Water Management Plan
Environmental Management Plan

SOUTH32
Worsley Alumina

BUSINESS BLUEPRINT

SOUTH32 WORSLEY ALUMINA (ABN 58 008 905 155)

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1 DECLARATION OF ACCURACY

I declare that:

1. I am aware that:
    a. *Section 491 of the Environment Protection and Biodiversity Conservation Act 1999 (Cth) (EPBC Act) makes it an offence in certain circumstances to knowingly provide false or misleading information or documents to specified persons who are known to be performing a duty or carrying out a function under the EPBC Act or the Environment Protection and Biodiversity Conservation Regulations 2000 (Cth).*
    b. *Section 112 of the EP Act makes it an offense to give or cause to be given information that to the person's knowledge is false or misleading to the Minister, the Authority, the CEO, a police officer, an inspector or an authorised person.*
    c. *The above offences are punishable on conviction by imprisonment or a fine or both.*
2. 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

Full name (please print)

Organisation (please print)

Date: / /

2 EXECUTIVE SUMMARY

South32 Worsley Alumina Pty Ltd (Worsley), as operator for and on behalf of the Worsley Bauxite-Alumina Joint Venture, is the proponent for the Worsley Mine Expansion Revised Proposal (the Revised Proposal).

Worsley proposes to continue Project operations by expanding the existing operational activities with the next phase of bauxite mining, providing access to future bauxite reserves and resources within the Primary Assessment Area (PAA) to sustain production at the Worsley Alumina Refinery near Collie. This expansion includes three main components:

- The Worsley Mining Development Envelope (WMDE), within which the next phase of mining is proposed to take place, within existing areas as well as expansion areas to the west and north of current operations at the Boddington Bauxite Mine (BBM). Worsley Alumina would continue to utilise existing crushing and conveying infrastructure;
- The Bauxite Transport Corridor (BTC), which would link current mining areas to new and future mining areas; and
- The Contingency Bauxite Mining Envelope (CBME), which would provide for an emergency supply of bauxite close to the refinery should it be required.

The full details of the Revised Proposal are detailed in the Worsley Environmental Review Document (Worsley, 2022) and subsequent Response to Submissions document (Worsley, 2024).

This Water Management Plan (WMP) details the expected impacts, management, monitoring and mitigation measures for Inland Waters associated with all Worsley operations. This plan will be continuously updated in accordance with adaptive management principles as the operation progresses into new mining areas.

This WMP has been prepared in accordance with the 'Instructions: How to prepare Environmental Protection Act 1986 Part IV Environmental Management Plans' published by the Western Australian Environment Protection Authority (EPA) (EPA, 2024) and the 'Environmental Management Plan Guidelines' published by the Department of Climate Change, Energy, the Environment and Water (DCCEEW) (DCCEEW, 2024).

The scope of this document includes operations within the Primary Assessment Area, Refinery Lease Area and Bunbury Port. These areas are collectively referred to as the Project Area and are shown in Figure 3-1. Specific risks to inland waters associated with construction activities (i.e. Potential Acid Sulfate Soils) will be covered under a separate Construction Environmental Management Plan (CEMP).

A summary of the information contained in this WMP is provided in Table 2-1.

Table 2-1: WMP Executive Summary

Proposal Name	**Worsley Mine Expansion Revised Proposal**
Proponent Name	South32 Worsley Alumina Pty Ltd
Ministerial Statement Number	Ministerial Statement 1237
Commonwealth Assessment	EPBC 2019/8437
Purpose of EMP	To outline Worsley's management and monitoring approach to ensure outcomes are achieved in accordance with conditions B16-1 and B12-1((2) of MS1237 and to minimise impacts on inland waters.
Key environmental factors, outcomes and objectives	Key environmental factors are: • Inland Waters • Flora and Vegetation • Terrestrial Fauna **Environmental Outcomes:** • No disturbance or adverse impacts to *Caladenia hopperiana* or *Caladenia caesarea* subsp. Mooradung associated with surface water and / or groundwater changes. • No adverse impacts to conservation significant flora, fauna or ecological communities as a result of surface and/or groundwater changes attributable to the proposal.

- No adverse impacts to native vegetation within or adjacent to the PAA as a result of surface and / or groundwater changes attributable to the proposal.
- No adverse impacts to hydrological regimes and water quality of the Hotham River, Marradong Brook, Augustus River, Murray River, Williams River and Thirty-Four Mile Brook attributable to the proposal.
- No adverse impacts to GDEs within or adjacent to the PAA as a result of surface and/or groundwater changes attributable to the proposal.
- No disturbance or adverse impacts to native vegetation within 30m of Augustus River bank attributable to the proposal.

Environmental Objectives:

- Operational impacts on riverbank erosion and sedimentation are minimised.
- Chemicals and hydrocarbons are managed to minimise the risk of contamination of surface water and groundwater.
- Water use is minimised through water efficiency measures.
- Chemicals and hydrocarbons are managed appropriately to prevent contamination.
- Risk of exposure of PASS is minimised.

Condition clauses

B12-1 The proponent must ensure the implementation of the proposal achieves the following environmental outcomes:

(2) ensure no disturbance or adverse impacts to:

a) threatened flora including *Caladenia hopperiana*;

b) *Caladenia caesarea* subsp. Mooradung;

B12-2 The proponent shall implement the proposal to achieve the following environmental objective:

(1) Avoid, where practicable, and otherwise minimise indirect impacts to flora and vegetation including but not limited to impacts from…changes in groundwater and surface water…".

B 16-1 The proponent shall ensure the implementation of the proposal achieves the following environmental outcomes:

(1) no adverse impacts to conservation significant flora, fauna or ecological communities as a result of surface and/or groundwater changes attributable to the proposal;

(2) no adverse impacts to native vegetation within or adjacent to the PAA as a result of surface and/or groundwater changes attributable to the proposal

(3) no adverse impacts to the hydrological regimes and water quality of the Hotham River, Marradong Brook, Augustus River, Murray River, Williams River and Thirty-Four Mile Brook attributable to the proposal;

(4) no adverse impacts to groundwater dependent ecosystems within or adjacent to the PAA as a result of surface and/or groundwater changes attributable to the proposal;

(5) no disturbance or adverse impacts to native vegetation within 30 m of the Augustus River bank attributable to the proposal.

(6) No adverse impacts to neighbouring groundwater users as a result of the proposal.

	B16-2 The proponent must review and update the Water Management Plan (South32 Worsley Alumina Version 5.4), that satisfies the requirements of condition C4 and demonstrates how achievement of the outcomes in condition B16-1 and B12-1(2)(a) and B12-1(2)(b) will be monitored and substantiated and submit for approval to the CEO prior to implementation of the proposal. **C4-2** The environmental management plan required under condition B16-2 requires a Groundwater Dependent Ecosystem Monitoring Framework that establishes: (1) identification of all areas of groundwater dependent ecosystems and *Caladenia hopperiana* and *Caladenia caesarea* subsp. Mooradung individuals that have the potential to be impacted by the proposal; (2) baseline groundwater monitoring of levels and quality, at groundwater dependent ecosystem locations and *Caladenia hopperiana* and *Caladenia caesarea* subsp. Mooradung locations, for not less than 12 months, that addresses, but is not limited to, the following parameters: a) groundwater levels; b) electrical conductivity or salinity; c) pH; d) nutrient levels (nitrogen and phosphorus); e) total dissolved solids; and f) dissolved metals. (3) comparison of monitoring results against comparable regional reference sites, to: a) distinguish regional climate/drying effects from proposal effects; and b) provide context for mounding and dryland salinity that may be caused by the proposal. (4) a monitoring procedure for water quality and groundwater levels, and schedule, for the identified locations of groundwater dependent ecosystems and *Caladenia hopperiana* and *Caladenia caesarea* subsp. Mooradung individuals; and (5) whether the trigger and threshold levels contained within the Water Management Plan (South32 Worsley Alumina Version 5.4) and any revisions approved under B16-2 are suitable to meet the outcomes.
Key components in the WMP	Please refer to Table 5-1 and Table 5-2 for Outcome-based and Objective-based Provisions.
Proposed construction date	December 2024
EMP Required pre-construction	Yes

3 CONTEXT SCOPE AND RATIONALE

3.1 PROPOSAL

South32 Worsley Alumina Pty Ltd (Worsley) operates the Worsley Bauxite-Alumina Project on behalf of the Joint Venture parties. Worsley sought approval for the Worsley Mine Expansion Revised Proposal (the Revised Proposal) to continue existing mining operations and access additional ore resources to maintain the continuity of the Boddington Bauxite Mine (BBM), which has been in operation for over 40 years.

Key elements of the Revised Proposal include:

- expansion of the existing mining envelope at the BBM (to become the Worsley Mining Development Envelope – WMDE),
- establishment of a Bauxite Transport Corridor (BTC) at the BBM, and
- establishment of a Contingency Bauxite Mining Envelope (CBME) and support infrastructure / facilities at the Worsley Refinery (the Refinery).

The alumina refinery production rate remains at 4.7 million tonnes per annum. The full details of the Revised Proposal are detailed in the Worsley Environmental Review Document (Worsley, 2022) and subsequent Response to Submissions document (Worsley, 2024).

3.1.1 Purpose and Scope

This Water Management Plan (WMP) details the expected impacts on groundwater, surface water and Groundwater Dependent Ecosystems (GDEs) and indirect impacts on conservation significant flora, fauna and ecological communities associated with changes to surface water and/or groundwater attributable to the Worsley operation. It also outlines the management, monitoring and mitigation measures implemented to ensure that these direct and indirect impacts are minimised to achieve the environmental outcomes.

The scope of this document includes operations within the Primary Assessment Area, Refinery Lease Area and Bunbury Port. These areas are collectively referred to as the Project Area and are shown in Figure 3-1.

Specific risks associated with construction activities (i.e. Potential Acid Sulfate Soils (PASS)) will be covered under a Construction Environmental Management Plan (CEMP).

This WMP has been written to be consistent with the requirements of conditions C4-1 and C5-1 of MS1237. In accordance with condition C1-1 no ground disturbing activities may take place until the CEO has confirmed in writing that this WMP meets the requirements of condition B16-2 of MS1237.

Impacts, monitoring and management activities associated with the Extended Mining Areas, managed under Part B(B) of MS1237, are excluded from this WMP.

In accordance with Condition C2-6 this WMP will be published on the South32 website and provided to the CEO in electronic form suitable for on-line publication by the Department of Water and Environmental Regulation within twenty (20) business days of being implemented, or being required to be implemented (whichever is earlier).

3.2 KEY ENVIRONMENTAL FACTORS

This Plan addresses the following key environmental factors

- Inland Waters. The Environmental Protection Authority's (EPA) objective for Inland Waters is "*To maintain the hydrological regimes and quality of groundwater and surface water so that environmental values are protected*".
- Flora and Vegetation, in which the EPA's objective is "To protect flora and vegetation so that biological diversity and ecological integrity are maintained"; and
- Terrestrial Fauna, in which the EPA's objective is "To protect terrestrial fauna so that biological diversity and ecological integrity are maintained".

3.2.1 Proposal Activities Potentially Affecting Inland Waters

Activities associated with the Project have the potential to either directly or indirectly impact on the key environmental factor of Inland Waters. Potential impacts to the environment (direct and indirect) that may result from Project activities such as vegetation clearing, water abstraction, vehicle and machinery movements, and construction and other mining activities, include:

- Riverbank erosion, sedimentation, scouring of streams or release of excessively turbid water as a result of clearing riparian vegetation and alteration of surface water drainage patterns;
- Decline of aquatic fauna from changes in flow regime and water quality, potentially leading to impediment of upstream pre-spawning migrations of freshwater fishes;
- Contamination of groundwater and / or surface water from Potential Acid Sulfate Soils (PASS) material and contaminants during removal of soils and sediment at river crossings;
- Contamination of surface water as a result of spills or stormwater run-off;
- Contamination of groundwater as a result of seepage of stored chemicals (including Bauxite Residue Disposal Areas (BRDAs));
- Deterioration or change in background water quality, such as salinity, due to indirect impact of mining activities;
- Changes to groundwater levels in the shallow aquifer as a result of clearing of native vegetation, disturbance to soil profile and rehabilitation;
- Potential impacts on surface water and groundwater values through increased water use;
- Changes to vegetation structure in Groundwater Dependent Ecosystems (GDEs) as a result of groundwater level rise; and
- Contamination (particularly hydrocarbon) of groundwater and / or surface water from operation of the Refinery, BBM, and the Bunbury Port.

Sensitive components which may be affected by the operation include:

- GDEs; and
- Conservation significant flora, fauna and ecological communities.

3.3 CONDITION REQUIREMENTS

Implementation and management of the Revised Proposal must be in accordance with the conditions of MS1237. Conditions addressed by this WMP are included in Table 3-1.

Table 3-1: EP Act and EPBC Act Approval Conditions Addressed by this WMP

Ref	Cond.	Condition Requirement	Plan Ref	Key commitments and activities
Approval Instrument: Ministerial Statement 1237				
MS1237	B12-1	The proponent must ensure the implementation of the proposal achieves the following environmental outcomes: (3) ensure no disturbance or adverse impacts to: a) threatened flora including *Caladenia hopperiana*; b) *Caladenia caesarea* subsp. Mooradung;	Flora and Vegetation Management Plan (200001092) Table 4-3 Table 5-1 Table 12-4 4.3.2.3 4.6 4.10.4 4.10.2	Targeted GDE Groundwater Monitoring Program Regional Surface Water Monitoring Program Regional Groundwater Monitoring Program Targeted Flora Survey - *C. hopperiana* and *Caladenia caesarea* subsp. Mooradung. Targeted Perched Aquifer – *C hopperiana* Monitoring Program
MS1237	B12-2	The proponent shall implement the proposal to achieve the following environmental objective: (1) Avoid, where practicable, and otherwise minimise indirect impacts to flora and vegetation including but not limited to impacts from…changes in groundwater and surface water…”.	4.2 4.6 5.2.2	As outlined in Section 4.6.
MS1237	B16-1	The proponent shall ensure the implementation of the proposal achieves the following environmental outcomes: (1) no adverse impacts to conservation significant flora, fauna or ecological communities as a result of surface and/or groundwater changes attributable to the proposal; (2) no adverse impacts to native vegetation within or adjacent to the PAA as a result of surface and/or groundwater changes attributable to the proposal (3) no adverse impacts to the hydrological regimes and water quality of the Hotham River, Marradong Brook, Augustus River, Murray River, Williams River and Thirty-Four Mile Brook attributable to the proposal; (4) no adverse impacts to groundwater dependent ecosystems within or adjacent to the PAA as a result of surface and/or groundwater changes attributable to the proposal; and (5) no disturbance or adverse impacts to native vegetation within 30 m of the Augustus River bank attributable to the proposal. (6) No adverse impacts to neighbouring groundwater users as a result of the proposal.	Table 4-3 Table 5-1 12.1 4.9.3 Table 5-3	Targeted Conservation Significant Flora Monitoring Program Targeted GDE Groundwater Monitoring Program Targeted GDE Vegetation Condition Assessment Regional Vegetation Condition Assessment Regional Surface Water Monitoring Program Regional Groundwater Monitoring Program

