conditioning.
- Small changes in predicted water levels in the immediate pond areas and the area upstream due to the change in simulated recharge conditions once the ponds are conditions and the ponds are operations.
- Limited salinity changes close to the ponds due to the limited leakage from the ponds and the assumed tidal recharge conditions.

Model prediction results also suggest that changes to water levels and salinity conditions are not expected to extend to the mangrove areas located downstream of the ponds.

Because of the temporary nature and relatively small size of any potentially affected areas, these modelled changes to groundwater are not considered to confer a significant risk to protected matters, including MNES or their habitats, beyond what has been approved. The ongoing monitoring and management of groundwater detailed in this GMMP will further reduce the risk of groundwater related impacts to protected matters.

Note also that Mardie Minerals have committed to annual groundwater model updates every year for the first three years of the project, a time period which reflects achieving a steady operational state for the project.

Monitoring changes in groundwater

BCI engaged Data Analytics Australia (DAA) to design a statistically sound method for determining operational triggers and thresholds to determine whether groundwater levels and salinities change over time, and whether any changes were attributable to the operations of the Mardie Project.

A modified Before After Control Impact (m-BACI) groundwater level and salinity monitoring methodology that provides daily analysis of hourly telemetered groundwater data to determine trigger or threshold exceedances was incorporated into Rev M of the GMMP that ultimately provided approval to commence filling of evaporation Ponds 1 to 3. This Pond 1-3 methodology has been operational since filling commenced on 10 September 2024 and has resulted in the reporting of numerous triggers and threshold exceedances.

A number of improvements or refinements of the Pond 1-3 methodology have been identified through the initial pond filling and applied to the updated methodology presented in this GMMP. Changes have also been made as a result of the recommendations of an independent review conducted by Pink Lake Analytics. These improvements to the methodology range from simply adding groundwater level to the interpretation graphs produced daily, to redefining the definitions of triggers and threshold exceedances, to the reallocation of impact and reference bores. All proposed changes are detailed in Section 7 of this GMMP. It is intended that, subject to regulators' approval, the updated methodology outlined in DAA (2025) is followed for the filling of Ponds 4 to 9 and the crystallisers.

Mitigation and Management Measures

Based on our experiences and learnings during the filling of ponds 1-3, a Groundwater Monitoring Procedure has been developed and included in this GMMP (Appendix F). This procedure outlines obligations, roles and responsibilities for the collection of the monitoring data for regular monitoring and ad-hoc monitoring events, definitions of trigger and threshold events and protocols for the management of these events, investigation and management measures to be adopted in the event of a threshold exceedance, and training and competency requirements for all BCI employees and contractors in relation to the GMMP.

Through the application of this procedure to date, Mardie Minerals is confident that we have maintained full transparency with the regulators through our compliance with conditions and notifications of exceedances, and avoided any impacts to protected matters, including MNES or their habitats. It is intended to adopt and continuously improve this procedure through regular review and update (minimum every three months) during the pond filling process, and a minimum of every 12 months following completion of filling.

Reporting and Review

Monitoring data will be assessed against trigger and threshold criteria and reported in monthly, quarterly and an annual report to the company CEO and Board. If the trigger or threshold criteria (or both) are exceeded during the groundwater monitoring period, the annual report will include a description of the effectiveness of trigger criteria level actions, and threshold criteria contingency actions that have been implemented to manage the impact, as well as an analysis of trends.

A Compliance Assessment Report (CAR) will be submitted to the Compliance Branch at DWER annually. The CAR will document compliance with conditions of approval including assessment of compliance with management plan requirements where management plans form part of the approval conditions. The CAR will be prepared in accordance with the Post Assessment Guideline for Preparing a Compliance Assessment Report, Post Assessment Guideline No. 3 (OEPA, 2012).

In addition to the ongoing reporting to regulators of any threshold events, a groundwater summary report will be prepared and submitted to DCCEEW and/or DWER each calendar year. The report will summarise groundwater level and quality, identifying any exceedance of trigger and threshold criteria, and provide details on contingency actions taken in the event of exceedance of trigger and threshold criteria exceedances.

This GMMP will be reviewed in accordance with regulatory timeframes (e.g. within 2 years of commencement of the Action, and every 5 years following approval of this GMMP) or as required following any significant amendments. A separate review, by an independent suitably qualified hydrologist, will be completed at least once before every 10-year anniversary of the first approval of the GMMP, and subsequently every 10 years for the life of the project (unless specified by the regulator in writing).

Conclusions

The Mardie project is a large-scale, unique development in the Pilbara region, encompassing a variety of physical and biological environments. This diversity is particularly evident in the area's groundwater systems, which are complex, as well as in the flora and fauna that could be affected by changes to these systems. By filling evaporation ponds 1, 2 and 3, Mardie Minerals Pty Ltd has had a valuable opportunity to demonstrate that the project is sound, and that any potential groundwater impacts are being effectively monitored and managed.

This revised Groundwater Management and Monitoring Plan (GMMP) includes significant updates to the modelling and monitoring methodologies and procedures. It also highlights Mardie Minerals' strong history of compliance with the substantial conditions set during the early filling phase of the project. Through this GMMP revision, Mardie Minerals aims to show that any potential groundwater impacts on protected matters, including Matters of National Environmental Significance (MNES), can be managed within the framework of existing regulatory requirements, noting that this includes additional commitments made as part of this GMMP update. If there are any questions or concerns, Mardie Minerals invites open and clear discussions with the regulator, its staff, and technical advisers to resolve any issues.

Proposal name	Mardie Salt Project: • Original Project • Optimised Project
Proponent name	Mardie Minerals Pty Ltd
Approval references	Original Proposal • Ministerial Statement 1211 (note that MS 1175 is superseded) • EPBC 2018/8236 (as varied). Optimised Proposal • Ministerial Statement 1211. • EPBC 2022/9169.
Purpose of the Plan	Support the maintenance of the hydrological regimes and quality of groundwater and surface water so that environmental values are protected.
Key environmental factor/s, outcome/s and objective/s	Key Environmental Factors: • **Inland Waters:** To maintain the hydrological regimes and quality of groundwater and surface water so that environmental values are protected. • **Benthic Communities and Habitats (BCH):** To protect benthic communities and habitats so that biological diversity and ecological integrity are maintained. Outcomes and Objectives: • **Key Environmental Objective:** No changes to the health, extent or diversity of intertidal benthic communities and habitat, including mangrove, coastal samphire and algal mat as a result of changes to groundwater regimes or groundwater quality associated with the proposal. • **Key Environmental Objective:** No adverse impact to water levels or water quality in Mardie Pool or Mt Salt Mound Spring because of changes to groundwater regimes or groundwater quality.
Condition clauses	Original Project • Ministerial Statement 1211 – Conditions B3-1, B3-2, B3-3 and C1-1(3). • EPBC 2018/8236 (as varied) – Conditions 30, 31, 33, 34, 40, 41, 42, 61 to 71. Optimised Project • Ministerial Statement 1211 – Conditions B3-1, B3-2, B3-3 and C1-1(3). • EPBC 2022/9169 – Conditions 30, 31, 33, 34, 40, 41, 42, 61 to 71.
Key components in the Plan	• Groundwater monitoring network and baseline investigations.

	• Environmental objectives, indicators and triggers and thresholds for investigation and corrective action. • Conceptual and numerical groundwater modelling. • Adaptive management, reporting and review.
Proposed construction date	Construction of the Original Project commenced in February 2021, and of the Optimised Mardie Project in September 2024.
Key operations date	Refer to Section 5 of this Plan for timing and staging.
Plan required pre-construction?	No – the GMMP must be approved prior to starting transfer of sea water, brine or waste product into any evaporation or crystalliser pond.

2. CONTEXT, SCOPE AND RATIONALE

2.1 The Project

The Mardie Salt and Potash Project (the project), currently being constructed by Mardie Minerals Pty Limited, is located on the north-west coast of Western Australia in the Pilbara region, approximately 80 km south-west of Karratha (Figure 1).

The Project will employ solar evaporation to condense sea water in a series of ponds, resulting in brine feedstock that will be used to produce crystallised salt products. Brine within evaporation ponds will reach concentration of 273 parts per million (ppm) at Pond 9 prior to salts being deposited in crystalliser ponds where brine concentration will exceed 600 ppm before crystallisation. The Project involves development of facilities to produce, process and export high purity industrial-grade salt and fertiliser-grade sulphate of potash (SOP) from sea water via solar evaporation, crystallisation, raw salt purification and SOP conversion (Figure 2 and Figure 3).

The Project area is characterised by coastal salt flats (a sabkha-type environment) with hyper-saline and shallow groundwater. These salt flats are separated from the ocean by a narrow near-coastal zone with sea-water quality groundwater that is influenced by tidal creeks that host mangrove communities. The evaporation ponds are constructed predominantly on the salt flats and underlain by hyper-saline brine. However, risk assessments conducted by AQ2 (2020) and AQ2 (2021) have indicated the potential for interaction between the Project ponds and the near-coastal zone in the event of seepage from the ponds (and the associated change in relative hydraulic gradients that will result from pond filling operations).

Further inland, salt crystallisers are proposed to be constructed north of Mardie Pool above the fresh water of the Fortescue Alluvial valley aquifer. In the vicinity of the crystallisers water level is 5-8 m below ground level. Mardie Pool is of cultural significance and the banks of Mardie Creek harbour several riparian species, however the dominant vegetation in the area is invasive mesquite (Prosopis species).

Figure 1 Mardie Project Regional Location

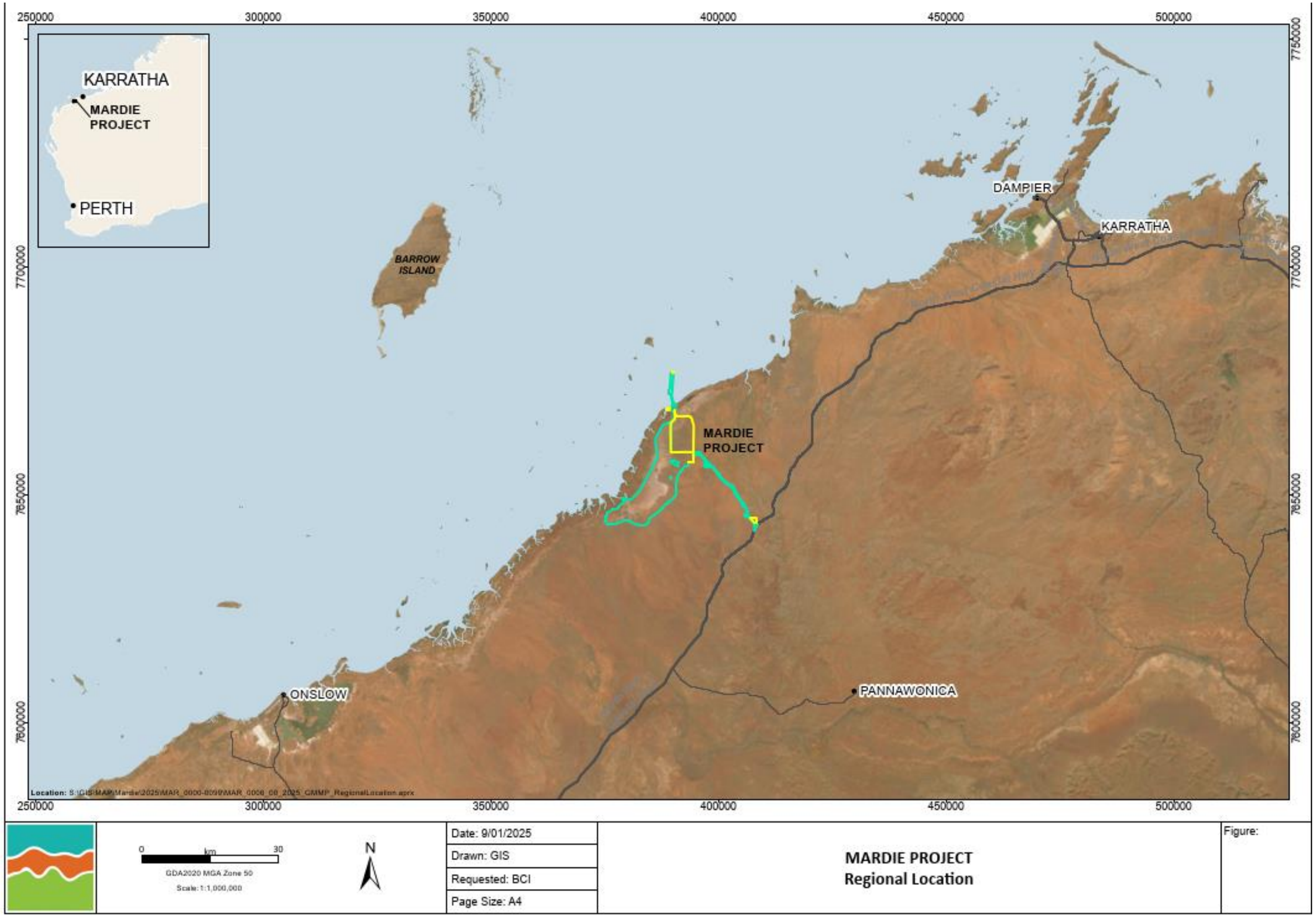
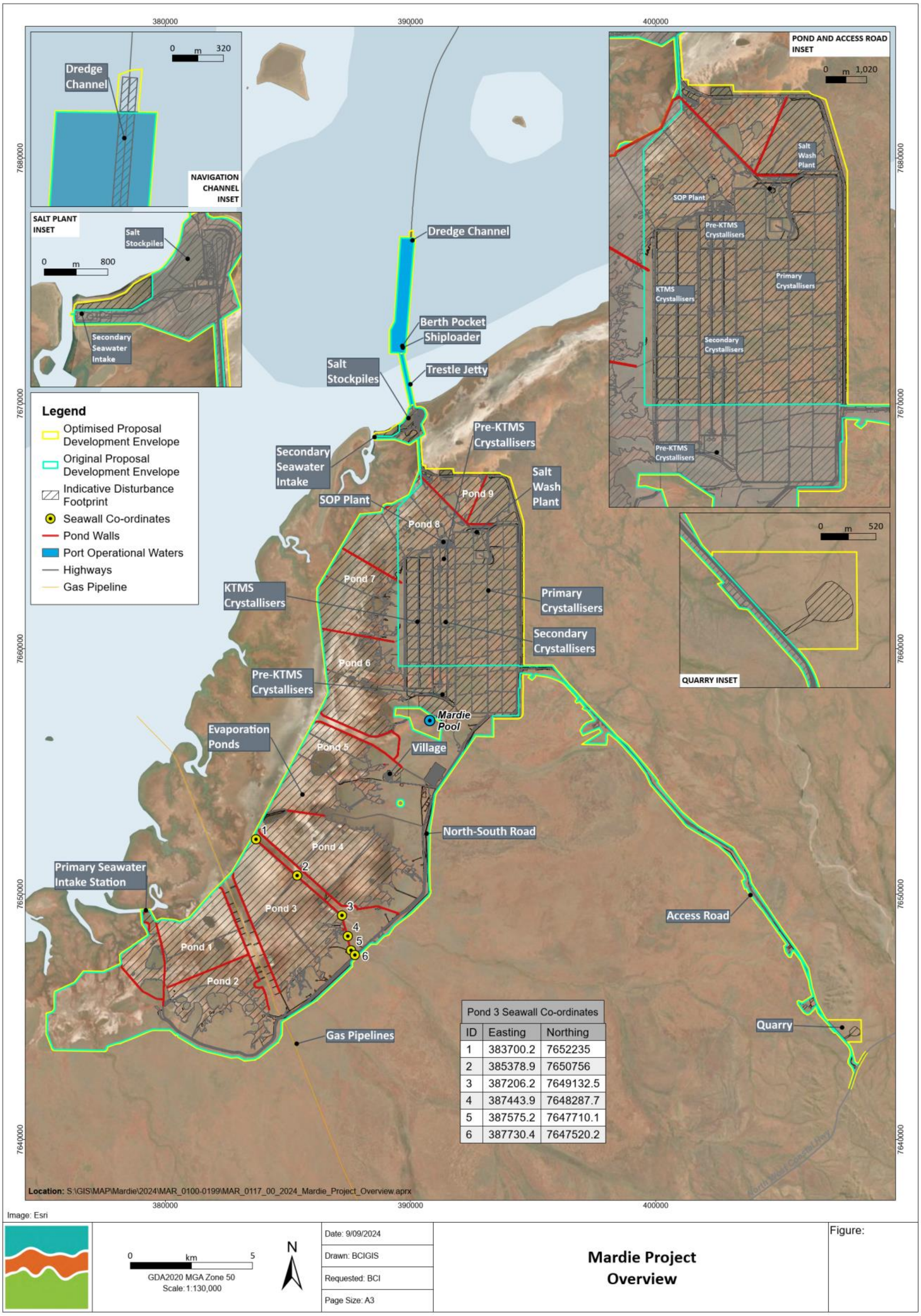
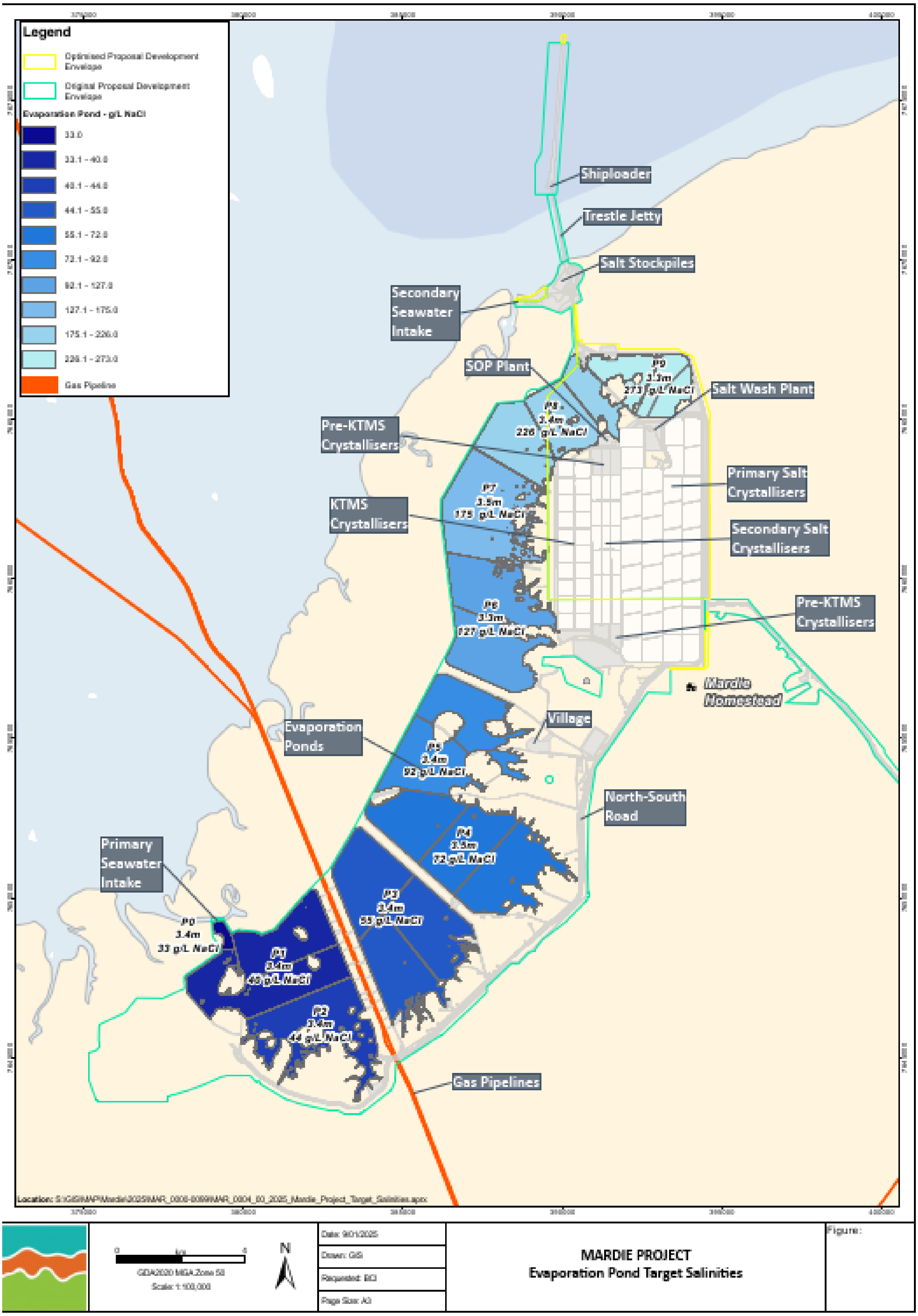


Figure 2 Mardie Project Layout – Optimised



Pond 3 Seawall Co-ordinates		
ID	Easting	Northing
1	383700.2	7652235
2	385378.9	7650756
3	387206.2	7649132.5
4	387443.9	7648287.7
5	387575.2	7647710.1
6	387730.4	7647520.2

Figure 3 Pond Salinity and Depth



2.2 Approvals

The Project was originally referred to the Western Australian Environmental Protection Authority (EPA) in April 2018 and the Department of Climate Change, the Environment, Energy and Water (DCCEEW) in June 2018. The original Mardie project was approved by the State with conditions under Ministerial Statement 1175 in November 2021, and by the Commonwealth with conditions under EPBC 2018/8236 in January 2022.

Significant amendments to the original proposal have since been outlined within the Optimised Mardie Proposal (OMP), which was submitted to the EPA and DCCEEW in March 2022. The OMP was approved by the State with conditions under Ministerial Statement 1211 (which superseded MS 1175) in October 2023, and by the Commonwealth with conditions under EPBC 2022/9169 in September 2024. Subsequently, the previous Commonwealth approval (EPBC 2018/8236 (as varied) was amended to align with (or 'mirror') the new OMP conditions set in October 2024.

2.3 Staged Filling Approach for Ponds 1, 2 and 3

In accordance with both the State regulator's conditional approval provided in April 2024, and the Commonwealth OMP approval on 9 September 2024, Mardie Minerals undertook a staged filling of Ponds 1, 2 and 3 with sea water between September and December 2024. The filling of each of the three ponds was undertaken with a 7-day hold on pond water level at 0.3m. This approach is consistent with the independent DWER review recommendations from late 2023.

This staged filling approach was intended to inform further development of modelling and monitoring that underpins this GMMP, and to monitor environmental responses under controlled operational conditions. Such an approach has a significant advantage over 'standard' environmental approvals processes because it allows for actual data to be input into predictive impact modelling. This reduces the uncertainty around the outputs of this modelling and de-risks the project from an environmental impact perspective.

During the initial filling procedure pond water levels were recorded daily (where possible) by Mardie Minerals against surveyed markers on the pond base and walls (Appendix A). Pond filling start dates are presented in Table 2-1 and pond level data is presented in Figure 4. It is noted that pond level observations were visual estimates only. Observed level was influenced on occasion by wind effects, wherein pond water is pushed up against the pond wall by consistently strong prevailing winds. Indicated levels were recorded at the deepest part of the ponds against the seaward wall, and the actual water depth reduces away from the coast as the salt flat surface elevation increases. During the initial filling procedure pond water levels were recorded daily (where possible) by Mardie Minerals against surveyed markers on the pond base and walls (Appendix A). Pond filling start dates are presented in Table 2-1 and pond level data is presented in Figure 4. It is noted that pond level observations were visual estimates only. Observed level was influenced on occasion by wind effects, wherein pond water is pushed up against the pond wall by consistently strong prevailing winds. Indicated levels were recorded at the deepest part of the ponds against the seaward wall, and the actual water depth reduces away from the coast as the salt flat surface elevation increases.

Table 2-1 Pond Filling Start Dates

Pond	Filling Start Date	Comment
1	10/09/2024	Ministerial Approval for pumping on 10 September 2024
2	06/10/2024	Free flow from Pond 1 to Pond 2 commenced
3	12/11/2024	Pond 2/3 Transfer Station commissioned

As detailed in Appendix A, during the staged filling of Ponds 1, 2 and 3 (September 2024 to January 2025), Mardie Minerals have reported:

- seven (7) threshold exceedances for groundwater levels and
- seven (7) threshold exceedances for salinity.

Each of the threshold exceedances was reported to the regulators (DWER and DCCEEW) within the required timeframes, in accordance with the conditions of MS 1211, EPBC 2018/8236 (as varied) and EPBC 2022/9169.

As detailed in Appendix A, these groundwater level and salinity exceedances are attributable to the ponds being unsealed (with the formation of the algal mat still in progress) and tidal recharge onto the sabkha (Figure 20) associated with the natural tidal cycle.

As a response to these threshold exceedances, Mardie Minerals undertook additional monitoring of the pond walls (via drones) to ensure the structural integrity of the pond walls. Reactive monitoring (outside of the scheduled BCHMMP monitoring) was undertaken for the groundwater and salinity threshold exceedance. To date, there has been no evidence of impact to the key environmental factors or MNES.

Targeted information on the findings from the monitoring data collected during the filling of Ponds 1, 2 and 3 is provided in Section 4.10.3 of Appendix C to the GMMP.

None of the threshold groundwater exceedances detected through monitoring and investigation by BCI Minerals have resulted in environmental impacts (including to protected matters) as a result of the threshold exceedances. Accordingly, whilst there have been additional monitoring requirements to inform exceedance investigations, no corrective measures have been undertaken at this time.

- The initial response of Pond 1's filling on groundwater levels was observed in monitoring wells S01A and S02A, positioned adjacent to each other within the pipeline corridor at the northern corner of the pond (Figure 4.17). Prior to 10 September 2024, these bores displayed the characteristic hydrological patterns of a tidal flat environment: water levels rapidly rose with incoming high tides and receded during neap tides. However, after 10 September 2024, both bores indicated a consistent rise in water levels, culminating in levels at or near the ground surface following the spring tide of 21 September 2024.
- CMB06_1D and CMB06_1S, a pair of deep and shallow bores located on the western side of Pond 1, are situated near a tidal creek. The groundwater levels in this area are strongly influenced by tidal fluctuations, with a natural range of 1 meter or greater. Following the filling of Pond 1, both bores responded with consistently elevated groundwater levels (Figure 4.17). This was sustained through the natural drainage and recharge cycles, which were maintained through connection to the adjacent tidal creek.
- Transect CMB01 consists of three sets of deep and shallow bores, each located further west from the Pond 3 seawall (Figure 4.18). Bores CMB01_1D and CMB01_1S, located closest to Pond 3, showed a consistent increase in water levels after the pond was filled, starting around 28 November 2024. However, bores CMB01_2D and CMB01_2S, and CMB01_3D and CMB01_3S did not show any clear response to the pond filling. A 0.1 m rapid rise in water level was recorded at all bores on 9 December 2024, likely caused by a significant rainfall event. Noting the Mardie BoM weather station, located about 12 km away, recorded 20.6 mm of rain.
- Bores N01_A, N02_A, and N02_B, situated at the western corner of Pond 3 near the northern end of the gas pipeline corridor, exhibited elevated water levels commencing around 24 November 2024. Prior to this date, these bores displayed cyclical water level fluctuations correlated with tidal inundation and subsequent recession during neap tides. In contrast, CMB02_1D and CMB02_1S, located adjacent to Pond 5 approximately 3 km north of Pond 3 (Figure 4.20), show no discernible response to the filling of Pond 3.

The changes to groundwater detailed above, were expected/predicted by the modelling.

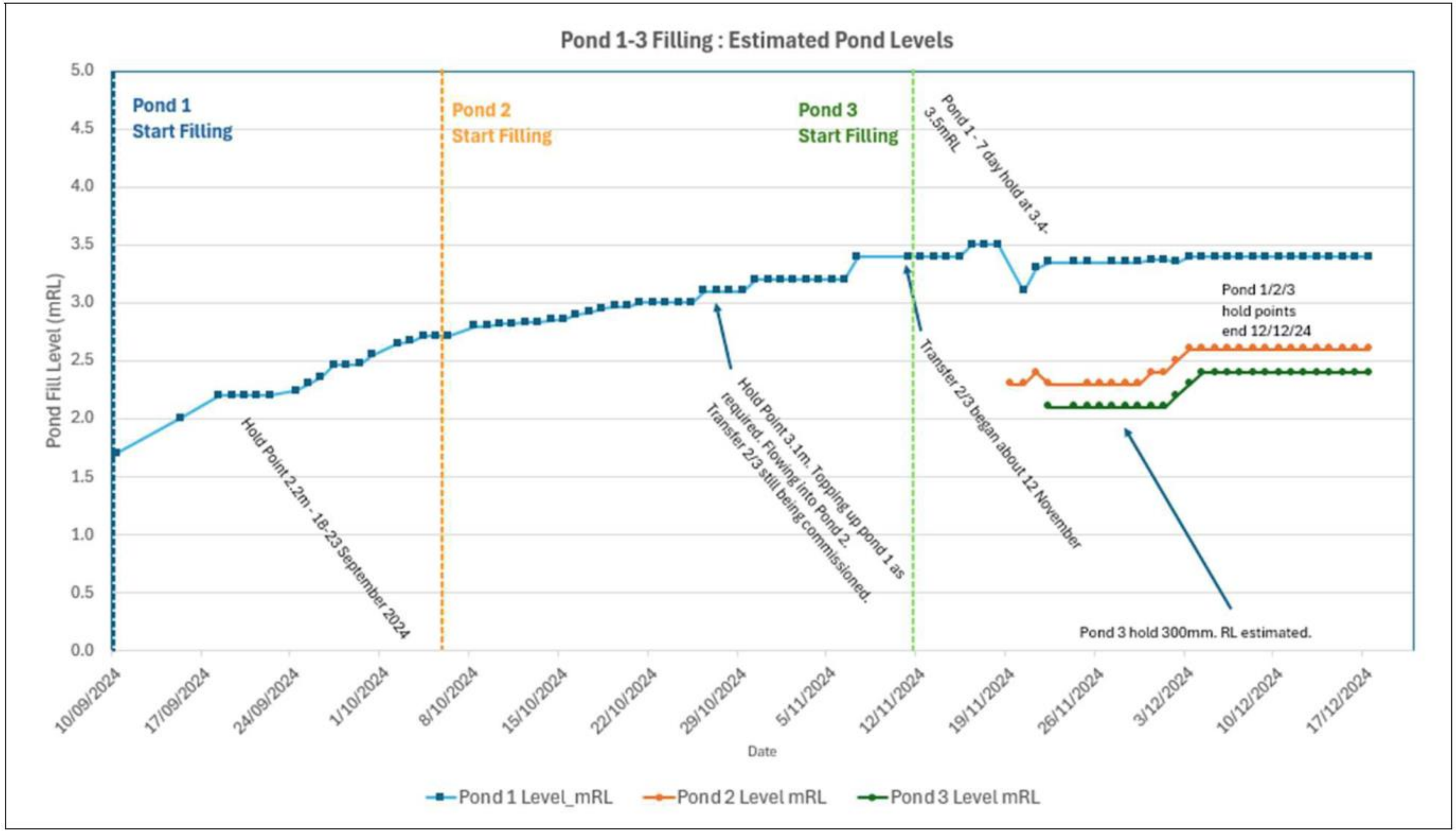
2.3.1 Ongoing Filling Approach for Pond 4 to Pond 9 and crystallisers

The filling of the remaining ponds (i.e. Ponds 4 to 9) and crystallisers will commence upon receipt of approval of this GMMP (Rev O), as per Condition 65 of EPBC 2018/8236 (as varied) and EPBC 2022/9169 and the conditional approval received from DWER in April 2024.

The filling of the Ponds 4 to 9 will not include a 7-day hold point on pond water levels, as it has been demonstrated the bore monitoring network in place is working reliably and effectively to detect changes to groundwater levels and quality.

Prior to operational filling with brine, it is intended that some of the ponds (Ponds 6 Pond 9) and crystallisers will be conditioned with sea water to facilitate the formation of a low permeability algal mat to limit long term leakage from the ponds. It is estimated that the conditioning process will occur over a period of up to six months. Filling and ongoing conditioning is already underway in Ponds 1 to 3. Filling of the ponds with sea water, prior to filling with brine is scheduled for Pond 9 first (where the greatest operational salinities are expected) followed by Ponds 8, 7, and 6. No conditioning is planned for Ponds 4 and 5, however, it is assumed that the conditioning of these ponds will be part of the initial operation, noting that the maximum expected concentrations for Ponds 4 and 5 are similar to the underlying groundwater salinity (up to around 120,000 mg/L). It is expected the water will flow reasonably quickly (days/weeks) into ponds 4 and 5 once the updated GMMP is approved and this water will serve to condition the ponds. There is therefore no need to put additional ‘conditioning’ water into these ponds prior to the commencement of pumping into pond 4.

Figure 4 Staged Pond Filling Level Data



2.4 GMMP Purpose

This GMMP outlines an approach to the monitoring and management of the potential impacts of the Project on groundwater and associated potential impacts on the environment consistent with MS 1211, EPBC 2018/8236 (as varied) and EPBC 2022/9169 conditions of approval.

The purpose of the GMMP is to ensure that:

- Changes to the health, diversity, and extent of benthic communities and habitat (BCH) (including subtidal macroalgae) as a result of changes to surface water, groundwater quality, groundwater regimes, and marine environmental quality associated with the proposal are detected as early as possible (MS 1211, Condition B1-3);
- The GMMP works together with the Benthic Communities Habitat Monitoring and Management Plan (BCHMMP) to ensure overlapping and holistic impacts are managed and monitored (MS 1211, Condition B1-4);
- There are no adverse impacts to water levels or water quality in Mardie Pool as a result of changes to groundwater regimes or groundwater quality (MS 1211, Condition B3-1);
- There are no changes to the health, extent or diversity of intertidal benthic communities and habitat, including mangrove, coastal samphire and algal mat as a result of changes to groundwater regimes or groundwater quality associated with the proposal (MS 1211, Condition B3-1); and
- Impacts to protected matters are minimised from changes to groundwater (EPBC 2018/8236 (as varied) and EPBC 2022/9169).

In accordance with conditions outlined in EPBC 2018/8236 (as varied) and EPBC 2022/9169 (Optimised Proposal) and as required by the Department of Water and Environmental Regulation's (DWER) April 2024 conditional approval of Rev K of the GMMP, this GMMP also incorporates data collected during the filling of Ponds 1 to 3 and builds this into the predictive modelling, groundwater monitoring and management programs presented here. The strength of this approach is that it uses actual operational data to inform modelling, monitoring and management, which significantly reduces risk and improves the certainty of the outcomes presented herein.

The implementation of the GMMP is a direct condition of EPBC 2018/8236 (as varied), EPBC 2022/9169 (Optimised Proposal) and MS 1211 (Optimised Proposal). The GMMP has been prepared with reference to the *'Instructions on how to prepare Environmental Protection Act 1986 Part IV Environmental Management Plans'* (EPA, 2021c) and the '*Environmental Management Plan Guidelines, Commonwealth of Australia 2014'* (DoE, 2014) in the context of the GMMP being submitted as part of the Approval conditions.

2.5 Environmental outcomes / objective/s

The GMMP has been developed to meet the relevant State and Commonwealth approval objectives including:

- **Commonwealth:**
  - No impacts within the development envelope greater than that permitted (EPBC 2018/8236 (as varied) and EPBC 2022/9169)
  - Avoiding and mitigating harm to protected matters as a result of groundwater changes (EPBC 2018/8236 (as varied) and EPBC 2022/9169)
  - Document and maintain records that demonstrate a detailed understanding of the hydrological regimes and processes operating, including but not limited to the existing coastal tidal inundation regime, natural water flows, and groundwater
  - Prevent impacts to the Mardie Pool, terrestrial, intertidal and subtidal protected matters and habitats (EPBC 2018/8236 (as varied) and EPBC 2022/9169)
  - Identify further impacts that may result on protected matters within and/or outside the development envelope (EPBC 2018/8236 (as varied) and EPBC 2022/9169)

- **State:**
  - No development that would have an adverse impact on the ecological function of intertidal and subtidal BCH (MS 1211)
  - No long-term (greater than five (5) years) net detectable loss of algal mat outside of the proposal footprint (MS1211)
  - No loss of subtidal BCH (including subtidal algae) outside the zones of impact authorised in condition A1-1 (MS 1211)
  - No adverse impact to water level or water quality in Mardie Pool as a result of changes to groundwater regimes or groundwater quality (MS 1211)
  - No changes to the health, extent or diversity of intertidal BCH, including mangrove, coastal samphire and algal mat as a result of changes to groundwater regimes or groundwater quality associated with the proposal (MS 1211).

2.6 Key Environmental Factors

The key environmental factors for the State considered in this GMMP are Inland Waters and BCH.

The EPA objective for Inland Waters is "*to maintain the hydrological regimes and quality of groundwater and surface water to ensure that environmental values are protected*" (EPA, 2018).

The EPA objective for BCH is "*to protect benthic communities and habitats so that biological diversity and ecological integrity are maintained*" (EPA, 2018).

Secondary factors, which are dependent upon the outcomes to Inland Waters and BCH, are marine fauna and terrestrial fauna (including significant species).

Proposal activities that may affect these factors are described in Table 2-2.

Table 2-2 Potential impacts to Inland Waters and/or BCH

Key Environmental Factors: Inland Waters and BCH	
Proposal activities that may affect this factor.	• Evaporation Ponds • Crystalliser Ponds • Bitterns storage dams and pipelines.
Environmental values that may be affected by implementing the Proposal.	• BCH, including mangrove, algal mat and samphire communities, as well as the biological systems that they support. • Water levels and/or water quality in Mardie pool as a result of changes to groundwater regimes or groundwater quality. • Protected matters and habitats associated with the Mardie Pool, terrestrial, intertidal and subtidal areas (EPBC 2018/8236 (as varied) and EPBC 2022/9169). • Livestock watering bores.
Ecosystem health condition / sensitive component of the key environmental factor.	• Groundwater salinity. • Groundwater levels.
Existing and/or potential uses.	• Pastoral Station (cattle).

2.7 Matters of National Environmental Significance (MNES)

The controlling provisions for the Project were listed threatened species and communities, listed migratory species and the Commonwealth marine area.

The Protected matters for the Project as per the EPBC Approval 2018/8236 (as varied) and EPBC 2022/9169 are:

- EPBC listed terrestrial fauna species including:
  - Pilbara leaf-nosed bat

- Pilbara olive python
- Northern Quoll

- EPBC listed marine fauna species including:
  - Marine turtles
  - Green sawfish
  - The short-nosed sea snake
  - Manta rays
  - Humpback whales
  - Australian humpback dolphin
  - Dugong
- EPBC Act flora species including *Minuria tridens*
- Threatened and Migratory Sea and Shorebirds.

The controlling provisions for the Project (EPBC 2018/8236 (as varied) and EPBC 2022/9169) are listed threatened species and communities and listed migratory species.

A number of MNES were identified and assessed as potentially impacted by the Optimised Mardie Project (Preston Consulting, 2022: Section 12.1, p. 272) with potential impacts to the following MNES:

- Pilbara leaf-nosed bat
- Australian Humpback Dolphin
- Humpback Whale
- Dugong
- Hawksbill Turtle
- Green Turtle
- Flatback Turtle
- Loggerhead Turtle
- Green Sawfish
- Threatened and Migratory Sea and Shorebirds
- Minnie Daisy.

Appendix B provides an assessment against the Commonwealth's Significance Impact Guidelines (2014) for potential impacts to the listed threatened species and ecological communities and listed migratory species.

2.8 Condition Requirements

The key conditions of EPBC 2018/8236 (as varied); EPBC 2022/9169 and Ministerial Statement 1211, relevant to this GMMP, are shown in Table 2-3.

As detailed below, Mardie Minerals also hold the following groundwater abstraction license(s) regulated under Section 5 of the R*ights in Water and Irrigation Act 1914* (RiWI Act), which permits Mardie Minerals to abstract groundwater for construction and operational purposes[1]:

- GWL205621(3), which has an annual allocation of 150,000 kL for dust suppression and camp water supply.

[1] Noting GWL205621(3) does not cover water use requirements associated with the operational activities for the quarry.

As required under the *RiWI Act* licence, Mardie Minerals provides annual records to the DWER to demonstrate compliance with the abstraction volumes granted under the 5C licence.

Table 2-3 Key Conditions of EPBC 2018/8236 (as varied); EPBC 2022/9169 and MS 1211 relevant to the GMMP (Revision O)

Cond. #	Condition Requirement	How/Where addressed in GMMP
EPBC 2018/8236 (as varied) and EPBC 2022/9169		
30	To avoid and mitigate harm to protected matters as a result of groundwater changes associated with the Action, the approval holder must comply with conditions B3-1, B3-2, B3-3, C3-1 and C4-1 of the WA Approval, to the extent that the WA Approval conditions relate to protected matters.	This GMMP (Revision O), and subsequent revisions as approved by the Delegate, has been prepared to address these conditions through its implementation – see below for further detail in response to WA Approval (MS 1211)
31	The approval holder must, prior to the commencement of the Action, document and maintain records that demonstrate a detailed understanding of the hydrological regimes and processes operating prior to the taking of the Action, including but not limited to the existing coastal tidal inundation regime, natural water flow, and groundwater regimes to the extent that it demonstrates the potential for to the Action to cause impacts to protected matters, validates the monitoring approach and management measures in the Groundwater Monitoring and Management Plan required by condition 61, and in line with the Australian and New Zealand guidelines for fresh and marine water quality (2018).	Section 2.9 and Section 3 detail the relevant technical studies completed to demonstrate and detail the understanding of the hydrological regimes and processes to the extent. Documents and records inter alia include aquifer test results, hydrogeological modelling, and actual bore monitoring data.
40	To detect changes to groundwater regimes, groundwater quality, and groundwater levels associated with the Action, the approval holder must not commence operations unless it has:	-
	a) established a network of groundwater monitoring bores that is able to detect changes in groundwater levels and groundwater quality.	Section 4 (Groundwater Monitoring Bore Network) details the extent of the groundwater monitoring bore network that has been established across the Development Envelope. The bore network has been collecting data as far back as February 2022, and is subject of planned maintenance as required, to ensure it is functional and operational.
	b) assigned and calibrated all reference bores and impact bores, installed to comply with condition 40a, and to enable implementation of the monitoring program outlines in the Groundwater Monitoring and Management Plan (GMMP).	Section 6.2.3 (Changes to Reference Bores) and Table 6-5, and Appendix D (DAA 2025) detail the use of three reference bores for each impact bore improved forecast accuracy and trigger detection as well as being consistent with guidelines. This GMMP also details the change to certain reference bores in Section 6.2.3 to continue to enable implementation of the monitoring program.
	c) completed the development and deployment of all software, equipment and monitoring protocols required to undertake monitoring and be able to detect whether any change in groundwater levels, and groundwater quality has occurred and to enable implementation of the monitoring program outlined in the GMMP.	Section 4 (Groundwater Monitoring Bore Network) and Table 4-1 and Table 4-3 detail the deployment dates for all telemetry for the groundwater monitoring bores located across the Development Envelope. The software and equipment were all deployed and operational before 10 September 2024, when the initial filling of Ponds 1, 2 and 3 commenced. Changes in groundwater levels and groundwater quality continues to be monitored daily.
41	The approval holder must maintain and ensure the working order of all groundwater monitoring bores, reference bores and impact bores from the commencement of the Action and installed to comply with condition 40a and to enable the implementation of the monitoring program outlined in the GMMP, until the expiry date of this approval. The approval holder must, until the expiry date of this approval, undertake monitoring on at least a monthly basis from the commencement of the Action until the expiry date of this approval which is capable of:	Section 7.2 (Groundwater Monitoring Schedule) and Table 7-1 detail the parameters and monitoring frequency for the groundwater monitoring bores that have been installed across the Development Envelope. Section 2.3 and Appendix A detail the monitoring data collected during the staged filling of Ponds 1, 2 and 3. The monitoring bore network is in working order and routine maintenance of certain bores has already been undertaken during 2024.
	a) demonstrating compliance with conditions C3-1 and C4-1 of the WA Approval,	In relation to WA Approval C3-1, Section 7.2 (Groundwater Monitoring Schedule) and Table 7-1 detail the parameters and monitoring frequency for the groundwater monitoring bores that have been installed across the Development Envelope. In relation to WA Approval C4-1, Section 7.3 (Association with other Management Plans) and Table 9-1 in Section 9 (Commitments Register) detail Mardie Minerals' commitment to this reporting requirement.
	b) detecting if any of the trigger value and thresholds specified in these conditions, including plans, are exceeded and determine if the exceedance is a result of the Action.	Table 6-1 and Table 6-2 in Section 6 detail the trigger value and thresholds. Section 7.4 (Groundwater Management Response Framework) and Appendix F detail the proposed response to any trigger value and threshold exceedances. During the initial filling of Ponds 1, 2 and 3, Mardie Minerals successfully used the monitoring bore network to detect trigger / threshold exceedances and used actual monitoring data to support incident investigations that were submitted to DCCEEW and DWER.
	c) detecting incremental change over time to groundwater level, and groundwater quality as a result of the Action.	Section 6.2.1 (Real time (or short-term) Monitoring), Appendix E1 and Appendix E2 (DAA 2022a, 2024b) detail the methodology for detecting incremental change over time to groundwater regimes, levels and quality. A modified BACI (m-BACI) approach based on daily data has been adopted to detect short-term changes in groundwater. This approach uses a daily automated data download process via a bespoke online tool developed by DAA that automatically updates data charts for each monitored.
42	After two years from the commencement of operations, the approval holder must provide to the department a report that documents compliance with conditions 40 and 41. The report should include assessment by a suitably qualified expert in the field of the whether the outcomes of trigger and thresholds exceedance investigations were scientifically validated and justified. The report should also assess whether any trigger and threshold exceedance investigations were conducted in accordance with commitments in the GMMP and whether management responses were conducted in accordance with the GMMP.	N/A in this version of the GMMP (Rev O), as the Proposal has only commenced in September 2024. However, Section 8 (Reporting) details the compliance and regulatory reporting requirements that Mardie Minerals will undertake and complete as required.

Cond. #	Condition Requirement		How/Where addressed in GMMP
43	To minimise impacts to protected matters and their habitats that include the Mardie Pool, open riparian woodlands vegetation and Benthic Communities and Habitat, the approval holder must, at least once per week, from the commencement of the Action until the completion of the Action, monitor the evaporation pond walls to detect any for surface expressions of seepage, brine spill and structural integrity.		Section 7.1 (Management Protocols) and Table 7-1 (Monitoring Schedule) detail the commitment to monitor the evaporation pond walls for surface expressions of seepage, brine spill and structural integrity. Prior to commencement of initial filling of Ponds 1, 2 and 3, and on an ongoing weekly basis since then, Mardie Minerals' Operations Team has been conducting weekly inspections of pond walls to detect any surface expressions of seepage, brine spill and structural integrity.
44	If any seepage and/or brine spill is detected at the evaporation pond walls, the approval holder must:		
	a)	Report the exceedance incident to the department in writing within 2 business days of the event in accordance with condition 113.	Table 9-1 in Section 9 (Commitments Register) details Mardie Minerals' commitment to this reporting requirement. Additionally, Section 7.4 (Groundwater Management Response Plan Framework) sets out the management framework to be followed for investigations if triggers and thresholds are breached. The framework inter alia includes an investigation of the exceedance incident, corrective measures implemented (in the short-term and medium to longer term, if required), and monitoring for effectiveness of corrective measures implemented.
	b)	Investigate the seepage and/or brine spill to determine its cause and the extent of any harm to protected matters and submit a report of the findings of this investigation to the department in writing within 15 business days of detecting the seepage and/or brine spill. The report must include:	
	i)	The findings of the seepage and/or brine spill event investigation,	
	ii)	Details of corrective measures implemented	
	iii)	An evaluation of the effectiveness of the corrective measures implemented.	
	iv)	Measures to prevent another seepage and/or brie spill event occurring in the future.	
61	The approval holder must implement the Groundwater Monitoring and Management Plan (GMMP) to avoid and mitigate harm to protected matters as a result of groundwater changes associated with the Action. The GMMP must be implemented for the life of the project.		This GMMP (Revision N) (and subsequent revisions to it, as to be approved by the Delegate) has been prepared to address this condition through its implementation.
62	By implementing the GMMP, the approval holder must achieve the following environmental outcome:		-
	a)	Prevent any harm to protected matters and their habitats within and outside the development envelope as a result of changes to groundwater regimes, groundwater quality, and groundwater levels associated with the Action.	Section 5.1 (Impacts to Matters of National Environmental Significance) and Appendix B outline the potential pathways for impact to MNES. Section 7 details the management / mitigation measures proposed to be implemented in the event that potential harm to protected matters is detected through implementation of the GMMP and monitoring as per the approved BCHMMP and MSMMP. Section 7.4 (Groundwater Management Response Plan Framework), Table 6-1 and Table 6-2 include the Groundwater Management Response Framework with examples of management / mitigation measures to avoid / minimise harm to protected matters.
63	The approval holder must review and revise the approved GMMP at the conclusion of the first instance of filling evaporation ponds 1, and 3.		Noted. Table -9-1 in Section 9 (Commitments Register) details Mardie Minerals' commitment to this reporting requirement.
64	At the conclusion of filling evaporation ponds 1, 2 and 3 the approval holder must undertake the following investigations:		-
	a)	All groundwater monitoring data collected to date and throughout the staged filling to be included in the groundwater model and an automatic model calibration process applied for the successively growing calibration period, which will allow for model uncertainty to be quantified as a by-product of the model calibration. The model uncertainty must then be considered in the predictive model simulations.	Section 5.3 (Regional 3-D Modelling) and Appendix C include the updated regional modelling undertaken between September 2024 and January 2025; the actual monitoring data collected throughout the staged filling of Ponds 1, 2 and 3 have been analysed and used to run the model many times (trial and error approach) and change aquifer parameters systematically (and within appropriate measured ranges) and simulated boundary conditions (recharge, evapotranspiration, pond filling) systematically and within appropriate ranges. The modelling runs were done to provide the best match between measured and modelled water levels. Both a manual calibration and the PEST (automated) history matched models were used to predict the impact of the operation of the ponds (to address uncertainty); for predictions with the PEST calibrated model, the "least error model" (Realisation 43) was used.
	b)	Model predictions must be undertaken for the entire project lifetime to consider the full impact of the project, including the more slowly occurring impact of salinity changes.	Section 5.3 (Regional 3-D Modelling) and Appendix C detail the model predictions for the life of the project. The Model in Appendix C discusses the predictions for the 60 years life of the project, and show: • Short term changes in water levels in the area of ponds during initial operation and conditioning. • Small changes in predicted water levels in the immediate pond areas and the area upstream due to the change in simulated recharge conditions once the ponds are conditioned and the ponds are operational. • Limited salinity changes close to the ponds due to the limited leakage from the ponds and the assumed tidal recharge conditions.
	c)	Determine approximate aquifer residence times by collecting environmental tracer data (groundwater age tracers) to provide greater evidence supporting the proposed "slow" groundwater flow.	Section 3.12 (Isotope Analyses) details the sampling undertaken and the analyses currently in progress to provide greater evidence to support the proposed 'slow' groundwater flow.

Cond. #	Condition Requirement	How/Where addressed in GMMP
		Noting there are only two laboratories in the world can undertake this kind of analysis, the closest being the GNS Science laboratory in New Zealand. Following the resolution of having to use mercuric chloride as a preservative for sample collection, all sampling was undertaken on 16 October 2024. While the isotope analysis is underway, it is a slow process and Mardie Minerals are committed to providing the results to the regulators as they become available.
	d) Independent review of the modified Before/After Control Impact approach proposed by Data Analysis Australia.	Appendix G provides the report from the Independent Reviewer (Pink Lake Analytics) on the modified Before/After Control Impact approach proposed by Data Analysis Australia. Additionally, Section 6.2.5 (Response to Independent Peer Review) and Appendix D, details the updates actioned based on the independent reviewer's report. Recommendations addressed include: • to reduce confusion, the nomenclature has been improved and clarity of definitions regarding trigger and threshold criteria has been updated; • more detail regarding the statistical models used in the ARIMA predictions has been provided for the short-term monitoring methodology. • consideration in the decisions made when changing certain interim reference bores to the long-term bores and transitioning certain bores to be considered long-term reference bores prior to filling of Pond 4; and • the short-term model and forecasts are now run daily via an automated system, rather than following a semi-manual weekly process.
	e) A regional groundwater model that demonstrates an understanding of, and supports the ability to predict, the potential impacts of the proposed action on the regional groundwater system and nearby receptors. This must include groundwater hydrology in areas upstream of the evaporation ponds, for input into the groundwater modelling.	Section 5.3 (Regional 3-D Modelling) and Appendix C provide the detail of the regional groundwater model undertaken for the life of the project. The model includes groundwater hydrology in areas upstream and downstream of ponds.
65	The approval holder must within 3 months of the conclusion of the initial filling of evaporation ponds 1, 2 and 3, submit a revised GMMP to the department for approval by the Minister. The approval holder must not undertake any further filling of the ponds until the revised GMMP is approved in writing by the Minister. At the completion of filling evaporation ponds 1,2, and 3, the GMMP must be updated with sufficient information and data to address the above requirements and be resubmitted to and approved by the Minister and DWER in writing prior to filling any other ponds.	Table 9-1 in Section 9 (Commitments Register) details Mardie Minerals' commitment to this condition. This updated GMMP (Rev O) provides the outcomes of the investigations required in accordance with Conditions 63 and 64.
66	The revision required by condition 63 must be revised based on the conclusions of the investigations required by condition 64. All commitments in the revised GMMP, including environmental outcomes, management measures, corrective measures, trigger values, thresholds and performance indicators must be SMART and based on referenced or included evidence of effectiveness. The GMMP must be consistent with the Environmental Management Plan Guidelines, and must include:	This GMMP (Rev O) has been prepared after conclusion of the investigations conducted in accordance with Condition 64, and is regarded as consistent with the Environmental Management Plan Guidelines.
	a) a table of commitments made in the plan to achieve the environmental outcome, and a reference to exactly where these commitments are detailed in the plan,	Refer to Table 9-1 in Section 9 (Commitments Register) for details.
	b) details of the data collection and modelling undertaken to inform the GMMP,	Section 2.3 (Staged Filling Approach for Pond 1 to Pond 3) and Appendix A (Staged Filling data) provide the data collection and modelling to inform the updates to this version of the GMMP (Rev O).
	c) impact avoidance, mitigation and/or repair measures, and the timing of those measures,	Section 7.4 (Groundwater Management Response Plan Framework) and Appendix F include the proposed response actions to avoid / mitigate impacts, as well as management / mitigation measures to be implemented.
	d) commitments capable of ensuring that the environmental outcomes are achieved,	Table 9-1 in Section 9 (Commitments Register) details BCI's commitment to the reporting requirements and requirements to update the GMMP.
	e) a monitoring program, which must include:	Section 7.2 (Groundwater Monitoring Schedule), Table 7-1; Table 6-1 and Table 6-2 include the details of the monitoring program. Section 7.4 (Groundwater Management Response Plan Framework) includes the detailed response methodology. The Groundwater Management Procedure (Appendix F) provides the framework for implementing the GMMP, collecting data, investigation incidents, and key roles and responsibilities for Mardie Minerals in implementing the GMMP.
	i) The early warning trigger values for groundwater regimes, groundwater quality, and groundwater levels that will trigger the implementation of management and/or contingency actions to prevent non-compliance with conditions B3-1 of the WA Approval,	
	ii) the thresholds for groundwater regimes, groundwater quality, and groundwater levels to demonstrate compliance with condition B3-1 of the WA Approval,	
	iii) the final design of monitoring that will meet the requirement of condition B3-1 of the WA Approval, including the timing and frequency of monitoring, ensuring monitoring can detect trigger values and thresholds,	

Cond. #	Condition Requirement	How/Where addressed in GMMP
	iv) corrective measures which must be implemented in response to trigger value exceedances,	
	v) corrective measures which must be implemented in response to threshold exceedances,	
	vi) proposed corrective measures if trigger values are reached, and	
	vii) details of how trigger value and threshold exceedances will be assessed to determine if the exceedance is a result of the Action,	
	viii) The approval holder must provide written justification in the form of a report as an appendix to the GMMP, for the proposed triggers, limits triggers and indicators as they relates to the protection of MNES habitat by providing analysis of baseline data (from relevant locations in the receiving environment) and comparison with Australian and New Zealand guidelines for fresh and marine water quality (2018), or default guideline values for high conservation/ecological value systems.	Appendix E (Groundwater Monitoring and Management: triggers and thresholds as they relate to protection of the MNES habitat) is the report providing justification for the proposed triggers, limits triggers and indicators as they relate to the protection of MNES.
	f) details of seepage recovery measures that will be implemented where seepage from evaporation ponds to groundwater is detected,	Section 7.4 (Groundwater Management Response Plan Framework) and Table 6-1 include examples of seepage recovery measures proposed for the Project. Seepage recovery measures may include: • Installation and/or operation of seepage recovery mechanisms and/or other interception method (e.g. trenches, water diversion drains) down-gradient from the impact site(s) to recover brine seepage); • Pumping of recovered groundwater to an appropriate disposal location (likely to be the adjacent evaporation pond) and surface water diversion drains may be used as transfer channels for such water; and • dewatering spears will be used to control groundwater inflows during pond conditioning and operations, to reduce or divert groundwater inflows to help prevent habitat disruption and to maintain stable water levels to reduce the potential impact on BCH.
	g) an assessment of the effectiveness and reliability of the proposed monitoring system, including:	The analysis and interpretation of actual monitoring data collected during the initial filling of Ponds 1, 2 and 3, as per Appendix A, has proven effective to detect changes to groundwater regimes, groundwater quality, and groundwater levels from September 2024 to date; this GMMP (Rev O) will continue to use the monitoring data. All detected thresholds exceedances during September 2024 to January 2025 have been investigated in accordance with Mardie Minerals' Incident Investigation Procedure and the Groundwater Monitoring Procedure. Both procedures include investigation of multiple lines of evidence to determine the possible cause/s for exceedance/s, including the approved BCHMMP and MSMMP for the Project. The Groundwater Management Response Framework (in Section 7.4.1 and Table 6-1) detail how exceedances are investigated, responded to and monitored (including reactive and ad hoc monitoring) in order to determine of exceedance is attributable to the Action.
	i) demonstration of whether and how the monitoring system will be able to detect changes to groundwater regimes, groundwater quality, and groundwater levels until at least the anticipated completion of the Action, and	
	ii) demonstrate if and how the monitoring system will be able to determine if exceedances are attributable to the Action,	
	h) reporting and review mechanisms to demonstrate compliance with the commitments made in the plan and the requirement specified in condition B3-1 of the WA Approval, including a commitment to review the GMMP at least once every 5 years,	Refer to Section 8 (Reporting) and Section 10 (Adaptive Management and Review of the Plan). Reporting will be done in accordance with compliance reporting requirements, notification of incidents, submission of incident investigation reports, annual reporting,
	i) an assessment of risks relating to achieving the environmental outcomes and risk management strategies and/or mitigation measures that will be applied to address identified risks, and	Refer to Section 5.4 (Risk Assessment) and Table 5-4 for the risk assessment to achieving the environmental outcomes and proposed strategies and/or mitigation measures that will be applied to address identified risks.
	j) references to other relevant plans or conditions of approval (including State approval conditions).	Section 7.3 (Association with other Management Plans) details the linkage of this GMMP (Rev O) to the BCHMMP and MSMMP. Section 2.8 (Condition Requirements) and Table 2-3 set out the relevant conditions of approvals, including the State conditions, to be complied with through implementation of the GMMP.
67	If the revised GMMP required in condition 63 has not been revised to the satisfaction of the Minister and therefore is not approved within 12 months of the date of evaporation ponds 1 to 3 being filled, the approval holder must undertake the following:	Noted. Table 9-1 in Section 9 (Commitments Register) details Mardie Minerals' commitment to the requirements detailed in Condition 67.
	a) Cease operations until the revised GMMP is approved in writing by the Minister.	
	b) If directed by the department, empty evaporative ponds 1 to 3. Contents of evaporative ponds are to be disposed in a manner approved in writing by the department.	Mardie Minerals will engage with the department in the event that such direction is given.
68	The approval holder must review the GMMP after 2 years of commencement of the Action. The approval holder must submit the findings of each review to the department. The review must be completed by a reviewer, or reviewers approved by the department and must include detailed reviews of the:	Noted. Table 9-1 in Section 9 (Commitments Register) details Mardie Minerals' commitment to the requirements detailed in Condition 68, for action in due course.
	a) Monitoring required by the approved GMMP, including monitoring bore network, monitoring methodology, monitoring frequency, and trigger and thresholds.	
	b) Implementation of the GMMP,	

Cond. #	Condition Requirement	How/Where addressed in GMMP
	c) Effectiveness of the GMMP regarding the achievement of its environmental objective.	
	d) Capacity to measure incremental impacts that may occur during the life of the Action,	
	e) Assessment of whether the GMMP requires revision at this time.	
69	The GMMP must be revised to address all recommendations for the reviewed required by condition 68 and submitted to the department for approval by the Minister. The revised GMMP must include:	Noted. Table 9-1 in Section 9 (Commitments Register) details Mardie Minerals' commitment to the requirements detailed in Condition 69, for action in due course.
	a) Revised modelling that includes all data collected to date	
	b) Revised monitoring and management measures in accordance with recommendations of the review undertaken in condition 68.	
70	The approval holder must review the approved GMMP at least once within every subsequent 5-year period following the approval of the GMMP. The approval holder must submit the findings and recommendations of each review to the department. The review must be completed by a suitably qualified expert and must include:	Noted. Table 9-1 in Section 9 (Commitments Register) details Mardie Minerals' commitment to the requirements detailed in Condition 70, for action in due course. Additionally, Section 10 (Adaptive Management and Review of the Plan) details Mardie Minerals' commitment to the requirements for review and update of the GMMP.
	a) A detailed review of the monitoring required by the approved GMMP, including monitoring bore network, monitoring methodology, monitoring frequency, and trigger and thresholds.	
	b) A detailed review of the implementation of the GMMP,	
	c) A detailed review of the effectiveness of the GMMP regarding the achievement of its environmental objective.	
	d) Revised modelling that includes all data collected to date,	
	e) Revised monitoring and management measures in accordance with recommendations of the review undertaken in condition 68.	
71	For any revision of the GMMP, all commitments in the GMMP, including environmental outcomes, management measures, corrective measures, trigger values, thresholds and performance indicators must be SMART and based on referenced or included evidence of effectiveness and accordance with condition 66. The GMMP must be consistent with the Environmental Management Guidelines.	Noted. Table 9-1 in Section 9 (Commitments Register) details Mardie Minerals' commitment to the requirements. Additionally, Section 10 (Adaptive Management and Review of the Plan) details Mardie Minerals' commitment to the requirements for review and update of the GMMP.
Ministerial Statement 1211		
A1-1	Groundwater abstraction - No dewatering of groundwater for any reason except to meet the requirements of condition B3-2.	Noted.
B1-1	The proponent must ensure the implementation of the proposal achieves the following environmental outcomes: (4) no change in the health, extent of coverage, or species diversity of intertidal benthic communities more than 100 m seaward of the pond walls as shown in Figure 2; and (5) adverse impacts to intertidal benthic communities are limited to an area within 100 m of the pond wall defined in Figure 2.	Section 7.3 (Association with Other Management Plans), Section 7.4 (Groundwater Management Response Plan Framework) and Table 6-1 include details of how monitoring (including reactive monitoring) will be done in accordance with the approved BCHMMP when exceedance of threshold for groundwater level or groundwater quality is detected through the groundwater monitoring network, and the management and mitigation measures to be implemented to avoid / minimise impacts on BCH more than 100 m seaward of pond walls.
B3-1	The proponent must ensure the implementation of the proposal achieves the following environmental outcomes: (1) no adverse impact to water levels or water quality in Mardie Pool as a result of changes to groundwater regimes or groundwater quality (2) No adverse impact to water levels or water quality in Mardie Pool as a result of surface water flows associated with the proposal (4) no changes to the health, extent or diversity of intertidal benthic communities and habitat, including mangrove, coastal samphire and algal mat as a result of changes to groundwater regimes or groundwater quality associated with the proposal;	Section 7.3 (Association with Other Management Plans), Section 7.4 (Groundwater Management Response Plan Framework) and Table 6-1 and Table 6-2 include details of how monitoring (including reactive monitoring) will be done in accordance with the approved BCHMMP when exceedance of threshold for groundwater level or groundwater quality is detected through the groundwater monitoring network, and the management and mitigation measures to be implemented to avoid / minimise impacts on Mardie Pool, and BCH.
B3-2	The proponent must: 1. implement the Groundwater Monitoring and Management Plan (GMMP; Rev F, submitted March 2023), once updated and approved in accordance with condition B3-3, and subject to the requirements of condition C1-1(3), with the purpose of ensuring the benthic communities and habitat environmental outcomes in condition B3-1 (1) and (4) and condition B1-2 are achieved, monitored, substantiated and satisfy the requirements of conditions C4 and condition C5; and 2. review the GMMP environmental management plan (Rev F, submitted March 2023); within one (1) year of the date of this statement to include: (a) the relationship between the GMMP environmental management plan and the BCHMMP environmental management plan, and how these plans work together to ensure overlapping and holistic impacts are managed and monitored, to ensure the environmental outcomes and objectives relevant to both plans are achieved.	This GMMP (Rev O) has incorporated feedback from DWER (on GMMP Rev F, Rev K and Rev N) and DCCEEW, peer review recommendations, updated technical studies including modelling and data collection from bores installed since 2022. Section 7.3 (Association with Other Management Plans) discusses the relationship between this GMMP and the approved BCHMMP and MSMMP.

Cond. #	Condition Requirement	How/Where addressed in GMMP
B3-3	The GMMP (Rev F, submitted March 2023) environmental management plan required by condition B3-2 is to be updated with project specific trigger values at the completion of baseline data collection.	This document GMMP (Rev O) addresses this condition. Additionally, Section 10 (Adaptive Management and Review of the Plan) and commitments in Section 9 and Table 9-1 outlines Mardie Mineral's commitment to ongoing review and updates to this GMMP (Rev O)
C1-1	The proponent must not undertake: (3) transfer of sea water, brine and/or waste product associated with the Mardie Project until the CEO has confirmed in writing that the environmental management plan required by condition B3-2 has been updated in accordance with condition B3-3 and meets the requirements of condition C4;	Noted. DWER conditionally approved GMMP Rev K in April 2024, and Mardie Minerals obtained approval from DCCEEW of GMMP Rev M in September 2024. The initial filling of Ponds 1, 2 and 3 commenced after approval EPBC 2022/9169 was granted in September 2024. Mardie Minerals notified DWER of commencement of operations on 10 September 2024 and undertook the first transfer of sea water into Ponds 1, 2 and 3.
C2-1	Upon being required to implement an environmental management plan under Part B, or after receiving notice in writing from the CEO under condition C1-1 that the environmental management plan(s) required in Part B satisfies the relevant requirements, the proponent must: (1) implement the most recent version of the confirmed environmental management plan; and (2) continue to implement the confirmed environmental management plan referred to in condition C2-1(1) other than for any period which the CEO confirms by notice in writing that it has been demonstrated that the relevant requirements for the environmental management plan have been met, or are able to be met under another statutory decision-making process, in which case the implementation of the environmental management plan is no longer required for that period.	Mardie Minerals will implement this GMMP (Rev O) as and when approved by the CEO.
C2-2	The proponent: (1) may review and revise a confirmed environmental management plan provided it meets the relevant requirements of that environmental management plan, including any consultation that may be required when preparing the environmental management plan; (2) must review and revise a confirmed environmental management plan and ensure it meets the relevant requirements of that environmental management plan, including any consultation that may be required when preparing the environmental management plan, as and when directed by the CEO: and (3) must revise and submit to the CEO the confirmed environmental management plan if there is a material risk that the outcomes or objectives it is required to achieve will not be complied with, including but not limited to as a result of a change to the proposal.	Noted for future revisions to the GMMP. Additionally, Section 10 (Adaptive Management and Review of the Plan) and commitments in Section 9 and Table 9-1 outline Mardie Mineral's commitment to ongoing review and updates to this GMMP (Rev O)
C2-3	Despite condition C2-1, but subject to conditions C2-4 and C2-5, the proponent may implement minor revisions to an environmental management plan if the revisions will not result in new or increased adverse impacts to the environment or result in a risk to the achievement of the limits, outcomes or objectives which the environmental management plan is required to achieve.	Noted for future revisions to the GMMP. Additionally, Section 10 (Adaptive Management and Review of the Plan) and commitments in Section 9 and Table 9-1 outlines Mardie Mineral's commitment to ongoing review and updates to this GMMP (Rev O)
C2-6	Confirmed environmental management plans, and any revised environmental management plans under condition C2-4(1), must be published on the proponent's website and provided to the CEO in electronic form suitable for online publication by the DWER within twenty (20) business days of being implemented, or being required to be implemented (whichever is earlier).	Noted. The conditionally approved GMMP Rev K in April 2024, and Mardie Minerals obtained approval from DCCEEW of GMMP Rev M in September 202, are currently published on the BCI Minerals corporate website (https://www.bciminerals.com.au/sustainability/environmental-protection.html). Upon approval of this GMMP (Rev N) Mardie Minerals will also publish this GMMP (Rev N) on its corporate website.
C3-1	The proponent must undertake monitoring capable of: (1) substantiating whether the proposal limitations and extents in Part A are exceeded; and (2) detecting and substantiating whether the environmental outcomes identified in Part B are achieved (excluding any environmental outcomes in Part B where an environmental management plan is expressly required to monitor achievement of that outcome).	As detailed in Section 7.2 (Groundwater Monitoring Schedule) and Section 7.3 (Association with other Management Plans) details the linkage of this GMMP (Rev N) to the BCHMMP and MSMMP. Additionally, Section 10 (Adaptive Management and Review of the Plan) and commitments in Section 9 and Table 9-1 outlines Mardie Mineral's commitment to ongoing review and updates to this GMMP (Rev O).
C3-2	The proponent must submit as part of the Compliance Assessment Report required by condition D2, a compliance monitoring report that: (1) outlines the monitoring that was undertaken during the implementation of the proposal; (2) identifies why the monitoring was capable of substantiating whether the proposal limitation and extents in Part A are exceeded; (3) for any environmental outcomes to which condition C3-1(2) applies, identifies why the monitoring was scientifically robust and capable of detecting whether the environmental outcomes in Part B are met; (4) outlines the results of the monitoring; (5) reports whether the proposal limitations and extents in Part A were exceeded and (for any environmental outcomes to which condition C3-1 (2) applies) whether the environmental outcomes in Part B were achieved, based on analysis of the results of the monitoring; and (6) reports any actions taken by the proponent to remediate any potential non-compliance.	As detailed in Section 8 (Reporting) and Table 9-1 in Section 9 (Commitments Register), Mardie Minerals will comply with this condition and all sub-conditions.

Cond. #	Condition Requirement	How/Where addressed in GMMP
C4-1	The environmental management plans required under condition B1-4, condition B2-2, condition B3-2, condition B4-3, condition B5-3, condition B5-4, condition B6-4, condition B6-6 and condition B8-3 must contain provisions which enable the substantiation of whether the relevant outcomes of those conditions are met, and must include: (1) threshold criteria that provide a limit beyond which the environmental outcomes are not achieved; (2) trigger criteria that will provide an early warning that the environmental outcomes are not likely to be met; (3) monitoring parameters, sites, control/reference sites, methodology, timing and frequencies which will be used to measure threshold criteria and trigger criteria. Include methodology for determining alternative monitoring sites as a contingency if proposed sites are not suitable in the future; (4) baseline data; (5) data collection and analysis methodologies; (6) adaptive management methodology; (7) contingency measures which will be implemented if threshold criteria or trigger criteria are met; and (8) reporting requirements.	This GMMP has been prepared in accordance with this condition. Section 7.2 (Groundwater Monitoring Schedule) and Appendix F detail the monitoring data collection for implementation of the GMMP. Additionally, Section 7.3 (Association with Other Management Plans) details the linkage of this GMMP (Rev O) to the BCHMMP and MSMMP.
C4-4	The environmental management plan required under condition B3-2 is also required to: (1) when implemented, substantiate and ensure that the outcome of conditions B3 -1 (1) and B3-1 (4) will be met; (2) provide the details, including timing, of hydrogeological investigations to be carried out that will: (3) provide a detailed understanding of the hydrological regime in the project area; (4) inform the final design of monitoring that will meet the requirement of condition C4-1; (5) inform the final design of management and mitigation actions that will be implemented to meet the outcomes of conditions B3 -1 (1) and B3-1 (4); and (6) detail the timing of monitoring bore installation and collection of baseline data, providing justification to demonstrate that data will represent baseline where it is collected after the commencement of operations.	Section 7.2 (Groundwater Monitoring Schedule) and Appendix F detail the monitoring data collection for implementation of the GMMP. Additionally, Section 7.3 (Association with Other Management Plans) details the linkage of this GMMP (Rev O) to the BCHMMP and MSMMP.
D1	Non-compliance Reporting	As detailed in Section 8 (Reporting) and Table 9-1 in Section 9 (Commitments Register), Mardie Minerals will comply with this condition and all sub-conditions.
D2	Compliance Reporting	As detailed in Section 8 (Reporting) and Table 9-1 in Section 9 (Commitments Register), Mardie Minerals will comply with this condition and all sub-conditions.

2.9 Relevant Technical Studies

A number of technical studies have been undertaken to support the development and / or implementation of this GMMP. A summary of the key studies and investigations that have been undertaken, or are ongoing, is provided in Table 2-4.

Significant work, including bore installation and monitoring (refer to Section 4), monitoring at Mardie Pool and Mt Salt Spring (refer to Section 6.2 and Section 6.3, respectively), and groundwater modelling, has been completed in support of developing the GMMP for the Project.

Table 2-4 Status of Key Studies and Investigations

Investigation	Details	Status (December 2024)
Terrestrial Monitoring Bore Drilling Program	Installation of monitoring bores in the vicinity of Mardie Pool and evaporation ponds to permit water level and quality investigations.	Completed
Coastal Monitoring Bore Drilling Program	Installation of monitoring bores on the coastal side of evaporation ponds and near the Robe River Delta Mangrove Management Area (RDMMA) to permit water level and quality investigations.	
Aquifer Testing.	Pumping tests of test bores within the Fortescue Alluvial aquifer and Carnarvon Superficial aquifer to quantify aquifer parameters.	
Conceptual Hydrogeological model and impact modelling across 2D transects	Development of a conceptual model and numerical impact modelling across 4 representative transects for a range of scenarios to estimate potential for environmental impacts from groundwater mounding or seepage from evaporation ponds.	Completed
Regional Groundwater modelling.	Development of a regional groundwater flow model to assess the potential impacts of the proposed evaporation ponds on the regional groundwater system.	Completed Refer to Appendix C
Mardie Pool Transient Electromagnetic (TEM) Survey.	In January 2024 anon-invasive TEM survey to investigate groundwater salinity distribution in areas where drilling was not permitted by traditional owners.	Completed
Mardie Pool Surface Water/Groundwater Interaction Investigation.	Data collection began October 2022.	Ongoing incorporation into conceptualisation and groundwater modelling. Collection of water level and quality data ongoing on a quarterly frequency. From October 2024 the collection of the water level and quality data is undertaken on a monthly basis.
Data collection began October 2022.Ongoing incorporation into conceptualisation and groundwater modelling.	Collection of water level and quality data ongoing on a quarterly frequency. From October 2024 the collection of the water level and quality data is undertaken on a monthly basis.	Collection of water level and quality data ongoing on a quarterly frequency. From October 2024 the collection of the water level and quality data is

Investigation	Details	Status (December 2024)
		undertaken on a monthly basis.
Baseline Groundwater level and quality monitoring.	Acquisition of water level, water samples and EC profiles from all monitoring network bores to characterise natural variation and ongoing variations which may be due to effects of the project.	Ongoing monitoring as described in this GMMP for each bore network.
Mt Salt Mound source analysis.	Site visit November 2022 and August 2023 found no discharge was evident at that time. Should artesian water discharge be found at Mt Salt, water samples will be taken to be compared to potential upgradient groundwater sources. Spring source will be investigated through analysis of stable isotopes or radionuclides.	Ongoing quarterly visits will continue noting that, to date, there has been no water discharge at the site.
Development of trigger and threshold criteria.	Development of trigger and threshold criteria for groundwater quality from the baseline groundwater quality data.	Triggers and Thresholds developed (Table 6-1 and Table 6-2 and details contained in Appendix D).

2.10 Stakeholder Consultation

Mardie Minerals have consulted extensively with and will have ongoing consultation with all stakeholders who are affected by the proposal for the life of Project. This includes (but not limited to):

- Indigenous community groups (Wirrawandi Aboriginal Corporation (WAC), Robe River Kuruma Aboriginal Corporation (RRKAC).
- Neighbouring pastoral lease owners (Pastoral Management Pty Ltd (PMPL)).
- Government agencies (EPA, DEMIRS, DWER; DBCA, Department of Planning, Lands and Heritage (DPLH); Main Roads Western Australia (MRWA); Pilbara Ports Authority (PPA); Department of Climate Change, Energy, the Environment and Water (DCCEEW)).
- Local Government (Shire of East Pilbara and Town of Port Hedland).
- Community / Special interest Groups (Hampton Harbour Boat and Sailing Club, Nickol Bay Sporting Fishing Club, Wildflower Society, Rangelands Natural Resource Management WA, Birds Australia / Birdlife Australia.

Consultation regarding the Project has included both the Original and the Optimised Proposals. In addition to the consultation completed in relation to the Proposals, additional consultation has more recently been undertaken with key stakeholders in relation to the Plan and will continue throughout the life of the Project.

3. GROUNDWATER AT MARDIE

3.1 Hydrogeology

The Mardie Project development envelope lies wholly within the bounds of the northern extremity of the onshore Carnarvon Basin. At this location, the Carnarvon Basin sediments dip gently to the north-west, and to the east the Basin onlaps the western edge of the Pilbara Craton approximately 30 km inland from the coast. Coastal Plain sediments of clay, gravel and calcrete, (often weathered to calcareous claystone), cover the entire area of interest.

3.2 Hydrostratigraphy

At Mardie two significant, distinct unconfined aquifer systems are present:

- the Fortescue Alluvial aquifer and the
- alluvial aquifer of the Coastal Plain (the latter referred to by DWER as the Carnarvon Superficial aquifer).

The extent of these systems is displayed in Figure 5, and the hydrostratigraphy of the systems is presented below.

3.2.1 Coastal Plain Alluvial Aquifer

The coastal plain alluvial aquifer is generally unconfined and formed in Pliocene / Quaternary sediments. It is in hydraulic connection with confined aquifers within the underlying Carnarvon Basin sediments (Yarraloola Conglomerate, Birdrong Sandstone) (Haig 2009).

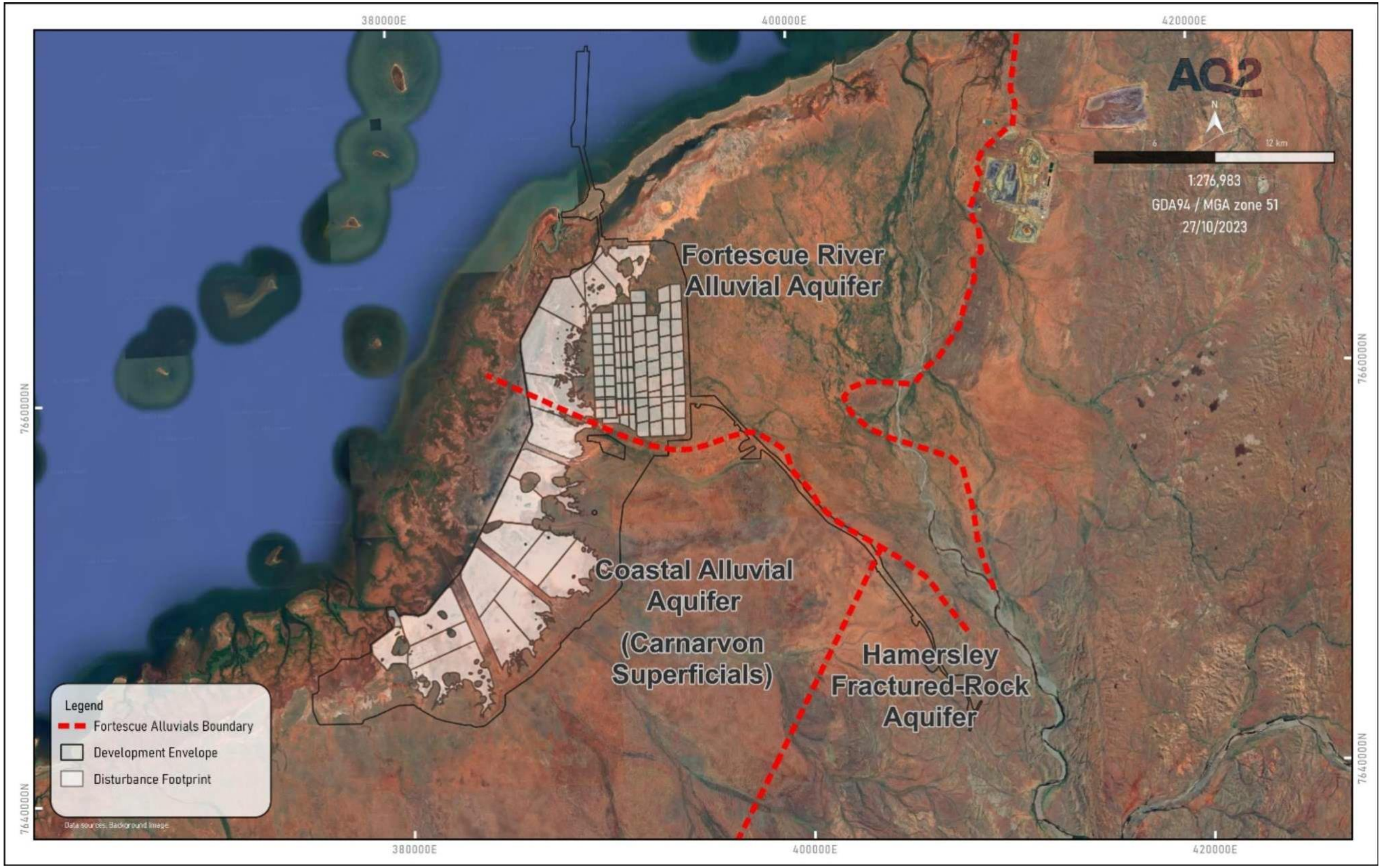
The hydrostratigraphy of the coastal aquifer has been defined through data from geotechnical investigations across the intra-tidal zone and deeper (~30 m) investigative test bores in the hinterland area to the south-east. Deeper information (>10 mbgl) is limited in the area of the sabkha (due to the logistical difficulties of operating in this zone). The generalised hydrostratigraphic units are summarised as follows:

- Alluvial Sand/ Pisolite – cover of unconsolidated alluvial sand and gravel, generally in the unsaturated zone on rising terrain inland from the intra-tidal zone, with moderate to high hydraulic conductivity.
- Silt/clay – thick layer of variably mixed silt, clay and (matrix-supported) gravel up to 10 m thick. Low hydraulic conductivity. Extensive beneath the sabkha zone.
- Calcareous Claystone/ Calcrete – sporadically noted across the area in deeper geotechnical test holes. Potentially a zone of marginally higher conductivity than clay when porosity has developed. Deeper test bores inland and up gradient from the sabkha have also intercepted deeper calcrete conglomerate along drainage channels which may extend beneath the sabkha where paleochannels extend into this zone.
- Limestone – extensive basement limestone bedrock unit (likely Trealla Limestone). Not drilled or tested under the sabkha zone.

3.2.2 Fortescue Alluvial Valley

The Fortescue River alluvial valley forms a large aquifer of fresh groundwater across the alluvial fan west of the main river channel. Gravel units within the valley sediments have the highest yield and a total saturated thickness of up to 15m (Commander 1994). Silt and gravel content is variable both vertically and horizontally, resulting in highly variable aquifer transmissivity and variations in water quality. The gravels grade laterally into overbank silt and clay deposits with much lower transmissivity, shallowing significantly near the southern edge of the valley. These overbank deposits are contiguous with the silt and clay unit of the Coastal Plain aquifer. Collectively, these low transmissivity units underlie much of the study area.

Figure 5 Unconfined Aquifer Systems at Mardie



3.3 Groundwater Levels and Flow

Regional groundwater level and flow direction is presented in Figure 6, generated from water levels measured in groundwater investigation bores which have been installed since 2019 at Mardie (Figure 7). The water table falls from the Fortescue River towards the north-west with groundwater level contour lines generally parallel to the coast (excluding localised variations due to creeks and hydrostratigraphic differences). To the east of the project, the water table gradient is relatively steep and mirrors the rise in terrain (towards the inland zone and shallowing basement).

In the intra-tidal zone and sabkha, the groundwater gradient is essentially flat at approximately 1:5,000. This is indicative of negligible lateral groundwater flow across this zone. Based on this, the following are posited:

- There is negligible lateral movement of groundwater from the sabkha to the ocean (or from the ocean inland).
- There is negligible lateral movement of groundwater parallel to the coast.
- In the absence of lateral groundwater movement, the primary water fluxes from the coastal zone are vertical, comprising:
    - Periodic recharge (infiltration) during the highest tides when the sabkha is inundated.
    - Evaporation of shallow water from the surface of the coastal flats and sabkha in the periods between inundation. The fine-grained nature of the sediments in this area (silt and clay) will have a large capillary rise and high porosity to support evaporation during this period.

3.4 Recharge

The greatest recharge to the coastal plain aquifer occurs during flooding in locations where the aquifer is in connection with the major rivers and creeks. Some direct recharge to the coastal plain will occur during major rainfall events when extensive flooding overbanks from the water courses and moves as sheet flow across the plain.

Within the alluvial valley, flood recharge at the Fortescue River has been noted to move as a pulse of increased water level towards the coast slowly over several months. Significant recharge generally only occurs with the passing of tropical cyclones or rain-bearing tropical low-pressure systems within the Fortescue River catchment. Monitoring bores north of Mardie Pool responded with 1 to 1.5 m water level rises in the months following a large rainfall event in June 2022, and lesser rises following smaller rainfall events in March/April 2023

On the coastal sabkha, recharge is driven by cyclic tidal inundation (outlined in Section 3.3). Hydrographs in Figure 8 provide examples of monitoring bore response to tidal inundation on the sabkha area between

Pond 3 and the nearest mangroves to the west. At these locations deep bores are screened at approximately 8-10 m below ground level (bgl) and shallow bores are screened across the water table. Water levels at the bores display a distinct rapid recharge at the time of inundation from high Spring tides. Data indicates that the soil profile is generally fully saturated by the first Spring tide which reaches the bore. The following high tides consequently keep the storage full until tides recede in following days to the point where the bore location is not inundated. From this time until the next inundation the water level in the bore gradually falls, while being overprinted with a small tidal pressure pulse. The water level recession between inundation events is due to evaporative discharge as described above.

Figure 9 displays hydrographs from bores which were originally installed for monitoring of the gas pipeline corridor (between Ponds 1-2 and Pond 3). The chart displays the differing response to rainfall and tidal recharge with distance from the coast.

Figure 6 Regional Groundwater Levels and Flow

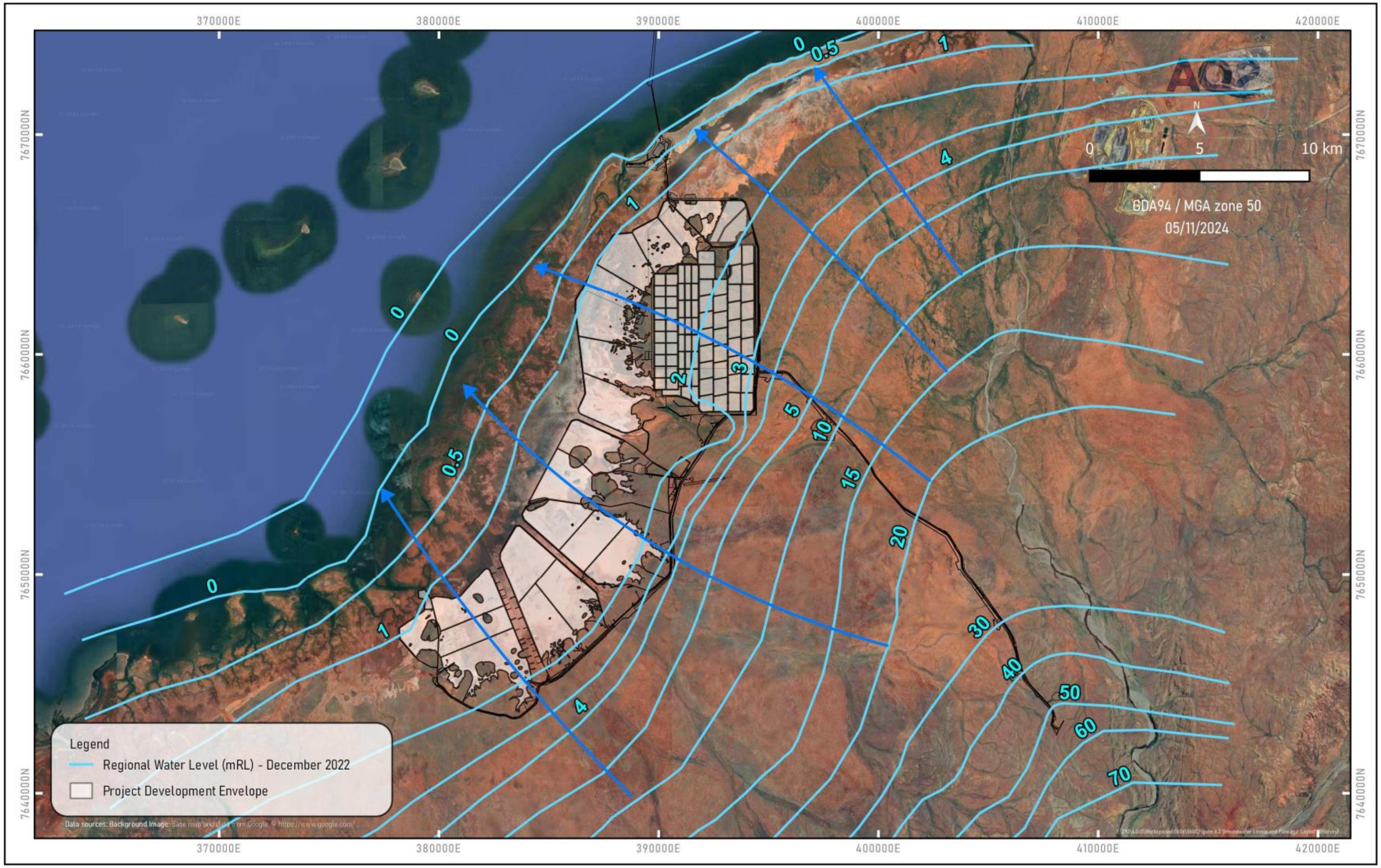


Figure 7 Location of Investigation Bores

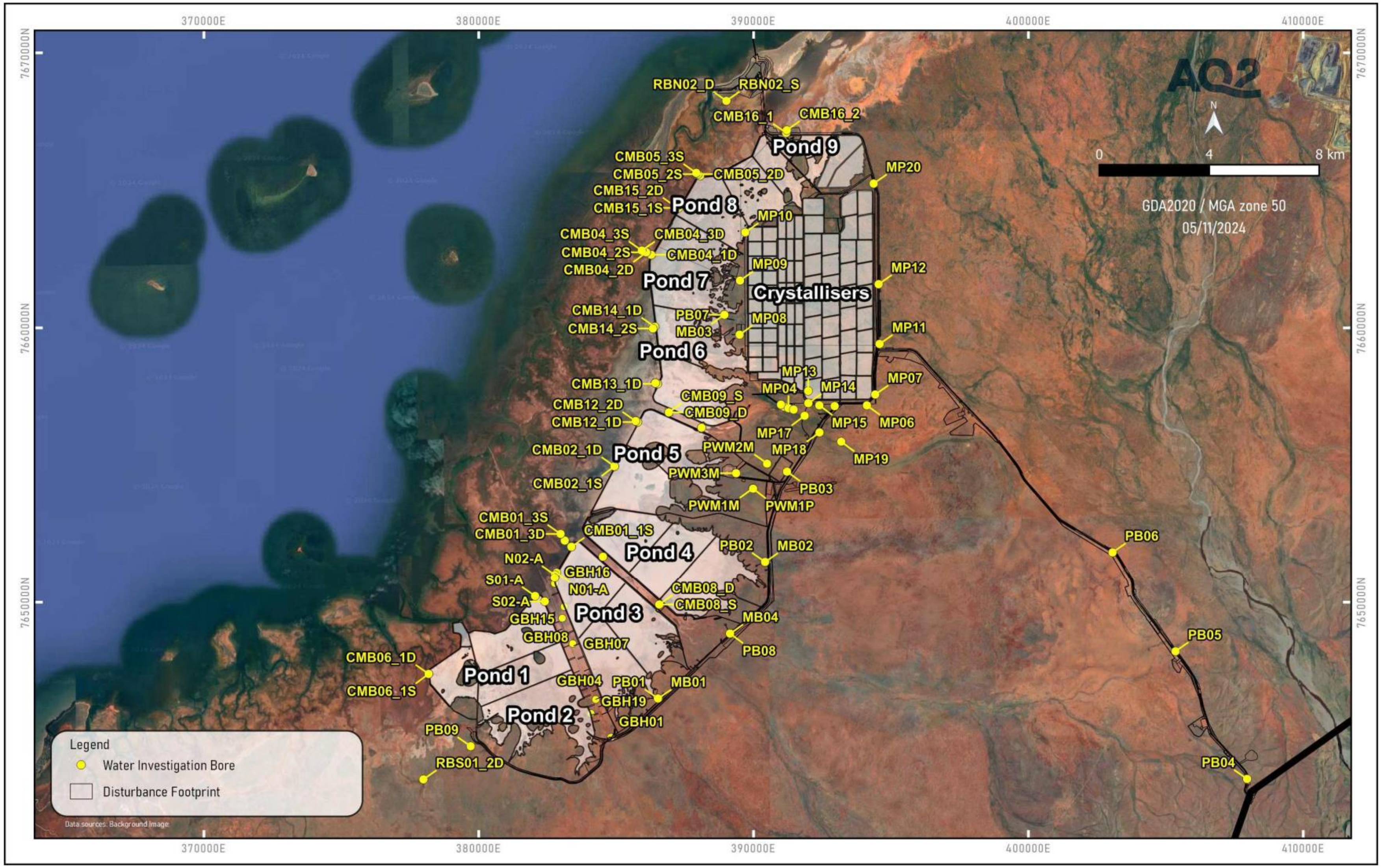
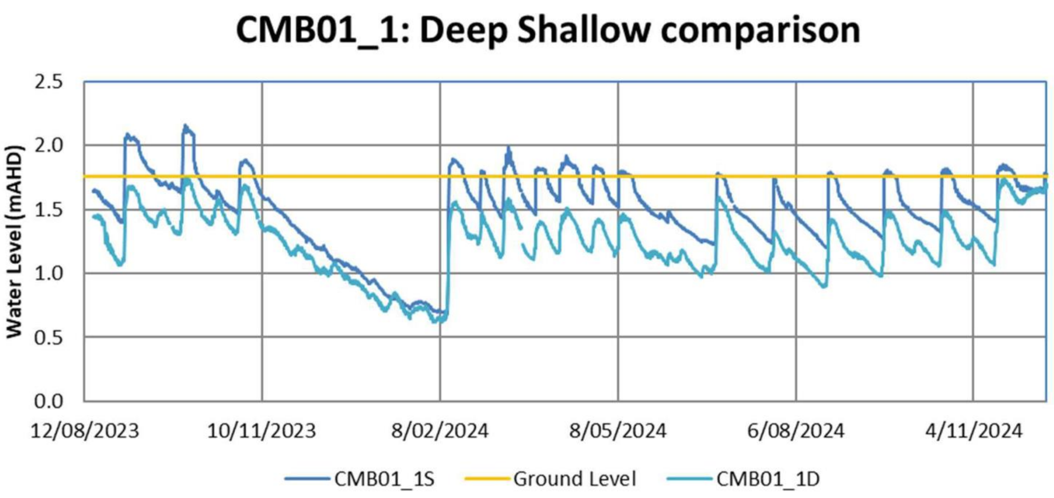
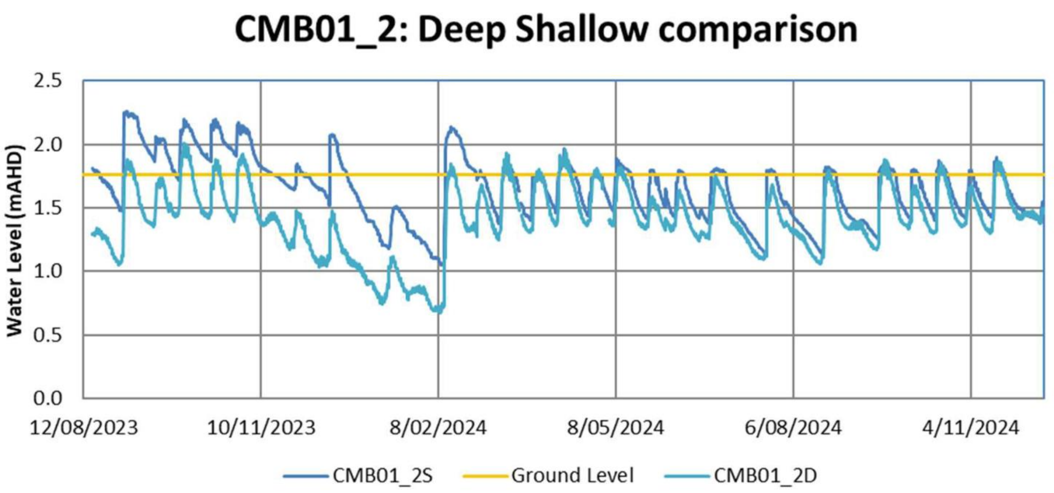


Figure 8 Hydrographs from the Tidal Area adjacent to Pond 3





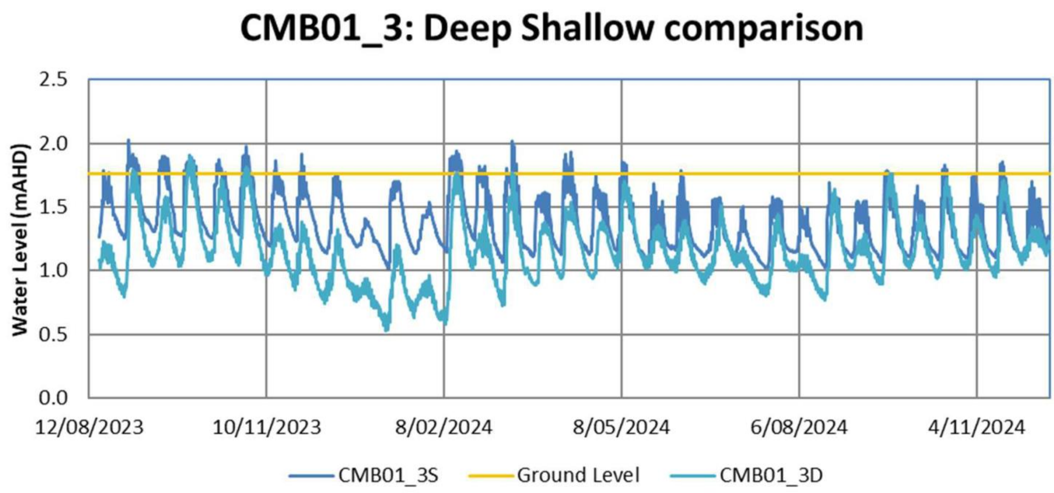
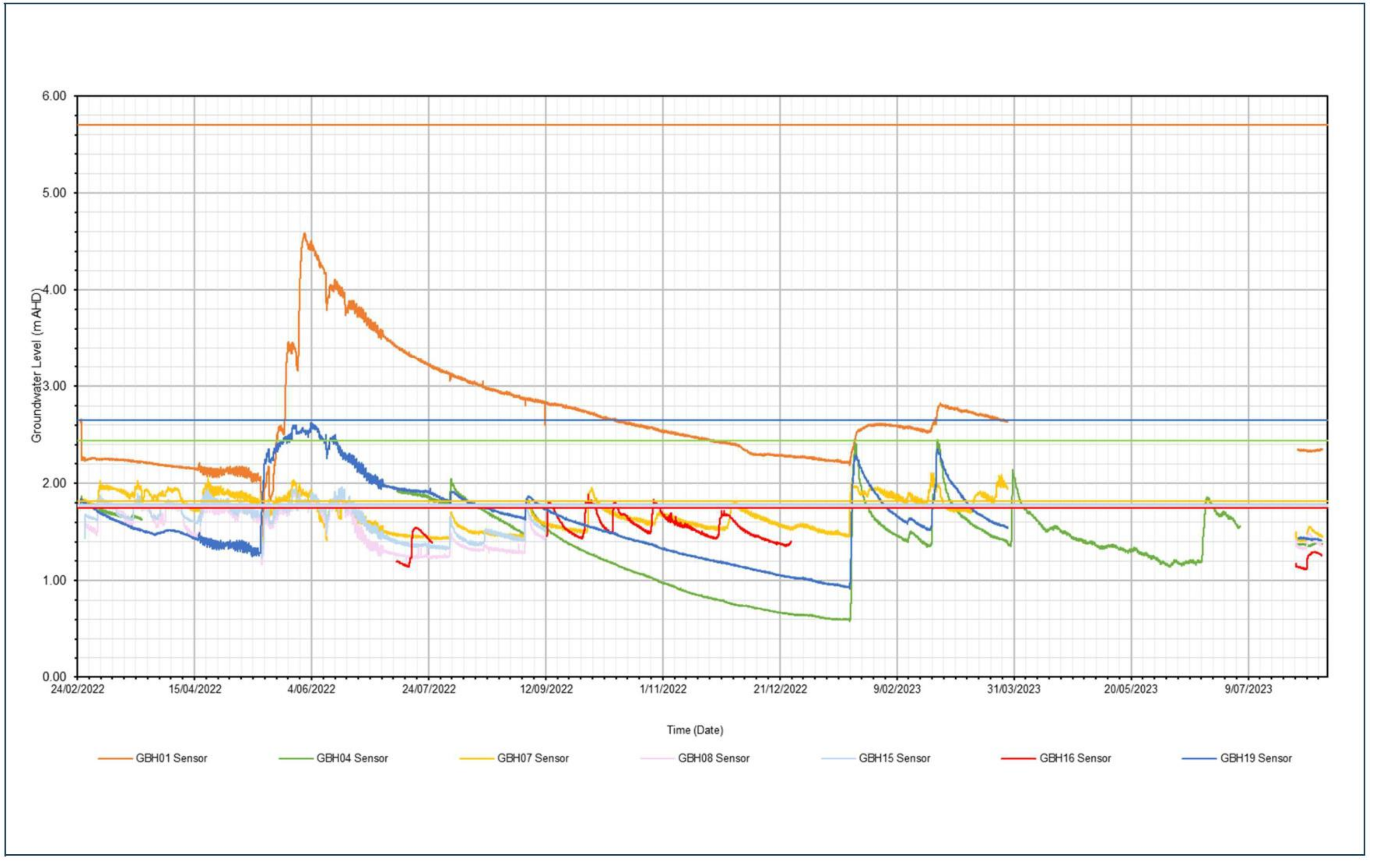


Figure 9 Hydrograph from Historical Bores on Gas Pipeline Corridor



3.5 Groundwater Quality

Figure 10 displays generalised groundwater salinity, (as electrical conductivity (EC)), at Mardie as seen in a large number of test pits and bores over several years. Where salinity profiles have been taken in monitoring bores, the EC used was from deeper in the bores at around 10mbgl. In test production bores, the EC was taken during pumping tests and is therefore biased towards the EC of the most productive strata.