MS1237	B16-2	The proponent must review and update the Water Management Plan (South32 Worsley Alumina Version 5.4), that satisfies the requirements of condition C4 and demonstrates how achievement of the outcomes in condition B16-1 and B12-1(2)(a) and B12-1(2)(b) will be monitored and substantiated and submit for approval to the CEO prior to implementation of the proposal.	This WMP Table 5-1 Table 5-2 Table 5-3 Table 5-4	
MS1237	C4-2	The environmental management plan required under condition B16-2 requires a Groundwater Dependent Ecosystem Monitoring Framework that establishes: (1) identification of all areas of groundwater dependent ecosystems and *Caladenia hopperiana* and *Caladenia caesarea* subsp. Mooradung individuals that have the potential to be impacted by the proposal; (2) baseline groundwater monitoring of levels and quality, at groundwater dependent ecosystem locations and *Caladenia hopperiana* and *Caladenia caesarea* subsp. Mooradung locations, for not less than 12 months, that addresses, but is not limited to, the following parameters: c) groundwater levels; d) electrical conductivity or salinity; e) pH; f) nutrient levels (nitrogen and phosphorus); g) total dissolved solids; and h) dissolved metals. (3) comparison of monitoring results against comparable regional reference sites, to: a) distinguish regional climate/drying effects from proposal effects; and b) provide context for mounding and dryland salinity that may be caused by the proposal. (4) a monitoring procedure for water quality and groundwater levels, and schedule, for the identified locations of groundwater dependent ecosystems and *Caladenia hopperiana* and *Caladenia caesarea* subsp. Mooradung individuals; and (5) whether the trigger and threshold levels contained within the Water Management Plan (South32 Worsley Alumina Version 5.4) and any revisions approved under B16-2 are suitable to meet the outcomes.	4.3.2.2 Figure 4-3 12.1 12.1 12.1 12.1.2 12.1.2.1	Targeted GDE Groundwater Monitoring Program Targeted GDE Vegetation Condition Assessment Regional Surface Water Monitoring Program Regional Groundwater Monitoring Program Targeted Population Surveys for *C. hopperiana* and *Caladenia caesarea* subsp. Mooradung

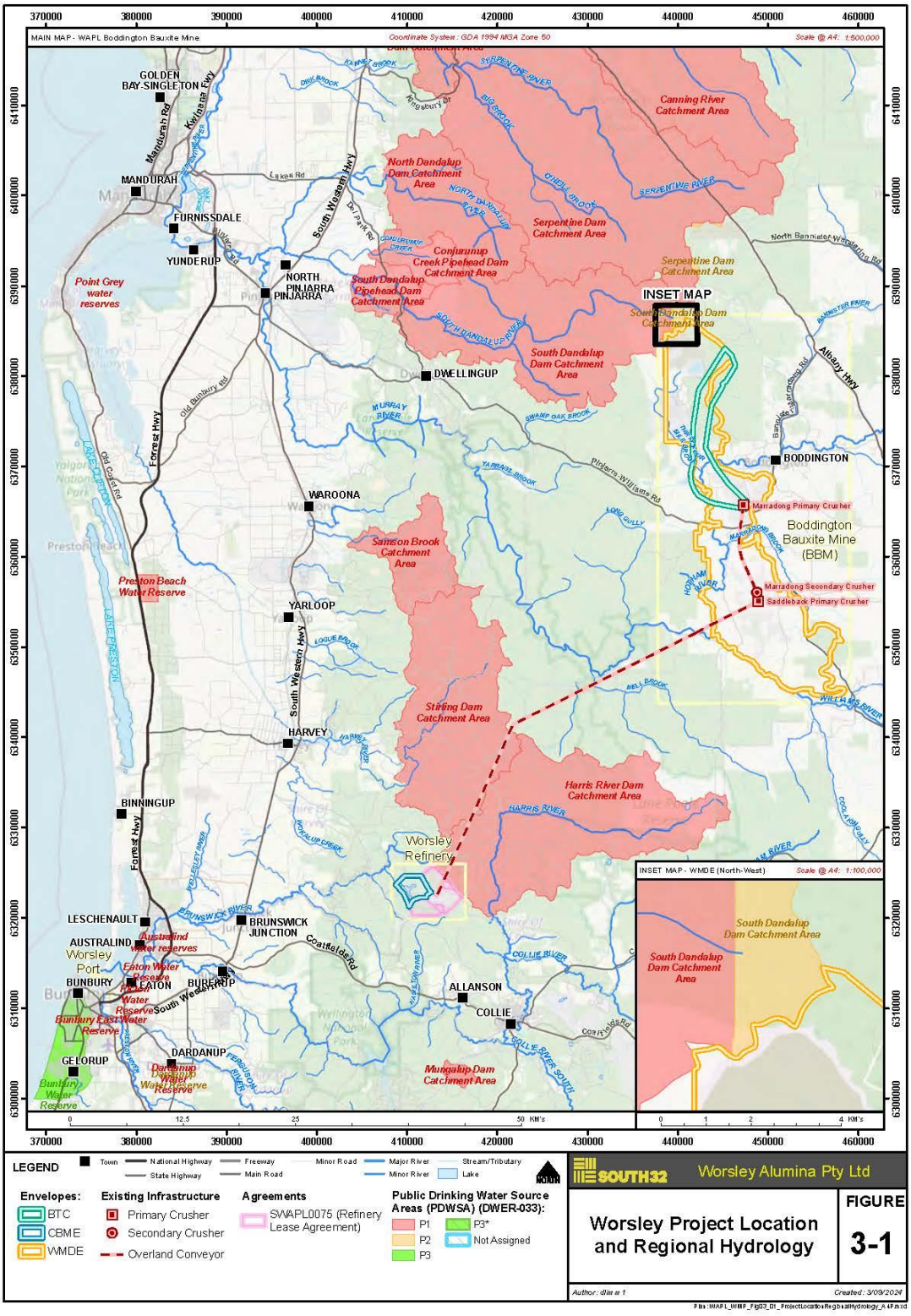

Figure 3-1: Worsley project location and regional hydrology

4 RATIONALE AND APPROACH

This WMP addresses the Inland Waters environmental factor and the EPA's objective to maintain the hydrological regimes and quality of groundwater and surface water so that environmental values are protected. The WMP addresses the required outcomes within MS1237 and other legal requirements and identified risks related to inland waters.

Worsley has operated in the region for over 40 years and, in this time, has conducted three detailed environmental impact assessments under Part IV of the *Environmental Protection Act 1986* (WA) to support the expansion of its operations. Worsley has a detailed understanding of the potential impacts to Inland Waters that could occur as a result of its proposed operations.

Management measures and monitoring programs have been developed and adjusted over time in consultation with external experts to ensure that potential impacts are able to be identified and acted upon prior to environmental impact occurring. Management measures have been developed with consideration for the mitigation hierarchy (avoid, minimise, rehabilitate and offset). This section provides the rationale for the choice of monitoring and management measures to demonstrate compliance with the outcomes required within MS1237.

4.1 ENVIRONMENTAL OUTCOMES

Required environmental outcomes have been defined within MS1237. These include:

- No disturbance or adverse impacts to *Caladenia hopperiana* or *Caladenia caesarea* subsp. Mooradung associated with surface water and / or groundwater changes.
- No adverse impacts to conservation significant flora, fauna or ecological communities as a result of surface and/or groundwater changes attributable to the proposal.
- No adverse impacts to native vegetation within or adjacent to the PAA as a result of surface and / or groundwater changes attributable to the proposal.
- No adverse impacts to hydrological regimes and water quality of the Hotham River, Marradong Brook, Augustus River, Murray River, Williams River and Thirty-Four Mile Brook attributable to the proposal.
- No adverse impacts to GDEs within or adjacent to the PAA as a result of surface and/or groundwater changes attributable to the proposal.
- No disturbance or adverse impacts to native vegetation within 30m of Augustus River bank attributable to the proposal.

4.2 ENVIRONMENTAL OBJECTIVES

Additional environmental objectives have been determined by the business to manage potential impacts to Inland Waters identified through risk assessment that are not addressed within MS1237:

BBM:

1. Minimise indirect impacts to flora and vegetation from changes in groundwater and surface water.
2. Minimise impacts on GDEs and SWDEs.
3. Minimise the risk of riverbank erosion and sedimentation.
4. Minimise risk of Worsley's mining operations impacting on water quality (salinity).
5. Minimise risk of adverse impacts to hydrological regimes of the Hotham River, Marradong Brook, Murray River, Williams River and Thirty-Four Mile Brook attributable to the proposal.
6. Minimise impacts on shallow aquifers.
7. Minimise groundwater abstraction.
8. Minimise risk of contamination of groundwater and surface water from chemicals and hydrocarbons.
9. Minimise the risk of exposure of PASS.

4.3 SURVEY AND STUDY FINDINGS

Worsley have undertaken studies to understand the potential impacts of bauxite mining on Inland Waters. These studies have supported the development of appropriate monitoring programs to ensure operational impacts are understood and minimised to prevent environmental harm. Detailed reviews of monitoring programs and associated data are completed on a regular basis applying an adaptive management approach to the monitoring and management of Inland Waters. These studies and reviews are summarised in Table 4-1.

Table 4-1: Inland Waters studies and reviews

Mining Area	Description	Reference
Saddleback	Flux Density Analysis to determine high salinity risk areas and revise the surface and groundwater monitoring program as appropriate.	WEC 2003, Salinity Risk Assessment for the Boddington Bauxite Mine Using FDA
Marradong	Flux Density Analysis to determine high salinity risk areas and revise the surface and groundwater monitoring program as appropriate.	Croton and Dalton 2008, Proposed Groundwater Monitoring for the Marradong Timber Reserve Mine Area
Hotham North	Flux Density Analysis to determine high salinity risk areas and revise the surface and groundwater monitoring program as appropriate.	Green et. al 2023a, Salinity Risk Assessment for the Hotham North Mining Area Using Flux Density Analysis
Saddleback and Marradong	Triennial Aquifer Reviews: These have been completed for operations occurring from 2004 onwards. The purpose of the triennial review is to assess the effectiveness of controls in managing impacts to the aquifers within the active areas of BBM.	Most recent: Green et al 2021, Boddington Bauxite Mine Triennial Aquifer Review July 2017 – June 2020 Green et al 2024, Boddington Bauxite Mine Triennial Aquifer Review July 2020 – June 2023
Primary Assessment Area (BBM)	Numerical Groundwater Model: quantify potential groundwater related effects of the proposed mining activities, specifically changes to groundwater levels and fluxes, to inform the assessment of groundwater impacts	GHD 2022, Groundwater Supporting Studies, Numerical Groundwater Modelling
Primary Assessment Area (BBM)	Assessment of bauxite mining impacts on the groundwater and surface water systems consisting of a desktop review and predictive groundwater flow modelling.	GHD 2022, Groundwater and surface water studies
Primary Assessment Area (BBM)	Additional Groundwater Model Uncertainty Analysis	GHD 2023, Technical Memorandum: *Groundwater uncertainty analysis to support addressing comments provided by the Office of Water Science*
Saddleback	A targeted study to understand the effects of Worsley Alumina's Boddington Bauxite Mine (BBM) on stream flows, stream salinities and groundwater levels.	WEC 2004, Review of the Bee Farm and Tunnel Rd Catchment Study
Saddleback and Marradong	Detailed groundwater monitoring program review for the BBM.	Croton, J.T, Mauger, G.W. & Dalton, J.A., 2020. Review of the Piezometer Network at the Boddington Bauxite Mining
Hotham North	Hydrology and hydraulics study to understand hydrological risks and support design of Hotham River Crossing and associated haul road alignment.	Egis 2023, Dilyan's Crossing Hydrology and Hydraulics Report
CBME	Hydrogeological assessment and groundwater model development for the proposed contingency bauxite mining at the CBME	GRM 2023, Contingency Bauxite Mining Envelope (CBME) Hydrogeological Assessment and Groundwater Model
Quindanning Timber Reserve	Detailed review of potential indirect impacts to *C. hopperiana* in the Quindanning Timber Reserve associated with the Revised Proposal providing recommended monitoring and management measures.	Green et al 2023b Review of the Indirect Impacts in the Quindanning Mining Area

4.3.1 Overview

The Worsley Bauxite-Alumina Project is located on the Darling Plateau within the Jarrah Forest bioregion and the Northern Jarrah Forest subregion, as described by the Interim Biogeographic Regionalisation for Australia. The principal landscape feature of the Project Area is an undulating topography with uplands ranging from 280–550 m above the set Australian Height Datum and valley floors with gentle to moderately steep slopes 50–100 m below this. In general, there is lateritic duricrust on the broad crests and upper slopes, either outcropping or obscured by shallow red or yellow gravelly soils. The slopes are characterised by a mottled clay subsoil or ferruginous duricrust with a surface gravel soil. Closer to the valley floor, the clay becomes deeper and the gravel less dominant. Red and yellow earths or duplex soils are common in the major valley systems. Bauxite ore has developed in the upper part of the weathered lateritic profile in the upland areas.

The climate in the Project Area is considered a Mediterranean climate with typically hot, dry summers (December to February) and mild, wet winters (June to August). The closest Bureau of Meteorology (BoM) rainfall station (Station No. 9509) is located within the Marradong region of the BBM and provides representative rainfall data for the BBM area. The mean annual rainfall recorded since 1907 at the Marradong station (9509) is approximately 715 mm (BoM, 2020a). A reduction in annual rainfall and an increase in the frequency of drought years has been noted since the 1970s, with the mean annual rainfall for the last decade (2009-2019) measuring approximately 576 mm (BoM, 2020a). Higher average rainfall has been recorded at the Refinery, which receives an annual average rainfall of approximately 870 mm.

Shallow throughflow in the upper gravelly sand horizon is considered to be the major source of streamflow in the jarrah forest, as opposed to overland flow and groundwater flow (Mauger et al. 1998). Rainfall that infiltrates the soil tends to perch on the clay subsoil and flow down-slope to discharge to streams. Stokes and Loh (1982) estimated that more than 90% of streamflow may be generated by this shallow throughflow. However more conservative estimates indicate that on an average annual basis about 25% of rainfall in the high rainfall zones becomes streamflow, and in the low rainfall zones about 1% (Bari & Ruprecht 2003).

4.3.2 Boddington Bauxite Mine

4.3.2.1 *Hydrology / Catchment*

The BBM mining areas occur within the Murray River System which is a proclaimed Surface Water Area under the *Rights in Water and Irrigation Act 1914* (RIWI Act). Surface water resources within proclaimed Surface Water Areas are managed and allocated by the DWER. Taking or diversion of surface water within these areas requires a licence granted by the DWER in accordance with the RIWI Act.

Two permanent water features intersect the BBM, the Hotham River and the Williams River. Flow in the Hotham River is seasonal, and both river systems are typically brackish, with salinity ranging from 1,100 to 13,000 mg/L in the Hotham River and 120 to 14,000 mg/L in the Williams River (GHD, 2022). The ephemeral tributaries that feed these water courses range from fresh to brackish.

Monitoring for the main tributaries within the PAA of Thirty Four Mile Brook and Marradong Brook have determined salinity ranging from 18 – 7,400 mg/L and 1,100 – 13,000 mg/L respectively.

4.3.2.2 *Soil and Groundwater Salinities*

Croton and Dalton (2004) found that the soil-salt storages of the mine area investigated were lower than those quoted in the literature; that is in the range from 0.85 to 1.10 kg/m^3 compared with 1.94 kg/m^3 from Tyskin & Croton (1988).

Groundwater quality is variable within the existing mining areas, ranging from fresh to 15,000 mg/L salinity. A groundwater assessment undertaken by GHD (2022) has provided a five-year average of Total Dissolved Solids (TDS) in groundwater across the broad areas (Table 4-2). Higher levels of salinity are recorded in the northern extents of the Boddington region adjacent to the existing Newmont Boddington Gold (NBG) mining operations.

Table 4-2: Groundwater quality TDS (5-yearly average) based on mining areas (GHD 2022)

Area	Average TDS (mg/L)	Average Minimum TDS (mg/L)	Average Maximum TDS (mg/L)
Saddleback	1975	142	8075
Marradong	1686	53	7143
NBG	4227	108	8636

4.3.2.3 *Hydrological Response to Bauxite Mining*

Large increases in streamflow, stream salinity and salt load can occur following clearing for agriculture. However, agricultural clearing is usually permanent while clearing for bauxite mining is temporary. A recent study into the impacts of bauxite mining on streamflow within the Northern Jarrah forest found that there was an initial increase in streamflow, peaking approximately 4 years after mining entry into the catchment, followed by a return to pre-mine flows after about 11 years (Grigg, 2017). The peak response was estimated to be approximately 18% of rainfall, which was comparable to findings from previous studies in the area (Grigg, 2017). The findings indicated that neither disruption of the upper regolith nor the post-mining rehabilitation altered the fundamental factors influencing the amount of groundwater recharge. This lead to the conclusion that subsurface flow processes, considered to dominate streamflow generation in jarrah forest catchments, are likely to be limited to the valley floor and immediate surrounds, neither of which are typically impacted by bauxite mining (Grigg, 2017).