Fresh water extends down the Fortescue River alluvial valley to meet the saline plume of the tidal flats approximately 7 km inland from the coast. Inland from the southern half of the Mardie Project within the Carnarvon Superficial aquifer, fresh groundwater within the coastal plain alluvium abuts the hypersaline saline water interface up to approximately 11km inland from the coast.

Hypersaline groundwater was intercepted across the entire intra-tidal zone and in some deep bores on the upland alluvial plain to the south-east. A selection of deep and shallow bores (2m/~8m pairings) installed on the tidal flats in 2023 (Table 3-1) have consistently displayed the presence of hypersaline water in the EC range 160,000 - 200,000 µS/cm, indicating that the quality of water is similar throughout the soil profile relevant to the receptors in this area (algal mats and mangroves). One shallow bore adjacent to the mangroves and creeks west from Pond 3 (CMB1_3S), presented slightly less hypersaline, likely due to tidal flushing. Bores adjacent to Pond 1 and a tidal creek at the south end of the project (CMB6_1S/D) presented salinity significantly greater than sea water (Table 3-1).

Salinity profiles from several monitoring bores in the Fortescue River valley alluvium north of Mardie Pool display increased salinity at the base of the bore, providing an indication of the location of the saline interface. Examples of the vertical salinity profile are shown in Figure 11.

Table 3-1 Salinity in Selected Coastal Bores

Bore ID**	Easting GDA2020 MGA50	Northing GDA2020 MGA50	Sample Conductivity (µS/cm)	Calculated TDS* (mg/L)
CMB1_1D	383346	7652050	189,000	141,000
CMB1_1S	383346	7652050	184,000	138,000
CMB1_2D	383129	7652268	173,000	130,000
CMB1_2S	383129	7652268	153,000	114,000
CMB1_3D	382977	7652509	169,000	127,000
CMB1_3S	382977	7652509	113,000	85,000
CMB2_1D	384909	7655003	202,000	151,000
CMB2_1S	384909	7655003	206,000	155,000
CMB6_1D	378177	7647380	57,000	43,000
CMB6_1S	378177	7647380	73,000	55,000

*Total Dissolved Solids assumed conversion factor 0.75, compensated to 25 degree °C at measurement

**D = deep screen 7-10m; S = shallow screen across water table.

Figure 10 Generalised Groundwater Salinity (as TDS)

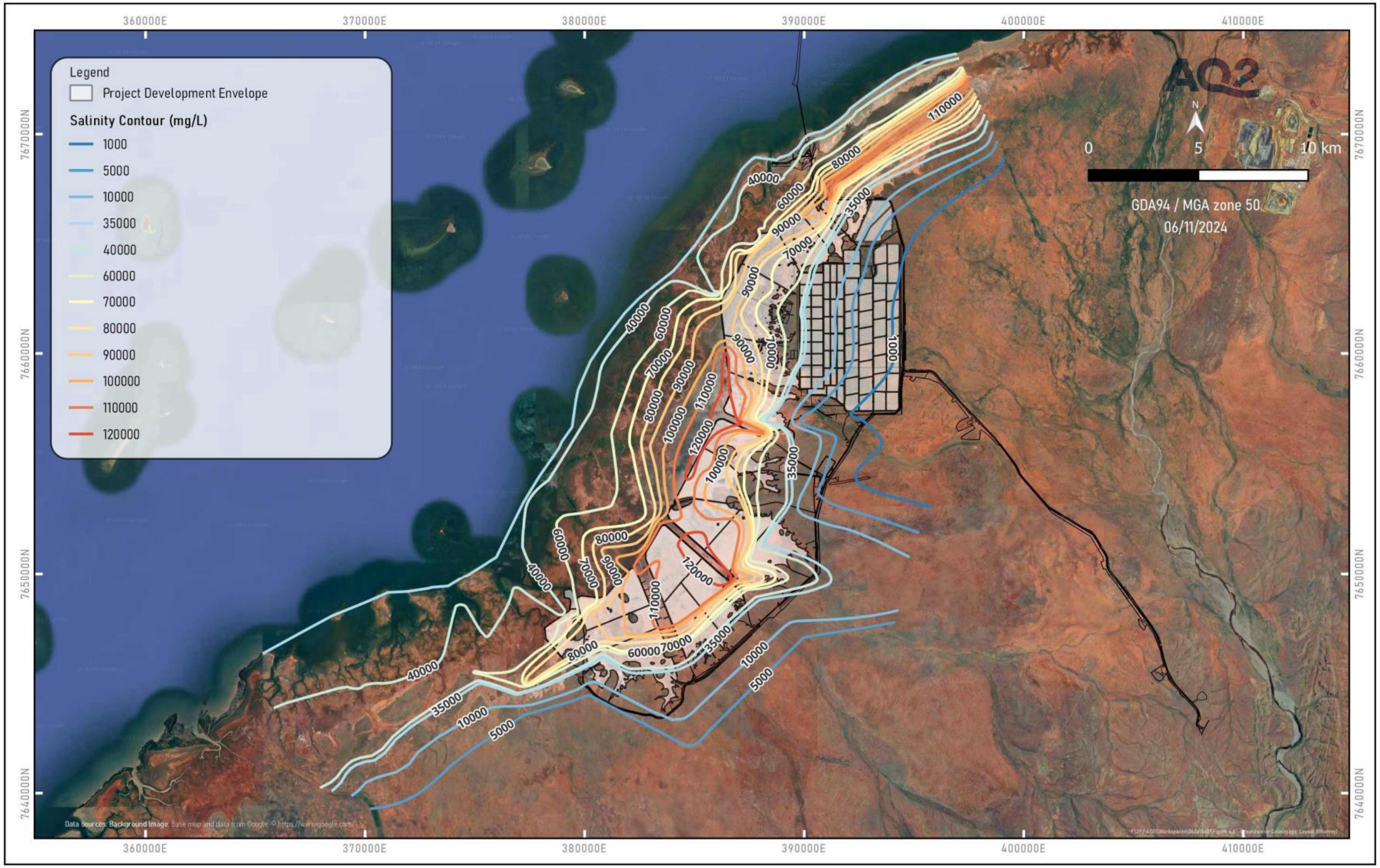
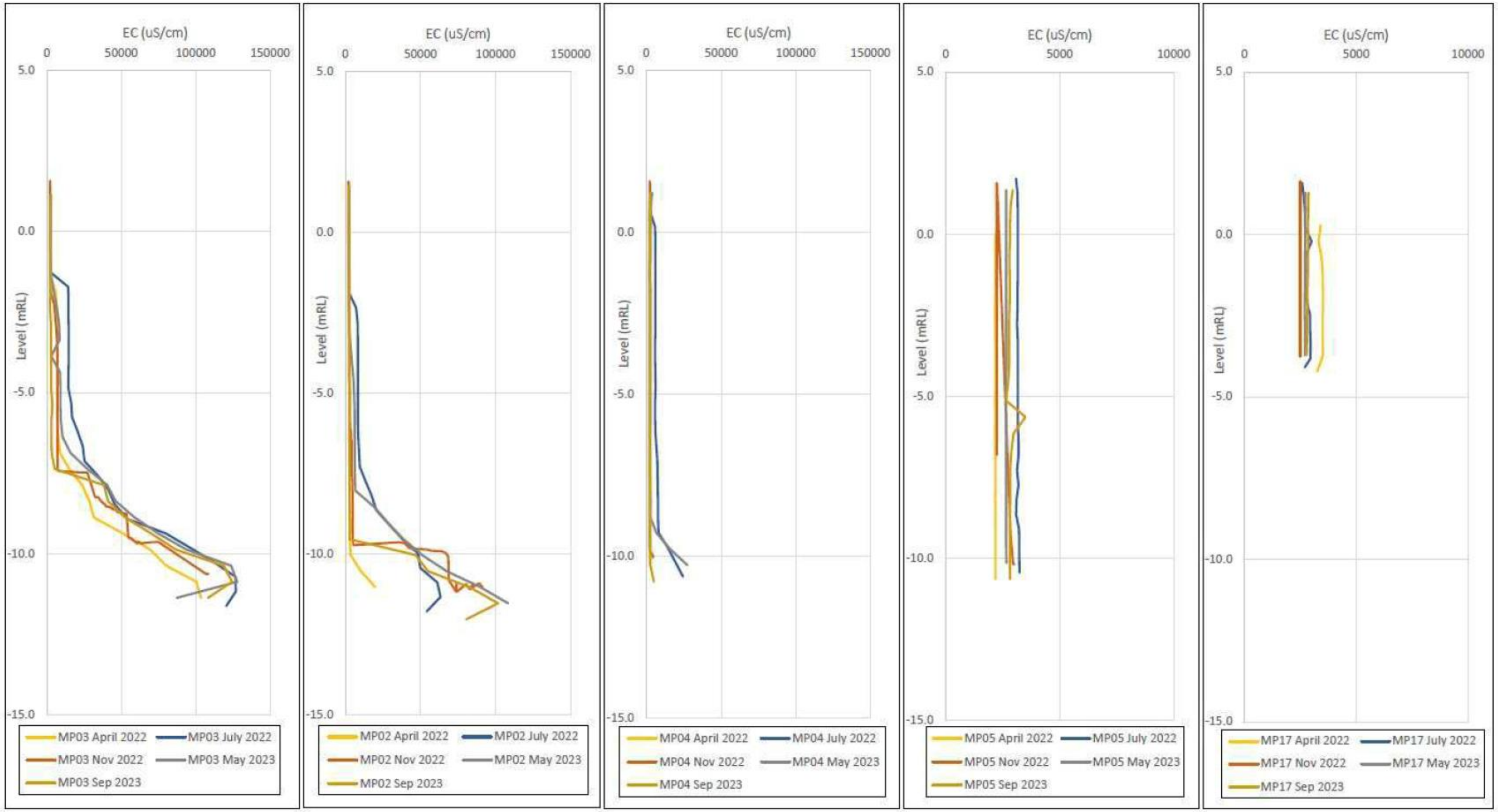


Figure 11 Salinity Profiles from Bores North of Mardie Pool



3.6 Evapotranspiration

Evapotranspiration is understood to contribute significantly to lowering the groundwater level in some parts of the project area. A historical infestation of mesquite (an invasive species) in the Fortescue River alluvium may have lowered the groundwater table by as much as 2 m (Haig 2009), and removal of the mesquite anecdotally permitted recovery of groundwater levels. Thick stands of mesquite were noted to be present north of Mardie Pool, and less-dense infestation is presently dispersed across much of the project area. It is noted that construction of crystallisers has and will promote removal of large areas of mesquite. This is likely to result in recovery of groundwater levels in some areas.

3.7 Hydrogeological Parameters

Constant rate tests and falling/rising head tests were carried out in a selection of Test Production bores and monitoring bores across the project site over several drilling campaigns. Hydrogeological parameters were also gathered from previous work in the area. It is noted that pumping tests were undertaken on bores primarily drilled for water supply, targeting cavernous calcrete and gravels around drainage lines on the coastal plain, and within the Fortescue River valley alluvial deposits.

Field information has been combined with published data from similar groundwater environments to approximate hydrogeological parameters for the conceptual models presented in this report. A summary of hydrogeological parameters is presented in Table 3-2.

Table 3-2 Summary of Hydrogeological Parameters

Location	Hydrogeological Unit	Source	Hydraulic Conductivity K (m/d)
Coastal Alluvial Inland Zone – upland areas	Calcrete/weathered Calcrete/gravel/clay targeting drainage lines	Pumping Test 2022	2.7-60
Fortescue River Valley	Silt/clay/gravel of the alluvial fan	Rising head tests in monitoring bores 2022	0.01-0.31 (average 0.08)
Coastal Inter-tidal/Sabkha Zone	Shallow silt/clay/gravel at water table	Rising head tests 2023 (bailed tests, low volume). 4 samples.	0.18-0.43 (average0.3)
Coastal Inter-tidal/Sabkha Zone	Deep (7-10m), presumed silt/clay/gravel (no geological samples)	Rising head tests 2023 (bailed tests, low volume). 3 samples.	0.07-0.54 (average 0.22)
Fortescue River Valley	Clay and gravel layers of the alluvial valley	Pumping Tests – 3 production bores – Commander (1993)	63-190

3.8 Groundwater and sea water interaction with terrestrial environments

Many parts of the Mardie Project development envelope have a long history of periodic groundwater and tidal inundation. Significant areas of the Project's development envelope have been exposed to long, hot dry periods, intermittently inundated with freshwater during significant rain events or by sea water during seasonally high tides or covered by salt crusts resulting from surface expression of hypersaline groundwater, particularly within the sabkha zone (see Figure 12 to Figure 14).

Figure 12 Pond environment prior to filling showing salt crust development.

Note salt crust on both sides of the (empty) pond walls confirms that groundwater is the source of the salt crust, not tidal inundation.

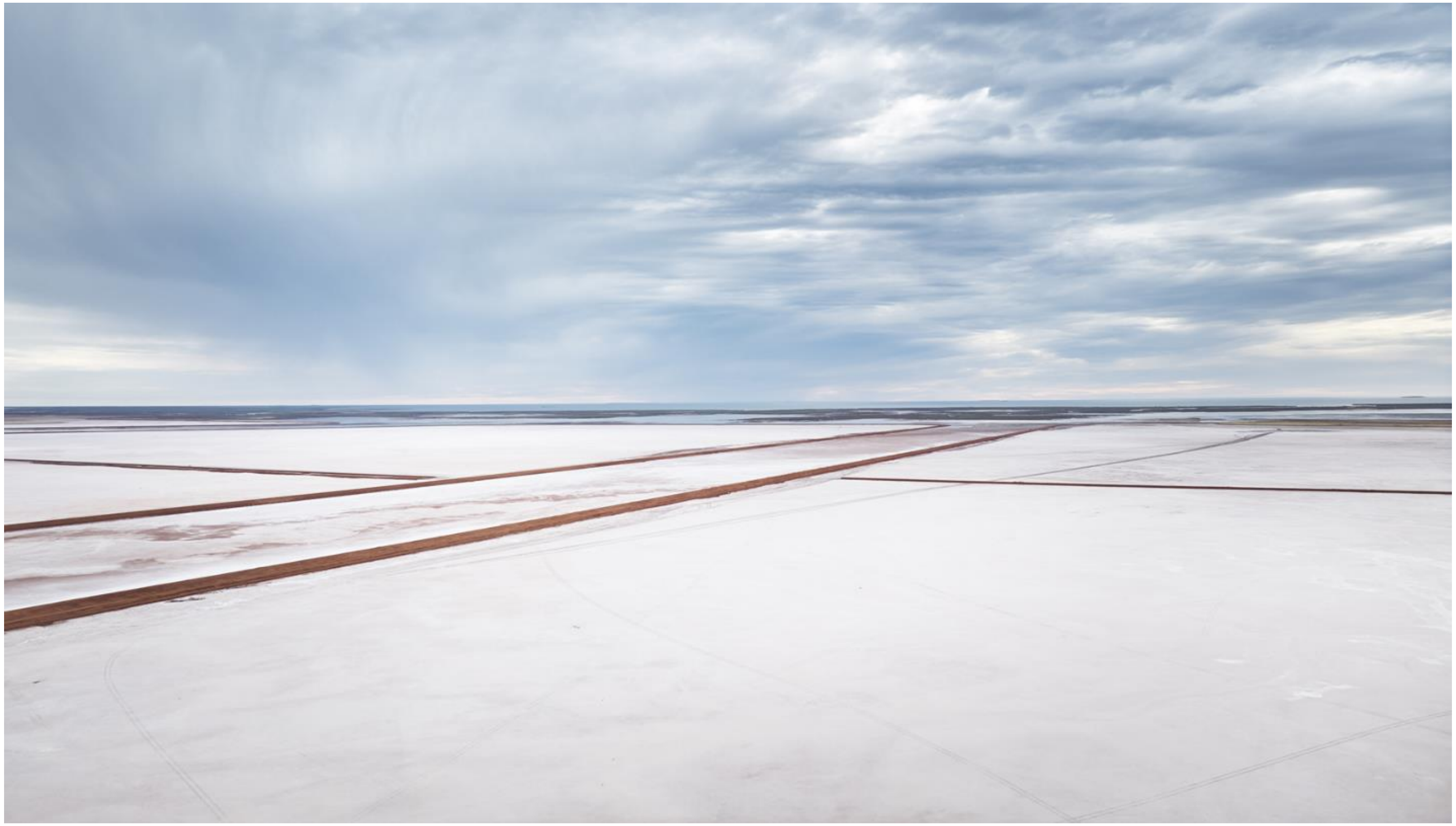


Figure 13 Spring Tides during pond filling in September 2024 shows sea water on both sides of the Pond 1 wall

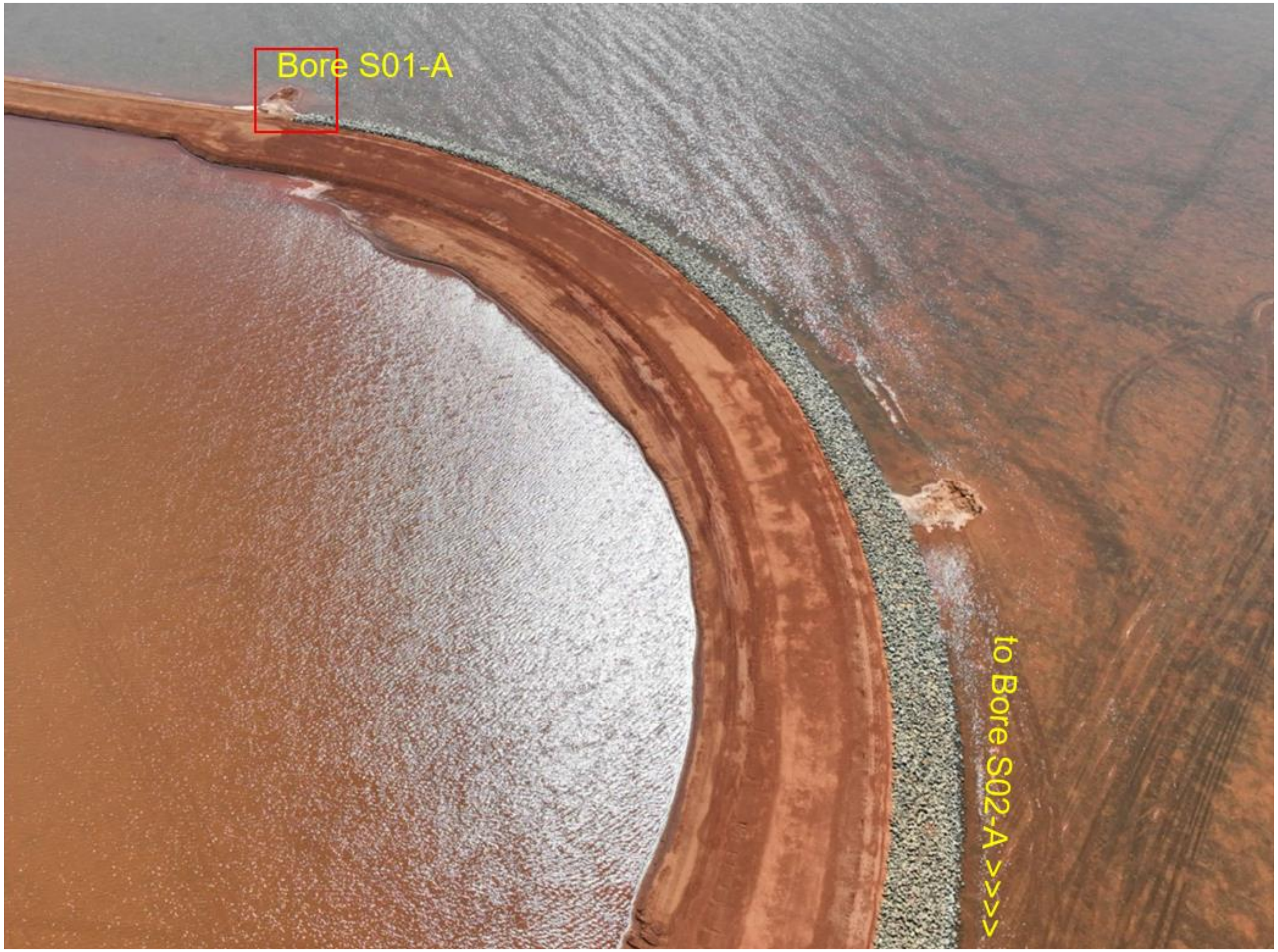


Figure 14 Receding high tide inundation outside of Pond 3 wall, November 2024

3.9 Conceptual Model – Sabkha and the Coastal Zone

Figure 15 presents the conceptual hydrogeological model passing through Pond 1, the intra-tidal/sabkha zone and the coastal zone. The location of the Pond 1 Section is shown in Figure 9.

The dominant groundwater influence in this area is the body of hypersaline water which has developed over an extensive period beneath the tidal flats (the sabkha). It extends for 30 km parallel to the coastline and approximately 5-10 km inland and is up to 5 km wide (see Figure 9 for contours of groundwater electrical conductivity).

Analysis of water level data across the sabkha indicates that the groundwater flow within the tidal flats is predominantly vertical. Sea water floods across the tidal flats on high Spring tides above a certain threshold level (see Section 3.2). A small amount of sea water remains behind as the tide recedes, within the pore space of the algal mat and near surface sediments, and within localised depressions on the sabkha. Evaporation of the residual sea water occurs between tidal inundation events, concentrating the brine at surface. A small-scale vertical flux process is set up in the near surface which concentrates the brine further in the period of drying between high Spring tides, which may be 7-10 days. The next inundation causes a small amount of recharge of the concentrated brine and crystallised salts into the sub-surface and mixing with the sea water which remains at surface.

Recharge of fresh groundwater occurs inland and across the hinterland, flowing gradually towards the coast. The fresh water intersects the hypersaline brine of the sabkha inland from the eastern edge of the tidal zone, where a wedge of hypersaline water is confined by the hydraulic pressure of the fresh water. Diffusion of hypersaline water into the fresh water occurs at this point.

On the seaward side of the sabkha, a sea water-hypersaline interface is present, and the base of the hypersaline plume extends to the sea floor where rapid mixing with sea water occurs. The recharge volume of the hypersaline groundwater from diffusion of fresh water and generation of new hypersaline water at the surface of the sabkha are balanced by discharge of hypersaline water at the western side of the system into the ocean.

During large rainfall flood events, fresh water will flood from creeks and overtop the hypersaline brine of the sabkha to flow across the flats to the ocean. This may dissolve some surficial salt and deposit silt across the sabkha for a short time, however the salt accumulation process will resume at the next high tides following the recession of flooding.

Figure 16 shows the expected conditions once Pond 1 is filled and operational and shows the approximate extent of Pond 1, and the expected change in water table resulting from Pond 1 seepage. Also shown is the change to the total recharge process.

3.10 Conceptual Model – Mardie Pool and Fortescue Alluvial Valley

Mardie Pool is a permanent water body of cultural significance which is incised several metres into the overbank deposits on the south flank of the Fortescue Alluvial Valley. The pool is approximately 300m long and up to 10m wide, with a seasonally variable surface area. The Groundwater Interaction Assessment (AQ2, 2023) indicates the following characteristics of the surface water-groundwater system at Mardie Pool.

Mardie Pool is likely to become a gaining stream or losing stream depending on the prevailing pool and groundwater levels. Mardie Pool will fill to the overflow level during rainfall events with an excess rainfall depth of <1mm across the reporting catchment. After flowing for a short period of time (usually days), outflow stops and the level in the pool will fall due to evaporation and loss of water through seepage. At this time the groundwater level in monitoring bores adjacent to the pool is lower than the level in the pool. After extended dry periods, the water level within Mardie Pool falls below the groundwater level noted in adjacent monitoring bores. Analysis of recession curves for the pool indicate that the pool water level is likely being supplemented with groundwater inflow, hence remaining a permanent surface water feature throughout the dry season.

Large rainfall events result in the flushing and filling of Mardie Pool with fresh water. A review of water quality (AQ2 2023) indicated that water salinity increased by a factor of 2-3 times over four months from July to November 2022 and was higher again in April 2023. By July 2024, salinity of Mardie Pool was significantly higher than that of sea water. Limited data indicates that the recorded salinity increases may be due to evaporation only, or a combination of groundwater inflows and evaporation.

Figure 17 and Figure 18 present the conceptual hydrogeological model for the Mardie Pool area on a section line which crosses the pool from south-west to north-east. The figures represent the main scenarios in which Mardie Pool is acting as either a gaining or losing stream.

The hydrogeological conceptual model for Mardie Pool is summarised as follows:

- Mardie Creek is incised into the overbank deposits on the southern flank of the Fortescue Alluvial Valley. Mardie Pool exists as a deeper section of the creek, which remains as a permanent surface water body of variable size.
- Mardie Pool will become a gaining stream or losing stream depending on the prevailing pool and groundwater levels. It will fill to the overflow level during significant rainfall events. After flowing for a short period of time, outflow stops and the level in the pool will fall due to evaporation and loss of water through seepage.
- When the groundwater level in in the surrounding aquifer is lower than the level in the pool, Mardie Pool acts as a losing stream. Fresher water will gradually seep into the banks and base of Mardie Pool.
- After extended dry periods, the level of water within Mardie Pool falls below the groundwater level noted in adjacent monitoring bores. Analysis of recession curves for the pool indicate that the pool water level is likely being supplemented with groundwater inflow (the pool becomes a gaining stream), hence remaining a permanent surface water feature throughout the dry season.
- Groundwater in bores to the north of Mardie Pool is saline at a depth which is below the base of Mardie Pool. While Mardie Pool is known to become more saline due to evaporation in dry periods, the pool is filled with fresh water during flood events. It is unclear whether saline groundwater contributes to the increase of salinity in Mardie Pool, however, shallow hypersaline groundwater is thought to exist in contact with the western end of the pool and may flow into the pool as the surface water level declines.
- In October 2024 the surveyed surface water level in Mardie Pool was 0.23 mAHD, approximately 1.5 m lower than groundwater level in monitoring bores several hundred metres to the north-east of the pool. This indicates low permeability strata surrounding the pool and localised groundwater flow towards the pool during extended dry periods.

Figure 15 Conceptual Groundwater Model for Pond 1 Section

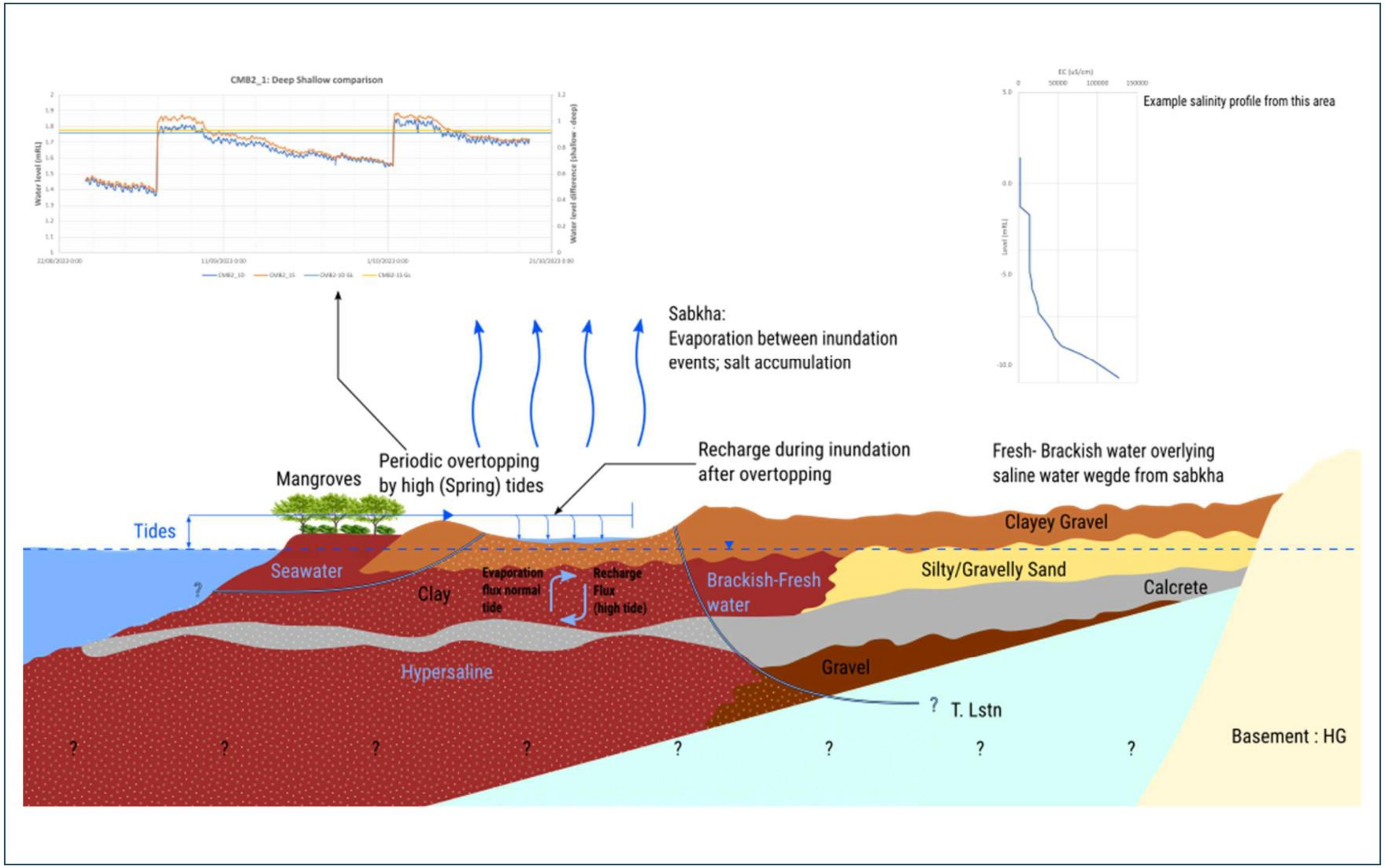


Figure 16 Conceptual Groundwater Model for Pond 1 Section – Operational

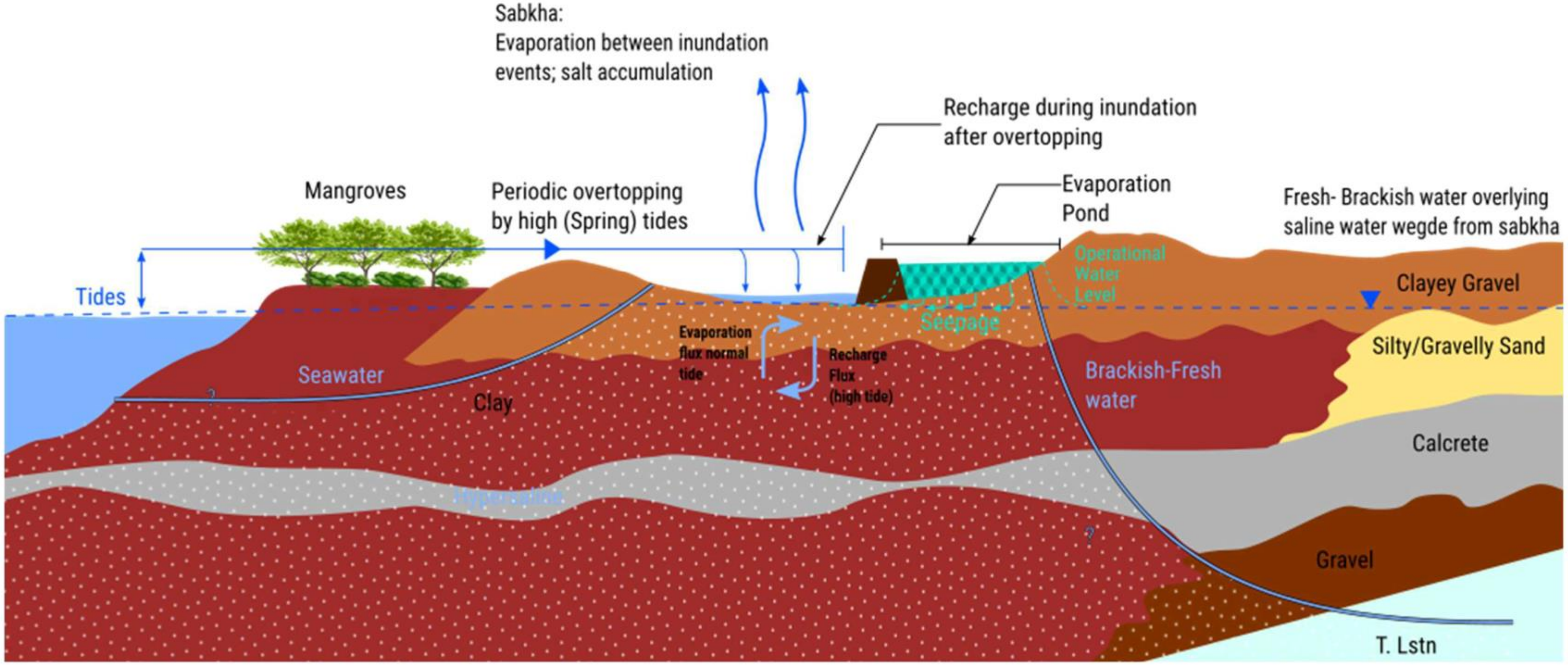


Figure 17 Conceptual Groundwater Model across Mardie Pool – Gaining Stream

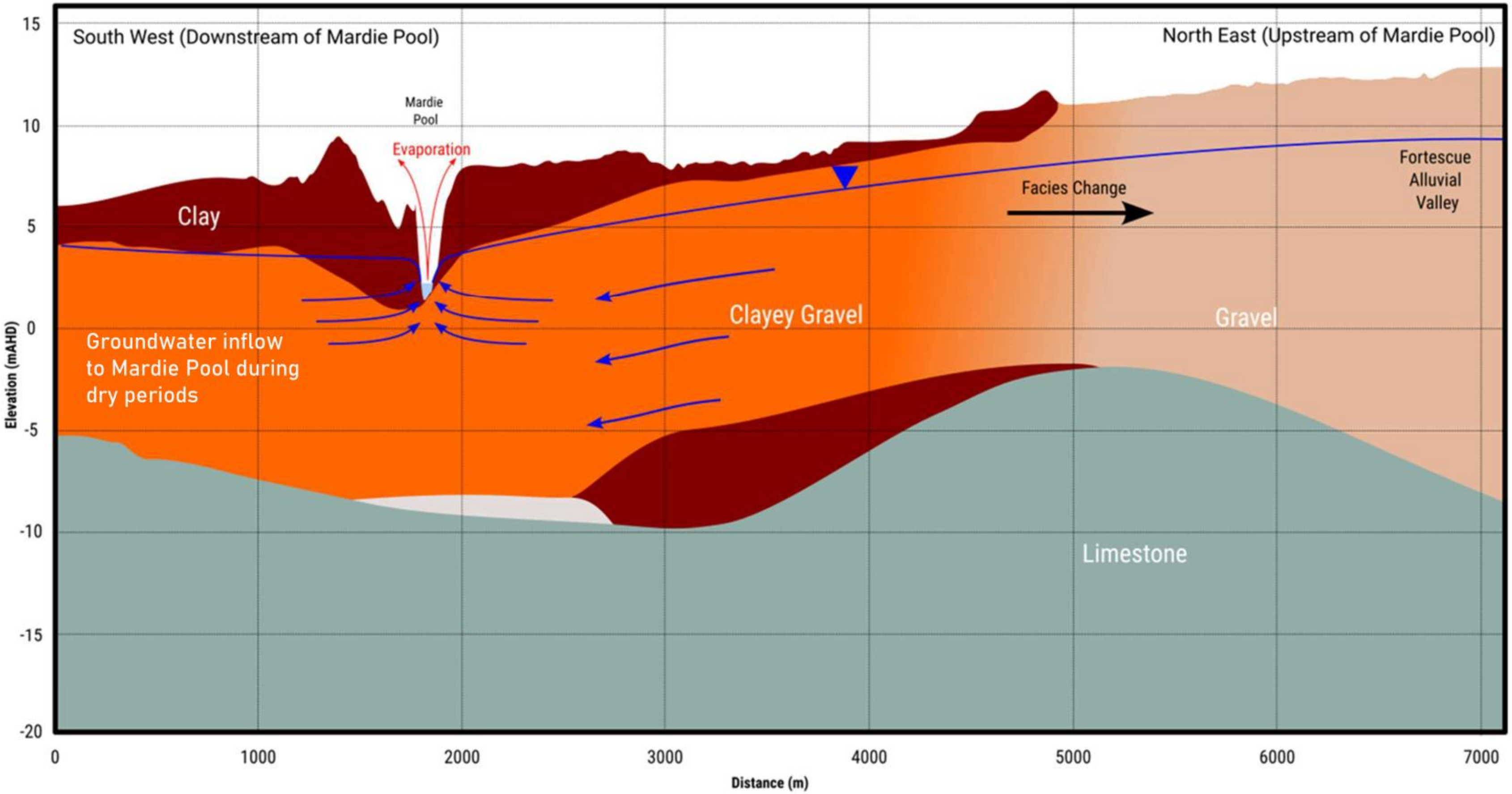


Figure 18 Conceptual Groundwater Model across Mardie Pool – Losing Stream

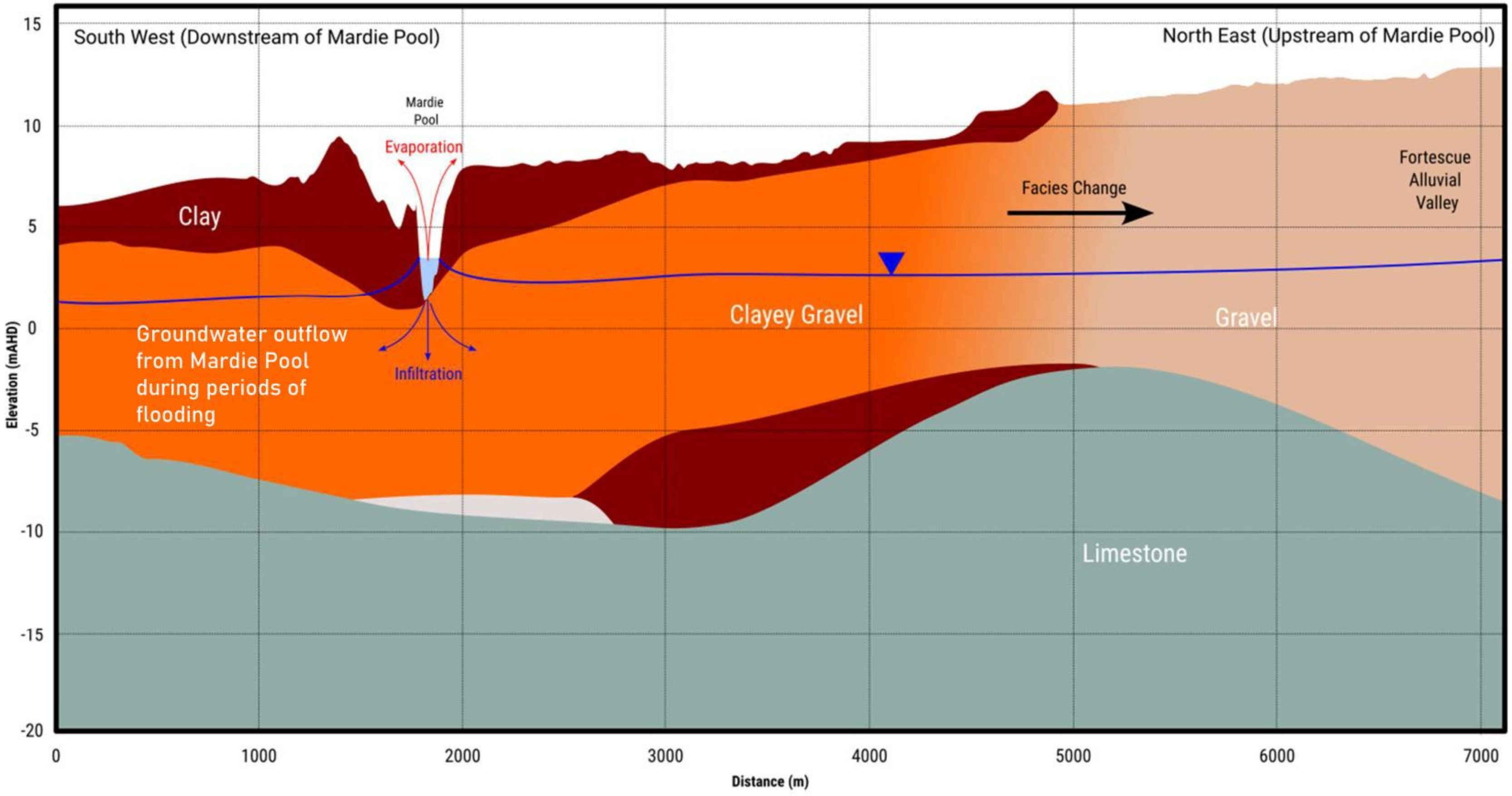
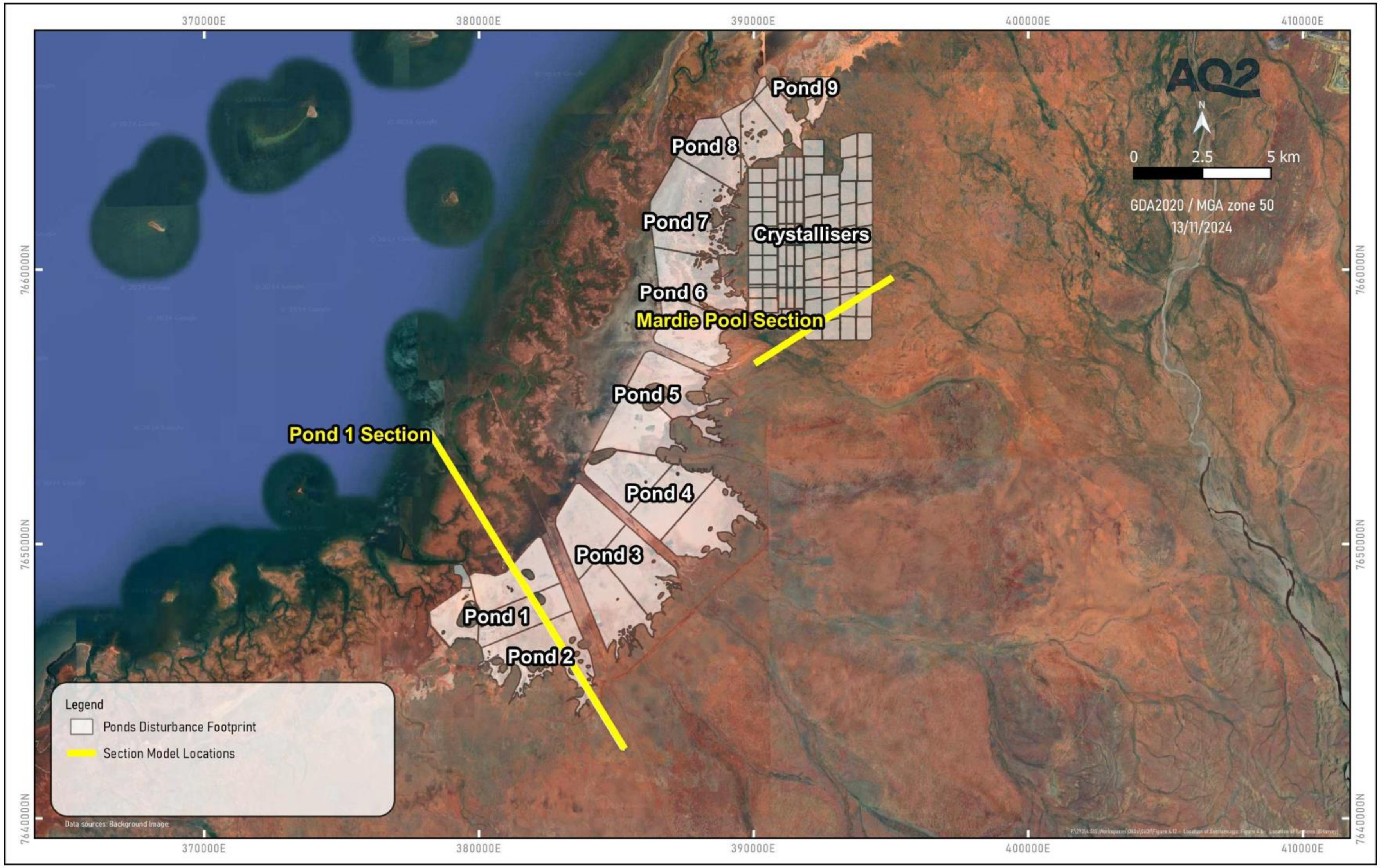


Figure 19 Location of Conceptual Sections



3.11 Regional Conceptual Hydrogeology

Regional groundwater flow and quality have been discussed in previous sections and are not discussed further here. The regional hydrostratigraphic model for the Mardie Project is developed primarily from the hydrogeological characteristics displayed in the 2-dimensional models which were previously constructed for sectional groundwater modelling (Figure 15 to Figure 18). The sectional models have been combined with extensive shallow hydrogeological drilling (for the Mardie Project) and other historical investigations across the wider project area, including the Fortescue River Valley drilling and testing investigations of Commander (1994) which describes the spatial lithological and hydrogeological variations though the northern part of the Project area.

Figure 20 and Figure 21 represent the regional conceptual hydrogeology for incorporation into the regional groundwater model. This model is composed of characteristics described in the following sections.

3.11.1 Hydrostratigraphic Units

The regional conceptual model consists of the following hydrostratigraphic units (HSU's) of varying thickness and spatial distribution. The surface clay unit and basal limestone are proposed to possess homogenous permeability (within each unit) across the entire model domain, while the hydrostratigraphy between these is proposed to transition horizontally through different lithologies as described below:

- **Surface Clay** - The surface clay unit represents the fine clay-silt which is generally present across the entire project area near surface. The unit is thinnest across the tidal flat (1-2 m) and gradually increases in thickness with distance from the coast.
- **Variable Gravel-Clay unit** – Beneath the surface clay is a thickness of gravel-clay with a composition that varies spatially across the Project area. This HSU is divided into four areas in the conceptual model (Figure 21):
    - **Fortescue Alluvial Valley Gravel-Clay** – gravel-clay unit with enhanced transmissivity representing the buried gravels of the infilled river valley.
    - **Clay** – higher clay composition and lower transmissivity beneath the tidal flats and coast extending north to Mardie Creek, where the HSU grades into gravels at the southern boundary of the river valley. At the eastern boundary of the tidal flats the clay grades into the inland gravel-clay.
    - **Inland Gravelly Clay** – representative of the colluvial Carnarvon Superficial aquifer which increases in thickness towards the south-east.
    - **Hard-rock Basement** – this small region represents outcropping weathered/fractured basement rock on the southern boundary of the Fortescue River Valley.
- **Limestone**– The basement HSU of the conceptual model is representative of the weathered limestone/calcrete which has been intercepted beneath alluvial clay and gravel across the project area. This HSU is potentially equivalent to Trealla Limestone, grading laterally to weathered bedrock near the southern boundary of the Fortescue Valley. The basal limestone forms the lower limit of the conceptual model.

3.11.2 Regional Recharge Zones

Due to the differing topography and lithology across the Project footprint and surrounds, recharge processes and rates are expected to vary considerably. Four distinct recharge areas have been defined in the conceptual model. Spatial distribution of recharge areas is detailed in groundwater modelling chapters:

- Tidal Recharge Zone – this area encompasses the coastal zone between the beach and the headwaters of the creeks. It is the first area to be inundated on the high tide.

- Salt Crust Recharge Zone – the tidal salt flat becomes inundated on the high tide above threshold topographic levels. The recharge process for the tidal flat is described in Section 4.7. The algal mat area and barren salt pan (upon which ponds are being constructed) are within this recharge zone.
- Rainfall Recharge Zone - the Inland recharge area consists of the Coastal Plain and the Fortescue Valley Alluvials, up-gradient from the salt flats. Recharge in this area is related to large rainfall events which result in rare sheet flooding across the plain.
- Enhanced Rainfall Recharge Zone – During rainfall and flooding events an enhanced rate of recharge is expected within the creek lines on the inland plains, and on the upper reaches of the tidal salt flats.

3.11.3 Mardie Pool Recharge and Evaporation

In the regional hydrogeological model, Mardie Pool (Figure 20) is conceptualised as a permanent water body of variable size which alternates between groundwater gaining and losing phases depending on the relative level of groundwater in the surrounding aquifer. Conceptualisation of the groundwater regime at Mardie Pool is described in Section 3.10 and shown in Figure 17 and Figure 18. Mardie Pool is known to flow during substantial rainfall events, while prolonged dry conditions result in extreme reduction of the pool surface area and depth. Mardie Pool has not been completely dry at any time during the period of investigations (2019-2024).

3.11.4 Regional Evapotranspiration Zones

Four evapotranspiration zones have been defined to allow for the varying vegetation density and species across the Project area. Spatial distribution of these areas is detailed in groundwater modelling chapters:

- Coastal Zone – barren mud areas and low-lying scrub on the coastal fringe are anticipated to possess a low evapotranspiration rate.
- Mangrove Zone – mangrove areas along the creeks between the coast and the salt flats are grouped as a band of likely higher evapotranspiration.
- Inland Zone – the salt flat and inland coastal plain are sparsely (to non-) vegetated and hence collectively will present a low rate of evapotranspiration.
- Mesquite Zone – Mesquite is known to be a significant groundwater user where groundwater depth permits (Commander 1994). Stands of mesquite have been defined through analysis of Sentinel 2 satellite images to determine the extent of thick, relatively healthy vegetation. Regions in which Normalised Difference Vegetation Index (NDVI) value has historically been consistently greater than 0.5 are assumed to indicate the presence of mesquite which is accessing groundwater. The conceptual model includes a broad area of mesquite infestation across the Fortescue River Valley alluvials (as it existed before clearing for crystalliser construction). Vegetation density (and therefore evapotranspiration rate) is variable within the general defined Mesquite zone.

Figure 20 Regional Hydrogeological Conceptual Model

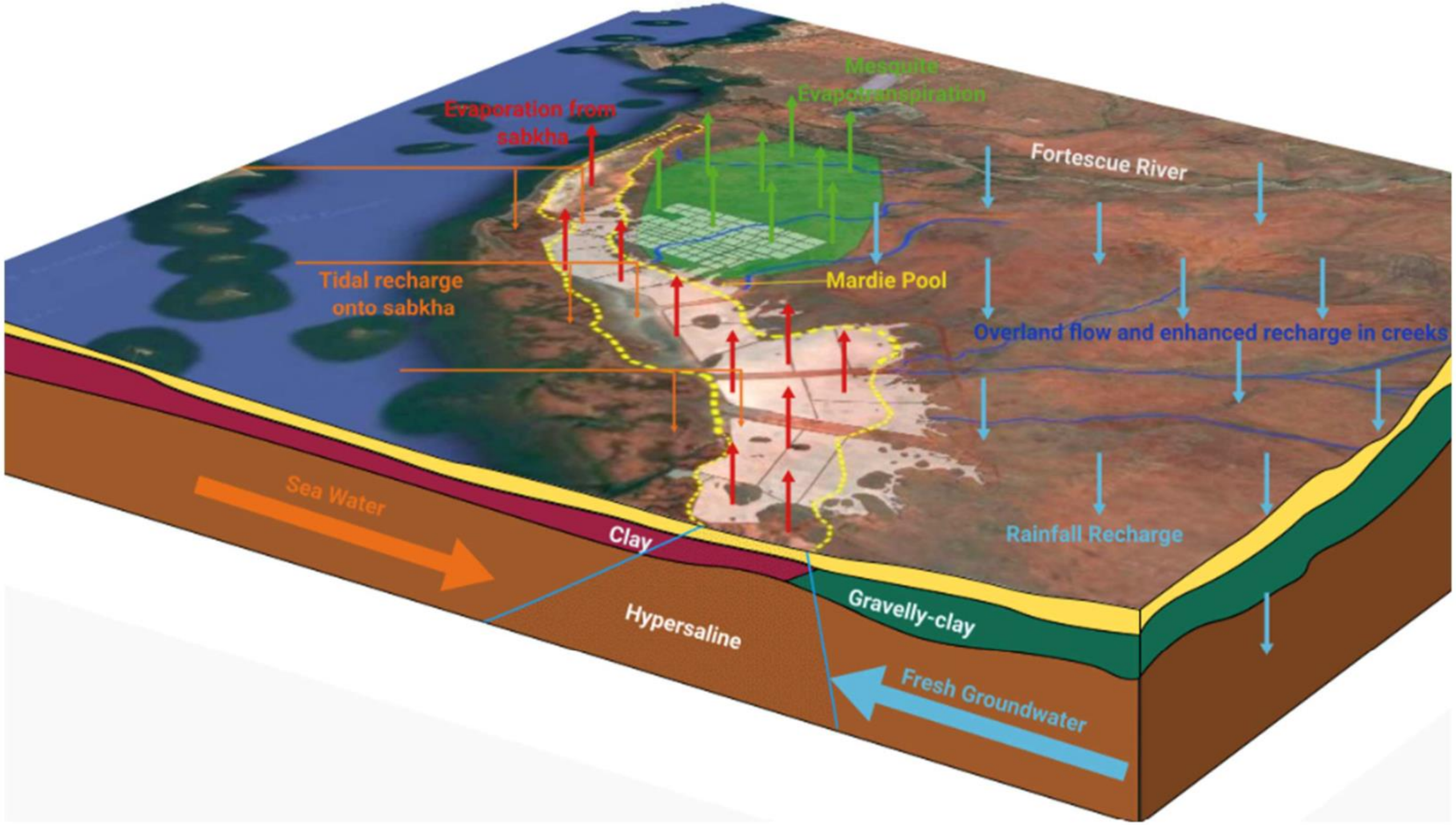
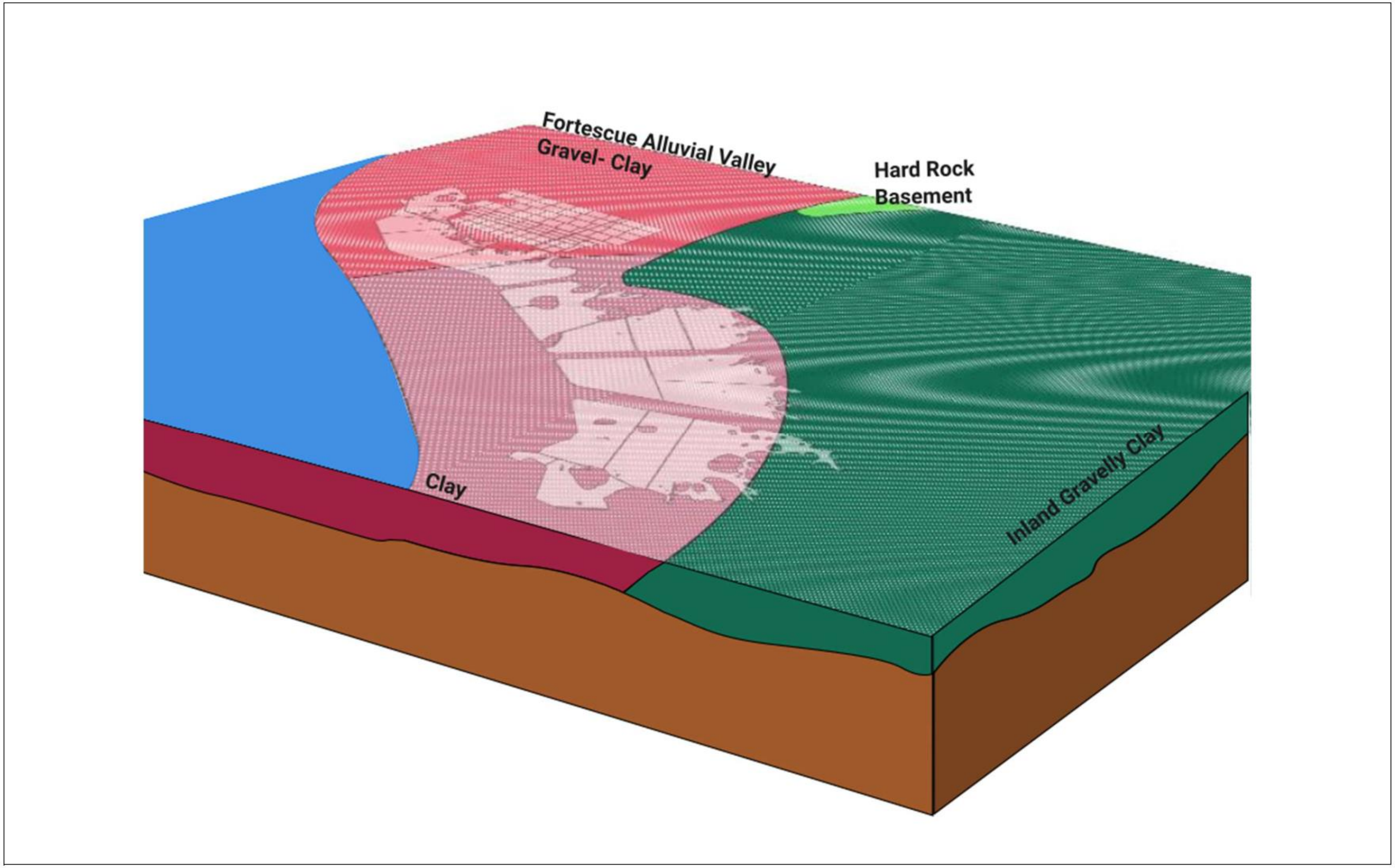


Figure 21 Regional Variable Gravel-Clay Hydrostratigraphic Divisions



3.12 Isotope analyses

In discussions between BCI and environmental regulatory bodies (DWER, DCCEEW), it was proposed by the DWER independent reviewer (Professor Henning Prommer) that determining the age of groundwater beneath the coastal salt flats at Mardie may contribute to the understanding of the hydrogeological regime. It was implied that groundwater age analysis would provide indication of the residence time of groundwater within the sabkha identified in the conceptual groundwater models that underpin the hydrological modelling.

The underpinning hydrogeological conceptual models for the groundwater system are described in Section 3.9 to Section 3.11 of this GMMP and are based on a wide range of static (geological) and transient (water level / water quality time series monitoring) data. The key elements of the conceptual models suppose that:

- The dominant groundwater influence in this area is the body of hypersaline water which has developed over an extensive period beneath the tidal flats (the sabkha), and
- The groundwater flow within the tidal flat is predominantly vertical (with a reflux flow being driven by evaporation and density).

More specifically, it is conceptualised that:

- Seawater floods across the tidal flats when high spring tides are above a certain threshold level. A small amount of seawater remains behind as the tide recedes, within the pore space of the algal mat and near surface sediments, and within localised depressions on the sabkha. Evaporation of the residual seawater occurs between tidal inundation events, concentrating the brine at surface. A small-scale vertical flux process is set up in the near surface which concentrates the brine further in the period of drying between high Spring tides, which may be 7-10 days.
- The next inundation causes a small amount of recharge of the concentrated brine and crystallised salts into the sub-surface and mixing with the fresh seawater which remains at surface. Recharge of fresh groundwater water occurs inland and across the hinterland, flowing gradually towards the coast. The fresh water intersects the hypersaline brine of the sabkha inland from the eastern edge of the tidal zone, where a wedge of hypersaline water is confined by the hydraulic pressure of the fresh water. Diffusion of hypersaline water into the fresh water occurs at this point.
- On the seaward side of the sabkha a seawater-hypersaline interface is present, and the base of the hypersaline plume extends to the sea floor where rapid mixing with seawater occurs. The recharge volume of the hypersaline groundwater from diffusion of fresh water and generation of new hypersaline water at the surface of the sabkha are balanced by discharge of hypersaline water at the western side of the system into the ocean, and
- During large rainfall flood events, fresh water will flood from creeks and overtop the hypersaline brine of the sabkha to flow across the flats to the ocean. This may dissolve some surficial salt and deposit silt across the sabkha for a short time, however the salt accumulation process will resume at the next high tides following the recession of flooding.

Thus, the hyper-saline brine underlying the sabkha is driven by vertical fluxes associated with the reflux-processes of evaporation and infiltration / density-drive percolation. Consequently, groundwater should either be older at depth or mixed (related to the mixing of upward and downward reflux flows).

Sampling Program

AQ2 was engaged by BCI to coordinate the sample acquisition and analysis, at the request of and in conjunction with Professor Prommer. After some discussion, it was agreed that Carbon-14 (C14) and Tritium dating methods were the most appropriate isotopes for analysis to determine residence times. It should be noted that only two laboratories in the world can undertake this kind of analysis, the closest being the GNS Science laboratory in New Zealand.

There were further delays in sampling due to the stated requirement for mercuric chloride to be used as a preservative for sample collection. Mercuric chloride is extremely toxic and requires specific licensing and appropriately qualified people to handle it if used on site. After ongoing discussion with GNS laboratory, it was agreed on 2 October 2024 that sample preservation using mercuric chloride was not required in this case.

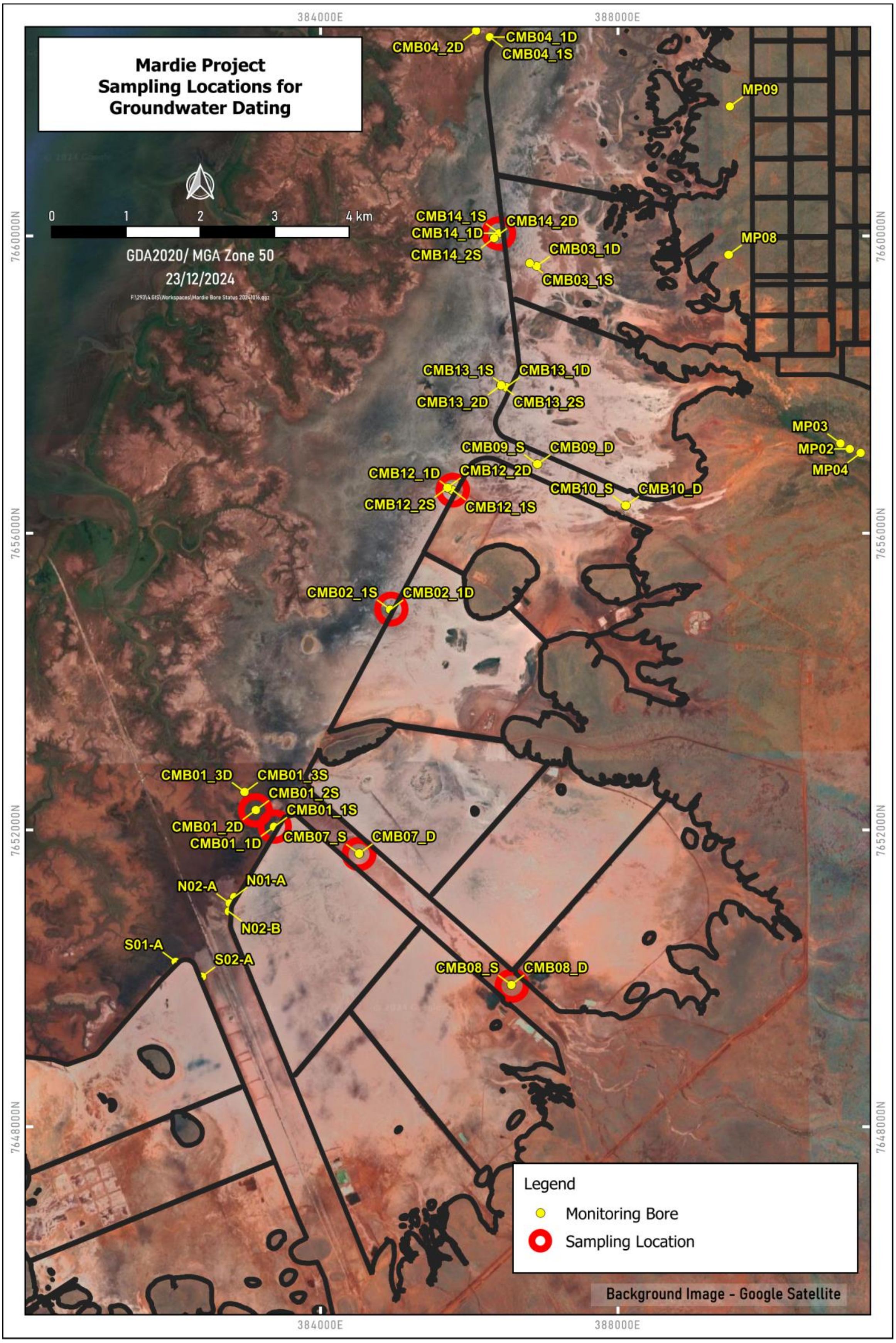
Sampling Locations

Through discussion between AQ2 and Professor Prommer, it was decided that sampling locations were to include one transect of bores perpendicular to the coast in the Pond 3/Pond 4 corridor, plus three other sites forming a transect parallel to the coast on the tidal flat. The final sampling locations are presented in Figure 22 and Table 3-3, below, and represent different areas and aquifer depths within the Project area. All sampling was undertaken on 16 October 2024.

Table 3-3 Sampling Locations for Isotope Analyses

Bore Name	Easting (mE) GDA20 Zone 50	Northing (mN) GDA20 Zone 50	Tritium Sample Bottles – 1L HDPE Plastic	Tritium Sample Bottles – 500mL Glass	Time of Sample	Comments
CMB08D	386569	7649915	1	2	07H00	Clear water sample
CMB07D	384522	7651682	1	2	08H00	Clear water sample
CMB07S	384520	7651680	1	2	08H00	Silty sample
CMB01_1S	383371	7652040	3	2	09H00	Silty sample, extra 1L sample taken
CMB01_1D	383372	7652042	1	2	09H00	Clear water sample
CMB01_2S	383130	7652266	3	2	10H00	Silty sample, extra 1L sample taken
CMB01_2D	383128	7652269	1	2	10H00	Clear water sample
CMB12_1S	385778	7656577	1	2	12H00	Very silty water sample, very low flow bore
CMB12_1D	385776	7656574	1	2	12H00	Clear water sample
CMB02_1S	384938	7654968	1	2	17H00	Silty water sample
CMB02_1D	384937	7654966	1	2	17H00	Clear water sample
CMB14_1S	386403	7660038	3	2	14H00	Clear water sample, extra 1L sample taken
CMB14_1D	386400	7660038	1	2	14H00	Clear water sample

Figure 22 Sampling Locations for Isotope Analyses



3.12.1 Analyses

Groundwater dating analysis methods were initially proposed to cover the potential wide range of groundwater age which may exist in the sabkha area:

- Tritium – The Tritium age analysis method relies on measuring the decay of radioactive Tritium (3H), which was introduced into the environment in large amounts by atmospheric nuclear weapons testing until the practice was reduced in the 1960s. The half-life of 3H is ~12 years, hence the method is useful for determining the age of relatively young samples (up to approx. 60 years).
- Carbon 14 – The C14 (or Radiocarbon) dating method is used to estimate the age of dissolved organic material within the sample through measuring the remaining proportion of C14. The Half-life of C14 is 5730 years, therefore the minimum detectable age from ^{14}C dating is 100-300 years old. GNS Science reports C14 dating to be accurate to +/-30 years for samples with 14C age less than 6000 years, and the method is useful for determining the age of samples up to 50 000 years.

Analysis of Tritium Concentration

The first set of five analyses were received on 23 January 2025 and the second set of four analyses were received on 20 February 2025. Combined, we now have Tritium data from nine separate bores.

Groundwater age was derived from Tritium concentration using the accepted formula:

$$T = \ln(C_0/C)/\lambda$$

Where:

T = groundwater age

C_0 = initial tritium concentration at recharge (estimated or from historical records)

C = measured tritium concentration

$\lambda = \ln(2)/12.3$ (tritium decay constant)

Base concentration of the input water (C_0) is not readily available. A value of 1.5 TU is representative for terrestrial precipitation in the southern hemisphere. Tritium concentrations in the ocean are lower and generally less than 1 TU. Given the great majority of recharge at the sample locations is oceanic tidal water, a value of C_0=0.8 TU was adopted as a base case, since the initial concentration must be at least slightly higher than the maximum measured concentration of Tritium in shallow samples. An alternative value of C_0=1.0 TU has also been considered to reflect potential for some rainfall-input to the recharge during the wet-season (i.e. a mixed C_0 reflecting inputs of oceanic water (<1 TU) and rainfall ((~1.5 TU).

Both cases also logically imply that the shallow water (at 2mbgl) is not purely fresh ocean water and has been subject to some tritium decay (i.e. the sample values are less than all assumed input values of tritium).

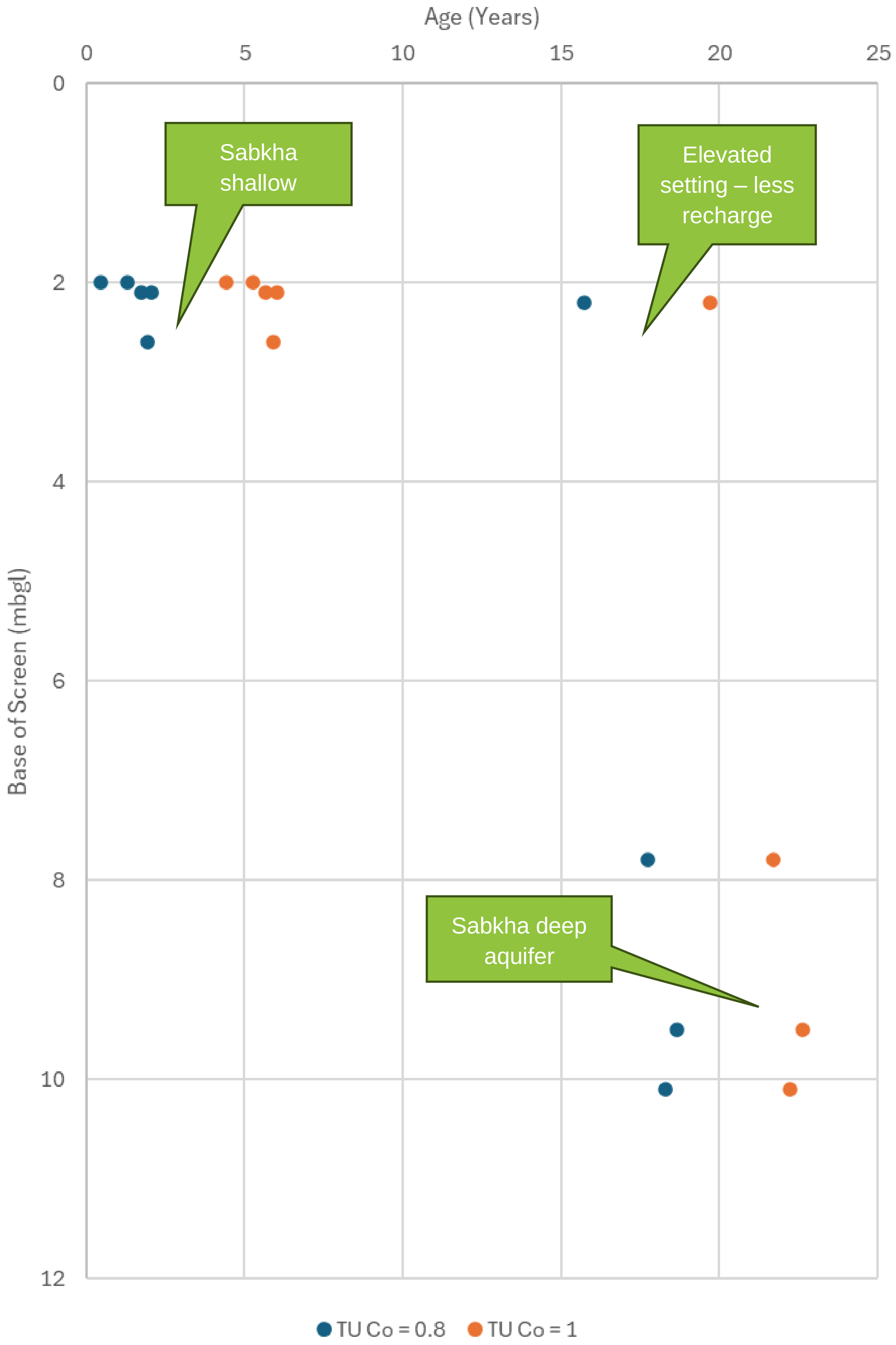
The results received to date and the calculated groundwater ages, are summarised in the table below. Six samples are from bores screened up to 2 mbgl (very shallow aquifer), while three are from bores screened between 8 and 10 mbgl.

Results (Batches 1 and 2) - Tritium

Bore ID	Easting	Northing	Drill Depth (m)	Cased Depth (m)	Screened Depth (m)	TU	Age (by Adopted C_0)	
							0.8	1
CMB01_1D	383372.5	7652042	9.7	7.8	6.8-7.8	0.295	18	22
CMB01_1S	383371.4	7652040	2	2	1-2	0.744	1	5
CMB01_2D	383128.6	7652269	10	9.5	8.5-9.5	0.280	19	23

Bore ID	Easting	Northing	Drill Depth (m)	Cased Depth (m)	Screened Depth (m)	TU	Age (by Adopted C_0)	
							0.8	1
CMB01_2S	383129.8	7652266	2.1	2.1	0.6-2.1	0.712	2	6
CMB02_1D	384937	7654966	10.1	10.1	8.6-10.1	0.286	18	22
CMB02_1S	384938	7654968	2.7	2.6	0.6-2.6	0.717	2	6
CMB07S	384520	7651680	2.2	2.2	0.7-2.2	0.33	16	20
CMB12_1S	385778	7656577	2	2	0.5-2.0	0.78	1	4
CMB14_1S	386403	7660038	2.1	2.1	0.5-2.1	0.726	2	6

The results above are presented in the figure below and show the estimated water ages with depth, based on the values of base concentration assumed (0.8 and 1).



Estimated Water Age with Depth (from Tritium Analysis for input concentrations of 0.8 TU and 1 TU)

3.12.2 Results and Implications

The Tritium results received to date clearly show groundwater age increases with depth for bores along the western sea wall of the ponds (i.e. tritium concentrations diminish with depth indicating older water). Adopting a C_0 of 0.8, the shallow groundwater is around 1 year old (indicative of recent and active recharge). At 10 m depth, groundwater is around 20 years old. This is consistent with the conceptual model where downwards groundwater movement is driven by evaporative concentration and increasing density.

Calculated age for an adopted C_0=1.0 is also provided. This assumes that some recharge to the aquifer may be attributed to rainfall. Results indicate that adopting C_0=1.0 will increase the calculated age of groundwater, however the relative ages (shallow vs deep bores) remain consistent, indicating slow and vertical movement of groundwater.

All of the isotope data analysed is therefore consistent with (indeed is supportive of) the conceptual models proposed, and (in line with the isotope related conditions articulated by both State and Commonwealth regulators), "…provide[s] greater evidence supporting the proposed 'slow' groundwater flow."

Further, much of the work that has been undertaken following regulator review of previous versions of the GMMP also supports the veracity of the conceptual models, including:

- Refined interpretation following more time series data (under natural conditions and with both pumping and loading hydraulic stresses).
- Incorporation of the conceptual model into a 3D model that includes density dependent flow that resulted in improved calibration throughout the model domain.
- Addressing the uncertainties in the conceptual model and its numerical representation (resulting from limited data and / or non-uniqueness) through a probabilistic automated calibration process. This provided a range of good calibrations (implying robustness in key elements of the conceptual model) with the best realisations requiring parameters lower (i.e. more conservative) than those adopted for a manual calibration.

This additional work, combined with the isotope data available to date, indicates a high level of confidence in the conceptual models that underpin the numerical modelling.

4. GROUNDWATER MONITORING NETWORK

To adequately characterise and understand the variability in groundwater from across the Project area, Mardie Minerals have been collecting data from over 100 groundwater bores from as far back as February 2022. The groundwater bore network being monitored by Mardie Minerals consists of:

- 18 terrestrial groundwater bores centred around Mardie Pool and the crystalliser network, which are monitored daily for this GMMP,
- 56 coastal bores focused on the western side of the evaporation ponds and spanning the entire north-south length of the Project, which are monitored daily for this GMMP, and
- 66 gas pipeline bores installed between Ponds 2 and 3 to monitor groundwater in the vicinity of the gas pipeline that intersects the Project development envelope and are used to report to Chevron-Santos in relation to the access agreement for the Gas Pipeline Corridor. As noted in Section 4.2 below, there are 11 bores in the gas pipeline corridor that are also used for the coastal monitoring network, these are not included in the total of 66 bores.

Details of the full bore network is described in greater detail in Section 4.1 to Section 4.3.

Telemetry instrumentation has been installed across the monitoring bore network to measure groundwater level and electrical conductivity (EC) hourly and to send that information to a data platform that can be accessed and queried in real time by BCI staff and consultants in Perth. Telemetry installation was completed during Q3 2024. The status of installation is detailed in Table 4-3 and Table 4-3.

Note that two surface water sites within Mardie Pool are being monitored manually. Since October 2024 the monitoring frequency has increased from quarterly to monthly.

4.1 Terrestrial Groundwater Monitoring Bore Network

Eighteen (18) monitoring bores were installed between 2022 and 2024 to provide data on groundwater characteristics (levels and quality) in the vicinity of Mardie Pool and Mardie Creek, and in areas surrounding the proposed crystallisers (Figure 23 and Table 4-1). Baseline data collection commenced from April 2022 across these bores.

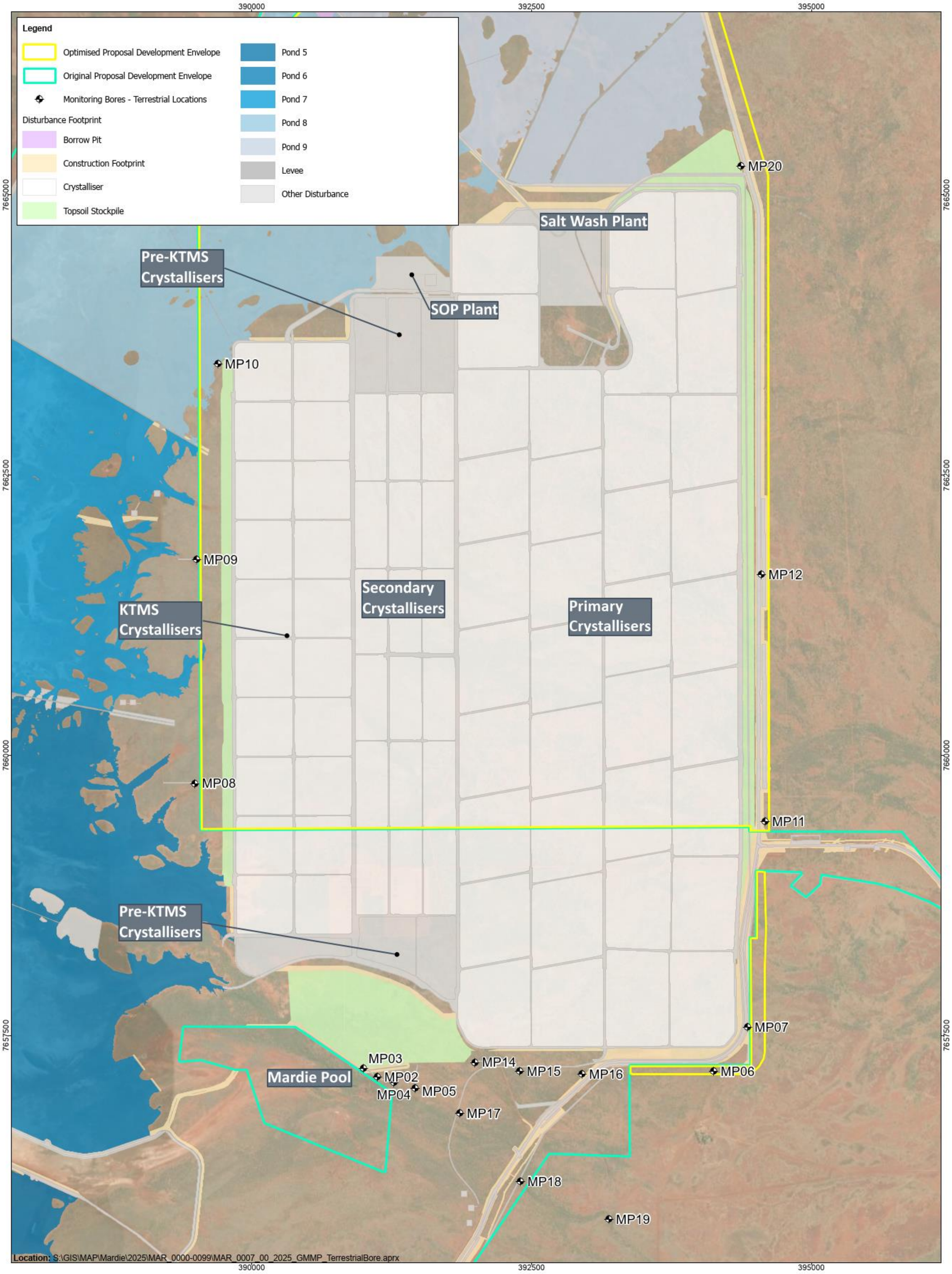
Four monitoring bores were installed up hydraulic gradient from Mardie Pool and adjacent to the proposed crystallisers, to serve as an early warning of changes in salinity and water level if hypersaline seepage or mounding from the crystallisers were to occur in future (sites MP06 and MP14 to MP16).

Four bores were installed parallel to Mardie Creek, outside the heritage buffer zone and between Mardie Pool and the crystallisers ponds (sites MP02 to MP05), to provide data on groundwater flow directions and gradients between the crystallisers and Mardie Pool.

Three monitoring bores (sites MP07 and MP11-12) were placed up-gradient from the Primary Crystallisers for background monitoring within the Fortescue Alluvial Valley. Three monitoring bores (sites MP08 to 10) were installed down gradient from the Secondary and KTMS Crystallisers to detect changes to the groundwater regime due to the crystallisers. An additional bore (site MP20) has been installed at the north-east corner of the crystallisers in July 2024.

Three bores (sites MP17 to 19) were placed along the creek line to the east of Mardie Pool to characterise groundwater conditions in the Mardie Creek channel upstream of Mardie Pool.

Figure 23 Terrestrial Groundwater Monitoring Bore Locations



	0 km 1 GDA2020 MGA Zone 50 Scale: 1:30,000	Date: 9/01/2025 Drawn: BCIGIS Requested: BCI Page Size: A3	**MARDIE PROJECT** **Monitoring Bores - Terrestrial Locations**	Figure:

Table 4-1 Terrestrial Monitoring Network

Location	Bore ID	Easting (GDA2020, MGA50)	Northing (GDA2020, MGA50)	Design	Purpose	Installation Date	Telemetry Installation Date (begin hourly WL/EC)
Mardie Pool – North Side Outside Channel	MP02	391123	7657129	Fully screened	Second line of detection of seepage from Crystalliser.	04/03/2022	21/08/2024
	MP03	390990	7657206			05/03/2022	05/07/2024*
	MP04	391272	7657080			02/03/2022	20/08/2024
	MP05	391458	7657027			01/03/2022	05/07/2024*
Primary Crystalliser – Adjacent	MP06	393708	7657166		First line of early detection of seepage from Primary Crystalliser.	10/03/2022	23/08/2024
Primary Crystalliser – Up Gradient	MP07	394434	7657578		Background monitoring upgradient from Primary Crystalliser.	13/03/2022	21/08/2024
Secondary/KTMS Crystallisers – Down Gradient	MP08	389493	7659744		Down-gradient monitoring of Secondary Crystalliser.	17/03/2022	22/08/2024
	MP09	389507	7661739		Down-gradient monitoring of KTMS.	18/03/2022	04/07/2024
	MP10	389699	7663493			12/02/2022	22/08/2024
Primary Crystalliser – Up Gradient	MP11	394585	7659412		Background monitoring upgradient from Primary Crystalliser.	16/02/2022	21/08/2024
	MP12	394558	7661615			14/02/2022	05/07/2024
	M20	394374.0	7665261.8			26/05/2024	30/06/2024
Primary Crystalliser – Adjacent	MP13+	391991	7657709		First line of early detection of seepage from Primary Crystalliser	20/03/2022	n/a - decommissioned
	MP14	391996	7657266			22/02/2022	05/07/2024
	MP15	392396	7657184			24/02/2022	04/07/2024
	MP16	392950	7657160			26/02/2022	21/08/2024
Mardie Creek -Upstream	MP17	391860	7656800		Upstream channel monitoring for base flow, adjacent to crystalliser.	28/02/2022	04/07/2024
	MP18	392404	7656195			20/03/22	05/0720/24

Location	Bore ID	Easting (GDA2020, MGA50)	Northing (GDA2020, MGA50)	Design	Purpose	Installation Date	Telemetry Installation Date (begin hourly WL/EC)
	MP19	393660	7655367		Upstream channel monitoring for base flow.	21/03/22	06/07/2024

* Sites MP03 and MP05 have hourly WL logger measurements since 6/10/22
+ Sites MP13 has not been included in the total of the 18 terrestrial bores as it is located within the crystalliser footprint and has been decommissioned.

Groundwater salinity in the terrestrial bores to the north and east of Mardie Pool have exhibited relatively consistent salinity (EC) levels since July 2022 Table 4-2, coincident with significant rainfall/recharge following a long period of no rainfall. All bores except for those near the tidal flats showed brackish water quality during this time.

Table 4-2 Historical Terrestrial Monitoring Bore Water Quality Data (lower and upper EC range across water column where available)

Location	EC Apr 2022 (µS/cm)	EC Jul 2022 (µS/cm)	EC Nov 2022 (µS/cm)	EC Apr 2023 (µS/cm)	EC Sep 2023 (µS/cm)	EC Dec 2023 (µS/cm)	EC Mar 2024 (µS/cm)
MP02	2500	2200	2200	2290-108200	1986-80312	2357-82440	2338–78676
MP03	2800	2100	3300	2760-87360	2555-108159	2626-125371	2384-117712
MP04	1900	4200	2200	3866-27370	2575-5043	2436-2628	2402–2402
MP05	2100	3000	2200	2642-2658	2935-2821	1416-2827	2597–2613
MP06	1400	1400	1500	1600-1594	1812-1665	1663-1781	765-1573
MP07	1400	1400	1400		1669-1585	866-2158	1546-1540
MP08	120000	82000	85000	86310->200000	82907-199073	87288-191222	98049–186864
MP09	160000	82000	93000	87220->200000	84002-181001	87954-148179	39265-189799
MP10	190000	99000	100000	104500->200000	103463-211619	98597-211949	108545-196311
MP11	1100	1100	1200	1303-1244	1272-1282	1382-1288	1210-1206
MP12	1100	1200	1200	1431-1284	1186-1315	1817-1337	1222-1234
MP13+	8600	7700	7800	8202-34700	8212-40728	8948-40336	8246-37094
MP14	1900	1900	2100	2185-2150	2141-2180	2165-2207	2093-2008
MP15	1500	1600	1700	1797-1789	1766-1809	1712-1812	1654-1684
MP16	1500	1500	1500	1500	1652-1836	1685-1850	1545-1711
MP17	3200	2500	2500	2717-2686	2865-2773	2876-2832	2613-2534
MP18	2500	3600	4700	1682-4212	2896-3873	3547-3717	3204-3297
MP19	2600	550	790	1465-1581	1731-1628	2007-1822	1807-1896
MP20							Installed May 2024. EC 3270 *
Mardie Pool West	n/a	890	2800	6536-6299	11766-10865	26571-25780	68301-66112

Location	EC Apr 2022 (µS/cm)	EC Jul 2022 (µS/cm)	EC Nov 2022 (µS/cm)	EC Apr 2023 (µS/cm)	EC Sep 2023 (µS/cm)	EC Dec 2023 (µS/cm)	EC Mar 2024 (µS/cm)
Mardie Pool East	n/a	1100	2500	6615-2864	13263-12148	35636-35756	76274-75890

+ Site MP13 has not been included in the total of the 18 terrestrial bores as it is located within the crystalliser footprint and has been decommissioned.

* Site MP20 has single logger point not profiles.

4.2 Gas Pipeline Corridor Monitoring Bore Network

Monitoring bores and vibrating wire piezometers (VWPs), located along the Chevron-Santos pipeline corridor between Ponds 1, 2 and 3 and at the western end of the corridor on the seaward side of Ponds 1 and 3 (the "GBH" series of bores) (Figure 24), provide more than two years of detailed water level data for this area (with some breaks in continuity).

Groundwater level behaviour is consistent for monitoring sites located within similar geomorphological domains (in general grouped by similar distance from the coast).

A significant rise of groundwater level is evident following rainfall events, with up to 2 m increase for the inland bores (GBH01/04/19) and variation of 0.5 m for those sites at the western end of the pipeline corridor near the western side of Ponds 1 and 3. Inundation during rainfall events is characterised by the recorded bore GWL appearing to be above ground level.

Bores at the western end of the pipeline corridor are affected by both rainfall events and tides, however, the bores are not affected by every Spring Tide period. Response appears to be dependent upon whether inundation occurs at the maximum high tide levels in the cycle.

Groundwater levels in bores GBH07/08/15 appear to become stable for several weeks in July 2022. Water level in all bores is constantly in flux at all other times. The closest bore to the coast, GBH16, exhibits tidal variations in this period.

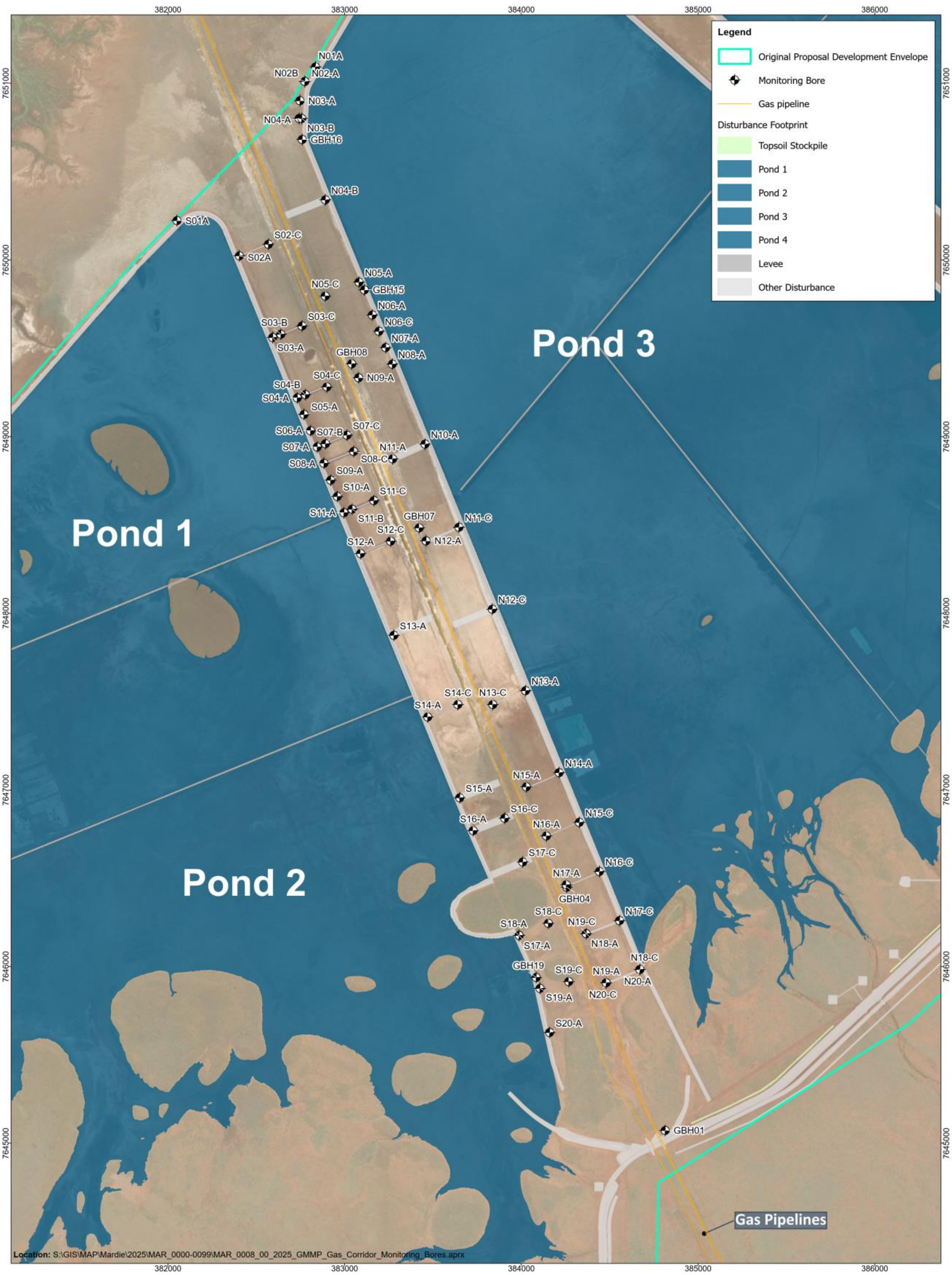
Four VWP sites were installed in 2021, in the embankment of and adjacent to a trial pond constructed as part of engineering investigations. The location of the sites is provided in Table 3-1 (the "VWP" series). The trial pond has since been incorporated into Pond 5. The data from these VWPs indicates the following:

Tidal response is similar to GBH16 for VWP01/03/04 which are located within the embankments. These VWPs also show similar response to the major rainfall event of May-June 2022.

From the gas corridor network, a subset of 6 bore/VWPs has been selected to be representative of conditions on the coastal side of the evaporation ponds and will be used in monitoring under this Plan, with Trigger and Threshold values set. These are:

- S01-A, S02-A – coastal side of Pond 1;
- N01-A, N02-A, N02-B– coastal side of Pond 3; and
- VWP01, VWP02 – coastal side of Pond 5.

Figure 24 Gas Pipeline Corridor Monitoring Bore Locations



0 km 1 GDA2020 MGA Zone 50 Scale: 1:19,000	N	Date: 15/01/2025 Drawn: GIS Requested: BCI Page Size: A3	**MARDIE PROJECT** **Gas Pipeline Corridor Monitoring Bores**	Figure:

4.3 Coastal Monitoring Bore Network

A total of 56 coastal monitoring bores have been installed along the western side of the evaporation ponds (Table 4-3 and Figure 25). Transects and single nested bore sites have been positioned to assist with characterisation of the groundwater regime beneath the supratidal flats and to permit detection of changes in levels and gradients (vertical and horizontal), and groundwater changes which may be attributed to surface flow variations at the western boundary of the Project. Details and the purpose of each monitoring bore is provided below in Table 4-3 and the location of the coastal monitoring bores is shown in Figure 25.

Water level and EC loggers are all in place in all coastal monitoring bores and are recording continuous data. Table 4-3 describes when permanent telemetry was installed for each bore.