This finding matches with findings from Croton and Dalton (2004) within Worsley Operational Areas. Detailed studies were initiated in 1975 to understand the effects of Worsley's mining activities on stream flows, stream salinities and groundwater levels. Croton and Dalton (2004) found the peak difference between trough levels appeared to vary in the range 5.5 to 10.0 m, with an average of 7.0 m. For stream flows and salinities, a response to mining was observed where stream flows for the treated catchment were changed from peaky short-lived winter flows to those with a defined post-peak recession and with a pronounced baseflow that extended into spring and summer. Salinities also changed in 1996, from values in the range 100 to 200 mg/L to those in the range 200 to 500 mg/L. However, the total flows during the 23 year study period were small, 9.0 mm for Bee Farm and 12.2 mm for Tunnell Rd, which correspond to runoff coefficients of just 0.06% and 0.08% respectively. This indicates that the changes in flow have no significance at the water resources scale.

The most influential factor in the hydrological behaviour of Croton and Dalton (2004) study was found to be the below-average rainfall since 1975. Figure 4-1 shows the hydrographs for two piezometers, one in the control catchment and the other in the mined catchment. The mining related response in G6148103, can be clearly seen as a rapid rise from 1988. It can also be seen that due to the natural declines from lower rainfall since 1975, the groundwater response to mining does little more than temporarily return the groundwater levels to levels close to those of the late 1970s.

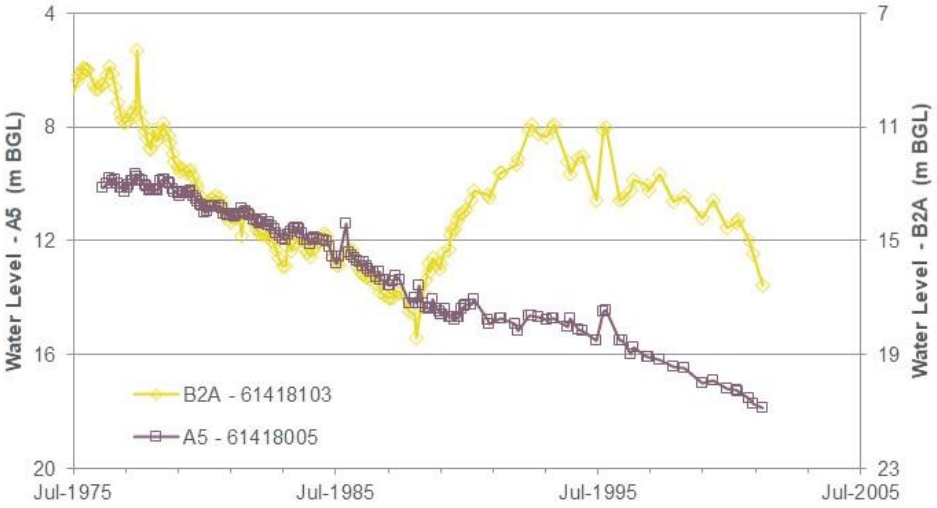

Figure 4-1: Depth to groundwater for control piezometer G6148005 in Tunnell Rd catchment and G6148103 in the Bee farm catchment (Croton & Dalton 2004).

This finding is further supported by McFarlane et.al (2020) who found that in the largely forested Darling Range, groundwater levels are falling below stream beds. This recorded ongoing decline in groundwater levels significantly reduces the potential risk of temporary groundwater mounding associated with bauxite mining.

Modelling undertaken as part of the Environmental Impact Assessment process for the Revised Proposal supports the findings of previous studies. The modelling found that changes in recharge dynamics due to bauxite mining have the potential to temporarily increase the water table by several metres, with a potentially large increase in the water table elevation immediately below the areas of clearing. However, the extent of mounding would be generally localised, with the magnitude of mounding decreasing towards low-lying areas and groundwater receptors (GHD, 2022).

A triennial aquifer review undertaken for the period 2017-2020 focussed on reviewing the effectiveness of management practices for minimising impacts on groundwater at the BBM. This study determined that the risk of groundwater levels rising above pre-

1975 levels during the period between clearing for mining and rehabilitation had continued to diminish due to the continuation of the low-rainfall period, resulting in declining groundwater-levels in forested areas (Croton, J.T., Mauger, G. W. and Dalton, J.A., 2021).

4.3.2.1 *Salinity Risk Assessment (Flux Density Analysis)*

The potential salinity-risk of bauxite mining depends on the initial groundwater-depth, the potential for the groundwater to rise, the salinity of the groundwater, the soil salt-storage profile of the valley floor, and the initial stream-salinity (Green et. al., 2023). To assess the salinity risk of Worsley's bauxite mining activities a Flux Density Analysis (FDA) is undertaken for each new mining area. To date this has been completed for Saddleback and Quindanning (Croton, J.T. and Dalton, J.A., 2004), Marradong (Croton, J.T. and Dalton, J.A., 2008) and Hotham North (Green et. al., 2023). The Flux Density Analysis process identifies high flux points and recommends additional monitoring locations for installation.

The most recent FDA for Hotham North (Green et. al. 2023) determined that the expected fluxes would be modest, and no high-risk areas for saline-groundwater discharge into fresh watercourses were identified. The groundwater in the valley floor of forested tributaries was 12 to 15 m below ground where measured, with groundwater rises expected to be less than 5 m, so the risk of saline discharge was considered to be low but not insignificant. Overall, it was considered that the salinity risk in the Hotham North Mining Area should be able to be managed through monitoring of key flux-density hotspots, with the potential for mine-planning adjustments to respond to any unforeseen groundwater-table rises (Green et. al., 2023). Worsley has agreed to install the additional monitoring locations recommended by Green et. al., 2023 (see Appendix A). The output from the FDA for Hotham North is presented as Figure 4-2.

4.3.2.2 *Groundwater Dependent Ecosystems*

Two types of GDEs, as defined by BoM (2020b), occur within the Project Area. These are:

- Aquatic ecosystems that rely on surface expression of groundwater. Within the BBM this includes the surface watercourses that receive groundwater inflow (Hotham River, Thirty Four Mile Brook, Marradong Brook and their tributaries), groundwater fed springs and swamps within the study area and their respective biological values; and
- Terrestrial ecosystems that rely on the subsurface presence of groundwater. Within the BBM and surrounding area this is considered to include riparian and phreatophytic terrestrial vegetation (depth to groundwater <10m), where vegetation has a seasonal or occasional dependence on groundwater.

Potential Groundwater Dependent Ecosystems (GDEs) are required to be identified within the PAA in accordance with condition C4-2(1) of MS1237. Potential GDEs were mapped by Mattiske (2021) based on the extent of the site-vegetation types that occurred in watershed areas and supported flora species known from wider botanical studies in the Northern Jarrah Forest to grow preferentially on seasonally wetter soils. This approach was considered to represent a precautionary approach in the absence of detailed groundwater level data being available across the PAA. Fifteen of the 40 site-vegetation types within the PAA were considered to represent potential GDEs. These site-vegetation types included A1, A2, AC, AD, AX, AY, AY/D, B, D, DG, L, SW, PW, Y and YG, which cover approximately 1,933 ha or 7% of the PAA (Mattiske, 2021). The G types associated with the low-lying watershed areas in the valleys (directly north of the PAA and BGM) and the heath in the valley north of Mount Saddleback (within the WMDE/BTC) were also included. However, these areas are likely to have surface aquifers in wetter seasons and may be reliant on water within 10 m below ground level (Mattiske, 2021). The extent of potential GDEs within the PAA is shown in Figure 4-3.

The identified GDE vegetation communities were further verified through completion of groundwater modelling (GHD, 2022). During the modelling process vegetation that occurred in areas within 10 m of the groundwater level were identified as being potential GDEs. The selection of the site-vegetation types as mapped by Mattiske (2021) were compared with these 10 m contours. The comparison showed a reliable alignment, despite the decrease in annual rainfall in recent years near Boddington (GHD, 2022).

GHD (2022) determined that in general, where mining occurs in topographically elevated areas, and the area of mining is relatively small, it is anticipated that groundwater mounding will dissipate during migration towards the discharge boundary (e.g., creeks and rivers). In that case the groundwater change should be sufficiently small to be within the existing natural variation of the water regime, and is not considered to pose an adverse risk to the GDEs. Where mining occurs in the lower topographical areas (where groundwater levels are shallower) any groundwater level rise has a reduced opportunity to dissipate, given the shortened distance to the creeks, rivers and associated GDEs, the groundwater level change may under certain conditions exceed natural variations. In this case impacts to GDEs may occur through saturation of the profile, mobilisation of salts, increased salt load and increased volumetric discharge to the surface water features.

Groundwater modelling was undertaken to determine the risk associated with potential groundwater mounding for the Revised Proposal. A further risk assessment for GDEs was conducted taking into account the existing groundwater level. GDE areas were deemed sensitive to groundwater level changes when located in areas where the groundwater level was shallow (0 to 2 m

below ground level), given that any mounding impacts in these areas will cause a relatively large decrease in unsaturated profile (GHD, 2020a). GDE areas deemed less sensitive to groundwater level alterations were those areas where groundwater level was deeper (5 to 10 m below ground level) as any mounding impacts will cause a relatively small decrease in unsaturated profile (GHD, 2020a). In general, GDE vegetation communities that utilise deep groundwater are typically trees, and these communities have been shown to be adaptable to changes in groundwater levels (GHD, 2020a). The outcomes of this risk assessment are presented in Figure 4-4. This was determined by applying the maximum modelled groundwater mounding to the zero clearing groundwater model state. Figure 4-4 provides the outcomes of the risk assessment in relation to areas of potential GDEs as identified by Mattiske (2021).

4.3.2.2.1 Mount Saddleback Heath Communities PEC

Areas of Mount Saddleback Heath Communities listed by DBCA as a Priority 1 Priority Ecological Community (PEC) are present at the BBM within the operational envelope (DBCA 2019). The Mount Saddleback Heath Communities are considered likely to represent groundwater dependent ecosystems (GDEs). The largest area of this PEC located within the Project Area is on Tunnell Rd and has a long history of groundwater abstraction and environmental monitoring. The area was first developed as an operational borefield in the early 1980s and continues to be utilised for this purpose. Mount Saddleback Heath Communities are protected in accordance with the Protected Areas Plan (01013619).

As discussed in Section 4.3.2.1 a triennial aquifer review undertaken for the period 2017-2020 found that continued low rainfall had continued to diminish the risk of rising groundwater levels associated with bauxite mining activities (Croton, J.T., Mauger, G. W. and Dalton, J.A., 2021). The report also found that the water level and quality in the Tunnell Rd borefield had remained stable over the review period suggesting that the heathland was well protected under current management measures (Croton, J.T., Mauger, G. W. and Dalton, J.A., 2021).

4.3.2.3 *Threatened Flora*

Detailed baseline vegetation and flora monitoring has been completed within the PAA and surrounding areas as detailed in the Revised Proposal ERD (Worsley, 2022). This baseline assessment included the identification of Threatened flora within and surrounding the PAA (Mattiske, 2021). Locations of Threatened flora identified within the PAA during the baseline assessment are included in Figure 4-4: GDE groundwater mounding risk assessment output and potential GDEs and C hopperiana locations (GHD, 2022 and Miattiske, 2021).

Targeted surveys for conservation significant flora will be completed as part of the pre-clearance surveys in accordance with the requirements of Condition B12-5 of MS1237. Any Threatened flora identified during these targeted surveys will be allocated to a Protected Area including a minimum 50 m buffer.

4.3.2.4 *Water Supply*

BBM currently abstracts ~500 ML/a of groundwater to support bauxite mining operations, as operations extend northward it is anticipated that water requirements will increase to ~900 ML/a primarily due to the increased dust suppression requirements for greater haulage distances.

BBM's current water supply utilises groundwater, surface water and recycled water as described below.

- Production Bores
  - Shallow production bores: average depth of approximately 35 m, targeting the shallow aquifer. These bores are located within the Saddleback Timber Reserve within the Tunnell Road borefield, and the Karafil Road borefield.
  - Deep production bores: located in fractured rock aquifers within the Saddleback and Marradong Timber Reserves. These bores are located in the Tunnell Road borefield, South East borefield, Karafil Road borefield, Fawcett borefield and Marradong borefield. These bores range in depth from 38 m to 103 m.
- Water storage dams or tanks constructed at each borefield hold abstracted water which is then either taken directly from the dam and used to suppress dust on haulroads, pits and other cleared areas or is pumped via pipeline to a water storage tank. Prior to use on haul roads all water is dosed with hypochlorite to ensure that the risk of spread of dieback is minimised.
- Potable water is produced at Marradong from abstracted groundwater through the use of a reverse osmosis water treatment system.
- Potable water is produced at Saddleback from the Tunnell Road borefield which is processed through a water treatment process including chlorine and caustic dosing and particle filters.
- Surface Water: Surface water use is limited to opportunistic use of rainfall collected in sumps and dams located throughout operational areas. These dams and sumps are designed to hold abstracted groundwater and / or potentially contaminated stormwater / recycled water from operational areas only (no catchment) and do not require a surface water licence.

- Recycled Water: All wastewater generated at the Saddleback workshop facility will be managed in accordance with the BBM Part V licence (L5960).

Additional water requirements for mining operations will continue to target groundwater as the primary source of supply. Additional production bores will target the deep fractured rock aquifer.

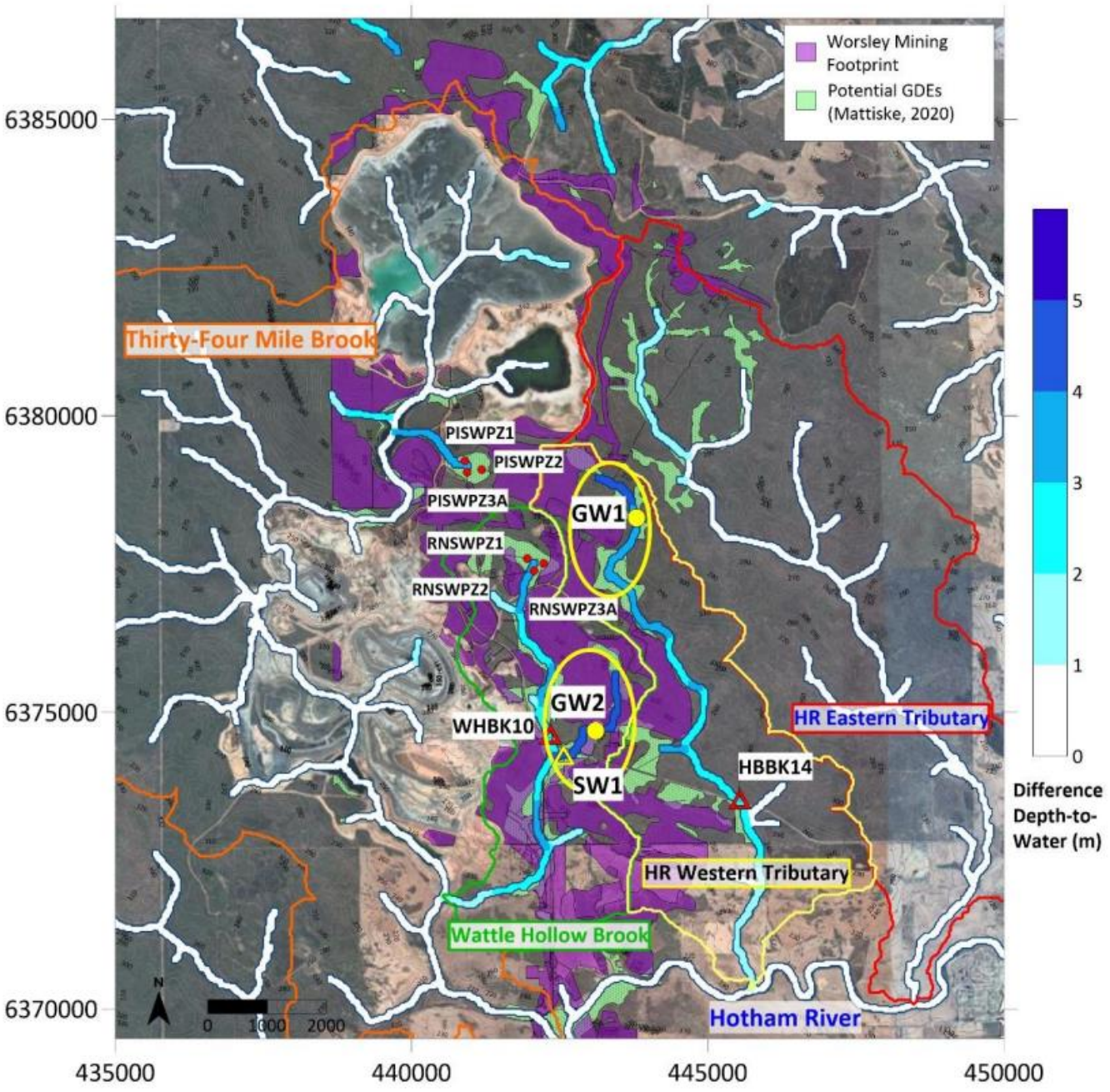

Figure 4-2: Map of the FDA estimated change in groundwater level along the valley floor due to land clearing of the Worsley mining footprint compared to the current catchment land use (Green et. al. 2023)*.