The coastal monitoring bores (CMB bores) have been installed with short screens and sealed to access the groundwater at discrete depths. Bores were installed as deep/shallow pairs adjacent to each other as follows:

- Shallow bores generally have screens from 0.5 to 2 mbgl.
- Deep bores generally have 1.5 m – 2 m screen at the base of the casing string (which is variably at 7-10 mbgl).
- In most cases a bentonite seal was installed from above the screen up to near surface.

Hypersaline groundwater was noted across the entire intra-tidal zone and in some deep bores on the upland alluvial plain to the south-east. A selection of deep and shallow bores (2m/~8m pairings) installed on the sabkha in 2023 have consistently displayed the presence of hypersaline water in the EC range 160 000 - 220 000 uS/cm (Table 3-1), indicating that the quality of water is similar throughout the soil profile relevant to the receptors in this area (algal mats and mangroves).

One shallow bore adjacent to mangroves and creeks west from Pond 3 (CMB1_3S) presented slightly less hypersaline, likely due to tidal flushing.

Bores adjacent to Pond 1 and a tidal creek at the south end of the Project (CMB6_1S/D) presented salinity closer to that of sea water.

Table 4-3 Coastal Monitoring Bore Network

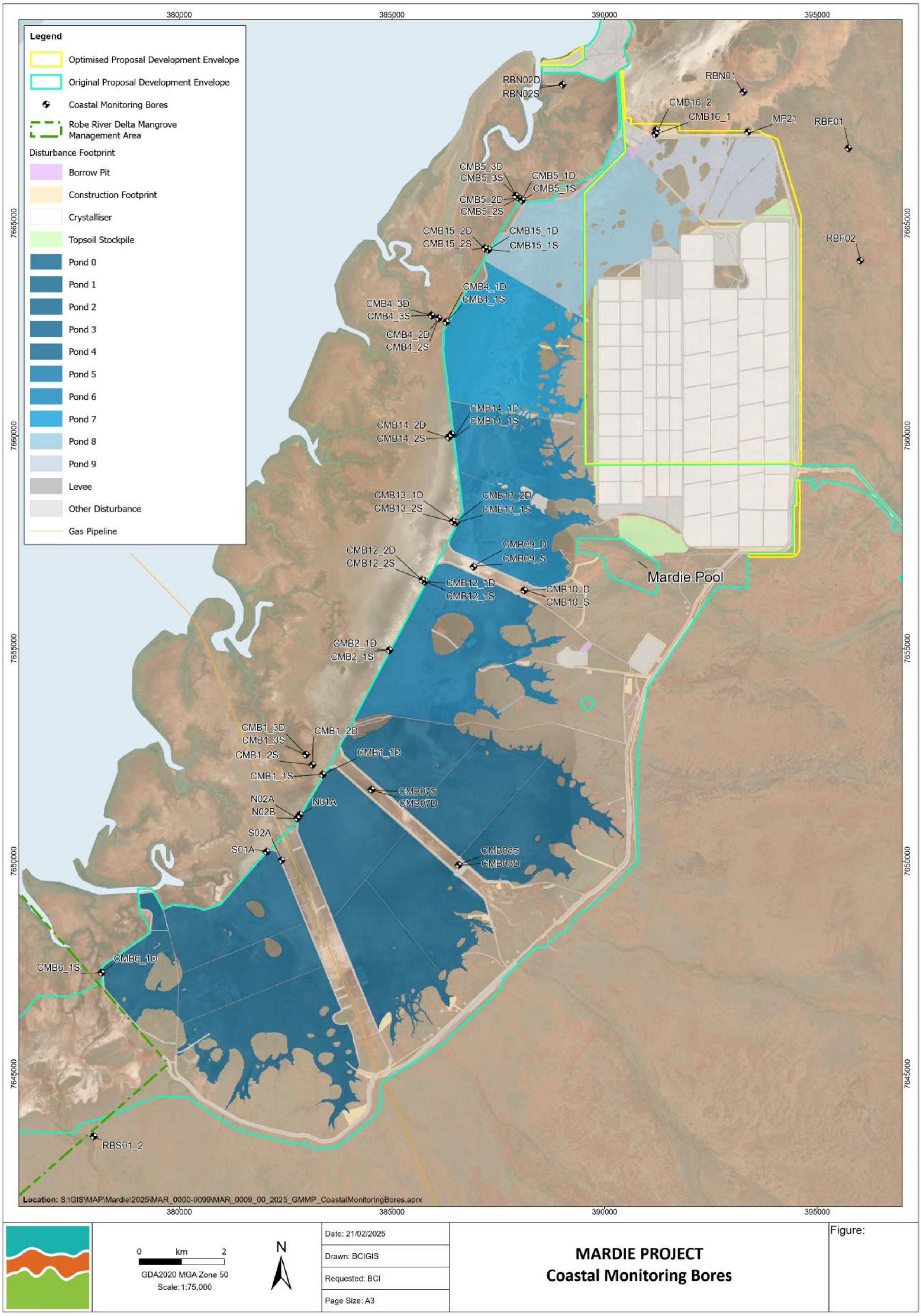
Bore ID	Easting (GDA2020, MGA50)	Northing (GDA2020, MGA50)	Purpose	Telemetry (WL) Installation Date	Telemetry (EC) Installation Date	SWL / EC / Telemetry*
CMB01_1D	383372	7652041	To quantify the magnitude of vertical hydraulic gradients and vertical variations of salinity. Monitor gradients and salinity in the inter-tidal zone between ponds and near the algal mat/ mangrove areas.	16/08/2023	20/03/2024	Y / Y / Y
CMB01_1S	383371	7652040		16/08/2023	20/03/2024	Y / Y / Y
CMB01_2D	383128	7652269		16/08/2023	20/03/2024	Y / Y / Y
CMB01_2S	383129	7652266		16/08/2023	20/03/2024	Y / Y / Y
CMB01_3D	382980	7652508		17/08/2023	20/03/2024	Y / Y / Y
CMB01_3S	382978	7652508		17/08/2023	20/03/2024	Y / Y / Y
CMB02_1D	384936	7654966		16/08/2023	20/03/2024	Y / Y / Y
CMB02_1S	384937	7654967		16/08/2023	20/03/2024	Y / Y / Y
CMB03_1D+	386909	7659595		27/10/2023	n/a	Y / Y / Y
CMB03_1S+	386816	7659632		6/10/2023	n/a	Y / Y / Y
CMB04_1D	386279	7662680		27/09/2023	20/03/2024	Y / Y / Y
CMB04_1S	386277	7662679		27/09/2023	20/03/2024	Y / Y / Y
CMB04_2D	386097	7662766		28/09/2023	20/03/2024	Y / Y / Y
CMB04_2S	386095	7662768		28/09/2023	20/03/2024	Y / Y / Y
CMB04_3D	385931	7662835		10/10/2023	20/03/2024	Y / Y / Y
CMB04_3S	385933	7662834		08/10/2023	20/03/2024	Y / Y / Y
CMB05_1D	388059	7665542		27/10/2023	20/03/2024	Y / Y / Y
CMB05_1S	388054	7665546		09/10/2023	06/05/2024	Y / Y / Y
CMB05_2D	387975	7665603		10/10/2023	05/05/2024	Y / Y / Y
CMB05_2S	387976	7665601		10/10/2023	05/05/2024	Y / Y / Y
CMB05_3D	387915	7665650		27/10/2023	05/05/2024	Y / Y / Y

Bore ID	Easting (GDA2020, MGA50)	Northing (GDA2020, MGA50)	Purpose	Telemetry (WL) Installation Date	Telemetry (EC) Installation Date	SWL / EC / Telemetry*
CMB05_3S	387917	7665647		10/09/2023	05/05/2024	Y / Y / Y
CMB06_1D	378175	7647383		16/08/2023	21/03/2024	Y / Y / Y
CMB06_1S	378176	7647381		16/08/2023	21/03/2024	Y / Y / Y
CMB07D	384516	7651674		11/05/2024	11/05/2024	Y / Y / Y
CMB07S	384516	7651674		11/05/2024	11/05/2024	Y / Y / Y
CMB08D	386569	7649911		10/05/2024	10/05/2024	Y / Y / Y
CMB08S	386568	7649917		10/05/2024	10/05/2024	Y / Y / Y
CMB09D	386918	7656926		10/05/2024	10/05/2024	Y / Y / Y
CMB09S	386918	7656926		10/05/2024	10/05/2024	Y / Y / Y
CMB10D	388113	7656366		10/05/2024	10/05/2024	Y / Y / Y
CMB10S	388113	7656366		10/05/2024	10/05/2024	Y / Y / Y
CMB12_1D	385780	7656579		11/05/2024	11/05/2024	Y / Y / Y
CMB12_1S	385780	7656579		11/05/2024	11/05/2024	Y / Y / Y
CMB12_2D	385710	7656612		11/05/2024	11/05/2024	Y / Y / Y
CMB12_2S	385710	7656612		11/05/2024	11/05/2024	Y / Y / Y
CMB13_1D	386494	7657965		02/07/2024	02/07/2024	Y / Y / Y
CMB13_1S	386494	7657965		02/07/2024	02/07/2024	Y / Y / Y
CMB13_2D	386423	7657997		02/07/2024	02/07/2024	Y / Y / Y
CMB13_2S	386423	7657997		02/07/2024	02/07/2024	Y / Y / Y
CMB14_1D	386404	7659938		06/06/2024	06/06/2024	Y / Y / Y
CMB14_1S	386404	7659938		06/06/2024	06/06/2024	Y / Y / Y
CMB14_2D	386331	7659955		03/07/2024	03/07/2024	Y / Y / Y
CMB14_2S	386331	7659955		03/07/2024	03/07/2024	Y / Y / Y

Bore ID	Easting (GDA2020, MGA50)	Northing (GDA2020, MGA50)	Purpose	Telemetry (WL) Installation Date	Telemetry (EC) Installation Date	SWL / EC / Telemetry*
CMB15_1D	387260	7664375		21/08/2024	21/08/2024	Y / Y / Y
CMB15_1S	387260	7664375		21/08/2024	21/08/2024	Y / Y / Y
CMB15_2D	387180	7664416		21/08/2024	21/08/2024	Y / Y / Y
CMB15_2S	387180	7664416		21/08/2024	21/08/2024	Y / Y / Y
CMB16_1	391196	7667097		10/05/2024	10/05/2024	Y / Y / Y
CMB16_2	391209	7667196		06/06/2024	06/06/2024	Y / Y / Y
N01A	382834	7651093		13/04/2023	01/05/2024	Y / Y / Y
N02A	382774	7651011		13/04/2023	21/03/2024	Y / Y / Y
N02B	382774	7651011		13/04/2023	21/03/2024	Y / Y / Y
S01A	382051	7650222		14/04/2023	21/03/2024	Y / Y / Y
S02A	382404	7650023		15/04/2023	21/03/2024	Y / Y / Y
RBN02S	389013	7668260		24/04/2024	11/05/2024	Y / Y / Y
RBN02_D	389013	7668259		24/04/2024	15/05/2024	Y / Y / Y
RBS01_2	389013	7668260			14/05/2024	Y / Y / Y
RBN01^	393266	7668088		12/03/2025	12/03/2025	Y / Y / Y
RBF01^	395732	7666767		12/03/2025	12/03/2025	Y / Y / Y
RBF02^	396008	7664119		12/03/2025	12/03/2025	Y / Y / Y
MP21^	393367	7667143		12/03/2025	12/03/2025	Y / Y / Y
RRDMMA_1	376108	766310	Current evaporation pond footprint design avoids this area.			
RRDMMA_2	373599	7645025				

* This column describes the installation status of Groundwater level loggers, EC loggers, and Telemetry.
\+ CMB03_1D and CMB03_1S have been decommissioned and are therefore not included in the total count of coastal monitoring bores, or displayed on Figure 25.
^ Installation of these additional bores will commence on 12/03/2025.

Figure 25 Coastal Monitoring Bore Locations



5. IMPACT MODELLING

5.1 Impacts to Matters of National Environmental Significance (MNES)

With regards to potential groundwater impacts to protected matters, the EPBC Approval 2018/8236 (as varied) and EPBC 2022/9169 require the GMMP to inform monitoring and management actions to prevent unapproved impacts to:

- Mardie Pool (as a potential freshwater source for terrestrial MNES); and
- terrestrial, intertidal and subtidal protected matters and habitats (including migratory shorebirds and their habitat).

Not all of the MNES considered under EPBC Approval 2018/8236 (as varied) and EPBC 2022/9169 have the potential to be impacted by any groundwater changes resulting from the Project. Similarly, changes to groundwater level or salinity resulting from the Project may not have significant impacts on flora and fauna, including MNES. Through this management plan, we therefore seek to:

- understand (through modelling) any likely changes to groundwater level or salinity resulting from the operation of the Project,
- monitor groundwater to ensure that any changes, modelled or otherwise, are detected, and if so,
- undertake an investigation that clearly outlines a plan to avoid, mitigate or manage impacts to MNES that may result from those changes.

5.2 Potential environmental impact pathways

Impact pathways relevant to this GMMP include:

- Potential movement, or restriction of movement, of hypersaline groundwater as a result of hydrostatic pressure of the brine in the ponds, causing localised changes in groundwater level and/or salinity; and
- Impacts to groundwater levels and salinity due to saline seepage or leaks from evaporation ponds or crystallisers.

Potential indirect impacts to MNES include alterations to the groundwater levels (including prolonged inundation of vegetation) and salinity which may impact the health, extent or diversity of intertidal BCH (i.e. mangroves, samphire and algal mats), Mardie Pool and the MNES that utilise these BCH (refer to Table 5-4 and Appendix B).

These species/habitat relationships are often uncertain, and this is particularly the case for coastal algal mats. Information collected to date through the migratory shorebird monitoring (Phoenix 2021a,b; 2022a,b; 2023a,b) indicates that the mats are not likely foraging or other primary habitat for shorebirds, however, it is acknowledged that algal mats may play a role in nutrient cycling and is not fully understood.

In line with the precautionary approach, and to build understanding of the potential indirect relationship between algal mats and MNES, Mardie Minerals have committed to undertaking targeted research (through the approved Research Offset Plan) and detailed monitoring (through the approved BCHMMP).

For example, as part of the Mardie Marine Research Offset Plan, Mardie Minerals have engaged Dr Kathryn McMahon from ECU to assess the ecological value and productivity of algal mats. The research will:

- Investigate and obtain quantitative data on carbon and nitrogen cycling within algal mats
- Undertake investigations to determine the carbon and nitrogen flux from the algal mat to estimate total percentage to ecosystem
- Investigate the reliance of detritus feeders on the Mardie algal mats, typically on the seaward edge

- Provide an assessment of the ecological value algal mats provide based upon investigative findings and quantitative data obtained on the primary productivity, nutrient and carbon fixing and flus to support a robust impact assessed from any impacted algal mat communities from the Proposal.

DCCEEW approved the Marine Research Offset Proposal for the OMP on 3 July 2024. Information collected through this work will be incorporated into future revisions of this GMMP to ensure potential impacts to algal mats are appropriately managed

5.3 Regional 3-D Modelling

A regional three-dimensional density dependent flow and transport model has been developed for the Project aligned with the requirements of State and Commonwealth regulators to estimate and incorporate uncertainty of the modelling into the predictions (Appendix C).

5.3.1 Modelling approach

Conceptual Hydrogeology Models (refer to Section 3.9, Section 3.10 and Section 3.11) were developed as a basis for detailed three-dimensional modelling by AQ2 (AQ2, 2025) (Appendix C). The objective of this modelling was to predict the water level and salinity impacts of any seepage from the ponds related to the operation of the Mardie Project on the underlying groundwater system.

The modelling approach included a manual calibration exercise followed by an automated calibration with the use of Ensemble Space Inversion (ENSI) implemented through the PEST _HP suite (Doherty, 2024). The model was calibrated or history matched by replicating pre-development groundwater conditions since early 2022 and the measured aquifer response to the filling of Ponds 1, 2 and 3 that has been underway since September 2024 (i.e. the hydraulic stress of the initial filling of Ponds 1, 2 and 3 has been used in model calibration and all groundwater monitoring data collected to date and throughout the staged filling of the ponds has been included in the calibration data set for the manually calibrated and PEST generated models). Refer to Section 5.7.3 of Appendix C for a detailed description of the calibration process.

The manual calibration exercise involved running the model many times (trial and error approach) and changing:

- Aquifer parameters systematically and within appropriate measured ranges.
- Simulated boundary conditions (recharge, evapotranspiration, pond filling) systematically and within appropriate ranges.

The aim was to provide the best match between measured and modelled water levels. This manual calibration approach was adopted prior to the completion of the automated (PEST) calibration due to the complexity of the model.

The single or manual model calibration runs were sense checked at completion (each model run taking around one hour) prior to the completion of subsequent runs. This was required prior to the PEST calibration as the model results are not as transparent as the manual calibration process. This also saved time and avoided multiple and very long PEST simulations being completed unnecessarily (each realisation took one to three hours to generate, with 50 realisations completed this resulted in a run time of around 3 to 4 days).

The second, automated approach to calibration was adopted to comply with IESC guidelines on modelling uncertainty (Peeters and Middlemis, 2023) and in accordance with DWER and DCCEEW comments on previous iterations of the modelling. The PEST calibration allowed aquifer parameters to vary, cell by cell, over the simulated aquifers in the project area (i.e., the main aquifer zones) based on a constrained range of aquifer parameters (i.e. in the automated calibration process, multiple parameter-values were considered within a maximum and minimum range). This approach was taken as there is still a large amount of uncertainty that remains regarding the aquifer characteristics and thus multiple parameters values are considered in a range of realisations; the approach is consistent with the IESC guideline on Ensemble uncertainty analysis (Peeters and Middlemis, 2023).

Together, these calibrations were used to obtain two sets of parameters (prior parameter probability distribution), and realisations (alternate calibrations or history matches) were generated. There is no greater or lesser confidence in either approach. Rather the automated approach removes any bias and allows a range of aquifer parameters to be assessed simultaneously.

The modelling completed to date has included calibration against and simulation of the filling of operational ponds (i.e. Ponds 1, 2 and 3). In this regard, it should be noted there is the free-flow of water between Ponds 1 and 2 (i.e. they are essentially linked and function as a single pond with no regulatory structure between them). This is largely an historical remnant of project design.

The impact of the hydraulic loading imparted by 'both' of these ponds on the underlying brine aquifer has been included, with Ponds 1 and 2 forming one large pond rather than two separate ponds (i.e. there are no walls or barriers between the two areas marked as Pond 1 and 2 and they are simulated as one continuous pond). Consequently, no "downstream" impacts from Pond 2 are simulated as Pond 1 is "downstream" of Pond 2; the propagation of impacts beyond the pond footprint is presented as the impacts, downstream, from Pond 1.

Prior to operational filling with brine, it is intended that some of the ponds (Ponds 6 to 9) and the crystallisers will be conditioned and the crystallisers with sea water to facilitate the formation of a low permeability algal mat to limit long term leakage from the ponds. It is estimated that the conditioning process will occur over a period of up to six months. Filling and ongoing conditioning is already underway in Ponds 1 to 3. Filling of the ponds with sea water, prior to filling with brine is scheduled for Pond 9 first (where the greatest operational salinities are expected) followed by Ponds 8, 7, and 6. No conditioning is planned for Ponds 4 and 5, however it is assumed that the conditioning of these ponds will be part of the initial operation, noting that the maximum expected concentrations for Ponds 4 and 5 are similar to the underlying groundwater salinity (up to around 120,000 mg/L).

Sea water will continue to be pumped into Pond 1 (salinity of 35,000mg/L and density of 1,025 kg/m3) and the water subject to solar evaporation (evapo-concentration) and transferred to Pond 2. Further evapo-concentration in the series of ponds will be used to achieve the estimated maximum pond salinity values summarised in Table 5-1.

Table 5-1 also shows the simulated pond conditioning schedule. Ponds will be operated with a pond elevation of between 3.3 and 3.5 mAHD.

Table 5-1 Pond Filling and Conditioning Schedule

Pond	Conditioning Period	Start of Operation	Maximum Operational Salinity (mg/L)
1	Mid-September 2024 to mid-March 2025	September 2024	40,000
2	Late September 2024 to late March 2025	September 2024	44,000
3	Late November 2024 to late May 2025	November 2024	55,000
4	-	March 2025	72,000
5	-	April 2025	92,000
6	Late April 2025 to late October 2025	May 2025	127,000
7	Mid-April 2025 to mid-October 2025	June 2025	175,000
8	Late March 2025 to late August 2025	July 2025	226,000
9	Mid-March 2025 to mid-August 2025	August 2025	273,000

For clarity, the intent is still to fill the ponds from the south and gradually move northwards, as outlined in Rev K of the GMMP. The majority of water entering the ponds will be delivered through this pathway.

By putting a small amount of water in ponds 9, 8, 7 etc earlier than can be achieved by pumping solely from the south to the north, we intend to maximise the time that algae has to grow on the floors of those ponds to support pond conditioning/sealing, and therefore minimise early pond seepage when the water 'arrives' from the south.

In line with the above, water will flow reasonably quickly (days/weeks) into ponds 4 and 5 once the updated GMMP is approved and this water will serve to condition the ponds. There is therefore no need to put additional ‘conditioning’ water into these ponds prior to the commencement of pumping into pond 4.

Integrated groundwater flow and transport modelling was completed as part of the *Mardie Project Conceptual Groundwater System and Regional Modelling* Assessment (AQ2, 2025) (refer to Appendix C to the GMMP).

The modelling simulated the filling and conditioning of Ponds 1 to 3 with sea water (as completed to date and used for model calibration), followed by filling and conditioning of Ponds 9, 8, 7 and 6 with sea water (i.e. simulating the project development plan). This conditioning of the pond floors and walls is designed to limit the leakage from the ponds to the underlying groundwater system and it is estimated that the conditioning process may take up to six months to complete. Accordingly, in the model predictions, six months of conditioning was included (as detailed in Section 6.0 in *Mardie Project Conceptual Groundwater System and Regional Modelling Assessment,* which is provided as Appendix C of the GMMP).

The results of these predictions suggested there would be only short-term water level and salinity impacts from the ponds during conditioning (i.e. six months), with a reduction in leakage from the ponds and water level and salinity impacts simulated after six months and for the remaining life of the project (up to 60 years).

Although it is estimated pond-conditioning will be achieved in 6 months, the actual period of time over which the conditioning would be achieved was identified as an important uncertainty. To address this, sensitivity-modelling was completed to assess the impacts of conditioning of the base of the ponds over an unrealistic (and unsustainable, from a production perspective) period of up to 1.5 years. This sensitivity modelling is described in Appendix B of the report *Mardie Project Conceptual Groundwater System and Regional Modelling Assessment* (refer to Appendix C of the GMMP). The results of this sensitivity modelling suggested that the longer conditioning period may result in the following:

- Elevated water levels persisting close to, or downstream of ponds for a period of up to 18 months (i.e. for the duration of the longer conditioning period). After this time, simulated pond leakage is reduced and water levels are predicted to decrease.
- Where complete conditioning takes longer, then some of the leakage from ponds 7, 8 and 9 occurs at process-water salinity. This is predicted to result in a marginal increase in salinity underneath and immediately downstream of the ponds.
- Water level and salinity impacts of the longer conditioning period are generally confined to the areas underlying or hyper-saline sabkha areas immediately downstream of the ponds (i.e. the tidal creeks and mangroves are not affected).
- The water level and salinity impact of conditioning of the crystallisers are predicted to be limited to the area and period of conditioning (i.e. Mardie Pool is not affected).

In summary, even under this unrealistic ‘worst possible case’ scenario of 18 months of pond seepage, this does not impact groundwater or salinity levels in the tidal creeks, mangroves or in Mardie Pool.

The actual time for conditioning to be completed will be assessed as part of ongoing pond water level monitoring during operations (that will be designed to maximise product recovery), and the measured groundwater level and salinity responses to pond filling. Once pond filling has progressed, the leakage from response from ponds can also be assessed by ongoing updates and validation of the groundwater flow and transport model. For this to be meaningful, pond filling and data collection would have to progress for a period of at least 6 months to a year.

5.3.2 Overarching results

Broadly, both the manual calibration and automatic calibration (PEST) models’ predictions for the 60 years life of the Project are similar and show:

- Short term changes in water levels in the area of ponds during initial operation and conditioning associated with the initial conditioning phase, where seepage through the base of the pond is expected.
- Small changes in predicted water levels in the immediate pond areas and the area upstream due to the change in simulated recharge conditions once the ponds are conditions and the ponds are operations.
- Limited salinity changes close to the ponds due to the limited leakage from the ponds and the assumed tidal recharge conditions.

Model prediction results also suggest that changes to water levels and salinity conditions are not expected to extent to the mangrove areas located downstream of the ponds. Contours of the predicted change in water level after 20 years are shown in Figure 26 for the manual calibration and in Figure 27 for the PEST calibration. Also shown on these figures are the Project extent, the location of Mardie Pool and the areas of mapped mangroves downstream of the ponds. A negative contour value represents an increase in water level while a positive contour value denotes a decrease in water level. For both cases the predicted water level increases are limited to the pond extents and do not extend to the mapped mangrove areas downstream. Water levels are predicted to decrease upstream of the ponds due to the changes to tidal and rainfall recharge once the ponds are constructed, conditioned and operated.

Specific pond by pond results from the manual calibration and the PEST calibration of the model are described in more detail below. Note that detailed model outputs, including all graphs of individual pond modelling predictions, are provided in Section 6 of Appendix C):

5.3.3 Modelling results – Manual Calibration

Salinity

The predicted salinity changes over the life of the Project that were determined for each pond using the manual calibration are outlined below, and can be seen graphically in Section 6.2 of Appendix C.

- Downstream of Pond 1, there are predicted decreases in salinity (~ 4,000 mg/L). This decrease is related to the small amounts of leakage from the Pond 1 over the life of the Project (maximum estimated salinity of Pond 1 is 40,000 mg/L which is lower than the measured salinity downstream of Pond 1 of ~100,000 mg/L) and the salinity that is predicted to develop in these areas as a result of the assumed tidal and recharge conditions. The predicted decrease in shallow salinity is up to 5,000 mg/L.
- Downstream of Pond 3 there are some predicted changes in salinity. These predicted changes in salinity are related to the leakage from the Pond 3 over the life of the Project (maximum estimated salinity of 44,000 mg/L which is lower than the measured salinity downstream of Pond 3 of ~100,000 mg/L) and the salinity that is predicted to develop in these areas as a result of the assumed tidal and recharge conditions. The predicted decrease in salinity is up to 10,000 mg/L.
- Downstream of Pond 4 there are some predicted changes in salinity. These predicted changes in salinity are related to the leakage from the Pond 4 over the life of the Project (maximum estimated salinity of 55,000 mg/L which is lower than the measured salinity downstream of Pond 4 of ~100,000 mg/L) and the salinity that is predicted to develop in these areas because of the assumed tidal and recharge conditions. The maximum predicted change in salinity is around 5,000 mg/L.
- Downstream of Pond 5 there are some predicted changes in salinity. These predicted changes in salinity are related to the leakage from the Pond 5 over the life of the Project (maximum estimated salinity of 92,000 mg/L which is less than the measured salinity downstream of Pond 5) and the salinity that is predicted to develop in these areas as a result of the assumed tidal and recharge conditions. The maximum decrease in predicted at shallow intervals is up to 5,000 mg/L.
- Downstream of Pond 6 there are some predicted changes in salinity. These predicted changes in salinity are related to the leakage from the Pond 6 over the life of the Project (maximum estimated

salinity of 127,000 mg/L which is comparable to the measured salinity downstream of Pond 6) and the salinity that is predicted to develop in these areas as a result of the assumed tidal and recharge conditions. The maximum predicted change in salinity is up to 5,000 mg/L.

- Downstream of Pond 7 there are some predicted changes in salinity. These predicted changes in salinity are related to the leakage from the Pond 6 over the life of the Project (maximum estimated salinity of 175,000 mg/L which is greater than the measured salinity downstream of Pond 6) and the salinity that is predicted to develop in these areas as a result of the assumed tidal and recharge conditions. Immediately underneath Pond 7 the salinity is predicted to decrease as the ongoing input of high salinity from tidal recharge is no longer simulated. This change in salinity is predicted over the model and is less than 10,000 mg/L. Further downstream there are smaller decreases in salinity of up to 5,000 mg/L, however, these are related to the tidal recharge conditions and not related to the operation of the ponds.
- Downstream of Pond 8 there are some predicted changes in salinity. These predicted changes in salinity are related to the leakage from the Pond 8 over the life of the Project (maximum estimated salinity of 226,000 mg/L which is greater than the measured salinity downstream of Pond 6) and the salinity that is predicted to develop in these areas as a result of the assumed tidal and recharge conditions. Immediately underneath Pond 8 the salinity is predicted to decrease by up to 15,000 mg/L as the ongoing input of high salinity is no longer simulated. Further downstream there are smaller increases in salinity predicted of up to 10,000 mg/L. Further downstream (1,000 m) there is limited in pact of the ponds.
- Downstream of Pond 9 there are some small shallow predicted changes in salinity. These predicted changes in salinity are related to the leakage from the Pond 9 over the life of the Project (maximum estimated salinity of 273,000 mg/L) and the salinity that is predicted to develop in these areas as a result of the assumed tidal and recharge conditions. At shallow intervals, the predicted increase in salinity is up to 16,000 mg/L immediately downstream of Pond 9.

For the Mardie Pool groundwater monitoring bores:

- At MP02, MP03, MP04 and MP05, no changes in salinity are predicted over the life of the Project
- At MP08 and MP09, a decrease in salinity is predicted over the life of the Project, related to the assumed recharge conditions included in the model prediction (up to 5,000 mg/L).
- At MP10, a small decrease in salinity is predicted (less than 5,00 mg/L), related to the assumed recharge conditions included in the model prediction. There is also a very little change predicted in the salinity profile of MP20.

Groundwater level

Changes to water levels were only observed to change from a no development scenario in the first five years; groundwater recharge results in long term water level trends that do not vary significantly over the remainder of the 60-year prediction. Accordingly, modelled water level changes over the first five years of the Project are outlined below, and can be seen graphically in section 6.2 of Appendix C:

- At the downstream end of Pond 1, water levels are predicted to remain elevated (at the simulated pond level of 3.4 mAHD after initial filling) as conditioning progresses. The conditioning is simulated to result in a decrease in simulated leakage (after six months) and from this time, water levels at this location are predicted to decrease. At the downstream end of Pond 1, predicted water levels are predicted to fluctuate in response to the tidal recharge simulated downstream of this location, however the simulated fluctuations, once the pond is constructed are less than those simulated for the No Development Case. Further downstream (50 m, 100 m, and 500 m) there is a small reduction in the predicted water level fluctuation after the filling of the pond and prior to the completion of conditioning initially. Once conditioning is complete and leakage is reduced, there is very little predicted impact at these locations (i.e., the simulated water levels for the Development and No

Development locations are the same). Further downstream of Pond 1 (1000 m) there is no significant change to water level impact predicted.

- At the downstream end of Pond 3, water levels are predicted to remain elevated (at the simulated pond level of 3.4 mAHD) after initial filling and as conditioning progresses. The conditioning is simulated to result in a decrease in leakage (after six months), and from this time, water levels are predicted to decrease at this location. At the downstream end of Pond 3, predicted water levels are predicted to fluctuate in response to the tidal recharge simulated downstream of this location, however the fluctuations in water level are less than those predicted for the No Development Case. Further downstream (50 m and 100 m) there is a reduction in the predicted water level fluctuation after the filling of the pond and prior to the completion of conditioning, of up to 0.7 m. Once conditioning is complete and leakage is reduced, there is very little predicted impact at these locations (i.e., the simulated water levels for the Development and No Development locations are the same). Further downstream of Pond 3 (1000 m, Figure 6.30 of Appendix C) there is little water level impact predicted.
- At the downstream end of Pond 4, water levels are predicted to remain elevated as conditioning progresses at the simulated pond level of 3.5 mAHD (after initial filling). Once conditioning is complete water levels are predicted to decrease. At the downstream of Pond 4, water levels are predicted to fluctuate in response to the tidal recharge simulated downstream, however the simulated fluctuations, once the ponds are constructed and operated are less than those simulated for the No Development Case. Further downstream (50 m, 100 m and 500 m) there is a small reduction in the predicted water level fluctuation of up to 0.5 m after the initial filling of the pond and prior to the completion of conditioning. After conditioning is complete, there is very little water level impact predicted at these locations. Further downstream of Pond 4 (1000 m) there is little water level impact predicted.
- At the downstream end of Pond 5, water levels are predicted to remain elevated, at the simulated pond level of 3.4 mAHD after initial filling and as conditioning progresses. Once conditioning is complete water levels are predicted to decrease at this location. At the downstream end of Pond 5, predicted water levels are predicted to fluctuate in response to the tidal recharge simulated downstream of Pond 5. The simulated fluctuations in water level predicted at the downstream end of Pond 5, once the pond is constructed and operated are less than those simulated for the No Development Case. Further downstream (50 m, 100 m and 500 m) there is a reduction in the predicted water level fluctuation after the filling of the pond and prior to the completion of conditioning of up to 1 m. After conditioning is complete limited water level impact is predicted at these locations. Further downstream of Pond 5 (1000 m) there is little water level impact predicted.
- At the downstream end of Pond 6, water levels are predicted to remain elevated at the simulated pond level of 3.4 mAHD after initial filling, as conditioning progresses. Once conditioning is complete water levels are predicted to decrease at this location. Predicted water levels at the downstream end of Pond 6 are predicted to fluctuate in response to the tidal recharge simulated downstream of Pond 6 at this location. The simulated fluctuations in water level predicted at the downstream end of Pond 6, once the pond is constructed and operated are less than those simulated for the No Development Case. Further downstream (50 m, 100 m and 500 m) there is a small reduction in the predicted water level fluctuation of less than 1 m after the filling of the pond and prior to the completion of conditioning. After conditioning is complete limited water level impact is predicted at these locations. Further downstream of Pond 6 (1000 m) there is little water level impact predicted.
- At the downstream end of Pond 7, water levels are predicted to remain elevated at the simulated pond level of 3.5 mAHD, after initial filling and as conditioning progresses. Once conditioning is complete water levels are predicted to decrease at this location. Predicted water levels at the downstream end of Pond 7 are predicted to fluctuate in response to the tidal recharge simulated downstream of Pond 7 at this location. The simulated fluctuations in water level predicted at the

downstream end of Pond 7, once the pond is constructed and operated are less than those simulated for the No Development Case. Further downstream (50 m, 100 m and 500 m) there is no difference in water levels predicted after conditioning is complete. Further downstream of Pond 7 (500 m and 1000 m) there is little water level impact predicted.

- At the downstream end of Pond 8, water levels are predicted to remain elevated at the simulated pond level of 3.4 mAHD after initial filling and as conditioning progresses. Once conditioning is complete water levels are predicted to decrease at this location. Predicted water levels at the downstream end of Pond 8 are predicted to fluctuate in response to the tidal recharge simulated downstream of Pond 8 at this location. The simulated fluctuations in water level predicted at the downstream end of Pond 8, once the pond is constructed and operated are less than those simulated for the No Development Case. Further downstream (50 m, 100 m and 500 m) there is a small reduction in the predicted water level fluctuation of less than 1.5 m after the filling of the pond and prior to the completion of conditioning. After conditioning is complete limited water level impact is predicted at these locations. Further downstream of Pond 6 (1000 m) there is little water level impact predicted.
- At the downstream end of Pond 9, water levels are predicted to remain elevated at the simulated pond level of 3.4 mAHD, after initial filling and as conditioning progresses. Once conditioning is complete water levels are predicted to reduce at this location and remain around 0.5 m higher than the No Development predicted water levels. Predicted water levels at the downstream end of Pond 9 are predicted to fluctuate in response to the tidal recharge simulated downstream of Pond 9 at this location. The simulated fluctuations in water level predicted at the downstream end of Pond 9, once the pond is constructed and operated are less than those simulated for the No Development Case. The water levels predicted further downstream of Pond 9 (50 m,100 m, and 500 m) during conditioning are predicted to be higher than the No Development Case predicted water levels by up to 1 m. After conditioning is complete, this increase in water levels is predicted to reduce to less than 0.5 m, 100 m downstream of Pond 9 and less than 0.2 m, 500 m downstream of Pond 9. Prior to and after conditioning, further downstream of Pond 9 (1000 m, Figure 6.40 in Appendix C) no impact is predicted.

For the Mardie Pool groundwater monitoring bores:

- At MP02 and MP03 and MP04 and MP05 located near Mardie Pool, no water level impact of pond operation is predicted.
- At MP08 and MP09 and MP10, located on the upstream side of the ponds, a water level increase of up to 1.5 m is predicted during conditioning, reducing to around 0.5 m after conditioning is complete.
- At MP09 and MP10, located on the upstream side of the ponds a water level increase of up to 1.5 m is predicted during conditioning, reducing to around 0.5 m after conditioning is complete.
- At MP20, located upstream of the crystalliser, limited water level impact from operation of the ponds is predicted. Water levels are predicted to be lower at this location due to the reduction in groundwater recharge in the crystalliser area. The predicted water level reduction is less than 0.5 m.

5.3.4 Modelling results – PEST Calibration

Salinity

The predicted salinity changes over the life of the Project that were determined for each pond using the manual calibration are outlined below.

- Downstream of Pond 1, there is a predicted decrease in salinity (~ 4,000 mg/L). This decrease is related to the small amounts of leakage simulated from Pond 1 over the life of the Project (maximum estimated salinity of 40,000 mg/L which is lower than the measured salinity downstream of Pond 1 of ~100,000 mg/L) and the salinity that is predicted to develop in these areas as a result of the assumed tidal and recharge conditions.

- Downstream of Pond 3, there are small, predicted changes in salinity. These predicted changes in salinity are related to the small amount leakage simulated from Pond 3 over the life of the Project (maximum estimated salinity of 44,000 mg/L which is lower than the measured salinity downstream of Pond 3) and the salinity that is predicted to develop in these areas as a result of the assumed tidal and recharge conditions. The maximum predicted change in salinity downstream of Pond 3 is 6,000 mg/L.
- Downstream of Pond 4, there are small, predicted changes in salinity. These predicted changes in salinity are related to the leakage from the Pond 4 over the life of the Project (maximum estimated salinity of 55,000 mg/L which is lower than the measured salinity downstream of Pond 4) and the salinity that is predicted to develop in these areas as a result of the assumed tidal and recharge conditions. A decrease is salinity of up to 5,000 mg/L is predicted at shallow intervals just downstream of Pond 4 and an increase of up to 6,000 mg/L is predicted at deeper intervals.
- Downstream of Pond 5, there are small, predicted changes in salinity. These predicted changes in salinity are related to the leakage from the Pond 5 over the life of the Project (maximum estimated salinity of 92,000 mg/L which is less than the measured salinity downstream of Pond 5) and the salinity that is predicted to develop in these areas as a result of the assumed tidal and recharge conditions. The maximum predicted change in salinity downstream of Pond 5 is less than 3,000 mg/L.
- Downstream of Pond 6, there are very small, predicted changes in salinity of less than 2,000 mg/L. These predicted changes in salinity are related to the leakage from the Pond 6 over the life of the Project (maximum estimated salinity of 127,000 mg/L which is comparable to the measured salinity downstream of Pond 6) and the salinity that is predicted to develop in these areas as a result of the assumed tidal and recharge conditions.
- Downstream of Pond 7, there are some predicted changes in salinity. These predicted changes in salinity are related to the leakage from the Pond 6 over the life of the Project (maximum estimated salinity of 175,000 mg/L which is greater than the measured salinity downstream of Pond 7) and the salinity that is predicted to develop in these areas as a result of the assumed tidal and recharge conditions. Downstream of Pond 7 (50 m and 100 m) there are some predicted changes in salinity (up to 10,000 mg/L) and these are related to the tidal recharge conditions, and leakage from Pond 7. No changes in salinity are predicted further downstream (1,000 m).
- Downstream of Pond 8, there are some predicted increases in salinity. These predicted changes in salinity are related to the leakage from the Pond over the life of the Project (maximum estimated salinity of 226,000 mg/L which is greater than the measured salinity downstream of Pond 8) and the salinity that is predicted to develop in these areas as a result of the assumed tidal and recharge conditions. At the downstream end of Pond 8 salinity is predicted to increase over shallow intervals up to 126, 000 mg/L (from an initial salinity of ~ 118,000 mg/L). Further downstream (50 m, 100 m and 500 m) salinity is predicted to increase by up to 2,000 mg/L over deeper intervals. Further downstream (1000 m) no significant increase in salinity is predicted.
- Downstream of Pond 9, salinity is predicted to increase. At shallow depth salinity is predicted to increase by less than 1,000 mg/L, with some increases of up to 20,000 mg/L at the downstream end of Pond 9. These predicted changes in salinity are related to the leakage from Pond 9 over the life of the Project (maximum estimated salinity of 273,000 mg/L) and the salinity that is predicted to develop in these areas as a result of the assumed tidal and recharge conditions. Further downstream, some decreases in shallow salinity are predicted, as well as some increase in deeper salinity but are not related to the operation of Pond 6.

For the Mardie Pool groundwater monitoring bores:

- At MP02, MP03, MP04 and MP05, some changes in salinity are predicted over the life of the Project, however, these are related to the applied recharge and salinity conditions and not pond leakage.
- At MP08, a small decrease in salinity is predicted, related to the assumed recharge conditions included in the model prediction.
- At MP09, an increase in salinity is predicted, however, this is related to the applied recharge and salinity conditions and not pond leakage.
- At MP10, there is no significant change in salinity is predicted. There is also a small change predicted in the salinity profile of MP20 over the life of the Project.

Groundwater level

Changes to water levels were only observed to change from a no development scenario in the first five years; groundwater recharge results in long term water level trends that do not vary significantly over the remainder of the 60-year prediction. Accordingly, modelled water level changes over the first five years of the Project are outlined below:

- At the downstream end of Pond 1, water levels are predicted to remain elevated (at the simulated pond level of 3.4 mAHD, after initial filling) as conditioning progresses. The conditioning is simulated to result in a decrease in simulated leakage (after six months) and from this time, water levels at this location are predicted to decrease. At the downstream end of Pond 1, predicted water levels are predicted to fluctuate in response to the tidal recharge simulated downstream of this location, however the simulated fluctuations, once the pond is operated are less than those simulated for the No Development Case. Further downstream (50 m and 100 m) there is a small reduction in the predicted water level fluctuation after the filling of the pond and prior to the completion of conditioning. Once conditioning is complete and leakage is reduced, there is very little predicted impact at these locations (i.e., the simulated water levels for the Development and No Development locations are the same). Further downstream of Pond 1 (1000 m) there is no significant water level impact predicted.
- At the downstream end of Pond 3, water levels are predicted to remain elevated (at the simulated pond level of 3.4 mAHD) after initial filling and as conditioning progresses. The conditioning is simulated to result in a decrease in simulated leakage (after six months), and from this time, water levels are predicted to decrease at this location. At the downstream end of Pond 3, predicted water levels are predicted to fluctuate in response to the tidal recharge simulated downstream of this location, however the simulated fluctuations in water level are less than those simulated for the No Development Case. Further downstream (50 m and 100 m) there is a reduction in the predicted water level fluctuation after the filling of the pond and prior to the completion of conditioning of up to 0.4 m. Once conditioning is complete and leakage is reduced, there is very little predicted impact at these locations (i.e., the simulated water levels for the Development and No Development locations are the same). Further downstream of Pond 3 (1000 m) there is little water level impact predicted.
- At the downstream end of Pond 4, water levels are predicted to remain elevated as conditioning progresses at the simulated pond level of 3.5 mAHD (after initial filling). Once conditioning is complete water levels are predicted to decrease. At the downstream end of Pond 4, water levels are predicted to fluctuate in response to the tidal recharge simulated downstream, however the simulated fluctuations, once the pond is constructed and operated are less than those simulated for the No Development Case. Further downstream (50 m, 100 m and 500 m), there is a small reduction in the predicted water level fluctuation of up to 0.5 m after the initial filling of the pond and prior to the completion of conditioning. After conditioning is complete, there is very little water level impact predicted at these locations. Further downstream of Pond 4 (500 m and 1000 m) there is little water level impact predicted.

- At the downstream end of Pond 5, water levels are predicted to remain elevated, at the simulated pond level of 3.4 mAHD after initial filling, as conditioning progresses. Once conditioning is complete water levels are predicted to reduce at this location. At the downstream end of Pond 5, predicted water levels are predicted to fluctuate in response to the tidal recharge simulated downstream of Pond 5. The simulated fluctuations in water level predicted at the downstream end of Pond 5, once the pond is constructed and operated are less than those simulated for the No Development Case. Further downstream (50 m, 100 m and 500 m) there is a reduction in the predicted water level fluctuation after the filling of the pond and prior to the completion of conditioning of up to 0.5 m. After conditioning is complete limited water level impact is predicted at these locations. Further downstream of Pond 5 (500 m and 1000 m) there is little water level impact predicted.
- At the downstream end of Pond 6, water levels are predicted to remain elevated at the simulated pond level of 3.4 mAHD after initial filling, as conditioning progresses. Once conditioning is complete water levels are predicted to reduce at this location. Predicted water levels at the downstream end of Pond 6 are predicted to fluctuate in response to the tidal recharge simulated downstream of Pond 6 at this location. The simulated fluctuations in water level predicted at the downstream end of Pond 6, once the pond is constructed and operated are less than those simulated for the No Development Case. Further downstream (50 m, 100 m and 500 m) there is a small reduction in the predicted water level fluctuation of less than 0.5 m after the filling of the pond and prior to the completion of conditioning. After conditioning is complete limited water level impact is predicted at these locations. Further downstream of Pond 6 (500 m and 1000 m) there is little water level impact predicted.
- At the downstream end of Pond 7, water levels are predicted to remain elevated at the simulated pond level of 3.5 mAHD, after initial filling and as conditioning progresses. Once conditioning is complete water levels are predicted to reduce at this location. Predicted water levels at the downstream end of Pond 7 are predicted to fluctuate in response to the tidal recharge simulated downstream of Pond 7 at this location. The simulated fluctuations in water level predicted at the downstream end of Pond 7, once the pond is constructed and operated are less than those simulated for the No Development Case. Further downstream (50 m, 100 m and 500 m) there is no change in predicted water levels predicted during and after conditioning is complete.
- At the downstream end of Pond 8, water levels are predicted to remain elevated at the simulated pond level of 3.4 mAHD, after initial filling and as conditioning progresses. Once conditioning is complete water levels are predicted to reduce at this location. Predicted water levels at the downstream end of Pond 8 are predicted to fluctuate in response to the tidal recharge simulated downstream of Pond 8 at this location. The simulated fluctuations in water level predicted at the downstream end of Pond 8, once the pond is constructed and operated are less than those simulated for the No Development Case. Further downstream (50 m, 100 m, and 500 m) there is a small reduction in the predicted water level fluctuation of less than 0.5 m after the filling of the pond and prior to the completion of conditioning. After conditioning is complete limited water level impact is predicted at these locations. Further downstream of Pond 6 (500 m and 1000 m) there is little water level impact predicted.
- At the downstream end of Pond 9, water levels are predicted to remain elevated at the simulated pond level of 3.4 mAHD, after initial filling and as conditioning progresses. Once conditioning is complete water levels are predicted to reduce at this location and remain around 0.5 m higher than the No Development predicted water levels. Predicted water levels at the downstream end of Pond 9 are predicted to fluctuate in response to the tidal recharge simulated downstream of Pond 9 at this location. The simulated fluctuations in water level predicted at the downstream end of Pond 9, once the pond is constructed and operated are less than those simulated for the No Development Case. Predicted water levels at the downstream end of Pond 9 are predicted to remain elevated after conditioning is completed (predicted water levels are predicted to be up to 0.5 m higher). The water levels predicted further downstream of Pond 9 (50 m and 100 m) during conditioning are

predicted to be higher than the No Development Case predicted water levels by up to 1 m. After conditioning is complete, this increase in water levels is predicted to reduce to less than 0.5 m 100 m downstream of Pond 9 and less than 0.2 m 500 m downstream of Pond 9. Prior to and after conditioning, further downstream of Pond 6 (1000 m) no impact is predicted.

For the Mardie Pool groundwater monitoring bores:

- At MP02 and MP03 and MP04 and MP05, located near Mardie Pool, no water level impact of pond operation is predicted.
- At MP08 and MP09 and MP10, located on the upstream side of the ponds, a water level increase of up to 0.7 m is predicted during conditioning, reducing to around 0.5 m after condition is complete.
- At MP09 and MP10, located on the upstream side of the ponds, a water level increase of up to 1.0 m is predicted during conditioning, reducing to around 0.7 m after conditioning is complete.
- At MP20, located upstream of the crystalliser, limited water level impact of operation of the ponds is predicted.

5.3.5 Overall water level changes

Contours of the predicted change in water level after 20 years are shown in Figure 26 for the manual calibration and in Figure 27 for the PEST calibration. Also shown on these figures are the Project extent, the location of Mardie Pool and the areas of mapped mangroves downstream of the ponds.

The contours of water level changes are calculated as the difference between the prediction that includes the pond development and the No Development prediction. A negative contour value represents an increase in water level while a positive contour value represents a decrease in water level. For both cases the predicted water level increases are limited to the pond extents and do not extend to the mangrove areas downstream. Water levels are predicted to decrease upstream of the ponds due to the changes (reduction) in tidal and rainfall recharge once the ponds are constructed, conditioned and operated.