*** Includes recommended new and continued surface and groundwater monitoring locations.**

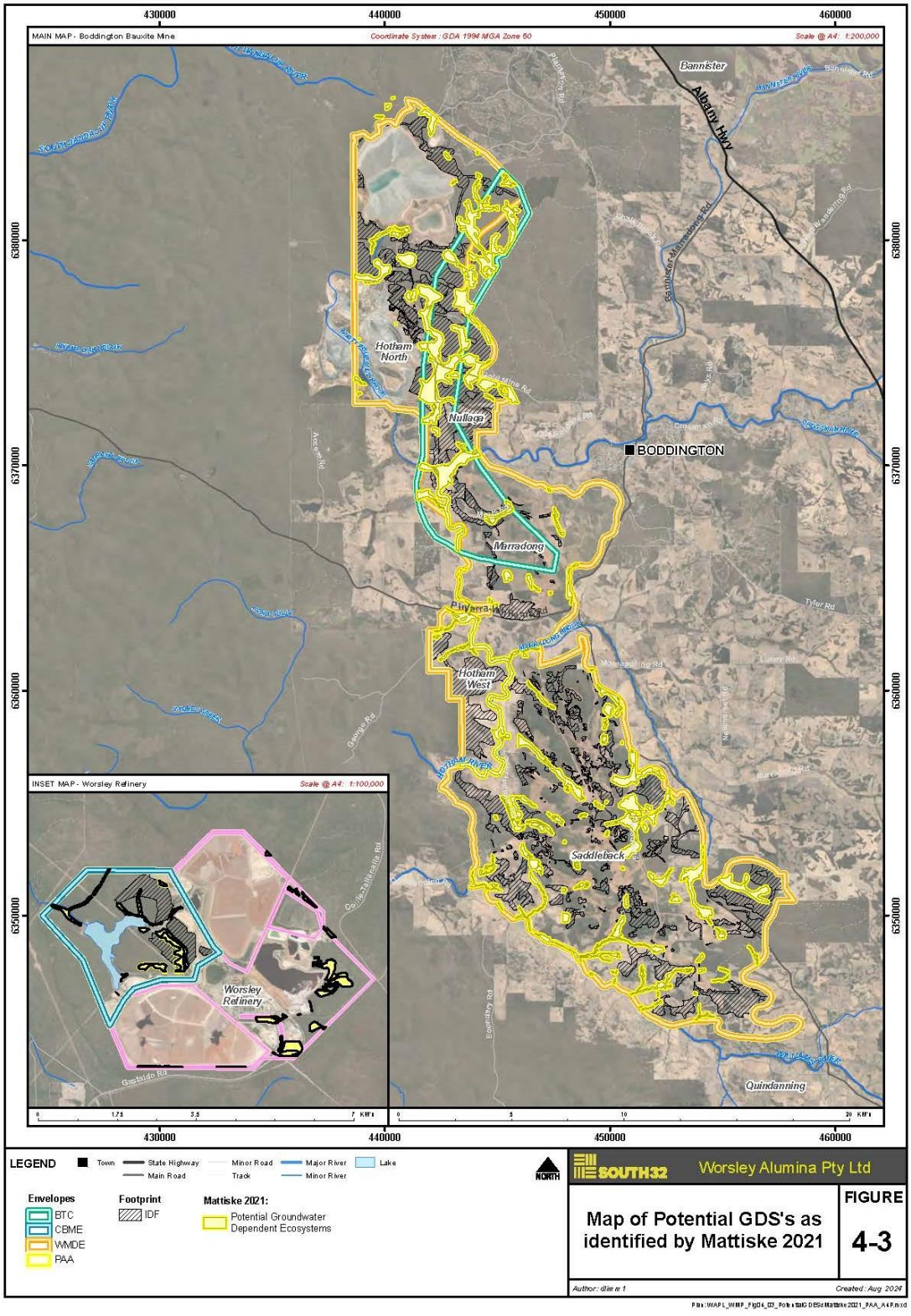

Figure 4-3: Map of potential GDEs as identified by Mattiske (2021)

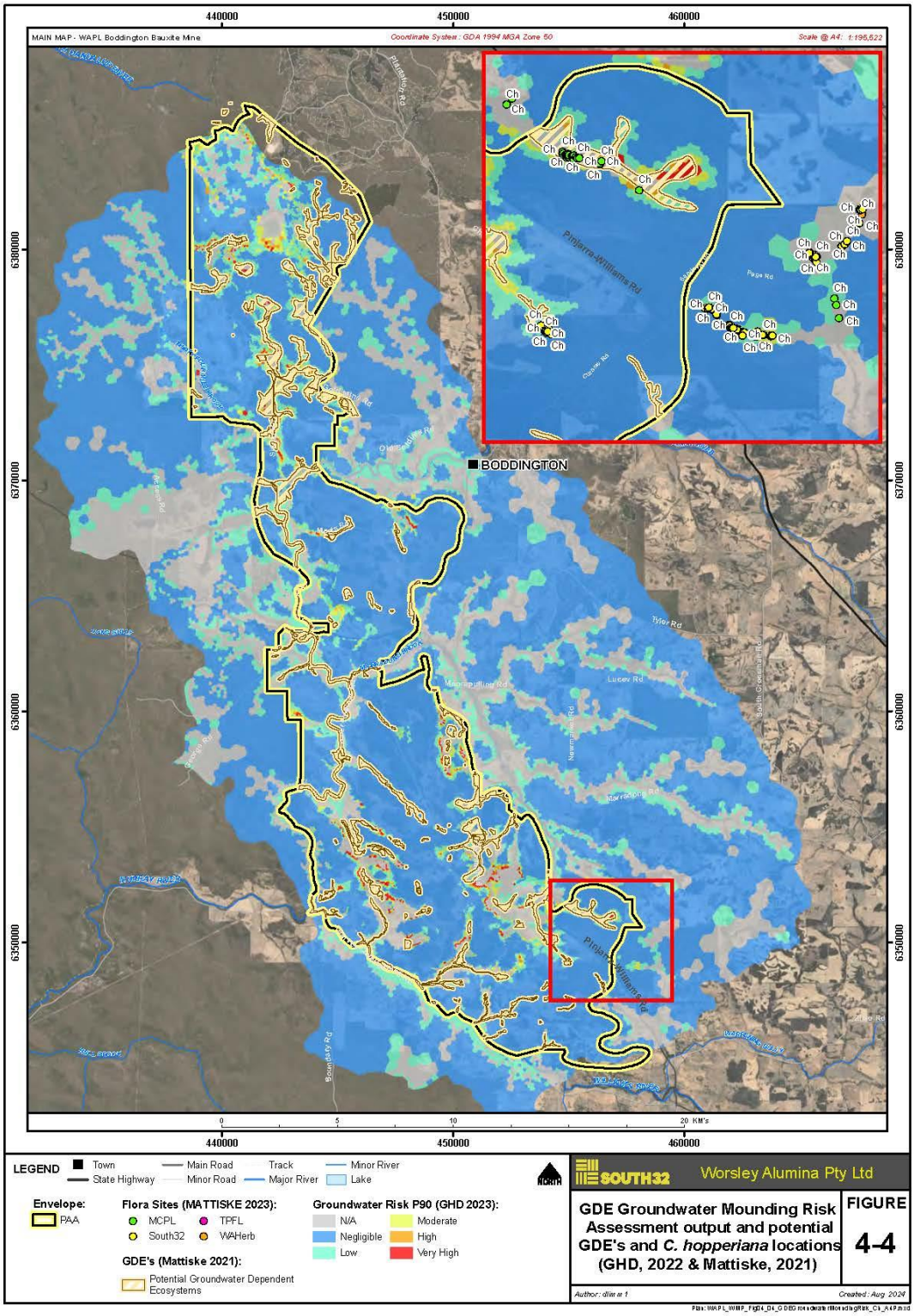

Figure 4-4: GDE groundwater mounding risk assessment output and potential GDEs and C hopperiana locations (GHD, 2022 and Mattiske, 2021)

4.3.3 Refinery

4.3.3.1 *Surface Water:*

The Refinery occurs within the Augustus River catchment, a tributary of the Brunswick River which is primarily used for agricultural purposes. The Freshwater Lake (FWL) at the Refinery was built in 1983 with the primary purpose of supplying fresh water to the Refinery.

The refinery water management system separates the refinery lease area into two catchments (see Figure 4-2):

- a clean water catchment in which clean surface water runoff is directed to the Freshwater Lake, which in turn discharges to the Augustus and Brunswick Rivers; and
- a contained, high-contamination risk catchment, which directs process liquors, water that comes into contact with process areas (including materials handling and refining areas, spill containment structures and residue areas) and recirculated process waters into the Refinery Catchment Lake.

The system consists of four key elements (see Figure 4-2):

1. Freshwater lake (FWL) - all clean and uncontaminated water from the catchment is directed into the FWL through a series of diversion and collection channels, separating this water from any potential sources of contamination. The FWL supplies potable water, water for Bayer process activities, cooling water and occasional make-up water to the refinery catchment lake. The only water which leaves the refinery lease area is uncontaminated and is discharged as overflow or via a gravity fed pump.
2. Refinery catchment lake (RCL) - collects runoff from the refinery, and seepage decant water and runoff from the residue disposal areas. The RCL is used for cooling purposes at the refinery and power station and as process water. The RCL is designed to withstand a storm of probable maximum precipitation without overflowing.
3. Pipehead dams – receive all decant and underdrainage water from the residue disposal areas and any seepage from under the refinery catchment lake and return these waters to the refinery catchment lake.
4. Solar evaporation ponds (SEP) - used for storage of oxalate.

Access to water is a critical enabler for the Refinery operations and a key resource for all communities within the South West. On a regional scale, the challenges associated with water management are likely to increase, with modelling suggesting a decrease in mean annual rainfall of 7 per cent and a 14 per cent reduction in surface water runoff in the period 2021 to 2050 relative to the period 1961 to 1990. If current climate trends continue, the South West of Western Australia will potentially experience 80 per cent more drought-months by 2070[1].

Supplementary water can be supplied via direct purchase through local providers, although this requires agreement with several providers and regulators to permit and allow purchase to progress. The main source of purchased water is from Wellington Dam. Water can be imported directly to the RCL via a dedicated pipeline if modelled rainfall and / or drought are likely to impact Refinery production. The site managed water balance calculations determine the amount to be purchased.

4.3.3.2 *Groundwater*

Three main aquifers and one aquitard have been described for that part of the Augustus River catchment occupied by the Refinery Lease Area (Wilkes et al. 2004). These are:

- shallow weathered zone aquifer comprising clayey sands and of 1 to 4 m thickness
- deep weathered zone aquifer characterised by weathered granite and ranging from 15 to 40 m thickness; and
- fractured zone aquifer within basement rock and along margins of dolerite dykes, and •saprolite clay aquitard between the shallow and deep weathered aquifers.

All aquifers remain localised and no locally significant abstraction from these aquifers is known to occur.

[1] Australian Government Department of the Environment and Energy; https://www.environment.gov.au/climate-change/climate-science/impacts/wa

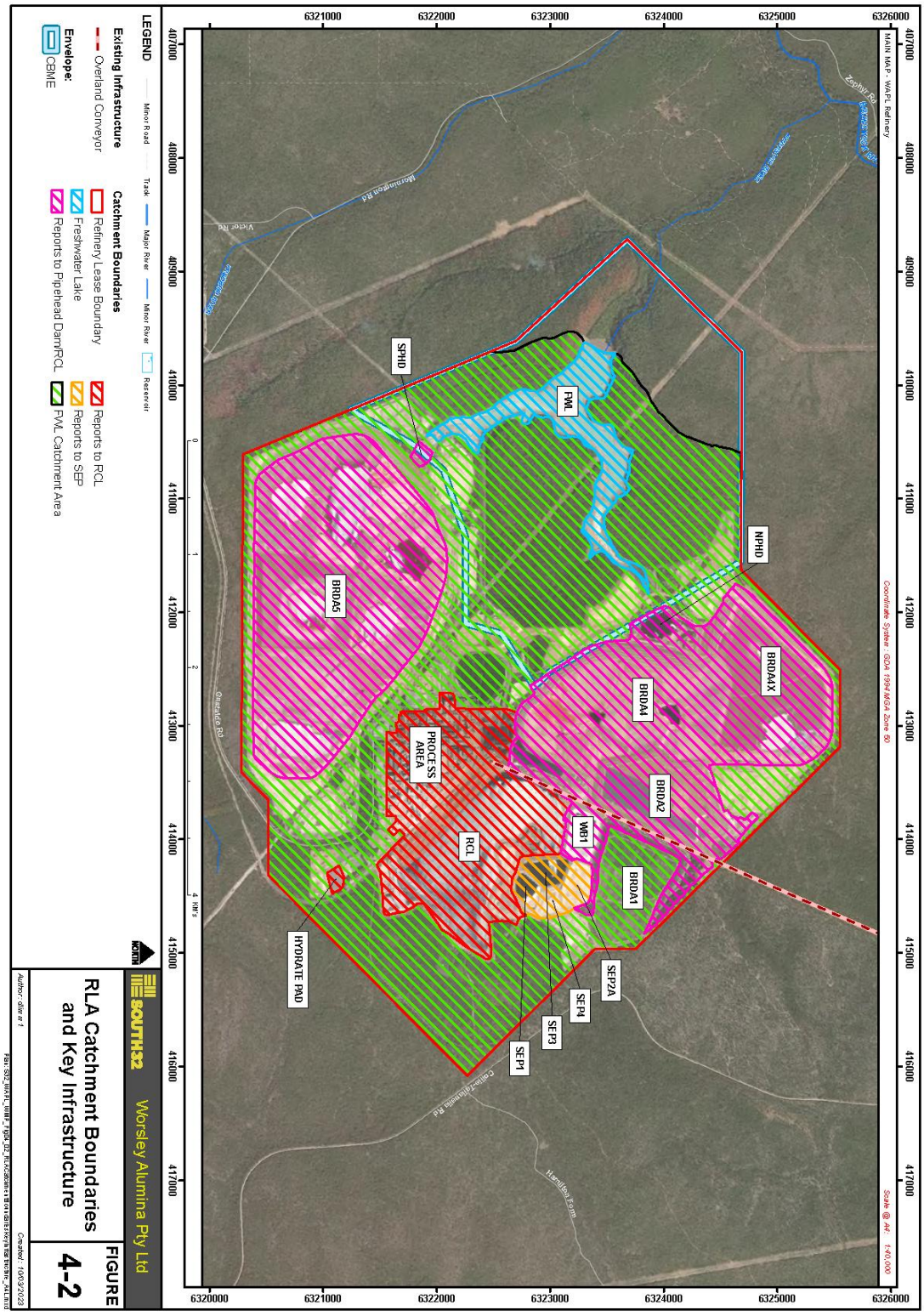

Figure 4-5: Refinery surface water catchments and key elements

4.3.3.1 *Environmental Water Provisions*

In May 2001, the Water and Rivers Commission (WRC, now the DWER) released the Environmental Water Provisions Policy for Western Australia, which formally recognised the setting aside of water for the environment. The policy aims to provide for the protection of water dependent ecosystems while allowing for the management of water resources for their sustainable use and development to meet the needs of current and future users.