Figure 26 Predicted Change in Water Level after 20 years of Operation: Manual Calibration

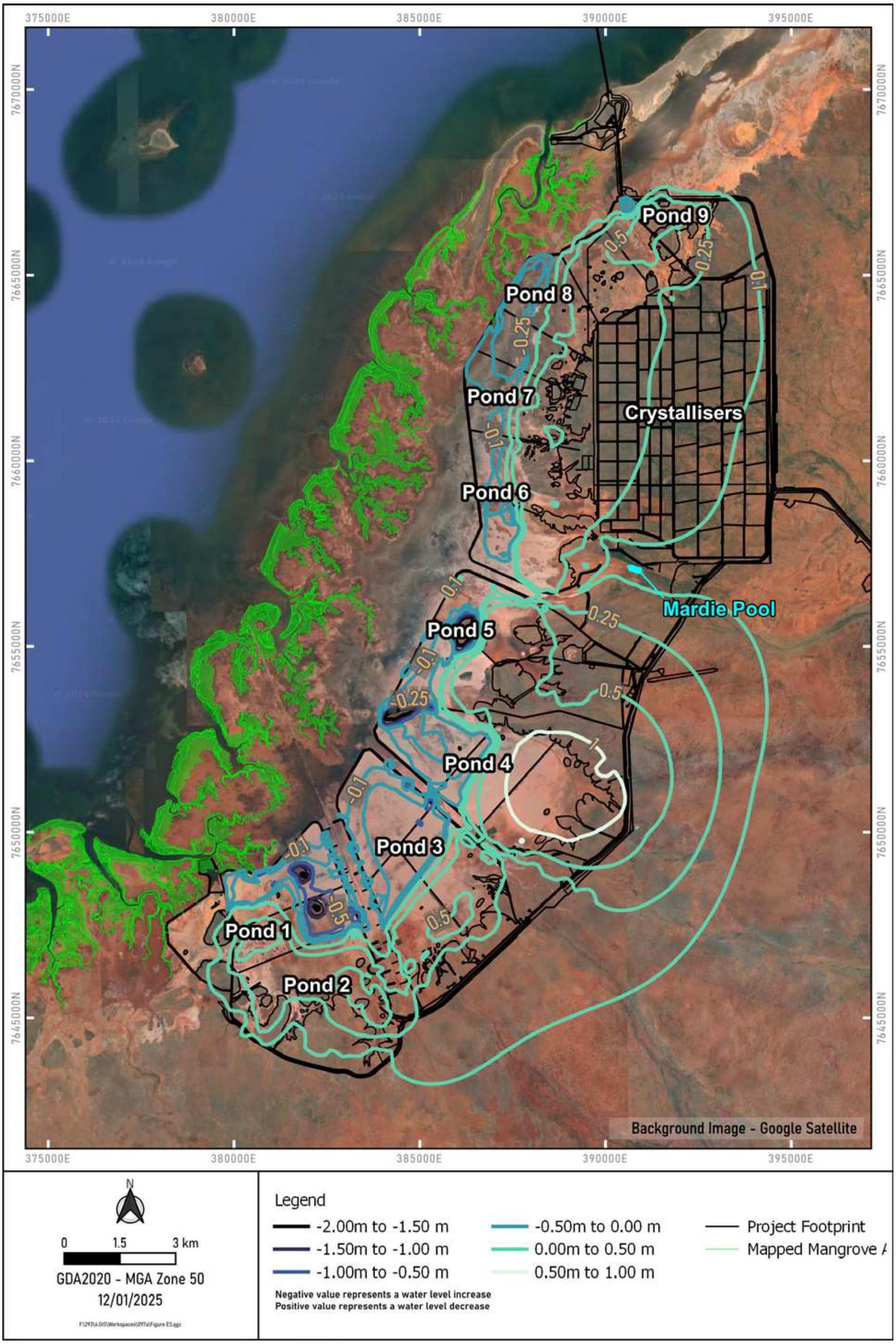
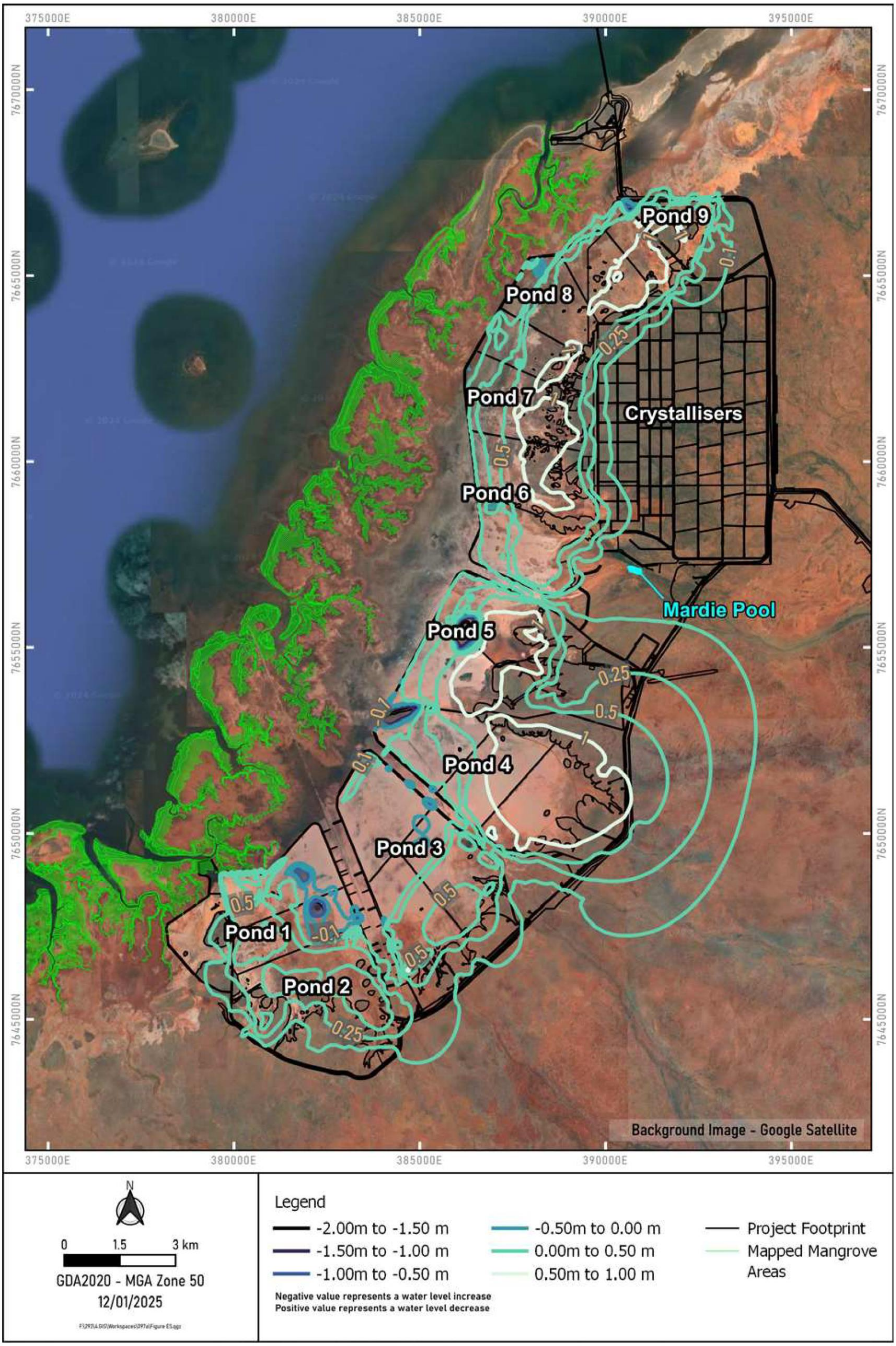


Figure 27 Predicted Change in Water Level after 20 years of Operation: Automatic Calibration



5.4 Risk Assessment

The risk assessment provided in Table 5-4 is a subset of the Project Environmental Risk Register which is maintained and regularly updated as part of the Mardie Minerals Environmental Management System. The scope of the risk assessment is based on the most recent Conceptual and Impact Hydrogeological Modelling (Appendix C) and details risks associated with changes to groundwater regimes and groundwater quality.

This Risk Assessment should be considered in conjunction with the BCHMMP risk assessment, as the two plans are connected where changes are observed to groundwater and BCH condition, and investigation determines that the changes are project related (see Section 7.2).

5.4.1 Risk Criteria

Each environmental risk is given a rating in terms of likelihood and consequence using the criteria in Table 5-2 and Table 5-3.

Table 5-2 Risk criteria matrix: Likelihood of impact occurring

Qualitative measure of likelihood (how likely is it that this event/issue will occur after control strategies have been put in place)	
Highly likely	Is expected to occur in most circumstances
Likely	Will probably occur during the life of the project
Possible	Might occur during the life of the project
Unlikely	Could occur but considered unlikely or doubtful
Rare	May occur in exceptional circumstances

Table 5-3 Risk Criteria matrix: Consequence of impact

Qualitative measure of consequences (what will be the consequence/result if this issue does occur rating)	
Minor	Minor incident of environmental damage that can be reversed
Moderate	Isolated but substantial instances of environmental damage that could be reversed with intensive efforts
High	Substantial instances of environmental damage that could be reversed with intensive efforts
Major	Major loss of environmental amenity and real danger of continuing
Critical	Severe widespread loss of environmental amenity and irrecoverable environmental damage

A risk score is assigned to inherent and treated risk pathways identified with the Project activities. The risk score is assigned using the risk matrix (Table 5-3) to generate a risk rating of low, medium, high or severe. In general, risk scores can be reduced by implementing a treatment that will reduce the likelihood of the impact from occurring. If a risk is eliminated or substituted, then the consequence can be reduced, reducing the risk score.

Table 5-4 Risk criteria matrix: Risk levels

	Consequence				
Likelihood	Minor	Moderate	High	Major	Critical
Highly Likely	Medium	High	High	Severe	Severe
Likely	Low	Medium	High	High	Severe
Possible	Low	Medium	Medium	High	Severe
Unlikely	Low	Low	Medium	High	High
Rare	Low	Low	Low	Medium	High

The risk assessment relies on the comprehensive description of Project activities, so that associated risks and potential impacts can be identified. The aspects and activities of the Project are fully listed in the Project Environmental and Heritage Risk Assessment. Only hazards that result in impacts to groundwater are discussed. The risk assessment is outlined in Table 5-5.

5.4.2 Risk Assessment

Table 5-5 Assessment of Environmental Risks associated with groundwater aspects of the Project

Factors for the Original and Optimised Project– MNES of relevance to groundwater matters	Environmental Risk	Possible Risk Pathway	Potential Impact on MNES	Risk Rating			Control / Management Measures to reduce the likelihood of the risk (Mitigation measures that will be implemented to address the risk or uncertainty)	Residual Risk Rating following implementation of Control / Management		
				Likelihood	Conseq.	Risk Rating		Likelihood	Conseq.	Risk Rating
Benthic communities and habitats (BCH) which include: - mangrove; - algal mat; and - samphire communities	Change to groundwater level and quality	Seepage from ponds and/or crystalliser A spill and/or leak of brine from the ponds/crystalliser or pipelines	Increased groundwater levels and/or changes to the quality of the existing groundwater may have an indirect impact on the health of BCH resulting in: - Loss of BCH (i.e. BCH unable to tolerate the change and BCH die) - Loss of BCH contribution to the nutrient cycle (i.e. decline in the health of the BCH, resulting in a reduction to their contribution to the nutrient cycle) - Loss of BCH resulting in a reduction to the foraging habitat for migratory shorebirds	Possible	High	Medium	Control / Management measures to address possible risk of seepage from ponds and/or crystalliser: - The design of the project has been amended to move the crystalliser ponds further away from Mardie Pool (from ~250m to ~1km northwards) to prevent any potential indirect impact from seepage. - Ongoing daily monitoring of groundwater levels and quality (salinity) will be conducted so the model can be verified. - Weekly visual inspections of Pond condition and any leakage, and the follow up of evidence through internal investigations (noting these are not trigger or threshold exceedance events). - Weekly visual inspections and observations of adjacent habitat areas (such as algal mats) to the Evaporation Ponds (noting these are not trigger or threshold exceedance events) - Daily site inspections of water infrastructure – pumps, roads, flow equipment. - Control pumps for sea water controlled by the Digital Control Centre via telemetry. - Weekly pond testing of brine density as a control of evaporation versus losses, and salinity. - Operational pond modelling to calculate steady-state brine densities and pond depths with weekly review frequencies. - Ongoing BCHMMP monitoring and, if required, implementation of the reactive monitoring as outlined in Section 3.1.3.3. of the BCHMMP. - Ongoing monitoring and, if required, implementation of reactive monitoring as outlined in Section 2.2.6 of the MSMMP. - Continue with routine monitoring of exceedance/s of the threshold criterion. - Implement any additional measures to minimise/prevent unauthorised harm to Protected Matters. - Continue with routine monitoring of Protected Matters in accordance with EPBC 2018/8236 (as varied), EPBC 2022/9169, and MS 1211. - Outline management options to avoid future exceedances. Control / Management measures to address possible risk of spill or leak of brine from ponds and/or crystalliser or pipelines: - Pipelines will utilise industry-standard materials to minimise the chance of leaks, and mitigation will be implemented to reduce this risk further. - Ponds have been designed with adequate freeboard and overflow features to minimise the risk of unplanned overflows and wall breaches. - Ongoing daily monitoring of groundwater levels and quality (salinity) will be conducted so the model can be verified. - Weekly visual inspections of Pond condition and any leakage, and the follow up of evidence through internal investigations (noting these are not trigger or threshold exceedance events) - Weekly visual inspections and observations of adjacent habitat areas to the Evaporation Ponds such as Algal Mats (noting these are not trigger or threshold exceedance events)	Unlikely	Moderate	Low

Factors for the Original and Optimised Project– MNES of relevance to groundwater matters	Environmental Risk	Possible Risk Pathway	Potential Impact on MNES	Risk Rating			Control / Management Measures to reduce the likelihood of the risk (Mitigation measures that will be implemented to address the risk or uncertainty)	Residual Risk Rating following implementation of Control / Management		
				Likelihood	Conseq.	Risk Rating		Likelihood	Conseq.	Risk Rating
							- Daily site inspections of water infrastructure – pumps, roads, flow equipment. - Control pumps for sweater controlled by the Digital Control Centre via telemetry - Ongoing pumping and water management infrastructure maintenance programs - Weekly pond testing of brine density as a control of evaporation versus losses - Operational pond modelling to calculate steady-state brine densities and pond depths with weekly review frequencies. - Continue with routine monitoring of exceedance/s of the threshold criterion. - Implement any additional measures to minimise/prevent unauthorised harm to Protected Matters - Continue with routine monitoring of Protected Matters in accordance with EPBC 2018/8236 (as varied), EPBC 2022/9169 and MS 1211 - Outline management options to avoid future exceedances. - Ongoing monitoring and if required, implementation of reactive monitoring as outlined in Section 2.2.6 of the MSMMP. - Continue with routine monitoring of exceedance/s of the threshold criterion.			
Benthic communities and habitats (BCH) which include: - mangrove; - algal mat; and - samphire communities	Change to groundwater levels and quality	Release of concentrated water/brine into the environment as a potential remediation response to an exceedance of trigger thresholds Note: If Mardie Minerals were to take this action, the concentrated water/brine would only be released into the Marine Environment and will not be disposed of to the terrestrial environment. Therefore, Mardie Minerals have not considered the potential risk against the terrestrial MNES of relevance to groundwater matters in this table.	Increased groundwater levels and/or changes to the quality of the existing groundwater may have an indirect impact on the health of BCH resulting in: - Loss of BCH (i.e. BCH unable to tolerate the change and BCH die) - Loss of BCH contribution to the nutrient cycle (i.e. decline in the health of the BCH resulting in a reduction of their contribution to the nutrient cycle) - Loss of BCH resulting in a reduction to the foraging habitat for migratory shorebirds	Possible	High	Medium	Control / Management measures to address possible risk of releasing concentrated water/brine into the environment as a potential remediation response to an exceedance of trigger thresholds: - Bespoke risk assessment and review of potential impact to MNES in consultation with the regulators, prior to the release of any concentrated water/brine. - Shut off water flows into pond/s if leaks are detected, or adjust the brine flows between ponds (using pumps, gates and weirs). - Increase the appropriate freeboard of the pond and adjust pond operating level. - Install cut-off bores, sumps and/or trenches and pump the water to the appropriate salinity pond. - Rectify breaches in pond walls to be structurally stable, fix containment systems and leaks in internal drainage structures. - Review the steady-state average brine density for each pond, and modify the 'Brine Movement Plan'. - Dilute the brine or slow down the evaporation process by pumping additional sea water (i.e. shandying) from the primary or secondary sea water intake system. - Continue with routine monitoring of exceedance/s of the threshold criterion. - Implement any additional measures to minimise/prevent unauthorised harm to Protected Matters. - Continue with routine monitoring of Protected Matters in accordance with EPBC 2018/8236 (as varied), EPBC 2022/9169 and MS 1211. - Outline management options to avoid future exceedances. - Ongoing BCHMMP monitoring and if required, implementation of the reactive monitoring as outline in Section 3.1.3.3. of the BCHMMP. - Ongoing monitoring and if required, implementation of reactive monitoring as outlined in Section 2.2.6 of the MSMMP.	Unlikely	Moderate	Low

Factors for the Original and Optimised Project– MNES of relevance to groundwater matters	Environmental Risk	Possible Risk Pathway	Potential Impact on MNES	Risk Rating			Control / Management Measures to reduce the likelihood of the risk (Mitigation measures that will be implemented to address the risk or uncertainty)	Residual Risk Rating following implementation of Control / Management		
				Likelihood	Conseq.	Risk Rating		Likelihood	Conseq.	Risk Rating
							- Implementation of monitoring as required under the Marine Environmental Quality Monitoring and Management Plan (MEQMMP) and if required, implement reactive monitoring/management in the event that environmental quality objectives are determined to be at risk.			
Benthic communities and habitats (BCH) which include: - mangrove; - algal mat; and - samphire communities	Decline in soil or groundwater quality leads to contaminated site.	Inefficiency of oily water separators leads to discharge of hydrocarbon contaminated water and seepage into groundwater	Increased groundwater levels and/or changes to the quality of the existing groundwater may have an indirect impact on the health of BCH resulting in: - Loss of BCH (i.e. BCH unable to tolerate the change and BCH die) - Loss of BCH contribution to the nutrient cycle (i.e. decline in the health of the BCH resulting in a reduction of their contribution to the nutrient cycle) - Loss of BCH resulting in a reduction to the foraging habitat for migratory shorebirds	Possible	Moderate	Medium	Control / Management measures to address possible risk of a decline in soil and groundwater quality due to operational inefficiencies of oily water separators: - Discharge of treated wastewater to be regulated under Part V of the Environmental Protection Act. - Adherence to the monitoring and reporting regime for the operation as regulated under the EP Act Part V approval. - Contamination regulated under Part V of the Environmental Protection Act. and the Contaminated Sites Act if not remediated. - Ongoing daily monitoring of groundwater levels and quality. - Daily site inspections of water infrastructure and equipment. - Spill kits located at key areas. - All spills controlled, contained and cleaned up. - Hydrocarbons and chemicals stored within suitably bunded areas. - Spill kits regularly checked and replenished, if required. - All hydrocarbons and chemical spills recorded. - Continue with routine monitoring of exceedance/s of the threshold criterion. - Implement any additional measures to minimise/prevent unauthorised harm to Protected Matters. - Continue with routine monitoring of Protected Matters in accordance with EPBC 2018/8236 (as varied), EPBC 2022/9169 and MS 1211. - Outline management options to avoid future exceedances.	Unlikely	Moderate	Low
Mardie Pool as a source of freshwater to MNES (i.e. Pilbara Leaf-nosed Bat and Pilbara Olive Python)	Change to groundwater levels and quality	Seepage from ponds and/or crystalliser A spill or leak of brine from the ponds/crystalliser or pipelines	Changes to the groundwater level and quality of the existing groundwater at Mardie Pool, may result in and alteration to the foraging behaviors of MNES due to a: - Decline in the health and/or loss of native vegetation (i.e. foraging habitat to MNES) - Reduced presence of MNES if Mardie Pool is no longer a potential source of freshwater.	Possible	High	Medium	Control / Management measures to address possible risk of seepage from ponds and/or crystalliser: - The design of the project has been amended to move the crystalliser ponds (which will be lined) further away from Mardie Pool (from ~250m to ~1km northwards) to prevent any potential indirect impact from seepage. - Updated modelling at the completion of filling Pond 1 – Pond 3, with real-time monitoring date to validate the potential risks impacts to groundwater levels and quality. - Ongoing daily monitoring of groundwater levels and quality (salinity) will be conducted so the model can be verified. - Weekly visual inspections of Pond condition and any leakage, and the follow up of evidence through internal investigations (noting these are not trigger or threshold exceedance events) - Weekly visual inspections and observations of adjacent habitat areas to the Evaporation Ponds such as Algal Mats (noting these are not trigger or threshold exceedance events) - Daily site inspections of water infrastructure – pumps, roads, flow equipment. - Control pumps for sea water controlled by the Digital Control Centre via telemetry. - Weekly pond testing of brine density as a control of evaporation versus losses.	Unlikely	Moderate	Low

Factors for the Original and Optimised Project– MNES of relevance to groundwater matters	Environmental Risk	Possible Risk Pathway	Potential Impact on MNES	Risk Rating			Control / Management Measures to reduce the likelihood of the risk (Mitigation measures that will be implemented to address the risk or uncertainty)	Residual Risk Rating following implementation of Control / Management		
				Likelihood	Conseq.	Risk Rating		Likelihood	Conseq.	Risk Rating
							- Operational pond modelling to calculate steady state brine densities and pond depths with weekly review frequencies. - Continue with routine monitoring of Protected Matters in accordance with EPBC 2018/8236 (as varied), EPBC 2022/9169 and MS 1211. Control / Management measures to address possible risk of spill or leak of brine from ponds and/or crystalliser or pipelines: - Pipelines will utilise industry-standard materials to minimise the chance of leaks, and mitigation will be implemented to reduce this risk further. - Ponds have been designed with adequate freeboard and overflow features to minimise the risk of unplanned overflows and wall breaches. - Ongoing daily monitoring of groundwater levels and quality (salinity) will be conducted so the model can be verified. - Weekly visual inspections of Pond condition and any leakage, and the follow up of evidence through internal investigations (noting these are not trigger or threshold exceedance events). - Weekly visual inspections and observations of adjacent habitat areas to the Evaporation Ponds such as Algal Mats (noting these are not trigger or threshold exceedance events). - Daily site inspections of water infrastructure – pumps, roads, flow equipment. - Control pumps for sweater controlled by the Digital Control Centre via telemetry. - Ongoing pumping and water management infrastructure maintenance programs. - Weekly pond testing of brine density as a control of evaporation versus losses. - Operational pond modelling to calculate steady state brine densities and pond depths with weekly review frequencies. - Continue with routine monitoring of Protected Matters in accordance with EPBC 2018/8236 (as varied), EPBC 2022/9169 and MS 1211.			
Mardie Pool as a source of freshwater to MNES (i.e. Pilbara Leaf-nosed Bat and Pilbara Olive Python)	Changes to groundwater level and quality	Groundwater drawdown from operations of the bore required to supply water to the camp facilities.	Changes to the groundwater level and quality of the existing groundwater at Mardie Pool, may result in and alteration to the foraging behaviors of MNES due to a: - Decline in the health and/or loss of native vegetation (i.e. foraging habitat to MNES) - Reduced presence of MNES if Mardie Pool is no longer a potential source of freshwater.	Possible	Moderate	Medium	Control / Management measures to address possible risk of changes to groundwater levels and quality from drawdown from operational bores to supply water to camp facilities: - Construction and operation of the water source bore(s) in accordance with the granted 5C licence granted under the RiWI Act. - Ongoing daily monitoring of groundwater levels and quality (salinity). - Daily site inspections of water infrastructure – pumps, roads, flow equipment. - Continue with routine monitoring of exceedance/s of the threshold criterion. - Implement any additional measures to minimise/prevent unauthorised harm to Protected Matters. - Continue with routine monitoring of Protected Matters in accordance with EPBC 2018/8236 (as varied), EPBC 2022/9169 and MS 1211. - Outline management options to avoid future exceedances.	Unlikely	Moderate	Low
Mardie Pool as a source of freshwater to MNES (i.e. Pilbara Leaf-nosed Bat and Pilbara Olive Python)	Decline in soil or groundwater quality leads to contaminated site.	Inefficiency of wastewater treatment plant (WWTP) to discharge contaminated water and seepage into groundwater	Changes to the groundwater level and quality of the existing groundwater at Mardie Pool, may result in and alteration to the foraging behaviors of MNES due to a:	Possible	High	Medium	Control / Management measures to address possible risk of a decline in soil and groundwater quality due to operational inefficiencies of wastewater treatment plant:	Unlikely	Moderate	Low

Factors for the Original and Optimised Project– MNES of relevance to groundwater matters	Environmental Risk	Possible Risk Pathway	Potential Impact on MNES	Risk Rating			Control / Management Measures to reduce the likelihood of the risk (Mitigation measures that will be implemented to address the risk or uncertainty)	Residual Risk Rating following implementation of Control / Management		
				Likelihood	Conseq.	Risk Rating		Likelihood	Conseq.	Risk Rating
			- Decline in the health and/or loss of native vegetation (i.e. foraging habitat to MNES) - Reduced presence of MNES if Mardie Pool is no longer a potential source of freshwater.				- Discharge of treated wastewater to be regulated under Part V of the Environmental Protection Act. - Adherence to the monitoring and reporting regime for the operation of the WWTP as regulated under the EP Act Part V approval. - Contamination regulated under Part V of the Environmental Protection Act. and the Contaminated Sites Act if not remediated. - Ongoing daily monitoring of groundwater levels and quality. - Daily site inspections of water infrastructure and equipment. - Continue with routine monitoring of exceedance/s of the threshold criterion. - Implement any additional measures to minimise/prevent unauthorised harm to Protected Matters - Continue with routine monitoring of Protected Matters in accordance with EPBC 2018/8236 (as varied), EPBC 2022/9169 and MS 1211 - Outline management options to avoid future exceedances.			
Mardie Pool as a source of freshwater to MNES (i.e. Pilbara Leaf-nosed Bat and Pilbara Olive Python)	Decline in soil or groundwater quality leads to contaminated site.	Inefficiency of oil water separators leads to discharge of hydrocarbon contaminated water and seepage into groundwater	Changes to the groundwater level and quality of the existing groundwater at Mardie Pool, may result in and alteration to the foraging behaviors of MNES due to a: - Decline in the health and/or loss of native vegetation (i.e. foraging habitat to MNES) - Reduced presence of MNES if Mardie Pool is no longer a potential source of freshwater. habitat for migratory shorebirds	Possible	Moderate	Medium	Control / Management measures to address possible risk of a decline in soil and groundwater quality due to operational inefficiencies of oily water separators: - Discharge of treated wastewater to be regulated under Part V of the Environmental Protection Act. - Adherence to the monitoring and reporting regime for the operation as regulated under the EP Act Part V approval. - Contamination regulated under Part V of the Environmental Protection Act. and the Contaminated Sites Act if not remediated. - Ongoing daily monitoring of groundwater levels and quality. - Daily site inspections of water infrastructure and equipment. - Spill kits located at key areas; - All spills controlled, contained and cleaned up; - Hydrocarbons and chemicals stored within suitably bunded areas; - Spill kits regularly checked and replenished, if required. - All hydrocarbons and chemical spills recorded. - Continue with routine monitoring of exceedance/s of the threshold criterion. - Implement any additional measures to minimise/prevent unauthorised harm to Protected Matters. - Continue with routine monitoring of Protected Matters in accordance with EPBC 2018/8236 (as varied), EPBC 2022/9169 and MS 1211 - Outline management options to avoid future exceedances.	Unlikely	Moderate	Low
Habitat (native vegetation) for terrestrial MNES fauna species	Change to groundwater levels and quality	Seepage from ponds and/or crystallisers A spill or leak of brine from the ponds/crystalliser or pipelines	Indirect impact to the health of terrestrial fauna habitat for MNES	Possible	High	Medium	Control / Management measures to address possible risk of seepage from ponds and/or crystalliser: - The design of the project has been amended to move the crystalliser ponds (which will be lined) further away from Mardie Pool (from ~250m to ~1km northwards) to prevent any potential indirect impact from seepage. - Updated modelling at the completion of filling Pond 1 – Pond 3, with real-time monitoring date to validate the potential risks impacts to groundwater levels and quality. - Ongoing daily monitoring of groundwater levels and quality (salinity) will be conducted so the model can be verified.	Unlikely	Moderate	Low

Factors for the Original and Optimised Project– MNES of relevance to groundwater matters	Environmental Risk	Possible Risk Pathway	Potential Impact on MNES	Risk Rating			Control / Management Measures to reduce the likelihood of the risk (Mitigation measures that will be implemented to address the risk or uncertainty)	Residual Risk Rating following implementation of Control / Management		
				Likelihood	Conseq.	Risk Rating		Likelihood	Conseq.	Risk Rating
							- Weekly visual inspections of Pond condition and any leakage, and the follow up of evidence through internal investigations (noting these are not trigger or threshold exceedance events) - Weekly visual inspections and observations of adjacent habitat areas to the Evaporation Ponds such as Algal Mats (noting these are not trigger or threshold exceedance events) - Daily site inspections of water infrastructure – pumps, roads, flow equipment. - Control pumps for sea water controlled by the Digital Control Centre via telemetry - Weekly pond testing of brine density as a control of evaporation versus losses - Operational pond modelling to calculate steady state brine densities and pond depths with weekly review frequencies. - Continue with routine monitoring of Protected Matters in accordance with EPBC 2018/8236 (as varied), EPBC 2022/9169 and MS 1211. Control / Management measures to address possible risk of spill or leak of brine from ponds and/or crystalliser or pipelines: - Pipelines will utilise industry-standard materials to minimise the chance of leaks, and mitigation will be implemented to reduce this risk further. - Ponds have been designed with adequate freeboard and overflow features to minimise the risk of unplanned overflows and wall breaches. - Ongoing daily monitoring of groundwater levels and quality (salinity) will be conducted so the model can be verified. - Weekly visual inspections of Pond condition and any leakage, and the follow up of evidence through internal investigations (noting these are not trigger or threshold exceedance events). - Weekly visual inspections and observations of adjacent habitat areas to the Evaporation Ponds such as Algal Mats (noting these are not trigger or threshold exceedance events). - Daily site inspections of water infrastructure – pumps, roads, flow equipment. - Control pumps for sweater controlled by the Digital Control Centre via telemetry. - Ongoing pumping and water management infrastructure maintenance programs. - Weekly pond testing of brine density as a control of evaporation versus losses. - Operational pond modelling to calculate steady state brine densities and pond depths with weekly review frequencies. - Continue with routine monitoring of Protected Matters in accordance with EPBC 2018/8236 (as varied), EPBC 2022/9169 and MS 1211.			
Habitat (native vegetation) for terrestrial MNES fauna species	Decline in soil or groundwater quality leads to contaminated site.	Inefficiency of oil water separators leads to discharge of hydrocarbon contaminated water and seepage into groundwater	Changes to the groundwater level and quality of the existing groundwater may result a decline in the health and/or loss of native vegetation (i.e. foraging habitat to MNES)	Possible	Moderate	Medium	Control / Management measures to address possible risk of a decline in soil and groundwater quality due to operational inefficiencies of oily water separators: - Discharge of treated wastewater to be regulated under Part V of the Environmental Protection Act. - Adherence to the monitoring and reporting regime for the operation as regulated under the EP Act Part V approval. - Contamination regulated under Part V of the Environmental Protection Act. and the Contaminated Sites Act if not remediated.	Unlikely	Moderate	Low

Factors for the Original and Optimised Project– MNES of relevance to groundwater matters	Environmental Risk	Possible Risk Pathway	Potential Impact on MNES	Risk Rating			Control / Management Measures to reduce the likelihood of the risk (Mitigation measures that will be implemented to address the risk or uncertainty)	Residual Risk Rating following implementation of Control / Management		
				Likelihood	Conseq.	Risk Rating		Likelihood	Conseq.	Risk Rating
							- Ongoing daily monitoring of groundwater levels and quality. - Spill kits located at key areas; - All spills controlled, contained and cleaned up. - Hydrocarbons and chemicals stored within suitably bunded areas. - Spill kits regularly checked and replenished, if required. - All hydrocarbons and chemical spills recorded. - Daily site inspections of water infrastructure and equipment. - Continue with routine monitoring of exceedance/s of the threshold criterion. - Implement any additional measures to minimise/prevent unauthorised harm to Protected Matters. - Continue with routine monitoring of Protected Matters in accordance with EPBC 2018/8236 (as varied), EPBC 2022/9169 and MS 1211. - Outline management options to avoid future exceedances.			
Habitat (native vegetation) for terrestrial MNES fauna species	Changes to groundwater level and quality	Groundwater drawdown from operations of the bore required to supply water to the camp facilities.	Changes to the groundwater level and quality of the existing groundwater may result in a decline in the health and/or loss of native vegetation (i.e. foraging habitat to MNES)	Possible	Moderate	Medium	Control / Management measures to address possible risk of changes to groundwater levels and quality from drawdown from operational bores to supply water to camp facilities: - Construction and operation of the water source bore(s) in accordance with the granted 5C licence granted under the RIWI Act. - Ongoing daily monitoring of groundwater levels and quality (salinity). - Daily site inspections of water infrastructure – pumps, roads, flow equipment. - Continue with routine monitoring of exceedance/s of the threshold criterion. - Implement any additional measures to minimise/prevent unauthorised harm to Protected Matters. - Continue with routine monitoring of Protected Matters in accordance with EPBC 2018/8236 (as varied), EPBC 2022/9169 and MS 1211. - Outline management options to avoid future exceedances.	Unlikely	Moderate	Low
M.tridens	Change to groundwater levels and quality	Seepage from ponds and/or crystallisers A spill or leak of brine from the ponds/crystalliser or pipelines	Changes to the groundwater level and quality of the existing groundwater may result in a decline in the health and/or loss of *M.tridens*	Possible	Moderate	Medium	Control / Management measures to address possible risk of decline in health and/or loss of M. tridens from a change to groundwater levels and quality from seepage of ponds/crystalliser and/or a leak/spill of brine from the ponds/crystalliser/pipelines: - Annual health monitoring of *M.tridens* located within the Development Envelope. - Implementation of the Offset and Research Strategy for *M.tridens*. - Pipelines will utilise industry-standard materials to minimise the chance of leaks, and mitigation will be implemented to reduce this risk further. - Ponds have been designed with adequate freeboard and overflow features to minimise the risk of unplanned overflows and wall breaches. - Ongoing daily monitoring of groundwater levels and quality (salinity) will be conducted so the model can be verified. - Weekly visual inspections of Pond condition and any leakage, and the follow up of evidence through internal investigations (noting these are not trigger or threshold exceedance events). - Weekly visual inspections and observations of adjacent habitat areas to the Evaporation Ponds such as Algal Mats (noting these are not trigger or threshold exceedance events). - Daily site inspections of water infrastructure – pumps, roads, flow equipment.	Unlikely	Moderate	Low

Factors for the Original and Optimised Project– MNES of relevance to groundwater matters	Environmental Risk	Possible Risk Pathway	Potential Impact on MNES	Risk Rating			Control / Management Measures to reduce the likelihood of the risk (Mitigation measures that will be implemented to address the risk or uncertainty)	Residual Risk Rating following implementation of Control / Management		
				Likelihood	Conseq.	Risk Rating		Likelihood	Conseq.	Risk Rating
							- Control pumps for sweater controlled by the Digital Control Centre via telemetry. - Ongoing pumping and water management infrastructure maintenance programs. - Weekly pond testing of brine density as a control of evaporation versus losses. - Operational pond modelling to calculate steady state brine densities and pond depths with weekly review frequencies. - Continue with routine monitoring of Protected Matters in accordance with EPBC 2018/8236 (as varied), EPBC 2022/9169 and MS 1211.			
M.tridens	Changes to groundwater regime	Groundwater drawdown from operations of the bore required to supply water to the camp facilities.	Changes to the groundwater level and quality of the existing groundwater may result in a: decline in the health and/or loss of *M.tridens*	Unlikely	Moderate	Low	Control / Management measures to address possible risk of changes to groundwater levels and quality from drawdown from operational bores to supply water to camp facilities: - Construction and operation of the water source bore(s) in accordance with the granted 5C licence granted under the RiWI Act. - Ongoing daily monitoring of groundwater levels and quality (salinity). - Daily site inspections of water infrastructure – pumps, roads, flow equipment. - Continue with routine monitoring of exceedance/s of the threshold criterion. - Implement any additional measures to minimise/prevent unauthorised harm to Protected Matters. - Continue with routine monitoring of Protected Matters in accordance with EPBC 2022/9169 and MS 1211. - Outline management options to avoid future exceedances.	Unlikely	Moderate	Low
M.tridens	Decline in soil or groundwater quality leads to contaminated site.	Inefficiency of wastewater treatment plant (WWTP) to discharge contaminated water and seepage into groundwater	Changes to the groundwater level and quality of the existing groundwater may result in a decline in the health and/or loss of *M.tridens*	Possible	Moderate	Medium	Control / Management measures to address possible risk of a decline in soil and groundwater quality due to operational inefficiencies of wastewater treatment plant: - Discharge of treated wastewater to be regulated under Part V of the Environmental Protection Act. - Adherence to the monitoring and reporting regime for the operation of the WWTP as regulated under the EP Act Part V approval. - Contamination regulated under Part V of the Environmental Protection Act. and the Contaminated Sites Act if not remediated. - Ongoing daily monitoring of groundwater levels and quality. - Daily site inspections of water infrastructure and equipment. - Continue with routine monitoring of exceedance/s of the threshold criterion. - Implement any additional measures to minimise/prevent unauthorised harm to Protected Matters. - Continue with routine monitoring of Protected Matters in accordance with EPBC 2018/8236 (as varied), EPBC 2022/9169 and MS 1211. - Outline management options to avoid future exceedances.	Unlikely	Moderate	Low
M.tridens	Decline in soil or groundwater quality leads to contaminated site.	Inefficiency of oil water separators leads to discharge of hydrocarbon contaminated water and seepage into groundwater	Changes to the groundwater level and quality of the existing groundwater may result in a decline in the health and/or loss of *M.tridens*	Possible	Moderate	Medium	Control / Management measures to address possible risk of a decline in soil and groundwater quality due to operational inefficiencies of oily water separators: - Discharge of treated wastewater to be regulated under Part V of the Environmental Protection Act. - Adherence to the monitoring and reporting regime for the operation as regulated under the EP Act Part V approval.	Unlikely	Moderate	Low

Factors for the Original and Optimised Project– MNES of relevance to groundwater matters	Environmental Risk	Possible Risk Pathway	Potential Impact on MNES	Risk Rating			Control / Management Measures to reduce the likelihood of the risk (Mitigation measures that will be implemented to address the risk or uncertainty)	Residual Risk Rating following implementation of Control / Management		
				Likelihood	Conseq.	Risk Rating		Likelihood	Conseq.	Risk Rating
							- Contamination regulated under Part V of the Environmental Protection Act. and the Contaminated Sites Act if not remediated. - Ongoing daily monitoring of groundwater levels and quality. - Daily site inspections of water infrastructure and equipment. - Spill kits located at key areas. - All spills controlled, contained and cleaned up. - Hydrocarbons and chemicals stored within suitably bunded areas. - Spill kits regularly checked and replenished, if required. - All hydrocarbons and chemical spills recorded. - Continue with routine monitoring of exceedance/s of the threshold criterion. - Implement any additional measures to minimise/prevent unauthorised harm to Protected Matters. - Continue with routine monitoring of Protected Matters in accordance with EPBC 2018/8236 (as varied), EPBC 2022/9169 and MS 1211. - Outline management options to avoid future exceedances.			
Threatened migratory sea and shorebirds	Change to groundwater regime and quality	Seepage from ponds and/or crystallisers A spill or leak of brine from the ponds/crystalliser or pipelines	Increased groundwater levels and/or changes to the quality of the existing groundwater may have an indirect impact on migratory shorebirds as a result of: - Loss of BCH (i.e. BCH unable to tolerate the change and BCH die) - Loss of BCH contribution to the nutrient cycle (i.e. decline in the health of the BCH resulting in a reduction of their contribution to the nutrient cycle) - Loss of BCH resulting in a reduction to the foraging habitat for migratory shorebirds	Possible	High	Medium	Control / Management measures to address possible risk of seepage from ponds and/or crystalliser: - The design of the project has been amended to move the crystalliser ponds (which will be lined) further away from Mardie Pool (from ~250m to ~1km northwards) to prevent any potential indirect impact from seepage. - Updated modelling at the completion of filling Pond 1 – Pond 3, with real-time monitoring date to validate the potential risks impacts to groundwater levels and quality. - Ongoing daily monitoring of groundwater levels and quality (salinity) will be conducted so the model can be verified. - Weekly visual inspections of Pond condition and any leakage, and the follow up of evidence through internal investigations (noting these are not trigger or threshold exceedance events). - Weekly visual inspections and observations of adjacent habitat areas to the Evaporation Ponds such as Algal Mats (noting these are not trigger or threshold exceedance events). - Daily site inspections of water infrastructure – pumps, roads, flow equipment. - Control pumps for sea water controlled by the Digital Control Centre via telemetry. - Weekly pond testing of brine density as a control of evaporation versus losses. - Operational pond modelling to calculate steady state brine densities and pond depths with weekly review frequencies. - Ongoing BCHMMP monitoring and if required, implementation of the reactive monitoring as outline in Section 3.1.3.3. of the BCHMMP. - Ongoing monitoring and if required, implementation of reactive monitoring as outlined in Section 2.2.6 of the MSMMP. - Continue with routine monitoring of exceedance/s of the threshold criterion. - Implement any additional measures to minimise/prevent unauthorised harm to Protected Matters. - Continue with routine monitoring of Protected Matters in accordance with EPBC 2018/8236 (as varied), EPBC 2022/9169 and MS 1211.	Unlikely	Moderate	Low

Factors for the Original and Optimised Project– MNES of relevance to groundwater matters	Environmental Risk	Possible Risk Pathway	Potential Impact on MNES	Risk Rating			Control / Management Measures to reduce the likelihood of the risk (Mitigation measures that will be implemented to address the risk or uncertainty)	Residual Risk Rating following implementation of Control / Management		
				Likelihood	Conseq.	Risk Rating		Likelihood	Conseq.	Risk Rating
							- Outline management options to avoid future exceedances. Control / Management measures to address possible risk of spill or leak of brine from ponds and/or crystalliser or pipelines: - Pipelines will utilise industry-standard materials to minimise the chance of leaks, and mitigation will be implemented to reduce this risk further. - Ponds have been designed with adequate freeboard and overflow features to minimise the risk of unplanned overflows and wall breaches. - Ongoing daily monitoring of groundwater levels and quality (salinity) will be conducted so the model can be verified. - Weekly visual inspections of Pond condition and any leakage, and the follow up of evidence through internal investigations (noting these are not trigger or threshold exceedance events). - Weekly visual inspections and observations of adjacent habitat areas to the Evaporation Ponds such as Algal Mats (noting these are not trigger or threshold exceedance events). - Daily site inspections of water infrastructure – pumps, roads, flow equipment. - Control pumps for sweater controlled by the Digital Control Centre via telemetry. - Ongoing pumping and water management infrastructure maintenance programs. - Weekly pond testing of brine density as a control of evaporation versus losses. - Operational pond modelling to calculate steady state brine densities and pond depths with weekly review frequencies. - Continue with routine monitoring of exceedance/s of the threshold criterion. - Implement any additional measures to minimise/prevent unauthorised harm to Protected Matters. - Continue with routine monitoring of Protected Matters in accordance with EPBC 2018/8236 (as varied), EPBC 2022/9169 and MS 1211. - Outline management options to avoid future exceedances. - Ongoing monitoring and if required, implementation of reactive monitoring as outlined in Section 2.2.6 of the MSMMP. - Continue with routine monitoring of exceedance/s of the threshold criterion.			
Threatened migratory sea and shorebirds	Change to groundwater levels and quality	Release of concentrated water/brine into the environment as a potential remediation response to an exceedance of trigger thresholds Note: If Mardie Minerals were to take this action, the concentrated water/brine would only be released into the Marine Environment and will not be disposed of to the terrestrial environment. Therefore, Mardie Minerals have not considered the potential risk against the	Increased groundwater levels and/or changes to the quality of the existing groundwater may have an indirect impact on the health of BCH resulting in: - Loss of BCH (i.e. BCH unable to tolerate the change and BCH die) - Loss of BCH contribution to the nutrient cycle (i.e. decline in the health of the BCH resulting in a reduction of their contribution to the nutrient cycle) - Loss of BCH resulting in a reduction to the foraging habitat for migratory shorebirds	Possible	High	Medium	Control / Management measures to address possible risk of releasing concentrated water/brine into the environment as a potential remediation response to an exceedance of trigger thresholds: - Bespoke risk assessment and review of potential impact to MNES in consultation with the regulators, prior to the release of any concentrated water/brine. - Shut off water flows into pond/s if leaks are detected, or adjust the brine flows between ponds (using pumps, gates and weirs). - Increase the appropriate freeboard of the pond and adjust pond operating level. - Install cut-off bores, sumps and/or trenches and pump the water to the appropriate salinity pond. - Rectify breaches in pond walls to be structurally stable, fix containment systems and leaks in internal drainage structures.	Unlikely	Moderate	Low

Factors for the Original and Optimised Project– MNES of relevance to groundwater matters	Environmental Risk	Possible Risk Pathway	Potential Impact on MNES	Risk Rating			Control / Management Measures to reduce the likelihood of the risk (Mitigation measures that will be implemented to address the risk or uncertainty)	Residual Risk Rating following implementation of Control / Management		
				Likelihood	Conseq.	Risk Rating		Likelihood	Conseq.	Risk Rating
		terrestrial MNES of relevance to groundwater matters in this table.					- Review the steady-state average brine density for each pond, and modify the 'Brine Movement Plan'. - Dilute the brine or slow down the evaporation process by pumping additional sea water (i.e. shandying) from the primary or secondary sea water intake system. - Continue with routine monitoring of exceedance/s of the threshold criterion. - Implement any additional measures to minimise/prevent unauthorised harm to Protected Matters. - Continue with routine monitoring of Protected Matters in accordance with EPBC 2018/8236 (as varied), EPBC 2022/9169 and MS 1211. - Outline management options to avoid future exceedances. - Ongoing BCHMMP monitoring and if required, implementation of the reactive monitoring as outline in Section 3.1.3.3. of the BCHMMP. - Ongoing monitoring and if required, implementation of reactive monitoring as outlined in Section 2.2.6 of the MSMMP.			

5.5 Environmental Management Measures

The leakage of water from Ponds and pressure on groundwater system has the potential to impact protected matters within the development area and adjacent areas. Modelling was undertaken under these scenarios to develop an understanding of the scale of potential impacts to then inform the development of indicators and relevant trigger and threshold criteria for the implementation of investigation and management actions.

Whilst there is a residual risk of changes to groundwater regimes in the very near vicinity to the ponds (within 100 m) and hence potential impacts to BCH, the management actions associated with this plan including daily trigger threshold monitoring, the monitoring of pond wall integrity, mitigation measures such as reversal of pond filling and the BCHMMP management actions are considered appropriate to reduce the likelihood of unauthorised impacts to protected matters.

Where potential impacts on protected matters are detected through monitoring, management and mitigation measures such as the installation of cut-off bores, sumps and/or water diversion trenches to pump the water to the appropriate salinity pond may be implemented. Constructing drains or collection ditches around the evaporation ponds will also help to capture seepage and direct it back to the ponds, reducing losses and avoiding/minimising potential impacts to protected matters. Dewatering spears will be used to reduce groundwater inflows and prevent habitat disruption, and to maintain stable water levels to avoid/reduce the impact on BCH.

To the extent any deviation between the onsite measurements and the modelling predictions is observed, an adaptive management approach has been incorporated into the revised GMMP to ensure the Groundwater Objective is achieved, outlined in greater detail in Section 10. Further to this, as detailed in the Approval conditions, there are subsequent remediation requirements that need to be implemented as part of threshold exceedance investigations, and these are described in Section 3.4.3.

Mardie Minerals are committed to ensure that the Project will be implemented in a manner that ensures the ecological integrity and function of the intertidal habitats that support the presence of EPBC Act Listed Threatened and Migratory Species are maintained. This is evidenced by the additional $372,000 (beyond what has been conditioned) that has been committed to research of Green Sawfish and Migratory birds, as per the recently submitted Research Offsets Proposal.

Table 5-6 Key Assumptions and Uncertainties and Status of Strategies to Address

Item	Assumption/ Uncertainty	Strategy to address uncertainty	Timing	Status of Strategies to Address
1	The hydrogeological model lacks certainty on groundwater conditions in the deeper substrates, particularly to the west of the project.	Installed shallow and deep boreholes in coastal zones to measure vertical salinity distributions in mangrove stands, algal mats and samphire communities to determine water quality and the existence (or not) of fresh groundwater flows. Hydraulic testing programme to determine in-situ permeability of gravelly clay layers and potential for transportation of hypersaline seepage from the ponds to BCH and Mardie Pool.	Terrestrial bores were installed in March 2022. Some coastal bores were installed in February 2022 and additional new coastal bores were installed adjacent to Ponds 1-5 in July 2023, and the coastal monitoring network for Ponds 1-8 was completed in July 2024. A series of pumping tests was completed in Q4 2022 to inform the regional groundwater impacts modelling.	There is a total of 56 coastal bores from Pond 1 through to Pond 8 that have now been installed from August 2023 through to August 2024 in addition to the existing gas pipeline bore which were installed and commissioned between July 2021 and April 2023. The Coastal Monitoring bores have been installed as nested shallow and deep pairs to assist with characterisation of the groundwater regime beneath the supratidal flats and to permit detection of changes in levels and gradients (vertical and horizontal), and groundwater changes which may be attributed to surface flow variations at the western boundary of the Project. Deep bores have been installed generally between 7 and 10 metres below ground level. Groundwater modelling completed in 2024 has included data from across the installed Coastal Bore monitoring network on the western edge of the Project. Section 5 of the GMMP and Appendix C describe how the hydrogeological model has been updated with this additional data to characterise the groundwater conditions and model. AQ2 has completed impact modelling as provided in Appendix C of this GMMP.
2	Changes to groundwater levels and quality can be detected and responded to effectively before an ecological impact occurs.	Acquire and utilise long-standing groundwater data from multiple sites to appropriately characterise the groundwater system in and around the development envelope.	The inland monitoring bore network around Mardie Pool and Crystallisers has been in place since April 2022 to acquire historical baseline groundwater level and quality data.	As at August 2024, 74 bores have been installed for the purpose of monitoring groundwater associated with the Mardie project, bringing the total number of bores at the Mardie site to over 100.