The DWER has adopted the concepts of ecological water requirements and environmental water provisions. Ecological water requirements are defined as: 'the water regimes needed to sustain key ecological values of water-dependent ecosystems at a low level of risk' (WRC, 2000). The DWER defines environmental water provisions as: 'the water regimes that are provided as a result of the water allocation decision-making process taking into account ecological, social and economic impacts' (WRC, 2000).

Ecological water requirements are determined based on the best scientific information available and are the primary consideration in the determination of environmental water provisions. Environmental water provisions may meet in part or in full the ecological water requirements. The DWER's preference is for the environmental water provisions of a water resource to be no less than the ecological water requirements.

Worsley will continue to work with the DWER to ensure any changes to operational water supply or requirements at the Refinery are in line with the Water Provisions Policy.

4.3.4 Carter's Freshwater Mussel

Aquatic-specific studies, listed in Table 4-3 have identified the presence of *Westralunio carteri* (Carter's Freshwater Mussel). The species has been recorded in the Freshwater Lake (located at the Refinery) and in the Augustus River, downstream of the Refinery (Hale et al, 1999 & Stantec, 2021). In addition, Carter's Freshwater Mussel has been recorded in several regional reference sites surrounding the Refinery Lease Area.

Table 4-3: Aquatic fauna baseline survey program

Mining Area	Survey Type	Description/Key Parameters Measured	Status/Timing
Primary Assessment Area (WMDE, and CBME)	Aquatic fauna survey	Carter's Freshwater Mussel Survey at Williams and Hotham Rivers (Stantec 2022)	2022
Refinery	Aquatic fauna survey	Water Quality Aquatic Macro-invertebrate and Fish monitoring of the Worsley Freshwater lake and Brunswick River Catchment (Worsley).	1999
		Augustus River Ecological Monitoring Program (WRM)	2010
		Ecological Water Requirements of Augustus River (WRM).	2005
		Refinery Freshwater Lake - Mercury Bioaccumulation in Carter's Freshwater Mussel and Habitat Values Assessment (Stantec)	2021

Further taxonomic studies to understand variation of Carter's Freshwater Mussel by Klunzinger et. al. in 2022 found that there were three sub-species of *Westralunio carteri.* They are described as "*W. carteri*" I as *Westralunio carteri* (Iredale, 1934) from western coastal drainages, "*W. carteri*" II and "*W. carteri*" III as *Westralunio inbisi* sp. nov. from southern and lower southwestern drainages. Two subspecies are further delineated: "*W. carteri*" II is formally described as *Westralunio inbisi inbisi* subsp. nov. from southern coastal drainages, and "*W. carteri*" III as *Westralunio inbisi meridiemus* subsp. nov. from the southwestern corner. *W.carteri* I is the sub-species present within the FWL and downstream within the Augustus River and other surrounding locations as identified in baseline surveys (Stantec, 2021).

The following information has been sourced from a GHD species review (GHD Memo, Environmental Approvals support for South 32, 2019) and further studies completed by Stantec (Stantec Memo, Worsley Refinery Freshwater Lake, 2021).

Description / Habitat

Carter's Freshwater Mussel is an elongate-shelled bivalve mollusc that can grow to 100 mm long, but rarely exceeds 90 mm. This species is endemic to south-western Australia where its current distribution is patchy and extends from around Gingin south to Waychinicup. Formerly, its distribution extended into the interior of the South West, but now it rarely occurs more than 50 km inland. It inhabits freshwater lakes, river systems, and other waterways favouring sandy or muddy sediments and is often associated with woody debris (Klunzinger et.al 2012a).

Newborn mussel larvae are less than 0.5 mm in length and have larval "teeth" used for temporary attaching to host fish gills. This is an important mechanism in the lifecycle that enables the mussel larvae to disperse upstream.

After several weeks, the juvenile mussels detach from the host fish and settle into creek bed sediment or other suitable riverbed substrate where they begin filter-feeding and growing (Klunzinger et.al 2012b). Mussels burrow into substrate and can move short distances using a muscular foot that is extended from the shell. They can also disperse downstream via water flow. This species can aestivate by burrowing deep into riverbeds during natural seasonal cycles when rivers dry. The lifespan is potentially in excess of 50 years.

Carter's Freshwater Mussel is thought to be an important species within the freshwater ecosystem of the South West. It is likely to have bio-filtration benefits to water quality by filtering algae, bacteria and other micro-organisms and organic particles (Pusch et al. 2001; Bogan 2008). The mussel also provides a source of food for other invertebrates such as freshwater crayfish, and a variety of vertebrate groups including fishes, turtles, birds and water rats (Walker et al. 2001). Additionally, mussels in general act as a bio-monitor of environmental quality due of their tendency to concentrate and store toxic substances such as heavy metals and pesticides (Walker et al. 2001).

The decline of Carter's Freshwater Mussel in the South West region is linked to increased salinity within the river systems (Klunzinger et.al 2015). Major river systems that have been severely impacted by salinity include Moore, Avon, Blackwood, Murray, Williams, Upper Warren, Upper Kent, Frankland, Bow and Lower Canning Rivers. Widespread increase in river salinity in the South West has resulted in a 50 percent reduction in this species' range (Klunzinger et.al 2015).

Distribution

There are few recent records of Carters' Freshwater Mussel of local or regional significance to the PAA. Several recent records have occurred in the vicinity of the CBME including: Augustus River, recorded in 2017 approximately 4 km north east of the CBME; 8.5 km west of the CBME in 2010, and records from the Collie River and Wellington Dam catchment area approximately 10 km south of the CBME in 2009 to 2011. Hale et.al (1999) recorded the species at two locations within the CBME artificial freshwater lake during water quality monitoring. These two mussel localities are not listed within the DBCA database searches. Stantec (2021) recorded five live individuals within the Freshwater lake and a healthy population within the Augustus River.

Stantec (2021) considered that the Freshwater Lake (an artificial constructed dam) did not reflect critical habitat for Carter's Freshwater Mussel given a number of factors including:

- variation and decline in water levels influenced by climate and abstraction for operational requirements;
- seasonally elevated turbidity;
- limited in-stream habitat;
- lack of connectivity for upstream/downstream migration; and
- a possible lack of freshwater fish as compatible parasitic larval hosts (Stantec, 2021).

A NatureMap database search identified 393 records of this species within the South West region. Figure 4-6 presents Carter's Freshwater Mussel records locally relevant to Worsley's operations. Most of the observations in the vicinity of the PAA were recorded between 1905 to 1971 (GHD 2019).

Klunzinger et al. (2015) has mapped the habitat suitability of the estuarine waterways and perennial streams of the southwest for the Carter's Freshwater Mussel based on the recorded salinity and presence or absence of the species. The river systems associated with the WMDE and BTC represent former potential habitat and are east of the current known distribution. In the catchment areas of the WMDE and BTC, the Hotham and Murray Rivers have been mapped as 'unsuitable habitat' and the Williams River and the Marradong and Thirty-Four Mile Brook have been mapped as 'unlikely to occur'. In addition, the DWER (2020) Healthy Rivers South-West database does not identify the WMDE or BTC areas as areas the species is likely to be found. In summary, there is a low likelihood of the species occurring in the WMDE and BTC and systematic targeted searches of the species over the past 20 years have confirmed this assumption (GHD Memo 2019).

A targeted survey for Carter's Freshwater Mussel was completed within the Williams and Hotham Rivers (Stantec, 2022) this survey did not identify the species to be present within either river system. The survey postulates that it is likely that the species is now completely extinct from Hotham and Williams Rivers, although historically the river systems were within their range. This absence is most likely driven by high salinity. Laboratory tolerance trials have shown that Carter's Freshwater Mussel has an acute salinity tolerance (LD50) of 1.6–3.0 g/L. The salinity levels at both Williams (7.02 to 8.79 g/L) and Hotham (8.54 to 11.78 g/L) are substantially higher than these tolerance levels (Stantec, 2022).

Potential Impacts and Threats

Potential impacts described below are based on impacts on important populations of Carter's Freshwater Mussel. An 'important population', as defined by the Department of the Environment (DoE – now DCCEEW) (2013), is a population that is necessary for a species' long-term survival and recovery. It is not known how many, if any subpopulations occur across the range of this species, however it is recognised that an increase in salinity impacting surface water quality has negatively influenced populations and distributions.

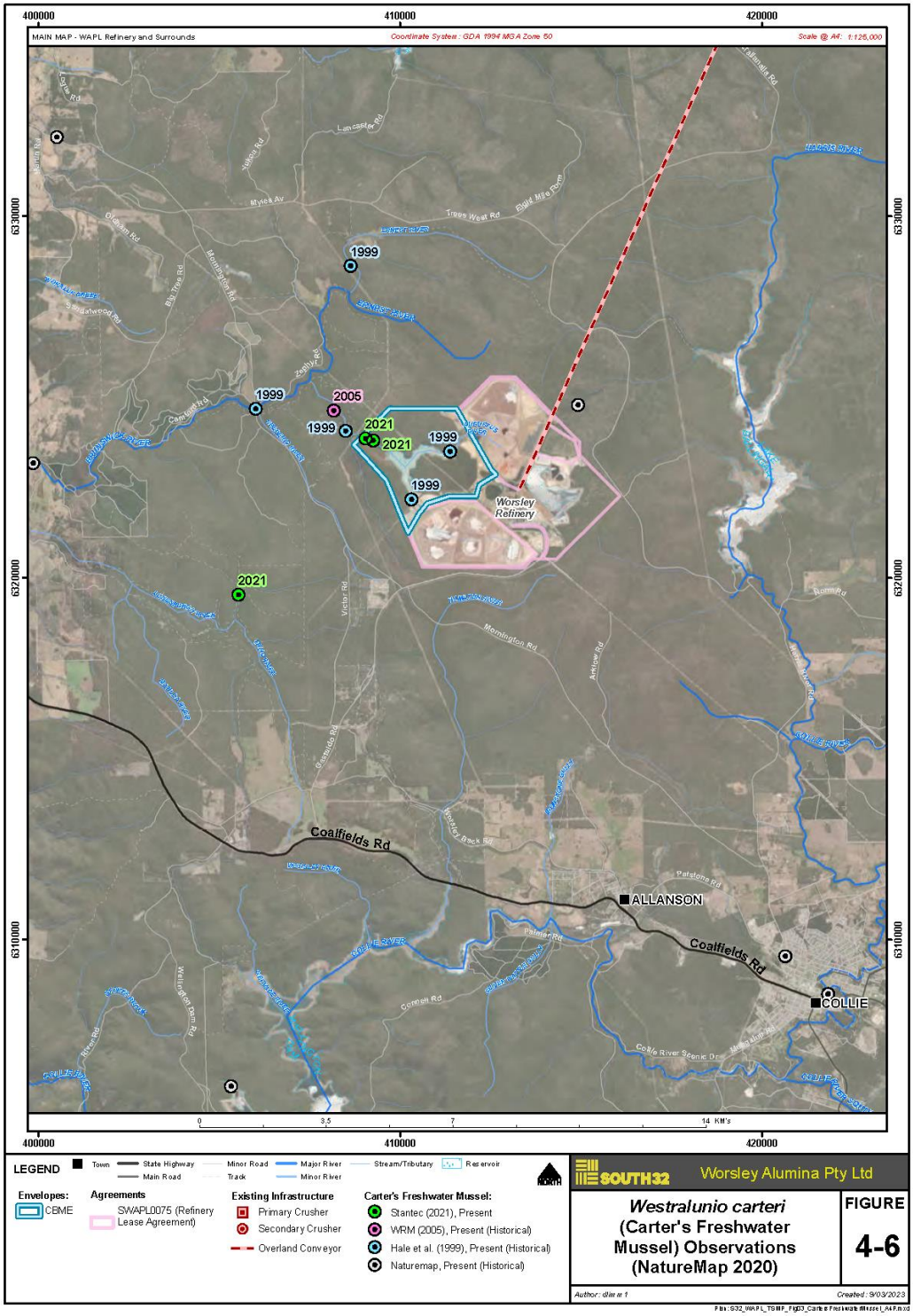

Figure 4-6: Worsley *Westralunio carteri* (Carter's freshwater Mussel) observations (NatureMap, 2020)

As discussed above, the WMDE and BTC are located outside the current known distribution of Carter's Freshwater Mussel. The species has been recorded in the Freshwater Lake and immediately downstream of the Freshwater Lake in the Augustus River as shown in (Stantec, 2021). Assuming environmental management and mitigation measures are implemented to avoid habitat loss and maintain water quality (including maintaining salinity levels to within tolerance levels), activities associated with the Revised Proposal within the PAA are unlikely to have a significant impact on the species.

Potential threats to Carter's Freshwater Mussel include:

- Drying climate / reduced rainfall;
- Water contamination;
- Population fragmentation;
- Habitat loss (clearing / Phytophthora dieback);
- Disrupted breeding cycle;
- Salinity;
- Introduced / feral species; and
- Water extraction / stream divergence.

A set of outcomes-based management provisions have been defined for Carter's Freshwater Mussel as outlined in Table 5-4.

4.4 KEY ASSUMPTIONS AND UNCERTAINTIES

The key assumptions and uncertainties within this WMP include:

- Local hydrological conditions for potential GDEs remains uncertain with ground truthing yet to be completed. The precautionary principle has been applied in this instance so that all potential GDEs (as identified by Mattiske, 2021) are assumed to represent GDEs until ground truthing confirms otherwise.
- The sensitivities of GDEs and SWDEs to changes in groundwater levels remains an area of some uncertainty and additional studies are required to ensure that impacts on any verified GDEs are minimised.
- Location of additional production bores are yet to be defined. Once the abstraction network is defined additional modelling will be conducted to ensure that any additional risk areas identified have monitoring bores installed with appropriate trigger and threshold limits to ensure compliance with environmental outcomes.
- Annual abstraction location and amounts may change over time.
- Additional monitoring bores will be required as mining progresses.
- Trigger levels will be refined over time as additional data is collected and collated.
- Inherent uncertainty associated with hydrological modelling. This is addressed through the completion of surface water and groundwater monitoring.
- Sufficient water will be able to be sourced to support mining and Refinery operations into the future.
- Clearing footprint is indicative.
- Impacts associated with surface water turbidity assume all runoff from operational areas are maintained within the operational footprint until final rehabilitation landform is established at which point the areas become free draining to the environment.
- Water contained within the operational area infiltrates to recharge groundwater.

4.5 RATIONALE FOR CHOICE OF INDICATORS

4.5.1 Potential Impacts

The environmental outcomes addressed by this WMP are largely interconnected and reflect potential direct and indirect impacts associated with changes in surface water and groundwater quality and quantity within the environment. Given this, selected indicators and associated trigger levels can often be applied to multiple environmental outcomes.

The environmental impact assessment process identified the following potential direct and indirect impacts to the environment for Inland Waters:

- Groundwater mounding associated with temporary removal of deep rooted vegetation;
- Increases in salinity in groundwater associated with groundwater mounding;
- Increase in stream salinity due to increase in saline groundwater discharge to streams;
- Changes in surface water flows associated with change in land use and landform or increased groundwater discharge.