Item	Assumption/ Uncertainty	Strategy to address uncertainty	Timing	Status of Strategies to Address
		Augment the existing groundwater bore network by designing and implementing a groundwater bore monitoring network that is capable of measuring and identifying changes in groundwater levels and quality (EC) at all ponds. Develop a groundwater monitoring methodology capable of detecting changes in groundwater levels and EC prior to the commencement of filling of ponds Develop trigger and threshold-based management protocols to ensure there is an appropriate response to any detected changes in groundwater	Coastal monitoring bores installed adjacent to Ponds 1-5 in July 2023 and up to Pond 8 in October 2023 continue to acquire baseline groundwater water level and salinity data in the intertidal zone. Historical bore/VWP data has been identified and incorporated to the coastal network, providing baseline groundwater levels and improving understanding of the system since July 2021 for Ponds 1-5. As monitoring methodology evolves to detect and measure potential changes to groundwater level and EC that may result from the operation of the Project, we have continued to build/augment groundwater bore monitoring network to ensure that measurements are spatially appropriate and can identify changes at time-scales appropriate for the highly variable (tidally influenced) groundwater environment Finalise monitoring methodology, including development of triggers and thresholds prior to filling of ponds Updated/approved management plan to outline management protocols to be undertaken should triggers/thresholds be breached.	74 monitoring bores (the 56 coastal and 18 terrestrial monitoring bores) are telemetered to deliver hourly data on groundwater level and EC We now have more than 1 years' worth of data for several of these bores. A detailed monitoring methodology to determine short- and long-term changes in groundwater level and to set triggers and thresholds using data from the filling of ponds 1-3 has been updated and is provided in Appendix D. This GMMP has been updated to describe protocols to be undertaken should triggers/thresholds be breached (Section 7.4 and Appendix F).
3	The level of reliance on 'fresh' groundwater by the various benthic primary producer communities at Mardie, including mangroves, samphire wetlands and algal mats over various timeframes requires quantifying.	Ensure the groundwater investigation and monitoring network provides sufficient information to characterise the groundwater regime (flow and quality) in the vicinity of coastal and inland groundwater receptors. Quantify natural groundwater quality/level variation within the dynamic coastal tidal	The coastal monitoring network consisting of 56 bores was completed in the period August 2023 to July 2024 adjacent to Ponds 1-8. The inland monitoring network of 18 bores was completed in April 2022. Baseline groundwater monitoring is in place across inland areas (from April 2022) and Ponds 1-5 (from July 2021 in historical bores) with full monitoring	The groundwater modelling report provided in the GMMP (as Appendix C) describes the physical characteristics of the benthic communities on the western edge of the Project. These areas are dominated by significant tidal fluctuations and tidal inundation of up to 4-6 hours in every 12 hour tidal cycle.

Item	Assumption/ Uncertainty	Strategy to address uncertainty	Timing	Status of Strategies to Address
		system and the inland system to determine appropriate trigger and threshold values.	coverage across all sites from August 2024 upon commissioning of final bores.	Groundwater level and quality data from coastal monitoring bores is regularly reviewed to detect changes to the groundwater regime. To date there has been no evidence of 'fresh' groundwater in the vicinity of the evaporation ponds or benthic primary producer communities to the west. No reliance on 'fresh' groundwater is believed to occur in the coastal habitat. Regional studies being undertaken by WAMSI at several sites along the Pilbara coast have reported similarly high salinities in surface sediments within these communities. Coastal sites will continue to be monitored for evidence of freshwater ingress.
4	The ecological water requirements of Mardie Pool are not known with certainty.	Ensure the groundwater and surface water monitoring network provides sufficient information to characterise the groundwater/surface water regime (flow and quality) for Mardie Pool and surrounds. Use the monitoring network to investigate the existing groundwater quality and flow regime in the context of the various vegetation species surrounding Mardie Pool. Employ remote sensing methods (geophysical survey) to identify the location of the saline water interface and its interaction with Mardie Pool where bore coverage is limited.	Groundwater and surface water data collected since April 2022 has been used to inform seepage modelling in the vicinity of Mardie Pool and the crystallisers (completed May 2024) Compilation of baseline data will continue until filling of the adjacent crystallisers. Operational data will be regularly assessed against groundwater modelling. Model will be recalibrated as necessary.	The ecological importance of Mardie Pool was assessed as part of the Mardie Project EIS process and EPBC 2018/8236 (as varied) describes the required monitoring of surface and groundwater flows to the Mardie Pool to protected relevant MNES. Whilst the Pool was found to be an important terrestrial fauna feature, it is heavily impacted by Mesquite encroachments and cattle access. Groundwater and surface water monitoring in the vicinity of the Pool shows that the water level and water quality is likely to be significantly affected by periods of surface flow where the pool fills and overflows and periods of drought where the water level falls and becomes more saline through evaporation. During extended dry periods the surface level falls below groundwater levels and hence is supplemented by groundwater.

Item	Assumption/ Uncertainty	Strategy to address uncertainty	Timing	Status of Strategies to Address
				Ongoing monitoring in the vicinity of the Pool is a requirement of Project Approval Conditions. Mardie Pool transect impact modelling was completed in January 2025 (AQ2). The GMMP has established monitoring and trigger/threshold mechanisms to detect any potential leakage to groundwater. Ongoing monitoring and investigations will inform subsequent iterations of the GMMP and supporting recalibration of the groundwater model following commencement of operations.
5	The extent, severity and impact on vegetation of potential groundwater mounding from the ponds is not able to be predicted with reliability, owing to the scale of the Project.	Ensure the monitoring and investigations described in (2) include transects perpendicular to the ponds.	Several transects of monitoring bores have been installed perpendicular to the ponds and Mardie Creek (parallel to groundwater gradient) to inform sectional groundwater modelling. Baseline groundwater monitoring is in place across inland areas (from April 2022) and Ponds 1 to 5 (from July 2021 in historical bores). The coastal monitoring network consisting of 56 bores was completed in the period August 2023 to July 2024 adjacent to Ponds 1-8. Updated modelling of the Pond 1, Pond 6, Pond 8 and Mardie Pool transects was completed in May 2024	Groundwater impact modelling has recently been completed along with updates to the conceptual groundwater model based on groundwater data collected into 2024. The impact pathway associated with a loss of product water to groundwater resources is described in Section 5 of the GMMP. Noting the conceptual hydrological model (refer Section 3.9 and Section 3.10) and the outcomes of the regional modelling (refer Section 5.3), significant changes to groundwater levels and quality beyond the immediate vicinity of the evaporation ponds and crystalliser are not expected.
6	Brine losses to the environment as seepage and leaks will diminish over time, due to geological and biological processes reducing infiltration rates through the clay floors and walls.	Additional investigations would be required for ponds where seepage losses have become an issue. This may include measurement of algal mat density inside ponds. Impacts of any seepage can be mitigated through seepage recovery mechanisms	The modelling incorporates a 6 month period of leakage from ponds. Monitoring of seepage will occur over this period, and where required, additional investigations (e.g. measurement of algal mat development) will occur prior to 6 month period. If any observed seepage has potential to impacts	The ongoing monitoring of pond and groundwater levels and quality throughout the coastal monitoring bore network will determine leakage rates against the model outputs. Actions to address seepage (and therefore groundwater triggers/thresholds that result from this) are

Item	Assumption/ Uncertainty	Strategy to address uncertainty	Timing	Status of Strategies to Address
			adjacent benthic communities/habitat, seepage recovery will be initiated.	outlined in the Groundwater Monitoring Procedure (Appendix F)
7	Influence of Sino Iron Project dewatering	Groundwater modelling will assess the impact of dewatering at Sino Iron on water levels and flow at Mardie Project. The potential for impacts on receptors like Mardie pool, Mt Salt Mound Spring and others will be assessed to determine necessary mitigation measures or monitoring locations.	Previous modelling by Strategen (2017) indicates the potential groundwater drawdown beneath the proposed crystallisers due to dewatering at Sino Iron Mine would be between 0 to 0.3 metres (after 60 years). However, it is also indicated that this drawdown is not likely to have a significant impact on the groundwater regime near the Mardie Project crystallisers and Mardie Pool Regional impacts modelling, to assess the impacts of the Mardie project is in progress and due for completion during Q4 2024.	Regional impacts modelling is in progress and due for completion in Q4 2024. The regional modelling incorporates relevant background water level and quality data collected from the current monitoring network and incorporates learnings from the ongoing monitoring data review.

6. GROUNDWATER MONITORING FRAMEWORK AND RATIONALE

6.1 Rationale for Monitoring Framework

Because of the size of the project and its proximity to the coast, groundwater characteristics vary widely across the development envelope. As outlined in Section 3, salinities across the site range from near fresh (approx. 1000 EC units) on the eastern edge of the project to hypersaline (up to 220,000 EC) in the coastal sabkha and reducing again to sea water salinities (50,000 EC) along the western edge of the project area. Groundwater depth and stability are similarly variable, being quite stable and relatively deep (4-8m) on the eastern edge of the project, becoming shallower (at or very near the ground surface in some instances) and increasingly variable in depth across multiple timescales due to tidal influence as you move westward towards the coast.

Because of this large variability in groundwater and the similarly diverse range of biota (incorporating terrestrial, intertidal and marine flora and fauna) that are present at the site, it is not appropriate (or indeed possible) to apply a singularly effective method for determining biological tolerance based management triggers and thresholds across the whole project footprint. Instead, the approach taken in this GMMP is one where hourly telemetered monitoring of groundwater across the site is assessed daily to identify changes (exceedances) to groundwater level and/or salinity. Where threshold changes to either groundwater level or salinity are detected, an investigation is undertaken to determine if any Matters of National Environmental Significance (MNES) or their habitats (ranging from mangroves and samphire to algal mats to *Triodia*) are likely to be impacted by that exceedance, and if so, to determine and implement appropriate management actions that must be undertaken to avoid, mitigate or (in the worst case scenario) offset those impacts.

To determine whether there have been changes to groundwater level and/or salinity, a ‘coastal’ network of 56 groundwater bores has been established to enable characterisation and monitoring of the highly saline and variable coastal groundwater environment, and a ‘terrestrial’ bore network of 18 bores provides the same for the more stable, less saline inland portion of the project around the crystallisers.

These two bore networks combine with 66 additional bores from within the pipeline corridor serve as the basis for the modelling, monitoring and management of groundwater that underpins this GMMP.

Primary factors: groundwater level and electrical conductivity

Groundwater related impact risks resulting from evaporative salt production (i.e. by evaporating sea water in ponds above groundwater that is naturally highly concentrated already) are intrinsically lower than for many other large developments because of their natural alignment with flooding and evaporation processes already occurring at the site. This is particularly true for the lower ponds on the Mardie project, where any seepage is likely to have a diluting effect on groundwater that is naturally 3-4 times the salinity of sea water.

Risk (or at least likelihood of impacts) is further reduced by consideration of the regional modelling undertaken for this project, which shows that the most significant impacts to groundwater are associated with pond filling, so are temporally short (months), and relatively localised (within approximately 100m of the pond walls), so the management of these issues to avoid or mitigate impacts can be relatively simple (e.g. through seepage recovery).

Regardless, and as described in Section 5.2, the key impact pathways from groundwater quality at the Mardie Pool is the potential leakage of highly saline water for the crystallisers down into the groundwater table. The overriding potential impact sources will be:

- salinity, both directly, through the creation of osmotic stress in vegetation/cyanobacteria, and indirectly, through the limitation of macronutrient availability for some vegetation (Ahmed et al 2022); and
- groundwater level (insomuch as it can result in increased exposure of native vegetation, in particular, to saline water.

Electrical Conductivity (EC) as a measure of salinity and groundwater level were therefore assessed as the most appropriate ongoing groundwater indicators for identifying potential impacts.

Whilst other quality indicators such as nutrients and metals were monitored during the EIS process, they were not considered suitable for use as indicators for triggers and thresholds due to their very low concentrations and the strength of EC as a reliable indicator of change with respect to groundwater quality. Mardie Minerals commit to providing further justification of this through more direct comparison against the ANZECC (2000) Marine Water Quality Guidelines in the revision of this GMMP to be provided after filling of pond 3.

Where there is a surface incident involving the potential leakage of contaminants, additional water quality parameters would be included in a targeted monitoring program for that event. During normal operations, there is not expected to be any additional contaminants associated with the production of salt that would represent a significant impact pathway to groundwater. This approach is consistent with the EPA Decision Reporting for the Original and Optimised Projects (Section 2.1.4 and 2.1.6 respectively of the EPA Decision reports).

Outcome-based Provisions

EPA Factors: Inland Waters and Benthic Communities and Habitats.

EPA Objectives:

- To maintain the hydrological regimes and quality of groundwater and surface water so that environmental values are protected.
- To protect benthic communities and habitats so that biological diversity and ecological integrity are maintained.

EPBC Approval Objectives

- Protection of EPBC matters and habitats associated with the Mardie Pool, terrestrial, intertidal and subtidal areas

Outcome of Pond filling and operations

- No changes to the health, extent or diversity of intertidal benthic communities and habitat, including mangrove, coastal samphire and algal mat, as a result of changes to groundwater regimes or groundwater quality associated with the proposal.
- No adverse impact to water level or water quality in Mardie Pool as a result of changes to groundwater regimes or groundwater quality

Key Environmental Values: benthic communities and habitats, significant fauna and their habitats.

Key impacts and risks: changes to hydrological regimes or water quality.

Table 6-1 Outcome-based Provisions and Monitoring – Outcome 1 (BCH)

Outcome 1 **No changes to the health, extent or diversity of intertidal benthic communities and habitat, including mangrove, coastal samphire and algal mat as a result of changes to groundwater regimes or groundwater quality associated with the proposal****					
Indicators:	**Response actions:**	**Monitoring Indicators, Methods, and Locations**	**Monitoring Timing and Frequency**	**Reporting**	**Applicable Approvals**

Trigger and threshold criterion – Groundwater level and Salinity
Coastal groundwater level
A prediction exceedance is defined as a groundwater level value falling outside the 95% prediction interval (as determined by the seven day ahead ARIMA model) for any given day.
A percentile exceedance is defined as a groundwater level value above or below the pre-pond filling 99th percentile or 1st percentile value, respectively, without at least two reference bores being outside their equivalent values.
Triggers are defined as at least 5 prediction exceedances in the previous 7 days or at least 5 percentile exceedances in the previous 7 days.
Thresholds are defined as at least 10 prediction exceedances in the previous 14 days or at least 10 percentile exceedances in the previous 14 days.
 	
Coastal salinity
A prediction exceedance is defined as an actual electrical conductivity value falling outside the 95% prediction interval for the seven day ahead ARIMA model and the difference between that day's EC value and the average of its reference bores' values on that day being at least 2,500 units greater than the median daily difference over the past 28 days.
A percentile exceedance is defined as an electrical conductivity value above the pre-pond filling 99% percentile value plus 10% and at least two reference bores are not above their equivalent value or below the 1st percentile minus 10% and at least two reference bores are not below their equivalent value.
Triggers are defined as at least 5 prediction exceedances in the previous 7 days or at least 5 percentile exceedances in the previous 7 days.
Thresholds are defined as at least 10 prediction exceedances in the previous 14 days or at least 10 percentile exceedances in the previous 14 days.
	Response actions as per the Groundwater Monitoring Procedure (Appendix F).
	
	Trigger criterion actions
	• Exceedance reporting (as per Section 8 of this Plan)
	• Increased data download frequency to daily to support investigation of trends.
	• Review of available groundwater level data from all available monitoring bores to determine the temporal and spatial trends.
	• Investigation undertaken and completed to determine cause of trigger criterion within 1 month of detection.
	• Investigation into BCH health as per the BCHMMP adaptive management framework.
	• Review of operational control effectiveness – Pond wall integrity, evidence of leakage, operating levels for example.
	
	Threshold criterion actions
	Phase 1
	• Investigation undertaken to determine cause of threshold exceedance within 1 month of detection.
	• Investigation into BCH health as per the BCHMMP adaptive management framework.
	• Review of operational control effectiveness – Pond wall integrity, evidence of leakage, operating levels for example.
	• Implement relevant management actions under the BCHMMP.
	• Suspension of any ongoing pond filling/transfer activities.
	Phase 2
	• Exceedance reporting (as per Section 3.4.2 of this Plan)
	• Depending on the outcomes of initial investigations, operational control mitigation and management measures will be proposed that are specific and measurable to rectify any loss of product from operating ponds.
	• Examples are provided below that would be considered noting that each exceedance will be considered individually, and also in the context of the overall system performance.
	  ○ Installation and/or operation of seepage recovery mechanisms and/or other interception method (e.g. trenches, water diversion drains) down-gradient from the impact site(s) to recover brine seepage).
	  ○ The recovered groundwater would be pumped to an appropriate disposal location (likely to be the adjacent evaporation pond) and surface water diversion drains may be used as transfer channels for such water.
	  ○ dewatering spears will be used to control groundwater inflows during pond conditioning and operations, to reduce or divert groundwater inflows to help prevent habitat disruption and to maintain stable water levels to reduce the potential impact on BCH.
	• Additional monitoring bores may also be installed between the between the affected bores and the relevant sensitive receptor to assist in confirming the effectiveness of the seepage recovery. Ongoing review of EC and groundwater level data from adjacent bores to determine the effectiveness of seepage recovery methods.
	Phase 3
	• If response measures are not found to be effective in reducing/reversing the impact, commence controlled emptying of the pond(s) adjacent to the impact site(s).
	• Progressive options may include: transfer of brine into adjacent ponds to reduce level/accelerate evaporation; in-pond dilution and slow release of brine to the environment at background EC concentration levels.
		Indicator
		• Groundwater level change outside of environmental variation.
		Method for data collection and analysis
		• Continuous water level monitoring in all impact/reference/coastal monitoring bores – download via telemetry / manual.
		• Daily analysis
		
		Location of impact / reference monitoring bores
		• Coastal and Pipeline Monitoring Bores
			Daily Monitoring	As per Section 8.	MS 1211
					EPBC 2018/8236 (as varied)
					EPBC2022/9169

Table 6-2 Outcome-based Provisions and Monitoring – Outcome 2 (Mardie Pool & Mt Salt Mound)

Outcome 2: No adverse impact to water levels or water quality in Mardie Pool or Mt Salt Mound Spring because of changes to groundwater regimes or groundwater quality					
No. Indicators:	**Response actions:**	**Monitoring Indicators, Methods, and Locations**	**Monitoring Timing and Frequency**	**Reporting**	**Applicable Approvals**
Trigger and threshold criterion – Groundwater level and Salinity For Mardie groundwater level: • A percentile exceedance is defined as a value above or below the pre-crystalliser filling 99th percentile or 1st percentile value, respectively. • Triggers are defined as at least 5 percentile exceedances in the previous 7 days. • Thresholds are defined as at least 10 percentile exceedances in the previous 14 days. For Mardie groundwater salinity, • A percentile exceedance is defined as an electrical conductivity value above the pre-crystalliser filling 99th percentile value (telemetered data) plus 10%. • Triggers are defined as at least 5 percentile exceedances in the previous 7 days. • Thresholds are defined as at least 10 percentile exceedances in the previous 14 days.	**Response actions as per the Groundwater Monitoring Procedure (Appendix F).** **Trigger criterion exceedance action** - Implement monthly monitoring frequency for water quality at the bore and immediately adjacent bores (where these exist). - Investigation undertaken to determine cause of impact within 1 month of detection. Research undertaken to determine means of mitigating cause of impact if deemed to be attributed to the Proposal. - Review of operational control effectiveness – Pond wall integrity, evidence of leakage, operating levels (for example). **Threshold criterion exceedance action** - Develop and implement Management Response Plan and mitigation actions within 1 month of threshold exceedance. - Depending on the outcomes of initial investigations, operational control mitigation and management measures will be proposed that are specific and measurable to rectify any loss of product from operating ponds. - Examples are provided below that would be considered noting that each exceedance will be considered individually, and also in the context of the overall system performance. ○ Installation and/or operation of seepage recovery mechanisms and/or other interception method (e.g. trenches, use of surface water diversion drains). ○ The recovered groundwater would be pumped to an appropriate disposal location (likely to be the nearest evaporation pond) and surface water diversion drains may be used as transfer channels for such water. ○ dewatering spears will be used to control groundwater inflows during pond conditioning and operations, to reduce or divert groundwater inflows to help prevent habitat disruption near Mardie Pool or Mt Salt Mound Spring.	**Indicator** - Electrical conductivity (EC) Method for data collection and analysis - Water sample from upper 2m of the water column. - EC telemetry data **Location of monitoring sites** - Terrestrial monitoring bores - Additional monitoring bore sites to be located and installed for Mt Salt Mound Spring (pending modelling results)	- Monthly groundwater quality sampling. - Monthly monitoring of EC profiles to be implemented within 1 month of trigger criterion being identified, to end of the quarter.	As per Section 8.	MS 1211 EPBC 2018/8236 (as varied) EPBC 2022/9169

6.2 Monitoring of Coastal bores

BCI engaged Data Analytics Australia (DAA) to design a statistically sound method for determining operational triggers and thresholds to determine whether groundwater levels and salinities change over time, and whether any changes were attributable to the operations of the Mardie Project.

A groundwater monitoring methodology and a salinity monitoring methodology were incorporated into Rev M of the GMMP that ultimately provided approval to commence filling of evaporation Ponds 1 to 3. This methodology (henceforth the 'Pond 1-3 methodology') has been operational since filling commenced on 10 September 2024 and has resulted in the reporting of numerous triggers and threshold exceedances (see Section 2.3).

A number of improvements or refinements of the Pond 1-3 methodology have been identified and applied during the initial pond filling, including through recommendations of the independent review by Pink Lake Analytics (Appendix G). Additional refinements, including the recalibration of reference bores, were proposed as part of the original Pond 1-3 methodology. DAA has made these refinements and updated its methodology, as outlined in DAA (2025) (Appendix D). The proposed changes are summarised in the various sub-sections below. It is intended that, subject to regulators' approval, the updated methodology outlined in DAA (2025) is followed for the filling of Ponds 4 to 9 and the crystallisers.

6.2.1 Real-time (or short-term) Monitoring

Groundwater level monitoring

Groundwater level has been chosen as an indicator because a change in groundwater level from baseline and/or seasonal values may indicate that:

- groundwater movements (particularly with regard to tidal movement in coastal areas) may have changed as a result of hydrostatic pressure beneath the brine in the ponds and this may have a localised effect on groundwater levels, and/or
- seepage or leaks from evaporation ponds may directly cause localised changes to groundwater level.

The development of a monitoring framework to detect short-term (daily) changes in groundwater levels due to pond filling was informed by data that showed several clear patterns of temporal groundwater variation linked to local tides. Because of this variation, any impact of pond filling will lead to different groundwater rises at different times in the tidal cycle for different bores. This means that a traditional Before-After Control-Impact (BACI) design and analysis with simple threshold and trigger values will not be appropriate.

Instead a modified BACI (m-BACI) approach based on daily data was designed to detect short-term changes in groundwater. This approach uses a daily automated data download process via a bespoke online tool developed by DAA that automatically updates data charts for each monitored bore and delivers daily push notifications and tracking of triggers and thresholds.

The m-BACI approach requires that multiple (typically three) reference (control) bores with similar groundwater behaviour are chosen (or 'matched') for each impact bore. This helps to minmise doubt as to whether it is the reference bore or the impact bore that has changed. For the initial periods of monitoring (10th September 2024 – current and until the use of long-term reference bores are approved), bores located at Ponds 7 and 8 were used as interim reference bores for detecting change at Ponds 1, 3, and 5. Matches were obtained by a process known as Dynamic Time Warping (DTW) – see Appendix D for more details.

For initial monitoring of Ponds 1 to 3, a statistical time-series model (ARIMA) was fitted to data for the impact bore and its reference bores to predict what is expected to happen at the impact bore for the current day and seven days ahead. A trigger was deemed to have occurred if observed data were outside the 95% prediction interval. A threshold was deemed to have occurred if there were triggers for seven consecutive days or longer. The triggers and thresholds were based on both one day ahead predictions and one week ahead predictions (that is, two sets of triggers and thresholds are concurrently tested and tracked, to detect two types of short-term/real time change, increasing the degree of conservativeness in the overall monitoring framework).

The initial monitoring criteria was set to be conservative with the intention of re-assessing following the filling of Ponds 1 to 3.

Based on the data collected from the filling of Ponds 1-3, the following observations regarding groundwater trigger and threshold monitoring were made (noting these are all discussed in detail in Section 5.2 [page 30] of the DAA report which is contained in Appendix D):

- Triggers from the one-day ahead model, which was design to detect rapid changes in groundwater level over a 24 hour period, were much less sensitive to changes detected in the 7 day ahead model and proved to not be useful in determining any additional potential impacts on flora/fauna that were not detected by the 7 day ahead model. As a result of this observation, daily reporting against the one-day ahead model is proposed to be dropped for the next stage of monitoring.
- A review of filling of Pond 1 revealed the current criteria for setting a trigger did not pick up a step change in groundwater for some impact bores. The ARIMA models for these bores adapted faster to the step change than expected as the reference bores were comparatively poor matches and had less influence on the models' predictions. As such, the model was able to adjust to the changing impact bore before a threshold could be reached. As a result of this observation, and to ensure that these changes in groundwater level are detected in future, the primary change proposed for monitoring during the filing of ponds 4-9 is that a separate (additional) percentile exceedance is recorded if the daily value for an impact bore is outside a specified historical range based on data collected from that bore prior to pond filling, and at least two reference bores are not outside their equivalent ranges. This is based on the assumption that the range of groundwater levels observed in our pre-pond filling environment are acceptable to flora/fauna in the area.
- The definitions for triggers and thresholds were causing a large number of triggers unnecessarily as a result of changes to groundwater levels well within the pre-operational range of groundwater levels. This issue was anticipated by the independent reviewer and the Commonwealth regulator prior to the analysis of results from filling of ponds 1-3. As a result of this observation, it is proposed that the old 'trigger' definition be redefined as "exceedances", with the new definitions for groundwater exceedances, triggers and thresholds being:

  These new definitions align with the recommendations of the independent reviewer of the monitoring methodology, and are considered to be more parsimonious in the sense that they should reduce the number of unnecessary threshold exceedance reports going to regulators, but remain significantly more conservative that might otherwise be achieved through the monthly requirement outlined in our Commonwealth conditions of approval (Condition 41 of EPBC 2018/8236 (as varied) and EPBC 2022/9169).

Salinity monitoring – short term

EC (salinity) in groundwater has been chosen as an indicator because a change from baseline and/or seasonal values may indicate:

- groundwater movements (particularly with regard to tidal movement in coastal areas) may have changed as a result of hydrostatic pressure beneath the brine in the ponds and this may have a localised effect on salinities in the area, and/or
- seepage or leaks from evaporation ponds may directly cause localised changes to salinity.

The monitoring framework to detect short-term (daily) changes in salinity is similar to groundwater level with only minor variations to the methodology due to the relative smoothness (lack of short-term variation) of the data and the lack of any obvious sign of tidal influence compared to groundwater level.

As for groundwater level, the initial monitoring criteria was set to be conservative with the intention of re-assessing following the filling of Ponds 1 to 3.

Specifically, triggers were defined as an actual EC value falling outside the 95% prediction interval on a single day and the difference between that day's EC value and the average of its reference bores' values on that day being at least 2,500 units greater than the median daily difference over the past 28 days. Thresholds were defined as seven consecutive days of triggers. The additional salinity threshold of 2,500 units was chosen for these coastal bores as an additional requirement to be met because:

a) any salinity change of that magnitude is very unlikely to confer any environmental impact as the water in all impact and reference bores is in the hypersaline range (160,000 to 220,000 EC), and

b) it filters out some of the 'false positives' that might otherwise be achieved through this modelling approach because the salinity levels in these hypersaline environments is very consistent, thus 95% prediction intervals are very 'tight' around average salinities.

Triggers and thresholds were defined in the same way as groundwater level data (but calculated separately) for the day ahead and seven day ahead prediction models. A trigger or threshold was deemed to have occurred if it occurred for either the one day ahead or seven day ahead model (or both).

As with groundwater level, and despite the addition of the 2,500 EC threshold, the review of salinity data collected from the filling of ponds 1-3 demonstrated that the definitions for triggers and thresholds proved to not be useful in determining any additional potential impacts on flora/fauna that were not detected by the 7 day ahead model. This is also discussed in detail in Section 5.2 [page 30] of the DAA report which is contained in Appendix D). As a result of this observation, it is proposed that the old 'trigger' definition be redefined as "exceedances", with the new definitions for groundwater exceedances, triggers and thresholds being:

- A <u>prediction exceedance</u> is defined as an actual electrical conductivity value falling outside the 95% prediction interval for the seven day ahead ARIMA model and the difference between that day's EC value and the average of its reference bores' values on that day being at least 2,500 units greater than the median daily difference over the past 28 days.
- A <u>percentile exceedance</u> is defined as an electrical conductivity value above the pre-pond filling 99% percentile value plus 10% and at least two reference bores are not above their equivalent value or below the 1st percentile minus 10% and at least two reference bores are not below their equivalent value.
- <u>Triggers</u> are defined as at least 5 prediction exceedances in the previous 7 days or at least 5 percentile exceedances in the previous 7 days.
- <u>Thresholds</u> are defined as at least 10 prediction exceedances in the previous 14 days or at least 10 percentile exceedances in the previous 14 days.

6.2.2 Long-term Change Monitoring

Monitoring to detect long-term changes will be undertaken during the next phase of pond filling via an additional, complementary statistical model that incorporates monthly data. This model, which is described in detail in Section 10 (page 72) of the DAA report (Appendix D) follows a more traditional before-after-control-impact (BACI) approach to detect changes in mean groundwater levels or electrical conductivity and follows Pardini (2018). It is enabled by development of a method for estimating the influence of tides on groundwater and removing them to create tidally corrected data.

Tidal correction reduces the need for rigorous matching of impact and reference bores – theoretically, after tidal correction any reference bore within the same proximity could be used.

As this component of modelling is to detect long-term effects, it will be implemented on a monthly basis, commencing with a ramp-up period to thoroughly trial the processes and identify any issues early on and as they arise. Whilst initially anticipated that this ramp-up period would commence after one year, it is now being proposed that it commences soon after the next phase of pond filling commences.

6.2.3 Changes to Reference Bores

As outlined in the previous GMMP (Rev N), there is an ongoing need to review impact and reference bores for monitoring across the life of the project to ensure 'best fit' data is used to inform all exceedances, and updated modelling outcomes can be applied to ensure that control or reference bores are likely to remain unaffected. It has therefore been appropriate to review the bores used as reference bores for filling of Ponds 1 to 3 (Table 6-3 and Table 6-4) and to assign appropriate pairings for future pond filling prior to commencement of filling of Ponds 4 to 9.

A larger pool of potential control or reference bores has been made available since filling of Ponds 1-3. Three additional reference bores (RBN02S, RBN02D and RBS01_2 - see Figure 25) were installed on 11 May 2024 with the intention they be used for ongoing monitoring of Ponds 4 to 9. Additionally, four bores (CMB1_3S, CMB1_3D, CMB4_3S and CMB4_3D - see Figure 25) nominally designated as impact bores in Rev M of the GMMP now lay outside the affected area identified in AQ2's most recent modelling using Pond 1-3 filling data (Appendix C) and are therefore not expected be impacted. These have been assessed for reclassification as long-term reference bores, with the aim of ensuring suitable bores are available to use as references for long-term monitoring.

As outlined in detail in Section 6 (page 33) of the DAA report (Appendix D), due diligence statistical analysis was completed on the long-term reference bores assessing data quality as well as comparisons with the short-term reference matches used for the initial pond filling. The assessment indicated that using a combination of RBN02S, RBN02D, RBS01_2, CMB1_3S, CMB1_3D, CMB4_3S, and CMB4_3D provides sufficient and suitable matches for the impact bores for all remaining ponds comparable to the interim reference bores.

There was also the need to identify reference bores for the impact bores in Ponds 4 to 9 (Table 6-5). In general, it was possible to find similar quality matches as had been found for the bores in Ponds 1 to 3. It is therefore proposed that bores CMB1_3S, CMB1_3D, CMB4_3S, and CMB4_3D are all transitioned to long-term reference bores for the monitoring after filling of ponds 4 to 9 commences.

Notwithstanding the updated bore matching was appropriate for future monitoring, DAA also recommend that additional long-term bores be installed with a focus around the Pond 9 area (and also note that the monitoring can proceed without these additional bores – they will merely provide backup references if necessary). Mardie Minerals is committed to installing these additional bores and will have them in place before Pond 9 is filled with production brine. Locations for additional bores have been selected, and consultants have been engaged to commence installation of those bores on 12 March 2025.

In line with the existing monitoring bores on the Mardie Project, once installed these additional bores will be fitted with telemetry instrumentation to measure groundwater level and electrical conductivity (EC) hourly. The data will be sent to a data platform that can be accessed and queried in real time by BCI staff and consultants in Perth.

Table 6-3 Impact and Reference Bore Locations for filling of Pond 1 to Pond 3

Location of Bores	Impact Bore ID	Easting (GDA2020, MGA50)	Northing (GDA2020, MGA50)	Reference Bore ID	Easting (GDA2020, MGA50)	Northing (GDA2020, MGA50)
Pond 1 (Relevant for Ponds 1 and 2)	CMB6_1D	378175	7647383	CMB5_2D	387975	7665603
				CMB4_2D	386098	7662765
				CMD5_1D	388060	7665541

Location of Bores	Impact Bore ID	Easting (GDA2020, MGA50)	Northing (GDA2020, MGA50)	Reference Bore ID	Easting (GDA2020, MGA50)	Northing (GDA2020, MGA50)
	CMB6_1S	378176	7647381	CMB5_1S	388057	7665544
				CMD5_2S	387976	7665601
				CMB4_2S	386095	7662768
	S01-A	382051	7650222	CMB5_2S	387976	7665601
				CMB4_1S	386276	7662681
				CMB5_1D	388060	7665541
	S02-A	382404	7650023	CMB5_2S	387976	7665601
				CMB4_1S	386276	7662681
				CMB4_2S	386095	7662768
Pond 3 (Relevant for Ponds 3 and 4)	CMB1_1D	383372	7652041	CMB4_1D	386279	7662680
				CMB5_1D	388060	7665541
				CMB5_2D	387975	7665603
	CMB1_1S	383371	7652040	CMB5_2S	387976	7665601
				CMB4_1S	386276	7662681
				CMB4_2S	386095	7662768
	CMB1_2D	383128	7652269	CMB4_1D	386279	7662680
				CMB5_1S	388057	7665544
				CMB5_2S	387976	7665601
	CMB1_2S	383129	7652266	CMB5_2S	387976	7665601
				CMB4_1S	386276	7662681
				CMB4_2S	386095	7662768
	CMB1_3D	382980	7652508	CMB5_1D	388060	7665541
				CMB5_2D	387975	7665603

Location of Bores	Impact Bore ID	Easting (GDA2020, MGA50)	Northing (GDA2020, MGA50)	Reference Bore ID	Easting (GDA2020, MGA50)	Northing (GDA2020, MGA50)
				CMB4_1D	386279	7662680
	CMB1_3S	382978	7652508	CMB4_1S	386276	7662681
				CMB5_2S	387976	7665601
				CMB4_2S	386095	7662768
	N01-A	382834	7651093	CMB5_2S	387976	7665601
				CMB4_1S	386276	7662681
				CMB5_1D	388060	7665541
	N02-A	382774	7651011	CMB5_2S	387976	7665601
				CMB4_1S	386276	7662681
				CMB5_1D	388060	7665541

Table 6-4 Impact and Reference Bore Locations for filling of Pond 4 to Pond 9 (GW = groundwater and EC = Electrical Conductivity/Salinity)

Bore ID	Pond	Impact/Reference	Latitude	Longitude	Gemotion State Date (GW)	Monitel Start Date (GW and EC)
CMB6_1S	1	Impact	-21.27120	115.82574	17/08/2023	21/03/2024
CMB6_1D	1	Impact	-21.27120	115.82574	17/08/2023	21/03/2024
SO1_A[a]	1	Impact	-21.24586	115.86329	11/08/2023	21/03/2024
SO2_A[a]	1	Impact	-21.24766	115.86665	11/08/2023	21/03/2024
NO1_A[a]	3	Impact	-21.23802	115.87088	12/08/2023	01/05/2024
NO2_A[a]	3	Impact	-21.23879	115.87038	12/08/2023	21/03/2024
CMB1_1S	3	Impact	-21.22948	115.87617	16/08/2023	20/03/2024
CMB1_1D	3	Impact	-21.22948	115.87617	16/08/2023	20/03/2024
CMB1_2S	3	Impact	-21.22739	115.87382	16/08/2023	04/05/2024
CMB1_2D	3	Impact	-21.22739	115.87382	16/08/2023	20/03/2024
CMB1_3S[b]	3		-21.22525	115.87244	17/08/2023	20/03/2024

Bore ID	Pond	Impact/Reference	Latitude	Longitude	Gemotion State Date (GW)	Monitel Start Date (GW and EC)
CMB1_3D[b]		Initially Impact. Reclassified to Long-term Reference for Pond 4 to Pond 9 filling				
CMB07_S[C]	3 & 4	Impact	-21.23286	115.88713		11/05/2024
CMB07_D[C]	3 & 4	Impact	-21.23286	115.88713		11/05/2024
CMB08_S[C]	3 & 4	Impact	-21.24275	115.89867		10/05/2024
CMB08_D[C]	3 & 4	Impact	-21.24275	115.89867		10/05/2024
CMB2_1D	5	Impact	-21.20313	115.89142	16/08/2023	20/03/2024
CMB12_1S	5	Impact	-21.20313	115.89142	16/08/2023	20/03/2024
CMB12_1D	5	Impact	-21.18864	115.89965		11/05/2024
CMB12_2S	5	Impact	-21.18864	115.89965		11/05/2024
CMB12_2D	5	Impact	-21.18833	115.89897		11/05/2024
CMB09_S[C]	5 & 6	Impact	-21.18557	115.91063		10/05/2024
CMB09_D[C]	5 & 6	Impact	-21.18557	115.91063		10/05/2024
CMB10_S[C]	5 & 6	Impact	-21.19071	115.92210		10/05/2024
CMB10_D[C]	5 & 6	Impact	-21.19071	115.92210		10/05/2024
CMB13_1S	6	Impact	-21.17616	115.90661		03/07/2024
CMB13_1D	6	Impact	-21.17616	115.90661		03/07/2024
CMB13_2S	6	Impact	-21.17586	115.90593		03/07/2024
CMB13_2D	6	Impact	-21.17586	115.90593		03/07/2024
CMB14_1S	6	Impact	-21.15833	115.90587		06/06/2024
CMB14_1D	6	Impact	-21.15833	115.90587		06/06/2024
CMB14_2S	6	Impact	-21.15818	115.90518		03/07/2024
CMB14_2D	6	Impact	-21.15818	115.90518		03/07/2024
CMB4_1S	7	Impact	-21.13353	115.90487	21/10/2023	20/03/2024
CMB4_1D	7	Impact	-21.13353	115.90487	08/11/2023	20/03/2024

Bore ID	Pond	Impact/Reference	Latitude	Longitude	Gemotion State Date (GW)	Monitel Start Date (GW and EC)
CMB4_2S	7	Impact	-21.13276	115.90313	21/10/2023	20/03/2024
CMB4_2D	7	Impact	-21.13276	115.90313	08/11/2023	20/03/2024
CMB4_3S[b]	7	Reference	-21.13215	115.90157	21/20/2023	20/03/2024
CMB4_3D[b]	7	Reference	-21.13215	115.90157		20/03/2024
CMB5_1S	8	Impact	-21.10782	115.92223	24/10/2023	06/05/2024
CMB5_1D	8	Impact	-21.10782	115.92223	27/10/2023	06/05/2024
CMB5_2S	8	Impact	-21.10732	115.92142	24/10/2023	05/05/2024
CMB5_2D	8	Impact	-21.10732	115.92142	24/10/2023	05/05/2024
CMB5_3S	8	Impact	-21.10684	115.92083	06/11/2023	05/05/2024
CMB5_3D	8	Impact	-21.10684	115.92083	20/03/2024	20/03/2024 (GW) 05/05/2024 (EC)
CMB15_1S	8	Impact	-21.11830	115.91441		20/08/2024
CMB15_1D	8	Impact	-21.11830	115.91441		20/08/2024
CMB15_2S	8	Impact	-21.11792	115.91365		20/08/2024
CMB15_2D	8	Impact	-21.11792	115.91365		20/08/2024
CMB16_1D	9	Impact	-21.09394	115.95248		10/05/2024
CMB16_2D	9	Impact	-21.09305	115.95261		06/06/2024
RBN02S	-	Reference	-21.08334	115.93144	24/04/2024	11/05/2024
RBN02D	-	Reference	-21.08334	115.93144	24/04/2024	11/05/2024
RBS01_2	-	Reference	-21.30593	115.82364		11/05/2024

[a] Not installed for bespoke Purposes of Mardie Project

[b] Installed as Impact bore, however modelling by AQ2 indicates suitability as reference bore given distance over 500m from pond wall. Can simultaneously continue to be monitored for two years in case any impacts are detected.

[c] Located inland between ponds rather than the coastal edge of ponds resulting in different tidal patterns.

6.2.4 Lessons learnt and further refinement

A range of other minor monitoring issues arose during the filling of ponds 1-3 and these were addressed through further refinement of the procedure and methodology. These include:

- Tidal inundation and recharge are large drivers of the fluctuations of groundwater, with different bores being affected differently. While the bore matching process and daily monitoring is sufficient (albeit with some refinements being proposed), further work into incorporating these effects into the statistical models will provide even more targeted identification of trigger and threshold events. In the current term, more trigger and threshold events will be identified as a result of *not* incorporating these model improvements, so the current regime retains a somewhat conservative approach to identifying material or 'real' changes resulting from project impacts.
- Addition of true 'ground levels' to monitoring graphs produced by the bespoke data platform to assist in interpretation has been implemented.
- While a review of Pond 1-3 filling demonstrates the updated monitoring criteria is sufficient in highlighting observed changes in groundwater level and salinity, the criteria will continue to be reviewed and may be refined as the monitoring progresses with changes only made to add confidence in picking up real changes or reducing false positives while still picking up real changes. An example of a refinement to the ARIMA model which can be considered during the next stages of pond filling may consider building of ground level into the modelling process. Incorporating the statistical properties of the ground level in the vicinity of the bore into the short-term and long-term monitoring models should improve model fit and reduce the currently experienced (albeit small number of) counter intuitive predictions from the ARIMA model which show groundwater levels (which are determined by pressure sensors inside the bore casings) as being significantly higher than ground level. Note that this analysis has currently only been implemented at the feasibility stage and further refinement is required prior to implementation.
- The initial model for triggers requires a daily value for the impact bore and each of the three reference bores. During November, one of the reference bores had missing and erroneous Electrical Conductivity data spanning over a number of days which were identified as sensor errors. A procedure has been automated to allow the model to continue and provide a preliminary trigger when missing data is identified to provide timely notifications along with a notification of the missing data. If only one reference bore is affected, the model is set to run using the other two reference bores for the days affected. Similarly, if erroneous data is identified for a reference bore, the data is reviewed over the following days to identify the period affected and the models updated to only include the other two reference bores. Note that this may result in a preliminary non-trigger being updated to a trigger (or vice-versa) as the data is updated. This procedure aims to reduce the length of this uncertainty period as much as possible.
- Likewise, it is possible there will be missing data for an impact bore. If that is the case, this methodology will take the conservative approach and treat that missing day as an exceedance, possibly leading to a trigger or threshold. Again, this may result in a non-trigger being updated to a trigger if data is removed, or a trigger being updated to a non-trigger if data is added.
- Initially, some bores provided estimated groundwater based on an estimated height of the bore. Following a survey of these bores to determine their heights, groundwater was necessarily adjusted. While this affected graphical outputs, it had no effect on the monitoring as the change was constant across the bore. If any bores require surveying in the future, it will not affect the monitoring methodology.
- Salinity stratification in the bore suggests salinity can vary based on the depth of the sensor. As the sensor is fixed, a rise in groundwater can cause more saline groundwater from below to be brought up and cause a rise in salinity. Since the groundwater and salinity monitoring methodologies are performed independently, this should have no effect on the veracity of the models, though it may provide a future avenue for improved modelling using this relationship.
- When a new bore is installed, there is a sensor ramp-up period observed which suggests that salinity may take some time before a change can be "fully observed". This is believed to be a result of the

groundwater adjusting to the bore and should not impact any already installed bores. However, it should be kept in mind for any future bore installations that there may be an adjustment period.

- Initial groundwater data collected was not compensating for the increased density of the hypersaline brine. Since the water level is calculated rather than measured, it has been possible for this prior data to be correctly (or as correctly as possible) compensated historically, and therefore provide a more accurate measure of groundwater levels. In general, this will reduce the variability of bore readings, with the greatest reduction in variability happening at the most saline bores, and little or no change happening at the more freshwater bores. We are continuing to use the uncompensated data for continuity, with the corrected data to be considered for use if more appropriate for the ongoing monitoring. Note that for the purposes of our modelling, the use of density-corrected or uncorrected data should not matter. A change in the variability of readings will be handled automatically by the model so long as the change is constant across each bore.

6.2.5 Response to Independent Peer Review

In November 2024, Data Analysis Australia received an independent review of its statistical methodology, undertaken by Pink Lake Analytics (Appendix G). A summary is provided here:

- to reduce confusion, the nomenclature has been improved and clarity of definitions regarding trigger and threshold criteria has been updated. For example, DAA has replaced the nomenclature of 'confidence interval' with 'prediction interval' throughout when referring to the ARIMA modelling component of the short-term monitoring. This reflects the true statistical process being applied.
- more detail regarding the statistical models used in the ARIMA predictions has been provided for the short-term monitoring methodology.
- DAA agree with the comments made by the independent reviewer regarding the principles for choosing reference bores and have continued to abide by these principles throughout, within the practical constraints. This includes consideration in the decisions made when changing the interim reference bores to the long-term bores (a necessary step highlighted prior to commencement of Pond 1 filling) and transitioning bores CMB1_3S and CMB1_3D to be considered long-term reference bores prior to filling Pond 4.
- the short-term model and forecasts are now run daily via an automated system, rather than following a semi-manual weekly process.
- A number of suggestions were made regarding the long-term methodology review and refinement which will be considered by DAA as part of its long-term methodology refinement. Of particular note, the independent reviewers identified that there will be a need for experimentation to determine the best model structures and parameters, including statistical interactions, to include in the final model (as per standard statistical practice).

With the additional months data now available, DAA is also refining and reviewing the choice of control bores for each reference bore to take into account the explicit incorporation of tidal factors to ensure the matches are appropriate prior to monitoring.

As outlined in the updated Monitoring methodology reports from DAA (see Appendix D, page 17); since running the models on a daily basis from 1 July 2024, only 3 one-day ahead triggers have been set across all bores combined. This improvement from early model runs is likely due to model stabilisation but could also be natural variation from month to month.

While the overall statistical principle in the GMMP is based upon the BACI concept, it is much more complex than a textbook BACI. This is because of the spatial and temporal variability in groundwater across the site, the ever-increasing availability of data from bores in all locations, the changing patterns and periodicity in the data over time that are both attributable to and not attributable to the impacts of pond filling, and the changing role of individual bores as a result of the progressive filling of the ponds. This has meant, for example, that some bores that were ideal as reference bores in the initial stages of filling are better suited as impact bores at later stages of pond filling.

To best manage this dynamic data set, it is appropriate to regularly review, using pre-determined data driven methods, how the data from each bore can be best used to determine if any of the changes we see in the highly variable groundwater data across the site are attributable to the project. We do this by:

- Collecting and analysing a very large amount of data (daily analysis of hourly salinity and groundwater level data collected from 74 telemetered bores across the site). It should be noted that whilst our Commonwealth conditions only require us to monitor groundwater monthly (as per Condition 41 in EPBC 2018/8236 and EPBC 2022/9169), we undertake hourly monitoring to ensure we appropriately represent the significant variability in the data)
- Regularly reviewing the choice of impact/reference bore matchings and using the best available bores/data at any point in time. We recognise that reference bores should not be changed without good reason since continuity of data is valued, however we also recognise that statistical power (the ability to accurately and precisely detect change in groundwater data that are attributable to the proposal) is the most important driver for groundwater monitoring. To this end, we have developed and applied a methodology (see Section 6.1 in Appendix D) for reference bore identification that removes subjectivity in bore choice. Further, we have committed to doing this for each revision of the GMMP, in accordance with Condition 68 and Condition 70 of the EPBCs 2018/8236 and EPBC 2022/9169 approvals.
- Installing further bores to maximise the range of options available for 'best fit' bore matching (e.g. to account for the spatial and temporal variability in the patterns of tidal influence on groundwater) and to ensure there is redundancy in the current bore network should these patterns change over time or as more data becomes available. This is evidenced by our commitment to install additional bores around Pond 9 in response to the recommendations of DAA coming out of their most recent review (refer to Section 6.2.3; Table 4-3 and Figure 25 of this GMMP (Rev O) which reflects the location of the additional bores that will be installed).
- Using the available data to understand sources of variation not the result of the proposal (e.g. tides), and where appropriate, implement a methodology that accounts for this variability with a view to maximising the statistical power of our analyses.
- In applying the above protocols to the data collected to date, and through the subsequent calculation of the statistical power of our analyses that determine daily if there have been impacts to groundwater as a result of the pond filling (see sections 7.2 and 7.3 in Appendix D), we have clearly and transparently demonstrated that the current monitoring system can and does detect changes in groundwater level and salinity that are the result of pond filling. This is further evidenced by our reporting and investigation of 17 threshold events to both regulators during the filling of ponds 1 to 3 (noting that these 'threshold' events are aligned with the predictions from the hydrological modelling that groundwater levels near the pond walls will increase during the initial filling of the ponds). None of the threshold exceedances investigated by BCI Minerals have resulted in impact to protected matters as a result of the threshold exceedances. Given the threshold exceedance have been found to have been caused by natural processes, no corrective measures will be undertaken at this time.

6.3 Monitoring at Mardie Pool

As discussed in Section 3.11.3, in addition to its important heritage values, Mardie Pool is a seasonal freshwater source (i.e. gaining system) that has the potential to benefit Pilbara Leaf-nosed Bat and Pilbara Oliver Python during some parts of the year. During the periods when Mardie Pool is hyper saline (i.e. losing system), these species must source freshwater from an alternative location. In recognition of these values, Mardie Pool has been excluded from the project's Development Envelope (DE) to ensure there are no direct impacts from the proposal.

Until October 2024, manual water quality readings were being taken from Mardie Pool itself and from October 2024, the water level readings frequency has changed to monthly. Installation of permanent bores in Mardie Pool is not possible due to Traditional Owner concerns regarding disturbance to a sacred site, which is also gender restricted (i.e. women only). The monitoring data collected to date is provided in Appendix H.

Because of its exclusion from the DE, the key impact pathway to water quality at Mardie Pool is through potential leakage of highly saline water from the upstream crystallisers into the groundwater table. To help mitigate this potential impact, a 1 km exclusion zone around Mardie pool has been established, and no ponds or crystallisers will encroach on that exclusion zone. Further, the evaporation ponds and crystallisers will be conditioned with sea water to facilitate the formation of a low permeability algal mat and ultimately a halite crust in the crystallisers, which will severely restrict any possible leakage from the crystallisers to Mardie Pool (see Section 2.3.1).

In addition to these avoidance measures, and to ensure that any movement of groundwater between the crystallisers and Mardie Pool can be detected prior to impacting Mardie Pool, Mardie Minerals have installed a network of 18 ‘terrestrial’ monitoring bores (refer to Figure 22) which will serve as an early warning system. Groundwater level and salinity (EC) have been monitored manually at the terrestrial bore network since 2022; Quarterly EC monitoring has occurred over a 2-year period in April 2022, July 2022, November 2022, April 2023, September 2023, December 2023 and March 2024. More recently, all of the Mardie Pool groundwater monitoring bores have been telemetered (refer to Table 4-1) and now provide hourly water level and conductivity data.

These ‘terrestrial’ bores will have triggers and thresholds for salinity and groundwater level (see below), similar to the coastal bore network. Also similarly to the coastal bore network, any exceedance of groundwater level or salinity thresholds will trigger an investigation into potential environmental impacts of the exceedance in line with our Groundwater Monitoring Procedure (Section 7.1), and any management actions or responses that are required to avoid, mitigation or (worst case) offset impacts. Mardie Minerals is committed to ensuring that Mardie Pool remains unaffected by operations throughout the life of the project.

6.3.1 Triggers and thresholds for terrestrial bores

Groundwater level and salinity data in the terrestrial bore network has very different characteristics to the coastal network bore data. Unlike the coastal bores, which are affected by tidal cycles, the terrestrial bores demonstrate very constant values, much like a typical inland groundwater bore network. Accordingly, establishment of groundwater triggers and thresholds in the terrestrial bores is a simpler process because it does not require bore matching with bores that are similarly affected by tidal cycles in order to determine differences. It is appropriate, however, to build on the lesson’s learned through the filling of ponds 1-3, and to apply the same principles used for establishing coastal bore triggers and thresholds to the terrestrial network:

For groundwater level, the following definitions for exceedances, triggers and thresholds are proposed:

- A <u>percentile exceedance</u> is defined as a value above or below the pre-crystalliser filling 99th percentile or 1st percentile value, respectively.
- Triggers are defined as at least 5 percentile exceedances in the previous 7 days.
- Thresholds are defined as at least 10 percentile exceedances in the previous 14 days.

For groundwater salinity, the following definitions for exceedances, triggers and thresholds are proposed:

- A percentile exceedance is defined as an electrical conductivity value above the pre-crystalliser filling 99th percentile value (telemetered data) plus 10%.
- Triggers are defined as at least 5 percentile exceedances in the previous 7 days.

- Thresholds are defined as at least 10 percentile exceedances in the previous 14 days.

Proposed exceedance values for the Mardie Pool bores are presented in Table 6-5.

As was observed during the filling of ponds 1-3, these triggers and thresholds will be conservative and precautionary, potentially generating unnecessary investigations. However, Mardie Minerals considers this precautionary approach is appropriate during the initial filling phase, and adjustments can be made in later updates to the monitoring methodology if necessary.

6.4 Mt Salt Mound Spring

It has been suggested the source of Mt Salt Spring be determined through water sample analysis. Personnel have visited Mt Salt Spring on several occasions, the most recent being July 2024, but no there water has been present. Anecdotal evidence suggests that the mound spring has not flowed for some time.

Mt Salt Mound Spring is within the coastal hypersaline plume of the tidal flats and also in a direction perpendicular to the dominant groundwater gradient so any seepage from the crystallisers is unlikely to have effect in that direction.

Whilst no criteria have been developed in relation to Mt Salt Spring, Mardie Minerals will continue to regularly visit Mt Salt Spring to check for artesian flow.

Table 6-5 Percentile Exceedance Values for Mardie Pool monitoring bores

Location	Bore ID	Purpose	EC lower 99th percentile	EC upper 99th percentile	Depth to Groundwater lower 99th percentile	Depth to Groundwater upper 99th percentile
Primary Crystalliser – Adjacent	MP06	First line of early detection of seepage from Primary Crystalliser	1095	1513	-7.63	-7.35
Mardie Pool – North Side Outside Channel	MP02	Second line of detection of seepage from Secondary Crystalliser	2312	2417	-5.71	-5.51
	MP03		2210	2854	-6.18	-6.01
	MP04		2295	2396	-6.08	-5.83
	MP05		2455	2525	-6.85	-6.70
Primary Crystalliser – Up Gradient	MP07	Background monitoring up-gradient from Primary Crystalliser	1397	1667	-8.30	-7.72
Secondary/ KTMS Crystallisers – Down Gradient	MP08	Down-gradient monitoring of Secondary Crystalliser	95049	106787	-3.19	-2.96
	MP09	Down-gradient monitoring of KTMS	93844	98418	-4.10	-3.86
	MP10		110957	116743	-3.19	-2.81
Primary Crystalliser – Up Gradient	MP11	Background monitoring up-gradient from Primary Crystalliser	717	1170	-8.66	-8.33
	MP12		1074	1154	-7.37	-7.26
	MP20		3195	3277	-5.53	-5.33

Location	Bore ID	Purpose	EC lower 99th percentile	EC upper 99th percentile	Depth to Groundwater lower 99th percentile	Depth to Groundwater upper 99th percentile
Primary Crystalliser – Adjacent	MP14	First line of early detection of seepage from Primary Crystalliser	1832	2000	-6.53	-6.31
	MP15		1230	1651	-6.66	-6.45
	MP16		1507	1666	-6.80	-6.59
Mardie Creek - Upstream	MP17	Upstream channel monitoring for base flow, adjacent to crystalliser	2508	2614	-5.88	-5.70
	MP18	Upstream channel monitoring for base flow	2962	3591	-7.12	-6.62
	MP19		2140	2867	-6.19	-6.05

7. MONITORING AND MANAGEMENT PROTOCOLS

7.1 Procedures and protocols

Mardie Minerals have developed and been implementing the Groundwater Monitoring Procedure [BCI-ENV-PRO-0005] (Appendix F) during the filling of Ponds 1, 2 and 3. The Groundwater Monitoring Procedure details the following:

- roles and responsibilities for the collection of the monitoring data;
- collection of the monitoring data for regular monitoring and ad-hoc monitoring events;
- definition and management of trigger and threshold events;
- investigation and management measures to be adopted in the event of a threshold exceedance; and
- training and competency for all BCI employees and contractors in relation to the GMMP.

Once groundwater levels or salinity have breached threshold criteria in either the coastal or terrestrial bore monitoring networks, an investigation is undertaken to determine if any Matters of National Environmental Significance (MNES) or their habitats (ranging from mangroves and samphire to algal mats to *Triodia* grassland habitat) are likely to be impacted by that exceedance, and if so, to determine and implement appropriate management actions that must be undertaken to avoid, mitigate or (in the worst case scenario) offset, those impacts.

Investigations are undertaken in accordance with the Groundwater Management Response Plan Framework detailed in Section 7.3.1.

7.2 Groundwater Monitoring Schedule

Monitoring commenced in early 2022 across the terrestrial monitoring bore network and will continue as per Table 7-1. Coastal monitoring bores have all been fitted with depth loggers, set to record water level up to hourly. These remote loggers are connected to telemetry systems for remote data download to enable real time checking / or downloaded.

The current schedule for groundwater monitoring is provided in Table 7-1.

Mardie Minerals commit to doing daily downloads of telemetered EC and groundwater level data and analysing them to determine if there have been trigger or threshold exceedances (as outlined in the DAA reports at Appendix D) each day of pond filling for ponds 1-3. The need for daily downloads will be reviewed following the filling of Pond 3.

Mardie Pool sampling is done manually, and does not have a groundwater bore installed (in consideration of cultural heritage concerns relating to the possible disturbance to a sacred site with gender restrictions (i.e. women only)). From the approval of this GMMP, this sampling will be undertaken manually on a monthly basis (subject to Traditional Owner permissions).

Table 7-1 Monitoring schedule

Purpose	Location	Parameter/s	Frequency Duration
Terrestrial Monitoring Bores			
Groundwater level	Table 5	Water level	Daily via telemetry
Groundwater quality		EC Bromide/pH	Daily via telemetry Monthly
Coastal Monitoring Bores			
Groundwater level monitoring	Tables 7 and 8	Water level	Daily via telemetry
Groundwater quality		EC	

Purpose	Location	Parameter/s	Frequency Duration
Ponds			
Structural integrity, leakage and soils associated with evaporation pond walls	All Ponds	Evidence of seepage or spill	Weekly via Site Environmental Management Plan
Minuria tridens			
Health assessment of the M. tridens populations located within the Development Envelope	All locations within the Development Envelope	Count of M. tridens populations with the following data recorded: • Plant height • Canopy width at widest point • Phenological status of plants (sterile, flowering, fruiting, seed) Presence of weed species Visual assessment of the health of each plant. Evidence of threatening processes (presence of weeds; predation by herbivores and changes to natural hydrology (e.g. inundation))	Annually

7.3 Association with other Management Plans

This GMMP provides monitoring and management actions related to possible groundwater seepage and/or mounding from pond filling and operations. Any exceedance of trigger and threshold values in the GMMP will trigger a range of actions (See section 3.3.2) which include the implementation of monitoring actions as presented in the approved BCHMMP and the MSMMP (refer Table 6-1 and Table 6-2). Similarly, investigations into trigger and threshold exceedances under the BCHMMP and MSMMP will include a review of monitoring data collected under the GMMP, and the implementation of additional monitoring if required.

The GMMP, MSMMP and BCHMMP interrelate to meet Condition 3-1(4) and Condition 3-1(6) of MS 1211, and Conditions 46 and 58 of EPBC 2018/8236 (as varied) and EPBC 2022/9169 approval. A review of the GMMP (Rev M) alongside the BCHMMP and MSMMP was completed and submitted to DWER (Ref: 0000-EV-LET-0023) on the 13 October 2024 as per Condition B3-2(2) of MS 1211. A future review of this GMMP (Rev O) alongside the BCHMMP and MSMMP will be completed and submitted to DWER by the 19 October 2025, as per Condition B3-2(1) of MS 1211.

The health of the *M. tridens* plants within the Development Envelope, and any potential impacts as a result of groundwater seepage and/or mounding will be monitored via the implementation of the annual health survey as detailed in the *M. tridens* Research and Offset Strategy.

Adaptive management of this plan is described further in Section 10.

7.3.1 Benthic Communities and Habitats (BCH)

The BCHMMP describes the monitoring and management measures to be implemented by Mardie Minerals to protect the health, diversity, and extent of BCH.

Monitoring will be undertaken quarterly at each site within the first two years, and then on an ongoing bi-annual (at the end of the dry and the wet seasons) frequency:

- Algal Mat Health – quarterly replicate transects
- Mangrove Health – quarterly replicate quadrats
- Samphire Health – quarterly replicate quadrats
- Subtidal seagrass Health – quarterly replica transects
- Tidal flood height / surface water height

If GMMP triggers are exceeded, monitoring for investigative purposes will also be undertaken as described in Section 3.1.3.3 of the BCHMMP (and as described under Step 4 of the Management Response Plan Framework, (Section 3.3.2).

7.4 Groundwater Management Response Framework (GMRF)

Mardie Minerals have a range of statutory requirements and other actions required of our approval conditions that will determine our response to any trigger or threshold exceedance of groundwater level or salinity. The Groundwater Management Response Plan Framework (GMRPF) outlined below is intended to be complementary to those requirements and will be initiated in the event that there is an exceedance of groundwater level or EC trigger (as outlined in the DAA methodologies in Appendix D).

It is acknowledged that the GMRPF is broad. This is considered appropriate for the Mardie Project given the highly spatial and temporal variability in the terrestrial (freshwater to brackish), intertidal (hypersaline) and marine (saline) environments across and near the Mardie Project site. This means the nature of any potential groundwater impacts will be similarly highly variable and the mitigations for these impacts will necessarily be bespoke.

The GMRPF includes a methodology to identify management responses and mitigation measures that may need to be tailored to a unique species and/or habitat (e.g. Mardie Pool). As discussed in Section 4.2 on page 6 of Appendix E (Justification of Triggers Thresholds and Tolerances for the protection of MNES Habitat) to the GMMP, it is necessary to ensure the water quality in Mardie Pool remains unaffected by the Project operations. As the key impact pathway for Mardie Pool is via potential leakage from the crystallisers, BCI has established a very high density of bores to determine if there is leakage from the crystallisers. It is appropriate that management measures are implemented rapidly following the detection of any changes to groundwater in these bores to ascertain if the change can be attributed to the Project – such management measures (as per Table 6-2) would be identified through monitoring at Mardie Pool (as discussed in Section 6.3) through the GMRF.

Trigger Exceedance

If there is an exceedance of a trigger values, the following process will be implemented. The investigation and responses will be dependent on the particulars of the trigger exceedance but as a minimum, Mardie Minerals will

- **Step 1: Define the exceedance:**
  - Location and date / measurement
  - Scale of exceedance
  - Relationship to previous exceedances triggers are defined as at least 5 prediction exceedances in the previous 7 days or at least 5 percentile exceedances in the previous 7 days (refer to page 4 of Appendix D to the GMMP)

- **Step 2: Identify the cause:**
    - Non-operational causes may include sampling/measurement errors, weather/climatic influences, natural variation, sensor or software malfunction;
    - Operational related causes may include seepage from ponds/crystallisers, leak from pipelines or overtopping of ponds.

Note: Operational related causes might be best assessed by reviewing the effectiveness of existing operational risk reduction controls (refer to Table 5-4).

If the cause of the trigger is attributable to the Proposal, Mardie Minerals will assess and implement an appropriate management and mitigation action. This could be something very minor (e.g. fixing a pipe) or more significant. Some potential responses are listed below, but note this is not an exhaustive list – it will very much depend on the nature and cause of the trigger exceedance:

- **Step 3: Determine and implement appropriate 'Trigger' response**
    - Make minor repairs, as appropriate
    - Shut off water flows into pond/s if leaks are detected, or adjust the brine flows between ponds (using pumps, gates and weirs)
    - Increase the appropriate freeboard of the pond and adjust pond operating level
    - Install cut-off bores, sumps and/or trenches and pump the water to the appropriate salinity pond
    - Rectify breaches in pond walls to be structurally stable, fix containment systems and leaks in internal drainage structures
    - Review the steady-state average brine density for each pond, and modify the 'Brine Movement Plan'
    - Dilute the brine or slow down the evaporation process by pumping in additional sea water from the primary or secondary sea water intake system.

Which of these (or potentially other) measures is implemented will depend on the nature and location of the mitigation that is required. Mardie Minerals acknowledge that some of these measures may, in and of themselves, introduce additional impacts to the environment, and so need to be carefully managed. Any plan developed to respond appropriately to a trigger exceedance that minimises environmental impacts will therefore need to be determined and risk assessed prior to implementation. Mardie Minerals commit to undertaking this bespoke assessment of the response within 5 days of the exceedance. This 5-day timeframe will not preclude the implementation of low-risk responses that could be implemented immediately to minimise environmental risk (e.g. repair of pond walls).

- **Step 4: Monitoring and reporting the 'Trigger' response**
    - Continue with routine monitoring of exceedance/s of the trigger/threshold criterion
    - Implement any additional measures to minimise/prevent unauthorised harm to Protected Matters
    - Continue with routine monitoring of Protected Matters in accordance with EPBC 2018/8236 (as varied), EPBC 2022/9169 and MS 1211 and/or update frequency of monitoring
    - Articulating the reporting requirements of this response
    - Outline management options to avoid future exceedances.

The nature and frequency of monitoring will be entirely dependent on Steps 1-3, but will likely involve additional monitoring to be undertaken as part of the BCHMMP and/or the MSMMP. Timeframes for monitoring the response will be bespoke depending on information from steps 1-3 above. Work undertaken during this step of the response will also identify a timeframe for evaluation of the monitoring to be undertaken.

Threshold Exceedance

Threshold exceedance occurs after at least 10 prediction exceedances in the previous 14 days or at least 10 percentile exceedances in the previous 14 days (refer to page 4 of Appendix D to the GMMP). The following steps will be undertaken if there is a threshold exceedance:

- **Step 5: Reassess the 'Trigger' response**
    - Evaluate the efficacy of the management and contingency measures already implemented
    - Evaluate the need for additional monitoring required to investigate potential other causes of the exceedance / impact
    - Conduct further technical investigations to be conducted and how to prevent the likelihood of continued exceedances without further management actions or intervention
- **Step 6: Identification and evaluation of additional measures**

It is not possible to reasonably determine what additional measures will be required. It will depend on the nature and location of the mitigation that is required, and the success (or otherwise) of measures implemented to date. Mardie Minerals acknowledge that some of these additional measures may, in and of themselves, introduce additional impacts to the environment, and so need to be carefully managed. Any plan developed to respond appropriately to a threshold exceedance that minimises environmental impacts will therefore need to be determined and risk assessed prior to implementation. Mardie Minerals commit to undertaking this bespoke assessment of the response within 10 days of the exceedance. As for the threshold response, this 10-day timeframe will not preclude the implementation of low-risk responses that could be implemented immediately to minimise environmental risk (e.g. repair of pond walls).

- **Step 7: Implementation, Monitoring and ongoing review of additional measures**

Additional measures identified during Step 6 will be implemented. All monitoring and reporting undertaken as a result of implementing Step 4 will be reviewed and changes implemented. A range of other actions may be undertaken depending on the nature and scale of the response, and in close collaboration with the regulators and in accordance with our statutory requirements and other requirements of our conditions of approval.

- **Step 8: Remediation Plans**

In line with both State and Commonwealth conditions of approval, Mardie Minerals will prepare remediation plans for consideration by the regulators within 6 months of breaching any threshold condition.

Review of process

The GMRPF outlined above will be trialled during the filling of ponds 1, 2 and 3, and will be reviewed and updated/refined in the subsequent update to this GMMP. Ongoing, this process and the validity of the conclusions reached by using this process will be independently reviewed after 12 months or after the first 10 exceedances occur, and then subsequently again with each scheduled review of the GMMP.

In addition to the implementation of the protective measures outlined in the GMRPF, after the first negative change to water quality in Mardie Pool is attributed to Project operations, an independent review of the GMRPF will be undertaken with a focus on identifying any changes needed to the GMRPF to avoid / minimise such impact from recurring, including identifying remediation of such impact.

Table 6-1 and Table 6-2 further set out the response framework in the context of triggers and thresholds, exceedances, monitoring and reporting.

7.5 Operational Monitoring Controls

Mardie Minerals will be undertaking a range of operational management practices that are relevant to achieving the objectives of the GMMP and in particular the management of the Brine product to prevent its loss of containment from the evaporation ponds and other structures. These monitoring activities will trigger review and actions if required, in accordance with the BCI Environmental Management System, the Operational Environmental Management Plan, the BCHMMP and this GMMP.

These measures include:

- Weekly visual inspections of Pond condition and any leakage, and the follow up of evidence through internal investigations (noting these are not trigger or threshold exceedance events)
- Weekly visual inspections and observations of adjacent habitat areas to the Evaporation Ponds such as Algal Mats (noting these are not trigger or threshold exceedance events)
- Daily site inspections of water infrastructure – pumps, roads, flow equipment.

Operational controls within the sea water pumping and storage system of relevance include:

- Pumps for sea water controlled by the Digital Control Centre via telemetry
- Ongoing pumping and water management infrastructure maintenance programs
- Weekly pond testing of brine density as a control of evaporation versus losses
- Operational pond modelling to calculate steady state brine densities and pond depths with weekly review frequencies.

7.6 Roles and Responsibilities

As outlined in its Environmental Policy, Mardie Minerals are committed to fully complying with applicable environmental laws and regulations and will strive to carry out all activities in a manner that minimises impacts to the environment. Further, Mardie Minerals commit to the sustainable management and efficient use of natural resources, and to the research, development, and management of the surrounding ecosystems.

The GMMP will be implemented within the overarching framework of the BCI Minerals Environmental and Social Management System Framework (June 2021) which includes the responses to incidents, complaints and emergencies, internal review and auditing and implementation of the Mardie Minerals environmental policy.

Mardie Minerals' key roles and responsibilities relevant to the implementation of the Plan are outlined in Table 7-2 and detailed in the Groundwater Management Procedure (Appendix F)**.**

Table 7-2 Key Roles and Responsibilities for GMMP Implementation

Role	Responsibility
Project Director	• Ensuring this Procedure is implemented for the Project and appropriately followed. • Supporting, reviewing and allocating time and resources to complete the activities required in this Procedure. • Reviewing and supporting corrective actions and improvements, ensuring that identified agreed initiatives, are prioritised and completed.
Manager Operations	• Ensure all personnel and Contractors involved in GMMP surveys and studies are appropriately experienced, qualified and supervised. • Implementing and maintaining this Procedure. • Supporting, reviewing and allocating time and resources to complete the activities required in this Procedure.

Role	Responsibility
	• Implementing components of this Procedure by ensuring all necessary responsibilities have been delegated for effective monitoring and management on site. • Supporting and reviewing corrective actions and improvements ensuring that where agreed initiatives are identified they are prioritised and completed. • Carrying out and supporting risk assessments undertaken for potential impacts when groundwater levels and/or salinity thresholds are exceeded.
Operations Superintendent	• Implementing and maintaining this Procedure. • Implementing components of this Procedure by ensuring all necessary responsibilities have been delegated for effective monitoring and management on site. • Deploying and monitoring pond level markers. • Carrying out and supporting risk assessments undertaken for potential impacts when groundwater levels and/or salinity thresholds are exceeded.
Construction Manager	• Implementing components of this Procedure by ensuring all necessary responsibilities have been delegated for effective monitoring and management on site.
Head of Environment & Heritage	• Implementing and maintaining this Procedure. • Liaising with regulatory authorities as required. • Supporting / reviewing / allocating time and resources to complete the activities required in this Procedure. • Supporting / reviewing corrective actions and improvements ensuring that, where agreed initiatives are identified, they are prioritised and completed. • Providing advice to relevant personnel regarding their responsibilities under this Procedure and the GMMP. • Ensuring all data is collected in accordance with Heritage obligations and protocols.
Manager Environmental Approvals & Compliance	• Implementing and maintaining this Procedure. • Liaising with regulatory authorities as required. • Ensuring monitoring and adaptive management actions are implemented in accordance with this Procedure. • Ensuring internal and external reporting requirements are undertaken in accordance with this Procedure. • Ensuring data collection for annual submission of the Ministerial Statement (MS) Compliance Assessment Report (CAR) and the annual *EBPC Act* compliance report. • Ensuring other reporting is undertaken in accordance with this Procedure (including the reporting/submission of documents and data (as required) under Conditions 5 to 9 of EPBC 2018/8236 and EPBC 2022/9169). • Ensuring all personnel involved in surveys and studies are appropriately experienced, qualified and supervised.
Specialist GIS	• Preparing and supporting spatial data to inform monitoring, investigations and audit activities. • Implementing and maintaining this Procedure.
Specialist Environment Compliance	• Leading investigations and audits associated with this Procedure.

Role	Responsibility
	• Reporting on, monitoring of and close-out corrective actions identified during monitoring, investigations and audits.
Site Environmental Advisor/s	• Ensuring that the day-to-day site requirements for environmental management are performed. • Ensuring that site environmental Policies and Procedures are in place for works. • Providing advice and support to the Construction Manager to enable risk control measures to be implemented in accordance with Company procedures. • Supporting Project activities to that conditions of approvals related to groundwater management are met. • Supporting Project activities so that all Company environmental requirements are met. • Supporting the implementation of GMMP monitoring programs and studies. • Maintaining monitoring records of ad-hoc monitoring or inspections. • Providing support for reporting and the provision of data to regulators as required under the GMMP. • Supporting and coordinating awareness training programs of personnel on the key requirements of this Procedure and the GMMP.
Health and Safety Personnel	• Providing support with and information for audits and inspections, including completing reviews, reports and corrective action development. • Completing formal site-based and/or health and safety system audits. • Ensuring the safety of employees is not compromised by implementing this Procedure.

8. REPORTING

8.1 Compliance Reporting

Monitoring data will be assessed against trigger and threshold criteria and reported in monthly, quarterly and an annual report to the company CEO and Board. If the trigger or threshold criteria (or both) are exceeded during the groundwater monitoring period, the annual report will include a description of the effectiveness of trigger criteria level actions, and threshold criteria contingency actions that have been implemented to manage the impact, as well as an analysis of trends.

A Compliance Assessment Report (CAR) will be submitted to the Compliance Branch at DWER annually. The CAR will document compliance with conditions of approval including assessment of compliance with management plan requirements where management plans form part of the approval conditions. The CAR will be prepared in accordance with the Post Assessment Guideline for Preparing a Compliance Assessment Report, Post Assessment Guideline No. 3 (OEPA, 2012).

A groundwater summary report will be prepared and submitted to DCCEEW and/or DWER (as required) each calendar year as per the EMP. The report will:

- Summarise groundwater level and quality, identifying any exceedance of trigger and threshold criteria.
- Provide details on contingency actions taken in the event of exceedance of trigger and threshold criteria exceedances.

8.2 Regulatory Reporting

Annual monitoring reports, as described above, will be provided to DCCEEW on an annual basis.

In accordance with Conditions of MS 1211, EPBC 2018/8236 (as varied) and EPBC 2022/9169, if monitoring or investigations at any time indicate an exceedance of threshold criteria specified in the GMMP, Mardie Minerals will undertake the following actions:

- Report the exceedance(s) to DCCEEW (in writing) within 7 days of the exceedance(s) being identified.
- Implement the threshold contingency actions required by the GMMP and continue to implement those actions until the CEO (and DCCEEW) has confirmed by notice in writing that it has been demonstrated that the threshold criteria are being met and implementation of the threshold contingency actions are no longer required.
- Within 21 days of being aware of the exceedance (MS 1211) Mardie Minerals will provide a report to the CEO (and DCCEEW), including the following:
- Details of contingency actions implemented.
- Implemented threshold contingency actions.
- The effectiveness of contingency actions against threshold criteria.
- Investigation findings.
- Measures to prevent the threshold criteria being exceeded in the future.
- Justification of the threshold criteria remaining or being adjusted based on better understanding.
- These actions will be conducted in accordance with criteria set by MS 1211.

8.3 Remediation Plan

In accordance with Condition 48(c)(iv) of EPBC 2018/8236 (as varied) and EPBC 2022/9169, exceedance of threshold criteria specified in the GMMP will trigger the development of a Remediation Plan to be reviewed alongside the GMMP by an independent suitably qualified hydrologist within 6 months of the exceedance being reported.

The Remediation Plan will describe:

- Contingency measures and remediation actions to be undertaken in response to a threshold exceedance.
- Details of those actions with regards to location, resource requirements, performance indicators and timing to achieve outcomes.
- Responsibilities and how BCI and specialist resources will be utilised, for example technical experts.
- Operational requirements during the term of the remediation action including any amendment or reduction requirements.
- Reporting and review requirements and commitments

If the independent review recommends that the GMMP be revised, Mardie Minerals will submit a revised GMMP to DCCEEW for the approval of the Minister within 8 months of any such exceedance, and an offset strategy to manage impacts where required.

A commitment has been included in Section 3.5 to develop a Project Remediation Plan that will be used as the basis for all Remediation Plan requirements.

9. COMMITMENTS REGISTER

Table 9-1 below details Mardie Minerals commitments in relation to this GMMP.

Table 9-1 Commitments Register

GMMP Reference	Commitment	Timing / Deliverable	Approval Reference
Modelling			
Section 5 and Appendix C	Regional Groundwater Model	Completed in January 2025.	EPBC 2018/8236 (as varied) EPBC 2022/9169
Section 2.3 and Appendix A Section 5 and Appendix C Section 3.12	The following investigations are to be undertaken with the findings incorporated into an updated GMMP: • All groundwater monitoring data collected to date and throughout the staged filling to be included in the groundwater model and an automatic model calibration process applied for the successively growing calibration period (e.g., using PEST-IES, White et al., 2020), which will allow for model uncertainty to be quantified as a by-product of the model calibration. The model uncertainty must then be considered in the predictive model simulations. • Model predictions must be undertaken for the entire project lifetime to consider the full impact of the project, including the more slowly occurring impact of salinity changes. • Determine approximate aquifer residence times by collecting environmental tracer data (groundwater age tracers) to provide greater evidence supporting the proposed "slow" groundwater flow. • A regional groundwater model that demonstrates an understanding of, and supports the ability to predict, the potential impacts of the proposed action on the regional groundwater system and nearby receptors. This must include groundwater hydrology in areas upstream of the evaporation ponds, for input into the groundwater modelling.	At the conclusion of filling evaporation ponds 1 through 3. Once isotope analyses have been finalised by the GNS laboratory, Mardie Minerals will work with Professor Prommer and AQ2 to provide an interpretation of the results, and to update the conceptual and numerical models, if/as appropriate	EPBC 2018/8236 (as varied) EPBC 2022/9169
Monitoring and Survey			
Section 4	Initial groundwater bore installation	Completed in 2023.	MS 1211 EPBC 2018/8236 (as varied) EPBC 2022/9169
Section 4	Additional bore installation to support ongoing control/reference bore selection and inform Stage 2 Regional Groundwater Modelling	Completed in Q3 2024.	MS 1211 EPBC 2018/8236 (as varied) EPBC 2022/9169
Section 6	Trigger and Threshold Criteria review and Control/Reference Bore Selection for Pond 4 through 8.	Completed in Q1 2025.	MS 1211 EPBC 2018/8236 (as varied) EPBC 2022/9169
Section 6.3	Trigger and Threshold Criteria and monitoring frequency review for Mardie Pool.	To be completed within 3 months of commencement.	MS 1211 EPBC 2018/8236 (as varied) EPBC2022/9169
Section 4.1 and Section 4.3 Table 4-2 and Table 4-3	Water level (VWP) and quality (EC/pH) instrumentation/telemetry installation for existing Coastal and Terrestrial Monitoring Bores.	Completed in Q3 2024 (excluding those to be manually monitored).	MS 1211 EPBC 2018/8236 (as varied) EPBC 2022/9169
	Groundwater level / head monitoring	Hourly, with data download via telemetry.	MS 1211 EPBC 2018/8236 (as varied) EPBC 2022/9169
	Groundwater EC monitoring – Coastal Bores	Hourly, with data download via telemetry.	MS 1211 EPBC 2018/8236 (as varied) EPBC 2022/9169
	Groundwater EC / pH monitoring – Terrestrial Bores	All telemetry installation completed for 74 bores	MS 1211 EPBC 2018/8236 (as varied) EPBC 2022/9169
Section 4.1 Section 6.3 Table 6-2 and Appendix E	Mardie Pool Surface Water / Groundwater investigation and ongoing monitoring	Completed, 2024. (Report attached to GMMP Rev L) Ongoing Monthly monitoring.	MS 1211 EPBC 2018/8236 (as varied) EPBC 2022/9169
Section 6.4 Table 6-2	Mt Salt Mound Spring Monitoring	Commenced in 2022. Quarterly monitoring ongoing.	MS 1211 EPBC 2018/8236 (as varied) EPBC 2022/9169
Section 7.3 Section 7.3.1 Section 7.4 and Table 6-1	Benthic Communities and Habitat Monitoring	Quarterly for first 2 years, then biannually as per the Benthic Communities and Habitat Monitoring and Management Plan (BCHMMP)	MS 1211 EPBC 2018/8236 (as varied) EPBC 2022/9169

GMMP Reference	Commitment	Timing / Deliverable	Approval Reference
Investigation and Reporting			
Section 7.1and Appendix F	Weekly Pond Condition Inspections	Weekly initially, with review after 6 months	EPBC 2018/8236 (as varied) EPBC 2022/9169
Section 7.1 and Appendix F	Monthly control and reference bore matching data review to inform ongoing suitability	Monthly, internal report and action when there is a material finding.	MS 1211 EPBC 2018/8236 (as varied) EPBC 2022/9169
Section 7 and Appendix F	Trigger and Threshold Criteria exceedance investigations	From commencement of operations at a frequency and detail described in this Plan in Table 7-1.	MS 1211 EPBC 2018/8236 (as varied) EPBC 2022/9169
Section 7, Section 8.1 and Appendix F	Investigation Reporting	Timing as per the investigation protocols in the GMMP, investigation report.	MS 1211 EPBC 2018/8236 (as varied) EPBC 2022/9169
Section 7.3.1 Section 10	Review of GMMP monitoring data upon a trigger or threshold exceedance occurring through the BCHMMP	As per timing and details in the BCHMMP	MS 1211 EPBC 2018/8236 (as varied) EPBC 2022/9169
Section 7.3.1 Section 10	Review of BCHMMP monitoring and management actions including reactive monitoring whenever a GMMP Threshold exceedance occurs	From commencement of operations at a frequency and detail described in this Plan in Table 7-1.	MS 1211 EPBC 2018/8236 (as varied) EPBC 2022/9169
Section 10	Review of the GMMP	October 2025 (MS 1211)	MS 1211 EPBC 2018/8236 (as varied) EPBC 2022/9169
Section 2.8 and Table 2-3	Review of the GMMP, based on the review completed by a reviewer, or reviewers approved by the department. • Monitoring required by the approved GMMP, including monitoring bore network, monitoring methodology, monitoring frequency, and trigger and thresholds. • Implementation of the GMMP, • Effectiveness of the GMMP regarding the achievement of its environmental objective • Capacity to measure incremental impacts at the conclusion of the Ramp period • Assessment of whether the GMMP requires revision at this time.	After 2 years of the commencement of the Action	EPBC 2018/8236 (as varied) EPBC 2022/9169 (Condition 68)
Section 2.8 and Table 2-3	Revision of the GMMP in line with the recommendations of the review required by Condition 68 and submitted to the department for approval by the Minister. The revised GMMP must include: • Revised modelling that includes all data collected to date • Revised monitoring and management measures in accordance with recommendations of the review undertaken in Condition 68.	Following the review of the GMMP as required by Condition 66 (i.e. After 2 years of the commencement of the Action)	EPBC 2018/8236 (as varied) EPBC 2022/9169 (Condition 69)
Section 2.8 and Table 2-3	Review the approved GMMP and submit the findings of each review to the department. The review must be completed by a reviewer or reviewers approved by the department and must include detailed reviews of the: • Monitoring required by the approved GMMP, including monitoring bore network, monitoring methodology, monitoring frequency, and trigger and thresholds. • Implementation of the GMMP, • Effectiveness of the GMMP regarding the achievement of its environmental objective. • Regular review of the choice of impact/reference bore matching and using the best available bores/data at any point in time.	At least once within every subsequent 5 year period following the approval of the GMMP.	EPBC 2018/8236 (as varied) EPBC 2022/9169 (Condition 70)
Section 2.8 and Table 2-3	The GMMP must be revised in line with the recommendations of the review required by Condition 68 and submitted to the department for approval by the Minister. The revised GMMP must include: • Revised modelling that includes all data collected to date • Revised monitoring and management measures in accordance with recommendations of the review undertaken in Condition 68. • Regular review of the choice of impact/reference bore matching and using the best available bores/data at any point in time.	After 2 years of the commencement of the Action	EPBC 2018/8236 (as varied) EPBC 2022/9169 (Condition 70)
Section 2.8 and Table 2-3	For any revision of the GMMP, all commitments in the GMMP, including environmental outcomes, management measures, corrective measures, trigger values, thresholds and performance indicators must be SMART and based on referenced or included evidence of effectiveness and in accordance with Condition 66. The GMMP must be consistent with the Environmental Management Plan Guidelines, and must include:		EPBC 2018/8236 (as varied) EPBC 2022/9169 (Condition 71)
Section 8	Monitoring data self-assessment protocol - internal	Annual Report	Internal Commitment
	Groundwater summary data report – DWER and DCCEW	Quarterly	MS 1211 EPBC 2018/8236 (as varied) EPBC 2022/9169
	Compliance Assessment Reporting – DWER	Annually	MS 1211
	EPBC Compliance Report - DCCEEW	Annually	EPBC 2018/8236 (as varied) EPBC 2022/9169
Section 8	10-year Environmental Performance Report	Within 3 months of the expiry of the 10- year period from substantial commencement	MS 1211, D2-7 EPBC 2022/9169

GMMP Reference	Commitment	Timing / Deliverable	Approval Reference
Section 2.8 and Table 2-3 Section 7 and Appendix F	In the event of seepage and/or brine spill at the evaporation pond walls: • The findings of the seepage and/pr brine spill event investigation; • Details of corrective measures implemented • An evaluation of the effectiveness of the corrective measures implemented; • Measures to prevent another seepage and/or brie spill event occurring in the future.	In writing, within 15 business days of the event.	EPBC2018/8236 (as varied) EPBC 2022/9169 (Condition 44)
Additional Commitments			
	Agency Communication and Check in: - Fortnightly during Pond filling including data provision	Fortnightly, by phone call / email	NA
Section 7.3	Review of GMMP alongside the BCHMMP	Within 1 year of MS 1211 approval: by 19 October 2024	MS 1211, B3-2 (2)
Section 10.2	GMMP review (internal)	Annually and in response to significant amendments	
Section 2.8 and Table 2-3 Section 10.2	Independent GMMP review by suitably qualified hydrologist, and updated GMMP if required	At least once before every 10-year anniversary of the plan for the life of the project	EPBC 2018/8236 (as varied) EPBC 2022/9169
Appendix G	Independent review of the modified Before/After Control Impact approach proposed by Data Analysis Australia.	Completed	EPBC 2018/8236 (as varied) EPBC 2022/9169 (Condition 64)
Section 2.8 and Table 2-3	Submit a revised GMMP to the department for approval by the Minister. The GMMP must be updated with sufficient information and data to address Condition 62 and Condition 63 and be resubmitted to and approved by the Minister and DWER in writing prior to filling any other ponds.	Within 3 months of the conclusion of filing evaporation Ponds 1 through 3	EPBC 2018/8236 (as varied) EPBC 2022/9169 (Condition 65)
Section 2.8 and Table 2-3	The approval holder must not undertake any further filling of the ponds until the revised GMMP is approved in writing by the Minister.	Within 3 months of the conclusion of filing evaporation Ponds 1 through 3	EPBC 2018/8236 (as varied) EPBC 2022/9169 (Condition 65)

Section 2.8 and Table 2-3	The revision required by EPBC 2018/8236 (as varied) and EPBC 2022/9169 Condition 66 must include:
	• a table of commitments made in the plan to achieve the environmental outcome, and a reference to exactly where these commitments are detailed in the plan,
	• details of the data collection and modelling undertaken to inform the GMMP,
	• impact avoidance, mitigation and/or repair measures, and the timing of those measures,
	• commitments capable of ensuring that the environmental outcomes are achieved,
	• a monitoring program, which must include:
	  ○ The early warning trigger values for groundwater regimes, groundwater quality, and groundwater levels that will trigger the implementation of management and/or contingency actions to prevent non-compliance with conditions B3-1 of the WA Approval,
	  ○ the thresholds for groundwater regimes, groundwater quality, and groundwater levels to demonstrate compliance with condition B3-1 of the WA Approval,
	  ○ the final design of monitoring that will meet the requirement of condition B3-1 of the WA Approval, including the timing and frequency of monitoring, ensuring monitoring is capable of detecting trigger values and thresholds,
	  ○ corrective measures which must be implemented in response to trigger value exceedances,
	  ○ corrective measures which must be implemented in response to threshold exceedances,
	  ○ proposed corrective measures if trigger values are reached, and
	  ○ details of how trigger value and threshold exceedances will be assessed to determine if the exceedance is a result of the Action,
	• The approval holder must provide written justification in the form of a report as an appendix to the GMMP, for the proposed triggers, limits triggers and indicators as they relates to the protection of MNES habitat by providing analysis of baseline data (from relevant locations in the receiving environment) and comparison with *Australian and New Zealand guidelines for fresh and marine water quality* (2018), or default guideline values for high conservation/ecological value systems.
	• details of seepage recovery measures that will be implemented where seepage from evaporation ponds to groundwater is detected,
	• an assessment of the effectiveness and reliability of the proposed monitoring system, including:
	  ○ demonstrate if and how the monitoring system will be able to detect changes to groundwater regimes, groundwater quality, and groundwater levels until at least the anticipated completion of the Action, and
	  ○ demonstrate if and how the monitoring system will be able to determine if exceedances are attributable to the Action
	• reporting and review mechanisms to demonstrate compliance with the commitments made in the plan and the requirement specified in condition B3-1 of the WA Approval, including a commitment to review the GMMP at least once every 5 years,
	• an assessment of risks relating to achieving the environmental outcomes and risk management strategies and/or mitigation measures that will be applied to address identified risks, and
	• references to other relevant plans or conditions of approval (including state approval conditions).
		Within 3 months of the conclusion of filing evaporation Ponds 1 through 3	EPBC 2018/8236 (as varied)
			EPBC 2022/9169 (Condition 66)

Section 2.8 and Table 2-3	If the revised GMMP required in condition 63 is not approved within 12 months of the date of evaporation ponds 1 to 3 being filled, the approval holder must undertake the following: a) Cease operations until the revised GMMP is approved in writing by the Minister; and	Within 12 months of the date of the evaporation ponds 1 to 3 being filled	EPBC 2018/8236 (as varied) EPBC 2022/9169 (Condition 67)

GMMP Reference	Commitment	Timing / Deliverable	Approval Reference
	b) If directed by the department, empty evaporative ponds 1,2 and3. Contents of evaporative ponds is to be disposed in a manner approved in writing by the department.		
Section 7.2 and Appendix F	The groundwater impact investigation and response process will be trialled during the filling of Ponds 1-3 and will be reviewed and updated/refined in the subsequent update to this GMMP.	Independently reviewed after 12 months or after the first 10 exceedances occur, and then subsequently again with each scheduled review of the GMMP.	Internal Commitment

10. ADAPTIVE MANAGEMENT AND REVIEW OF THE PLAN

This GMMP is intended to be reviewed and updated as ongoing monitoring and operations progress.

10.1 Adaptive Management Process

Mardie Minerals are committed to improving environmental results and management practices throughout the implementation of the Project and therefore will use an adaptive management approach for this GMMP. Adaptive management practices will include:

- Monitor and evaluate performance against the outcome-based triggers and thresholds. Perform quarterly reviews of monitoring data and compare data and information against established baseline, trigger and threshold values and ongoing monitoring and reference data.
- Monitor and evaluate the effectiveness of the management actions against the management targets.
- Review of management actions throughout the implementation of the Project, and identification of potential new management measures, methodologies, and technologies that may be more effective.
- Specifying monitoring and reporting procedures to provide for continuous improvement, consistent with an adaptive management approach.
- In the event one or more of the triggers, thresholds or management targets has not been met, or is considered at risk of not being met, review and adjust the management measures and monitoring to ensure the objectives are met, based on what is learned from evaluation of the monitoring data, or any new data that becomes available.
- Review any assumptions considering the monitoring data or any new data that becomes available.
- Review/audit of the outcomes and revisions of the GMMP required as per the approvals and as per the frequency noted in Section 9.

10.2 Review

This GMMP will be reviewed in accordance with regulatory timeframes (e.g. within 2 years of commencement of the Action, and every 5 years following approval of this GMMP) or as required following any significant amendments.

A separate review, by an independent suitably qualified hydrologist, will be completed at least once before every 10-year anniversary of the first approval of the GMMP, and subsequently every 10 years for the life of the project (unless specified by the regulator in writing). A revised GMMP addressing the recommendations of this review, accompanied by the recommendations of review, will be submitted to the CEO, DWER and DCCEEW for approval, within 3 months of the most recent 10-year anniversary of the first approval of the GMMP.

Mardie Minerals will update and submit proposed amendments to the Plan following every review (if that review recommends changes), including each independent hydrologist review.

All reviews, including annual reviews, will include:

- Outcomes of monitoring programs.
- Recommendations from the reviewer(s), including that of the independent hydrologist.
- Implementation and effectiveness of management measures and monitoring programs.
- Threshold/trigger criteria and threshold/trigger level actions.
- Review of any exceedances and investigations during the review period.
- Longer term trend analysis.
- Changes to relevant legislation, policy, guidelines, management plans and industry practices.
- Changes to operational activities.

- Changes to approval conditions.
- Changes to the conservation status of fauna species.
- The identification of a conservation significant fauna species not previously confirmed within the Project area.
- Recurring incidents of death/injury to a conservation significant fauna species.
- Stakeholder consultation.

10.2.1 Peer Review

An independent peer review was undertaken in 2021 (report dated 5/01/22) with the purpose of providing an assessment and analysis of the suitability of an early version of the GMMP to adequately and correctly address the study outcomes to achieve the objectives with confidence. The peer review was a requirement of Ministerial Statement (1175) 1211 and EPBC 2018/8236 (prior to the mirroring of the EPBC 2022/9169 conditions).

The peer reviewer provided a number of recommendations and observations including:

- Justification to demonstrate that generated data will accurately represent the baseline.
  - Provided for in modelling studies and GW level indicator methodology.
- Installing multilevel bores or set of bores with various screen level.
  - Coastal bore network installed – deep and shallow bores.
- Monitoring bores at the location west side of pond 1 and around Robe River delta.
  - Coastal bore network installed – RRDMA avoided.
- Rationalisation for the monitoring well positions and their adequacy.
  - Coastal bore network installed, described in AQ2 reporting.
- Plan and potential steps to minimise identified preliminary triggers.
  - Trigger and threshold criteria, mitigation and management actions.
- Hydrological regime in the Project area to address the gaps of the baseline data.
  - Provided for in modelling studies and GW level indicator methodology.
- Establishing an adequate linkage between the investigations and the claimed identification data for the conceptualisation.
  - Conceptualisation in modelling report.
- Deeper discussion of the uncertainties about natural recharge and evaporation estimates and changes.
  - Conceptualisation in modelling report.
- Saline water flow influence on regional groundwater flows paths.
  - Conceptualisation in modelling report.
- Collecting the water quality data for Mardie pool and creeks.
  - Quarterly monitoring since 2022.
- Review and elaboration on the indirect impacts of the Project on BCH, availability of historical data.
  - Described in BCHMMP and link to GMMP.
- Estimation of the evapotranspiration, quantification of the acceptable level of impact
  - Conceptualisation in modelling report
- Salt precipitation and dissolution processes in modelling
  - Conceptualisation in modelling report
- Management and mitigation actions of the potential environmental impacts and risks of long-term environmental changes such as climate change.

– GMMP relevant management and mitigation actions included. Climate Change impacts assessed through EIA process.

The GMMP was subsequently updated to address those matters of relevance under the Federal and State approval conditions noting that a number of observations were considered outside the scope of the GMMP approval conditions.

Following a number of iterations of the GMMP and review by DWER and DCCEEW, a second independent review was undertaken of the GMMP and the initial peer review recommendations and observations. The review noted that the updated GMMP had adequately addressed the peer review recommendations, and also provided additional observations.

This Revision O represents cumulative updates across bore installation, baseline data gathering and supporting technical studies including updated modelling. Table 5-6 provides direct responses to observations and recommendations from these peer reviews.

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Appendix A: Staged Pond Filling (Pond 1 to Pond 3) Monitoring Data

Appendix B: Statement Against Significant Guidelines for MNES

Appendix C: Mardie Project Conceptual Groundwater System and Regional Modelling Assessment (AQ2, 2025)

Appendix D: Statistical Methodology for Coastal Groundwater Monitoring for the Mardie Salt and Potash Project (DAA 2025)

Appendix E: Groundwater Monitoring and Management: triggers and thresholds as they relate to the protection of MNES habitat

Appendix F: Mardie Minerals Groundwater Monitoring Procedure [0000-EV-PRO-0005]

Appendix G: Independent Review of Statistical Methodology – Groundwater Monitoring for the Mardie Project (Pink Lake Analytics, 2025)

Appendix H: Mardie Pool Surface Water Monitoring Data