These impacts are interconnected and have a limited duration associated with the temporary change in land use during mining activities. The expected duration of the identified potential impacts represents the period from initial clearing within a given area until the reestablishment of deep-rooted vegetation. We know from studies of the bauxite mining operations of Alcoa World Alumina Australia in the High Rainfall Zone of the Darling Plateau, e.g. Croton (in press) and Ruprecht, et al. (1990), that groundwater levels typically return to those equivalent to the unmined situation within 5 to 20 years (Croton, JT & Dalton JA, 2004).

4.5.2 External Contributing Factors

The catchments within which Worsley operates are large with many contributing factors that must be factored into an assessment of impacts. Of highest relevance are:

- Drying Climate: the drying climate has led to a regional decline in groundwater levels and reduced surface water flows. An increase in the frequency of extreme weather events must also be considered.
- Historic land use: areas surrounding the Worsley operation are largely used for agricultural purposes with most native vegetation historically removed. Some areas are also utilised for plantation and the harvesting of these plantation crops are likely to influence groundwater and surface water.
- Dryland salinity: The Hotham River and Williams River are known to be impacted by salinity associated with historic land clearing in the upper catchments.
- Newmont Boddington Gold (NBG): Worsley's operations will be adjacent to the existing NBG facility. Potential cumulative impacts have been considered in the EIA process to ensure that required environmental outcomes are achieved.

4.5.3 Selected Indicators

A summary table of the indicators selected to ensure compliance with each environmental outcome and the rationale for their selection are included in Table 4-3.

Table 4-4: Indicators selected for ensuring compliance with environmental outcomes

Environmental Outcome	Selected Indicators	Monitoring Program	Justification and Trigger Level	Ref
1. No disturbance or adverse impacts to *Caladenia hopperiana* or *Caladenia caesarea* subsp. Mooradung associated with surface water and / or groundwater changes.	Depth to groundwater (mbgl)	BBM Targeted GDE Groundwater	*C. hopperiana* and *C. caesarea* subsp. Mooradung are both shallow rooted species. Depth to groundwater trigger levels have been established in Appendix A using a risk based approach to ensure that groundwater mounding does not lead to adverse impacts on these two species.	4.10.2 Table 12-8 Table 12-9
	Groundwater salinity (TDS)	BBM Regional Groundwater	Increasing salinity associated with groundwater mounding has the potential to impact these two species and their habitat. This is a secondary impact associated with groundwater mounding. Changes in groundwater level, and thus salinity, occur over extended periods of time and are observed as long term trends compared with control sites outside the influence of Worsley operations. The monitoring bores installed within and surrounding Quindanning Timber Reserve (surrounding the *C. hopperiana* populations) were installed in 2005 providing up to 19 years of historic monitoring data for comparison and understanding of Regional trends. Worsley has installed loggers in all targeted groundwater monitoring bores which are downloaded on a quarterly basis. Downloaded data is reviewed internally on an annual basis and is reviewed externally by a qualified hydrogeologist on a triennial basis. The identification of any concerning trends within targeted monitoring bores during this triennial review represents the trigger level for this indicator.	Table 12-1 Table 12-7
	Surface water salinity (EC/TDS)	BBM Regional Surface Water	During the winter and spring period areas in east QTR supporting *C. hopperiana* are known to become inundated with surface water with seasonal flows occurring within an unnamed tributary to Marradong Brook. This waterway will be sampled on a monthly basis during flows. Trigger and threshold values for TDS will be established following a minimum 12 month baseline monitoring period. These levels will be set so as to prevent potential indirect impacts associated with changes in salinity in surface water from affecting *C. hopperiana*. Trigger values will reflect a change in EC/TDS equivalent to 2SDE from the average baseline value.	Table 12-5 Table 12-7
	Presence and abundance of *C. hopperiana* and *C. caesarea* subsp. Mooradung.	Targeted flora survey for *C. hopperiana* and *C. caesarea* subsp. Mooradung	This indicator will be used to verify the effectiveness of all management measures (including those specific to Inland Waters) in achieving the environmental outcome. The targeted flora monitoring program will be conducted 3 yearly across potential impact and control sites to verify the continued presence and abundance of known populations of *C. hopperiana* and *C. caesarea* subsp. Mooradung. Targeted surveys will continue for the duration of potential impacts plus two subsequent monitoring periods whilst rehabilitation in surrounding areas is establishing. Following this surveys may continue but at a reduced frequency.	Table 5-1

Environmental Outcome	Selected Indicators	Monitoring Program	Justification and Trigger Level	Ref
			Note: Targeted surveys for Conservation significant flora are included in Pre-Clearance procedures. Any newly identified individuals / populations of C. hopperiana and C. caesarea subsp. Mooradung will be incorporated into this targeted flora monitoring program.	
2. No adverse impacts to conservation significant flora, fauna or ecological communities as a result of surface and/or groundwater changes attributable to the proposal.	Depth to groundwater (mbgl) Groundwater salinity (EC/TDS)	BBM Regional Groundwater Refinery Regional Groundwater	The regional groundwater monitoring programs at BBM and the Refinery provide a wide network of monitoring sites designed to identify local changes in groundwater and identify regional changes in groundwater levels and salinity. Changes in groundwater level, and thus salinity, occur over extended periods of time and are observed as long term trends compared with control sites outside the influence of Worsley operations. Worsley has loggers installed in targeted groundwater monitoring bores and takes measurements at peak and trough for other regional sites. All monitoring data for BBM is reviewed internally on an annual basis and is reviewed externally by a qualified hydrogeologist on a triennial basis. The identification of any concerning trends within targeted monitoring bores during this triennial review represents the trigger level for this indicator. At the Refinery the monitoring program is targeted at early detection of contamination of groundwater and as such has real time sampling (every 6 hours) for water level and EC. This sampling program will support the identification of impacts associated with groundwater changes in the event that mining occurs within the CBME. Monitoring data at the Refinery is analysed by an external Hydrogeologist on an annual basis. This report is provided as an attachment to the AER.	4.9 12.1 Table 12-7 4.9 12.2
	Surface water salinity (EC/TDS)	BBM Regional Surface Water Refinery Regional Surface Water	The Regional Surface Water monitoring programs identify upstream and downstream monitoring locations where possible to allow determination of impacts from Worsley operations on surface water quality. Trigger levels are set to ensure downstream water levels remain within 2SDEV of the average upstream water quality for EC/TDS and Turbidity. This minimizes the potential for non-operational impacts leading to trigger level exceedances and allows for some natural variation within the system associated with first flush events whilst still ensuring levels remain within the expected tolerance range for the ecosystems supported by the waterways. Where an upstream location is not available a trigger level is determined based on the previous two years of monitoring prior to Worsley operations commencing within the applicable sub-catchment.	4.9 12.1 Table 12-7
	PEC vegetation health	5 Yearly Heath and Protected Areas	These indicators will be used to verify the effectiveness of all management measures (including those specific to Inland Waters) in achieving the environmental outcome.	

Environmental Outcome	Selected Indicators	Monitoring Program	Justification and Trigger Level	Ref
	Presence of Conservation Significant flora and fauna	Vegetation Condition Assessment Targeted flora surveys Targeted fauna surveys	Five Yearly vegetation health assessments will be completed within Protected Areas supporting conservation significant flora, vegetation and communities to ensure that management measures have been effective in maintaining the systems in a healthy state. Targeted flora and fauna monitoring programs will be conducted in Protected Areas and Ecological linkages to verify the presence and abundance of conservation significant flora and fauna in these areas.	4.10.2 4.10.4
3. No adverse impacts to native vegetation within or adjacent to the PAA as a result of surface and / or groundwater changes attributable to the proposal.	Depth to groundwater (mbgl) Groundwater salinity (TDS) Surface water salinity (TDS)	BBM and Refinery Regional Groundwater BBM and Refinery Regional Groundwater BBM and Refinery Regional Surface Water	Native vegetation within and adjacent to the PAA has been surveyed to understand the vegetation types present. Groundwater modelling has been completed to understand the potential areas of impact and define any potentially sensitive areas (i.e. GDEs). A Targeted groundwater monitoring program has been designed for these more sensitive areas (refer Outcome 5 below). The Regional groundwater monitoring programs address the less specific risk of adverse impacts to vegetation from changes in groundwater quality and quantity with monitoring focused on identifying regional trends in depth to groundwater and salinity. The Regional surface water monitoring program is designed to identify changing quality in surface water primarily turbidity and salinity. In addition, Worsley monitoring flow from existing DWER gauging stations to understand any changes in flow rates in the major rivers in the region.	4.9 12.1 12.2
	Vegetation condition	Regional vegetation condition assessment (5 yearly)	To verify the effectiveness of the above monitoring programs and triggers to achieve the required outcome a 5 yearly assessment of the vegetation health within and adjacent to the PAA will be conducted. This will rely on remote sensing with field validation to confirm vegetation health.	4.10.2.1
4. No adverse impacts to hydrological regimes and water quality of the Hotham River, Marradong Brook, Augustus River, Murray River, Williams River and Thirty-Four Mile Brook attributable to the proposal.	Surface water salinity (TDS) Surface water turbidity (TSS)	BBM Regional Surface Water Refinery Regional Surface Water	The Regional surface water monitoring program is designed to identify changing quality in surface water primarily turbidity and salinity. Where possible monitoring locations are selected upstream and downstream of potential impacts associated with Worsley operations. Trigger and threshold levels for turbidity and salinity are defined in Appendix A. Trigger levels are set to ensure downstream levels remain within 2SDEV of the recorded upstream monitoring point for the same period and the upstream historical average. This trigger level ensures that the conditions in the river remain within the natural variation experienced within the stream and do not lead to additional stress on the existing ecosystems.	12.1 12.1.2

Environmental Outcome	Selected Indicators	Monitoring Program	Justification and Trigger Level	Ref
			In addition, Worsley monitor flow of the Hotham and Williams rivers at existing DWER gauging stations to understand any changes in flow rates in the major rivers in the region.	
	Surface water flow	Refinery Regional Surface Water	**BBM:** The impact to the environment as a result of surface water flows is considered low as a result of the soil profile and hydrology of the area in which the Worsley project is located. Green et al (2024) describe the infiltration rate of the surface soils as being very high greatly exceeding most rainfall intensities concluding that infiltration excess overland-flow is likely to be rare, brief and localised occurring only in very extreme weather events. Worsley designs the mining areas to be self-contained in terms of water management during mining activities, ensuring all water is contained within the cleared area (utilising drainage sumps and bunds to direct water into the pit rather than out of the boundary) which prevents any surface flow containing suspended solids entering the environment, but allowing infiltration through the sumps and ensuring rehabilitation designs reverse this, ensuring all rehabilitated areas are free draining, preventing ponding and returning the natural surface flows post mining (noting that in the most case rainwater will infiltrate resulting in little surface flow). Given the above, Worsley's BBM operations do not have a measurable impact on surface water flows in these large waterways so no trigger or threshold values are able to be set. Instead, an objective-based provision has been included in Table 5-2. **Refinery:** A gauging station is in place within the Augustus River (ARGS) which is maintained by Worsley. Environmental flows into the Augustus River are required in accordance with Worsley's Surface Water Licence (SWL 68041)to ensure the ongoing health of the river's ecosystem. Compliance to the Surface Water Licence forms the basis of the trigger and threshold values set for this outcome for the Refinery.	Table 5-2 4.9 12.2
5. No adverse impacts to GDEs within or adjacent to the PAA as a result of surface and/or groundwater changes attributable to the proposal.	Depth to groundwater (mbgl) Groundwater salinity (TDS)	BBM Targeted GDE Groundwater Refinery Regional Groundwater	Flora and vegetation surveys and groundwater modelling have been used to identify the location of potential GDEs Figure 4-4 Potential impacts identified for GDEs associated with the Worsley operation include groundwater mounding and dryland salinity impacts associated with rising groundwater table. For this reason these two metrics have been selected as indicators for this outcome. A Targeted groundwater monitoring program has been designed for areas of GDE that have the potential to experience changing groundwater conditions. This monitoring program will be reviewed on an annual basis to ensure areas of proposed mining in the 10 Year Mine Plan are adequately covered. Additional	Figure 4-4 4.9.3 12.1

Environmental Outcome	Selected Indicators	Monitoring Program	Justification and Trigger Level	Ref
			monitoring bores will be installed as required following triennial reviews and as mining progresses into new areas. CBME operations are not anticipated to commence in the near term. Monitoring bores will be installed in accordance with recommendations received with the numerical groundwater modelling (GRM, 2023). A minimum 18 month baseline will be collected prior to any clearing commencing in the CBME.	12.2
	Surface water salinity (TDS)	BBM Regional Surface Water Refinery Regional Surface Water	GDEs are often associated with waterways meaning that changes in surface water quality could impact on the health of the GDE. Potential impacts identified for GDEs associated with the Worsley operation for surface water relate to stream salinity and changing surface water flow regimes. The Regional surface water monitoring programs include monitoring of stream salinity (TDS). The variability in TDS is high with first flush events often recording high TDS and subsequent results reflecting lower TDS levels. Where possible monitoring locations are selected upstream and downstream of areas of potential impact associated with Worsley operations. Trigger and threshold levels for turbidity and salinity are defined in Appendix A. Trigger levels are set to ensure downstream levels remain within 2SDEV of the recorded upstream monitoring point for the same sample period and within the historical upstream range. This trigger level ensures that the conditions in the river remain within the known salinity variation experienced within the stream.	4.9 12.1 12.2
	Vegetation condition	Targeted GDE Vegetation Condition Assessment (5 yearly)	These indicators will be used to verify the effectiveness of all management measures (including those specific to Inland Waters) in achieving the environmental outcome. Five Yearly vegetation health assessments will be completed within Protected Areas supporting potential GDEs (such as the Mount Saddleback Heath Communities PEC). Any deterioration in GDE health recorded during this assessment will be treated as a Trigger to require further detailed investigations.	4.10.2.1
6. No disturbance or adverse impacts to native vegetation within 30 m of Augustus River bank attributable to the proposal.	Surface water salinity (EC)	Refinery Regional Surface Water	Potential impacts identified for vegetation adjacent to the Augustus river associated with the Worsley operation relate to stream salinity and changing surface water flow regimes. The Refinery Regional Surface Water monitoring program include monitoring of stream salinity (TDS) within the Augustus River. A trigger level for 300 uS/cm has been set for the Augustus River monitoring site (ARGS) (see Appendix B) ensuring water in this system remains of a high quality to support the adjacent vegetation.	4.9 12.2

Environmental Outcome	Selected Indicators	Monitoring Program	Justification and Trigger Level	Ref
	Disturbance to native vegetation	Annual Clearing Reconciliation Annual Inspection	To verify compliance with this outcome an annual inspection of the area will be completed to ensure no disturbance has occurred within the defined Protected Area for the Augustus River. This will be supported by the Annual Clearing Reconciliation conducted for the business where all clearing areas within State forest are verified and reported. Five Yearly vegetation health assessments will be completed within Protected Areas (including the Protected Area for the Augustus River) to ensure that management measures have been effective in maintaining the systems in a healthy state.	4.10.2.1
	Vegetation condition	Targeted GDE and Vegetation Condition Assessment (5 yearly)		

4.6 BBM MANAGEMENT AND CONTROL STRATEGIES

4.6.1 Protected Areas

Protected Areas have been defined for areas of conservation significance as detailed in Figure 4 of MS1237. Disturbance within Protected Areas is not permitted except in accordance with Condition B2 of MS1237. Worsley has committed to:

- Stream / Watercourse protection in accordance with the Water Quality Protection Note 6: vegetation buffers in sensitive water resources (Department of Water, 2006) for systems rated as category 3 or higher by the Department of Water and Environmental Regulation for areas outside State Forest and Timber Reserves (excluding requirements for crossings by linear infrastructure e.g., haul roads).
- River and Stream Zone protection for all streams of order 3 and above in accordance with the Forest Management Plan 2024 – 2033 (CPCWA, 2023) within State Forest and Timber Reserves (excluding requirements for crossings by linear infrastructure e.g., haul roads).
- Protection of listed State and/or Federal Priority and Threatened Ecological Communities with a minimum 30 m buffer applied; and
- Protection of Threatened flora locations with a minimum 50 m buffer applied.

These Protected Areas are a key management measure for ensuring the achievement of the Environmental Outcomes and Objectives of the WMP.

4.6.2 Minimise Native Vegetation Disturbance (Mine Planning)

The Mine Planning process aims to reduce the number of hectares of clearing required for mining related activities through avoidance and minimisation of impact by defining mining pods, haul roads and areas for stockpile management prior to disturbance. This planning allows for efficiencies in stockpile and haul road location and design and a smaller associated disturbance footprint. Minimising the disturbance footprint in minimises the potential for indirect impacts associated with subsequent changes to groundwater and surface water associated with the removal of deep rooted vegetation.

4.6.3 Predictive Modelling

Groundwater modelling using FDA and detailed numerical groundwater models have been completed as part of the EIA process.

A fundamental output of these models is the prediction of water table rise associated with mine-related clearing.

The FDA will be applied as the key tool for prediction of water table rise in new mining areas, with the modelling predictions to be tested by the monitoring program outlined in Section 5.6 and Appendix A.

A detailed review of groundwater level monitoring data will be conducted 5 years after commencement of operations in a new area to verify the accuracy of the predicted water table rise from the FDA and numerical groundwater model. If differences between actual and predicted groundwater conditions are found to be significant (as assessed by the external hydrogeologist) the numerical model will be reviewed as well as risks associated with the findings and adaptive management will be applied as required.

4.6.4 Salinity Hazard Assessment and Salt Storage

All proposed mining areas within the PAA have been subject to salinity risk evaluation using the Flux Density Analysis (FDA) technique. FDA is a modelling technique that identifies areas at risk of groundwater rise due to the temporary removal of vegetation for mining, particularly valley floor ecosystems that are influenced by groundwater. The maps created using FDA allow the relative impacts of mining in different areas to be compared and for possible salinity hazard ‘hot spots’ to be defined (i.e. defines potential new areas of groundwater discharge).

Where the FDA indicates potential salt risk, additional groundwater monitoring bores may be installed as recommended by hydrogeologist and further evaluation may be completed, including an evaluation of soil-salt storage through a drilling and sampling program.

4.6.5 Water Use Efficiency

4.6.5.1 *Water Supply*

Worsley BBM operations have approval to source up to 900 ML/annum of water from groundwater and surface water in the vicinity of the mining areas. To meet current operational water requirements, groundwater is pumped from production bore fields to either a dam, bladder or tank located in close proximity to each bore field. Water usage is recorded via flow meters situated on each production bore, and at the outlet from each dam.

The opportunity exists for Worsley to continue to develop groundwater at the BBM as a supply for mining operations. Depending on underlying geology, deep bores may provide a means of locating water supplies near future mining operations. Previous water exploration and groundwater drilling campaigns have been successful in targeting and developing relatively high-yielding aquifers. By drilling new bores in zones associated with dolerite dykes, in the deep fractured rock aquifer, bore yields are typically greater than 100 kL/day.

Worsley is also considering alternative water sources to minimise groundwater abstraction into the future at the BBM. This includes:

- Potential for harvesting surface runoff from haul roads; and
- Sourcing water from borrow pits.

Development of alternative future water sources must consider the location and timing of future mining operations and the potential impacts from additional water abstraction. Future considerations for surface water sources will depend on the local situation and factors such as prevailing topography, stream flow and stream water quality characteristics, etc.

4.6.5.2 *Water Efficiency*

The majority of the BBM's water consumption is for dust suppression on haul roads and plant sites. The balance is used as potable water for domestic drinking purposes. Worsley aims to reduce water usage across the operations at the BBM. The following methods are employed to reduce water usage:

- Employees and contractors are made aware of appropriate water conservation practices in the site induction;
- Water truck operator training to ensure haul roads are not over watered, nor are they watered when not required;
- Manage abstraction to meet demand and maximise rainfall inputs in winter (i.e. reduced abstraction in lead up to winter);
- Monitor water levels in dams and manage abstraction accordingly;
- Water recycling in workshop and crusher areas;
- Regular water infrastructure maintenance;
- Dams lined to prevent seepage loss (Karafil HDPE lined all other dams clay lined, South Pit Sump clay base only);
- Water Communications: Weekly water abstraction reporting, fortnightly water usage meeting;
- Dust suppressant chemicals or surface binding agents are used wherever they are cost and operationally effective; and
- Annual dust suppressant refresher training to ensure correct use of dust suppressant by operators.

4.6.6 Progressive Rehabilitation

Rehabilitation forms an important component of the mitigation hierarchy. The current primary objective of rehabilitation undertaken by Worsley on Timber Reserve land is to: "regenerate a stable productive forest ecosystem planned to maintain recreation, conservation and nominated forest values." The reestablishment of native vegetation through rehabilitation counters the impact of clearing and stabilises the groundwater levels over time.

Specific goals of rehabilitation are:

- **Recreation** - where practicable, to provide or maintain recreational and heritage values in accordance with approved DBCA plans
- **Conservation** - to regenerate, in the long-term, floral and faunal characteristics compatible and consistent with the surrounding Eastern Jarrah Forest biodiversity
- **Landscape** - to create a rehabilitated landscape compatible with the general landform and physiography
- **Landform** - ensure the resulting landforms and soils are safe, stable and resilient

- **Hydrology** - to restore the hydrological balance through the establishment of deep-rooted vegetation in rehabilitated areas
- **Protection** - to minimise impacts on non-mined areas, to conserve the residual soils, to minimise dieback spread, and ensure that unacceptable fire hazards do not accumulate.

In seeking to meet these goals, the desired result is a safe multiple-use forest in which rehabilitated and undisturbed stands are integrated to the maximum practical extent.

Worsley aims to complete rehabilitation in a timely manner to ensure areas that are not required for infrastructure are returned to native forest as soon as practicable. Worsley recognises that QTR represents an area of biological importance and has committed to complete revegetation (seeding and fertilising) of areas cleared within the early rehabilitation areas identified in Figure 6 of MS1237 within 4 years after clearing activities commenced in those areas, excluding areas that are used for infrastructure'. This management measure will minimise the extent and duration of potential indirect impacts associated with changes in surface water and groundwater. Worsley also prioritise rehabilitation in areas adjacent to Protected Areas and Ecological Linkages in accordance with Condition B2 of MS1237 again reducing the extent and duration of impacts in these areas identified as containing matters of high conservation value.

Where mining occurs on agricultural land, the Private Land Rehabilitation Management Procedure (01020410) is followed. This Procedure outlines requirements for Restoration Agreements between Worsley and the landowners prior to the commencement of rehabilitation. These agreements are generally based on pre-existing land use as identified during baseline botanical surveys prior to disturbance (i.e. return of native forest in equal or larger area to what was disturbed).

Native forest seed mixes incorporate local provenance tree and understorey species including deep rooted plant species. Worsley is confident that the current rehabilitation program and the adaptive management approach used to keep the program up to date will continue to provide a suitable basis for a comprehensive and appropriate rehabilitation program.

4.6.7 Groundwater Abstraction

Groundwater abstraction may be utilised by Worsley in the event that monitoring indicates groundwater mounding has the potential to impact on GDEs or flora / vegetation of significance (e.g. PECs, Threatened flora). Groundwater abstraction will be used as a short-term measure to mitigate these impacts whilst rehabilitation is establishing in surrounding areas to provide long term control of groundwater levels. Should groundwater abstraction be required to be used as a management measure the following must be completed:

- Complete an assessment of groundwater quality and determine likely abstraction volumes and rates required to counter predicted mounding.
- Assess proximity of existing water management infrastructure and determine whether a feasible storage location exists for abstracted groundwater.

If water quality is verified to meet the ANZECC (2000) *Water Quality Guidelines for Livestock Drinking Water Quality* it will be used to support ongoing operations where feasible (e.g. dust suppression). Groundwater will be dosed with hypochlorite (dieback control) prior to use in accordance with current groundwater use practices. The water will be stored in existing storage locations (dam, tank, bladder) where possible. Alternatively, purpose-built storage (tank/bladder/dam) will be installed near the pumping location. Storage locations will have associated standpipe arrangements to allow for utilisation of water in dust management in accordance with current operating practices.

Where use for the operation is not feasible water may need to be discharged to the environment. This activity requires a Licence to Discharge under Part V of the EP Act. Any discharge must be in accordance with any such Licence issued to Worsley ensuring location of discharge, water quality and water quantity limits outlined within the Licence are met to ensure ongoing protection of the environment.

If water quality does not meet set quality criteria for onsite use or discharge (in accordance with Licence to Discharge), options for improving water quality must be investigated and implemented. This should include consideration of installation of containerised / mobile water treatment systems.

4.6.8 Hazardous Materials and Spills Management

All facilities at the BBM operate in accordance with the EP Act Licence (L5960-1983-11) and the *Explosives and Dangerous Goods (Dangerous Goods Handling and Storage) Regulations 1992*. The Spill Management SWI (01027460) is required to be followed in the event of a spill.

4.6.9 Sediment Control

Drainage in BBM areas disturbed for mining is managed by the control of storm water runoff to prevent environmental effects including erosion, sedimentation of streams, release of excessively turbid water and spread of forest disease.

Drainage is managed using a preventative risk-based approach which considers design and management controls in accordance with the Site Drainage – BBM Standard (STA-402), Trunk Haul Road Design and Construction specification (00112148) and relevant agreed working arrangements.

These documents include design specifications and procedures to ensure the following requirements are met:

- Drainage lines must be secure and control the flow of water to natural or purpose-built sumps. Sumps must be designed and managed to maximise infiltration, contain water-borne silt and prevent uncontrolled overflow.
- Perimeter drains must be established for all clearing areas to ensure all runoff is contained within operational areas.
- Sumps must be designed for different Intensity Frequency Duration events based on the level of risk associated with a breach.
- Sensitive Area sumps must be designed to contain a rainfall event with a duration of 72 hours and frequency of 1 in 100 years (calculated to represent 158 mm rainfall).
- All other sumps must be designed to contain a rainfall event with a duration of 72 hours and frequency of 1 in 2 years (calculated to represent 85 mm rainfall).
- Culverts used to guide water to a well-constructed sump of adequate capacity must meet minimal design requirements.
- Sumps must be audited, inspected and maintained to ensure ongoing integrity.
- Forest track drainage must be in place and maintained to minimise water pooling and erosion in forest areas.
- Drainage from pit haul roads must be contained within operational pits.

4.7 REFINERY MANAGEMENT AND CONTROL STRATEGIES

4.7.1 Augustus River

4.7.1.1 *Overview*

The isolation of potentially contaminating activities to the area within the RCL catchment and the robust design and safeguards of the BRDAs are considered adequate for the protection of downstream water quality in the Augustus River. The location of the FWL immediately downstream of the RCL and the pipe head dams of the BRDAs offer a second barrier against the accidental release or movement of potentially contaminating materials into the Augustus River. Additionally, both the FWL and the Augustus River downstream of the FWL are routinely monitored for changes in water quality (see Section 5.6). To date monitoring has not identified any impacts on the Augustus River associated with operation of the BRDAs.

4.7.1.2 *Operating Strategy*

Worsley has developed an operating strategy that outlines the arrangements, agreed with DWER, as part of the Surface Water Licence (SWL68041(5)) issued under Section 5C of the RIWI Act. The operating strategy outlines commitments regarding the extraction, diversion and use of surface water from the Augustus River.

4.7.1.3 *Ecological Monitoring Program*

The Ecological Monitoring Program was designed via a collaborative process between Worsley, DWER and Wetland Research & Management. Under the monitoring program, baseline data from the Augustus River, together with reference data from the Hamilton River, will be used to compare the response of aquatic biota to the modified releases from the FWL and therefore, determine the ability of the ecosystem to adapt.

Baseline hydrological and ecological data was collected between 2010 and 2013, as part of the EMP for the Augustus River (WRM, 2014).

4.7.1.1 *Protected Area*

A 30 m buffer has been applied to the Augustus River within the CBME and Refinery Lease Area. This buffer has been defined as a Protected Area ensuring that no direct impacts to native vegetation attributable to the Project occur within this area. This Protected Area also ensures potential indirect impacts on Carter's Freshwater Mussel, which is known to be present in the Augustus River, are minimised.

4.7.2 FWL Exclusion Zone

Worsley will maintain a mining exclusion zone from the high-water mark of the Freshwater Lake (FWL) of 50 m. This exclusion zone is designed to minimise potential indirect impacts associated with disturbance in the CBME on Carter's Freshwater Mussel which is known to be present in the FWL and Augustus River (see Section 4.3.4).

4.7.3 Strategic Water Source Planning

Worsley has developed a long-term water supply strategy (Worsley, 2007; WorleyParsons, 2011; GHD, 2012) in response to the changing rainfall patterns and predicted water scarcity risks in the region, to ensure there are sufficient and secure source(s) of water to meet the demands of the existing and expanded Refinery. The water supply strategy will:

- Involve consideration of water efficiency measures, increased harvesting of water from the RLA and the use of new or existing offsite sources;
- Allow for the purchase of water from offsite supply; and
- Be developed in consultation (where appropriate) with DWER, Department of Energy, Mines, Industry Regulation and Safety (DEMIRS) and the Water Corporation.

The Refinery Water Balance has been developed to assess both short and long-term water sources and efficiencies that will provide protection in times of drought or an oversupply of water.

4.7.4 Water Efficiency

Worsley aims to improve water use efficiency and thereby reduce freshwater usage across the operation. Potential water saving initiatives have been identified for the Refinery, which are the subject of current or future studies including;

- A new, higher efficiency mud washing circuit with a potential reduction in water consumption;
- Reduced dilution in FAC050 through an improved product wash design; and
- Recovery of waste heat from Digestion.

Further opportunities will continue to be investigated.

4.7.5 Hazardous Materials and Spills Management

The Refinery operates in accordance with Dangerous Goods Site Licence (DGS009760) under the *Explosives and Dangerous Goods (Dangerous Goods Handling and Storage) Regulations 1992* (WA), issued and enforced by DEMIRS. The licence outlines the conditions on the storage and handling of hazardous materials. Spills are managed in accordance with the Spill Management SWI (01027460).

4.8 BUNBURY PORT MANAGEMENT AND CONTROL STRATEGIES

4.8.1 Hazardous Materials and Spills Management

The Port has a Dangerous Goods Site Licence (DGS009760) under the *Explosives and Dangerous Goods (Dangerous Goods Handling and Storage) Regulations 1992* (WA), issued and enforced by DEMIRS. The licence outlines conditions on the storage and handling of hazardous materials.

Spills management at the Port is managed in accordance with the Spill Management SWI (01027460).

4.8.2 Hydrocarbon Contamination

Phase separated hydrocarbons have been encountered in a shallow monitoring bore at the Port since it was drilled in 2001 (Peter Clifton, 2009 and Hydrosearch, 2002 in Golder 2014). Investigations into this contamination indicate that a clay layer beneath the aquifer appears to be preventing the downward migration of the hydrocarbon.

The hydrocarbon contamination issue has been reported to DWER under the requirements of the *Contaminated Sites Act 2003*.

4.9 WATER MONITORING PROGRAMS

Water monitoring programs have been designed and implemented to manage water related aspects associated with operations at the BBM, Refinery and Bunbury Port. The locations and frequencies of water sampling for these operational areas are outlined in Appendices A-C. The water monitoring programs include monitoring required under existing EP Act Licences.

Results that exceed predetermined trigger levels will be investigated and managed in accordance with the TARP outlined in Section 5.1 of this document.

As new mining areas are developed, the monitoring programs and TARPs will be reviewed and modified as required.

All sample analysis will be undertaken by an appropriately accredited laboratory.

4.9.1 Water Monitoring Program Intent

Worsley's Water Management Plan and associated monitoring program has been designed in consultation with independent qualified third parties in order to meet the following management objectives:

- Ability to detect groundwater trends at the earliest possible opportunity;
- Ability to rapidly detect and respond to any environmental impact associated with operational activities;
- Ensure compliance with legal obligations; and
- Determine whether current controls are effective in managing environmental impacts.

In addition to the above, the monitoring program should also be leveraged off technology (where possible) to enable the rapid detection and management of emerging environmental issues.

4.9.2 Water Monitoring Program Design Principles

Pre-Operational / Baseline Monitoring

For new operational areas, additional surface water monitoring locations and monitoring bores will be installed to allow at least 18 months of baseline data to be collected prior to disturbance activities taking place. Baseline monitoring data is used to devise appropriate site-specific trigger levels that take into consideration the environmental values being protected and the risk of impact from operations. Where additional historic monitoring information is available this will be included in the determination of baseline conditions for setting of trigger and threshold levels.

Active Mining / Abstraction / Refining / Shipping

Ongoing monitoring is required during active operations and groundwater abstraction. Monitoring should be suitable in terms of scale and identified risk and in line with the content of this review.

Post-Operational / Rehabilitation Monitoring

Monitoring will continue as described above for a pre-determined 'sunset' period post mining. The duration of this sunset period will be determined by the rehabilitation plan specific to each operation and outcomes from historical monitoring (i.e. identification of consistent recovery trends over specific timeframes).

4.9.3 Targeted Groundwater Dependent Ecosystem (GDE) Groundwater Monitoring Program

Potential GDEs are identified prior to disturbance in accordance with section 4.3.2.2. Areas of potential GDEs with the potential to have indirect impacts associated with the proposal have been identified through FDA and groundwater modelling and are displayed in Figure 4-4. A targeted GDE Monitoring Program has been established to monitor these areas of potential impact against set trigger and threshold criteria. A minimum 18 months of baseline monitoring data is required prior to setting of trigger and threshold criteria. Where additional historic monitoring information is available this will also be included in the setting of trigger and threshold levels. All targeted GDE monitoring sites will be monitored in accordance with the Regional Groundwater Monitoring Program with the addition of continuous loggers for WL and EC which will be downloaded on a quarterly basis. This will allow identification of localised vs regional changes in groundwater quantity and quality. Full details on the monitoring metrics, frequency and the process applied to determine trigger and threshold levels for this monitoring program are detailed in Appendix A.

4.10 OTHER APPLICABLE MONITORING PROGRAMS

4.10.1 Carter's Freshwater Mussel Monitoring Program

Carter's Freshwater Mussel (CFWM) is listed as Vulnerable under both the EPBC Act and the EP Act and is a Matter of National Environmental Significance (MNES). Carter's Freshwater Mussel has been identified within the FWL and downstream within the Augustus River. A targeted surface water and sediment monitoring program has been developed and will be implemented to ensure the ongoing protection of this species. This monitoring program is provided as Appendix D. Additional protection measures for this species are discussed in section 4.7.

4.10.1.1 *Aim and Overview*

The aim of the Carter's Freshwater Mussel (CFWM) Monitoring Program is to monitor the CFWM populations and conditions at the Freshwater Lake (FWL) and downstream within the Augustus River, within the development envelope, to detect any adverse impacts from the Worsley Revised Proposal. The Program has been designed to assess against the management provisions outlined in Table 5-3.

The Program will enable the assessment of CFWM and follows a Before-After-Control-Impact (BACI) design. The primary focus is to assess the CFWM populations, in relation to water quality and sediment quality, to understand potential contaminants that may impact the health of the species. The Program will be implemented for the life of the Revised Proposal (approximately 15 years), with relevant sampling intervals proposed, supported by an underlying adaptive management approach. The Program may be amended based on the findings of monitoring over time and through consultation / recommendations from regulators.

4.10.1.2 *Objectives and Rationale*

The objective of the monitoring program is to determine if habitat suitable for supporting CFWM is being maintained. To address this objective, the following tasks will be undertaken:

- conduct a CFWM survey to verify population size in FWL, including peripheral and deepwater areas, using appropriate methods;
- monitor water and sediment quality in FWL and downstream Augustus River, comparing results to available guidance;
- monitor water levels in FWL and downstream Augustus River;
- monitor population density in FWL and downstream Augustus River, targeting peripheral and deepwater habitats;
- survey freshwater fish in FWL and downstream Augustus River, to determine the presence of suitable fish host species for CFWM; and
- develop water and sediment site-specific guideline values (SSGVs) to complement CFWM monitoring.

Detailed sampling methods for the CFWM Monitoring Program are provided in Appendix D, noting that changes may be required over time, and should be informed by key findings and outcomes of monitoring. The key sampling components and methods developed are based on the ecology of CFWM and address the objective of the Monitoring Program.

4.10.2 Vegetation Condition Assessment

4.10.2.1 *Targeted GDE Condition Assessment*

Vegetation condition assessment will be completed by qualified botanists for areas of potentially impacted Mt Saddleback Heath Communities (PEC), a potential GDE of conservation significance, on a regular basis (5 yearly). Where modelling predicts potential impacts to other GDEs (see Section 4.3.2.2) these areas will be included in the Targeted GDE Vegetation Condition Assessment monitoring program. Baseline vegetation condition will be established for newly included areas prior to commencing operations within 500m of the GDE, where possible (i.e. disturbance has not occurred in the area to date). Monitoring programs will include control sites to take into account Regional impacts on vegetation condition such as climate change.

4.10.2.1 *Regional Vegetation Condition Assessment*

Regional vegetation condition will be assessed on a 5 yearly basis using remote sensing technologies. Relative condition of vegetation within and adjacent to the PAA will be compared with areas of comparable vegetation types outside the potential impact area to identify any potential areas of vegetation decline associated with the Worsley operations. If areas of concern are identified during the desktop survey, additional targeted surveys will be initiated to verify the findings and, where verified, further investigations will be conducted to determine the contributing factors for the decline in vegetation condition.

4.10.3 Sustainable Yield Testing

Sustainable Yield Testing of all production bores will be undertaken every 6 years to ensure that abstraction rates remain within environmentally sustainable limits. Sustainable Yield Testing must be completed for both shallow and deep fractured rock aquifer production bores and bore fields. Outcomes of Sustainable Yield Testing must be reported within the Annual Environmental Report.

4.10.4 Targeted Conservation Significant Flora Surveys

Targeted surveys for conservation significant flora will be completed by suitably qualified botanists within relevant Protected Areas. Surveys will be designed in accordance with applicable EPA Technical Guidelines. Surveys will be completed on a 3-5 yearly basis to assess the continued presence of conservation significant flora and their relative abundance. Presence and abundance will be compared with historic monitoring results to identify any significant changes in abundance and distribution as well as identify any concerning trends. Refer to the Flora and Vegetation Management Plan (200001092) for additional information on targeted conservation significant flora monitoring programs.

4.10.5 Targeted flora survey for *C. hopperiana* and *C. caesarea* subsp. Mooradung

This targeted flora monitoring program will be conducted 3 yearly by qualified botanists. The survey program will span potential impact and control sites to verify the continued presence and abundance of known populations of *C. hopperiana* and *C. caesarea* subsp. Mooradung whilst allowing consideration of regional impacts such as climate change and natural variation in populations to be considered. New populations of *C. hopperiana* and *C. caesarea* subsp. Mooradung identified during Pre-clearance surveys will be incorporated into the monitoring program as applicable. Targeted surveys will continue for the duration of potential impacts plus two subsequent monitoring periods whilst rehabilitation in surrounding areas is establishing. Surveys may continue following this period but may be at a reduced frequency.

4.10.6 Targeted Perched Aquifer - *C. hopperiana*

Caladenia hopperiana is listed as Endangered under both the EPBC Act and the EP Act and is a Matter of National Environmental Significance (MNES). *C. hopperiana* has been identified within the PAA in areas of QTR. A targeted groundwater and surface water monitoring program has been developed and will be implemented to ensure the ongoing protection of this species. This monitoring program is provided as part of Appendix A. Additional protection measures for this species are discussed in the Flora and Vegetation Management Plan (200001090).

4.10.6.1 *Aim and Overview*

The aims of the Perched Aquifer – *C. hopperiana* Monitoring Program are to

- determine whether a perched aquifer is present to support the species (i.e. verify if the species and its habitat represents a GDE).
- Determine whether the surface water flows in the area supporting C. hopperiana are sustained by surface water runoff or fed by groundwater discharge.

To support this assessment two shallow groundwater monitoring bores have been installed within the QTR (Q09 and Q11) and surface water quality monitoring has recommenced at historic monitoring points associated with *C. hopperiana* (S42 and S32). The groundwater monitoring locations will be used to determine the presence and persistence of any perched aquifers in association with *C. hopperiana*. The surface water monitoring program will assess surface water quality and approximate duration of flows for the ephemeral stream present in the areas supporting *C. hopperiana* on the eastern side of the Pinjarra Williams Rd. The Program will be implemented for the life of the Revised Proposal (approximately 15 years), with relevant sampling intervals proposed, supported by an underlying adaptive management approach. The Program may be amended based on the findings of monitoring over time and through consultation / recommendations from regulators.

4.10.6.2 *Objectives and Rationale*

To address the provisions of the WMP, monitoring by Worsley personnel is required to better understand the groundwater / surface water interactions and associated implications for appropriate management measures for populations of *C. hopperiana*. The objectives of the monitoring program are as follows.

- obtain baseline monitoring data for the shallow aquifer (if present) over a two year period;

- monitor surface water quality and groundwater quality and determine whether groundwater baseflow is likely to contribute to surface flows (salinity);
- monitor surface water flow duration to understand baseline flow patterns.
- allow development of appropriate site specific trigger and threshold values by a qualified hydrogeologist (following 2 year baseline monitoring period).

5 WATER MANAGEMENT PROVISIONS

This section describes the provisions of this WMP, which when implemented, will achieve the environmental outcomes and objectives addressed by this WMP. These measures also ensure that the requirements established by MS1237 and other legislative instruments, as outlined in Section 3.3 are met. These are based on the approach described in Section 4.

Objective-based and outcome-based provisions are provided separately for the BBM, Refinery and Bunbury Port.

5.1 TRIGGER AND ACTION RESPONSE PLAN (TARP)

5.1.1 Overview

The TARP is applicable to all surface, groundwater and sediment monitoring completed at Worsley. The water monitoring program is described in Appendices A-C and includes the utilisation of field / laboratory samples and real time loggers (sensors).

Sensors deployed in targeted aquifers will sample a range of water quality parameters. At the Refinery and Port this will include temperature, pressure (water level) and electrical conductivity in which data will be logged at 6-hour intervals and transmitted to a centralised database every 24 hours. Any reading outside of a specified range (refer to Appendices for each operational location) will trigger an automatic alert to key management personnel via email. For BBM, a recent review of the groundwater monitoring network (Croton, J.T., Mauger, G. W. and Dalton, J.A., 2020) suggested only water levels will be logged at regular intervals and will be reviewed by six monthly manual download.

Data extraction is targeted for annual reviews however, is available at any time and will be analysed in detail for any exceedance or information request.

An investigation will commence in the event that:

- Data is not received when expected (i.e. communication or equipment issues);
- Received data is outside historic norms (i.e. trigger levels have been breached);
- The validity of the data is in question for any other reason; and / or
- Water abstraction exceeds water usage volume limits.

The investigation will be specific to the type of trigger and will be modified as necessary to achieve a thorough understanding of the event and confirmation of any associated remedial actions.

The TARP outlined in Section 5.1.3 summarises the process that will form the basis of the investigation.

5.1.2 Trigger Levels

Trigger levels are set on advice from expert third party input. Individual trigger levels are set for each monitoring site following consideration of the following:

- Historical monitoring data;
- Purpose of monitoring location; and
- Likelihood and consequence of potential environmental impacts.

Trigger levels are maintained within the internal environmental monitoring database system and are reviewed annually for the Refinery and 3 yearly for BBM by qualified hydrogeologists ensuring adaptive management is applied. Trigger level exceedance notifications are received automatically following upload of monitoring data into the environmental monitoring database. A summary of the current Trigger Levels utilised within the monitoring programs is included in Appendices A and B.

5.1.3 TARP Plan

Trigger

- Monitoring results outside the relevant trigger level;
- Concerning trend identified during annual monitoring review undertaken in association with the Annual Environmental Reporting process;
- Concerning trend identified by hydrogeologist during Triennial Aquifer Review for BBM;
- Visual inspection identified potential contamination / issue; and / or
- Complaint raised concerning water quality and quantity.

Action

- Conduct field analysis on identified sample point;
- Inspect field equipment to ensure correct operation;
- Review monitoring results against historical monitoring data;
- Review recent monitoring results for adjacent downstream and upstream monitoring sites;
- Review any relevant operational data that may have led to the trigger alert;
- Determine if an incident has potentially occurred;
- Record any incidents, outcomes and actions in the relevant risk and incident management software (G360); and
- Report any Environment Incidents in accordance with applicable internal requirements and operational licences.

Response

- Investigate the exceedance;
- Increase monitoring frequency where relevant;
- Undertake additional monitoring if necessary or when requested by stakeholders;
- Where concerning trends are identified, initiate a third-party review by appropriately qualified personnel to verify monitoring data, assess potential causes and recommend mitigating actions as required; and
- Develop corrective / preventative actions based on the outcomes of the investigation and / or additional monitoring.

Plan

- Prioritise actions based on the risk to the environment and likelihood of a repeat incident;
- Monitor the completion of actions to ensure they have been effective; and
- Review incident potential for other locations and nominate action list to relevant supervisor via appropriate risk software (G360).

5.2 BODDINGTON BAUXITE MINE

5.2.1 BBM Outcome Based Provisions

The outcome based provisions for the BBM are documented in Table 5-1.

Table 5-1: BBM outcome-based provisions for Inland Waters

EPA factor/s and objective/s: Inland Waters, Flora and Vegetation, Terrestrial Fauna

Outcome/s:

1. No disturbance or adverse impacts to *Caladenia hopperiana* or *Caladenia caesarea* subsp. Mooradung associated with surface water and / or groundwater changes.
2. No adverse impacts to conservation significant flora, fauna or ecological communities as a result of surface and/or groundwater changes attributable to the proposal.
3. No adverse impacts to native vegetation within or adjacent to the PAA as a result of surface and / or groundwater changes attributable to the proposal.
4. No adverse impacts to hydrological regimes and water quality of the Hotham River, Marradong Brook, Murray River, Williams River and Thirty-Four Mile Brook attributable to the proposal.
5. No adverse impacts to GDEs within or adjacent to the PAA as a result of surface and/or groundwater changes attributable to the proposal.
6. **No adverse impacts to neighbouring groundwater users as a result of the proposal.**

Key environmental values: Conservation significant flora, fauna and ecological communities, GDEs, groundwater resources, surface water resources

Key impacts and risks: Groundwater mounding, Groundwater decline, **salinity, surface water flows.**

Reference & Relevant outcome(s)	Trigger & Threshold Criteria	Response Actions	Monitoring	Timing / frequency of monitoring	Reporting
Conservation significant flora and GDEs					
BBM1 **Outcome 1**	**Trigger Criteria:** Measured groundwater level for deep monitoring bores located in areas known to support Threatened flora rise above trigger levels outlined in Table 12-8.	**Trigger Level Actions:** 1. Cease clearing of native vegetation in areas surrounding the potentially impacted population (within 500 m initially). 2. Conduct a hydrogeological investigation for the area including a review of groundwater levels relative to climatic and regional trends. 3. Prioritise rehabilitation of available areas within the sub-catchment of the impacted population. 4. Verify effectiveness of response actions through continued monitoring of groundwater levels. 5. Apply minimisation actions in accordance with hydrogeologist recommendations following investigation (this may include installation of abstraction bores).	**Indicator:** *Depth to groundwater (mbgl),* Targeted Groundwater Monitoring Program Targeted Threatened flora monitoring program	 Quarterly download from data logger 3 yearly (until 10 years post completion of mining activities)	Water monitoring data included in Annual Environmental Report Threshold exceedance reporting to DWER

Reference & Relevant outcome(s)	Trigger & Threshold Criteria	Response Actions	Monitoring	Timing / frequency of monitoring	Reporting
		6. Clearing operations may recommence when groundwater levels return to below set trigger levels however, overall sub-catchment land use balance must be maintained (i.e. rehabilitation must equal clearing in any given year). 7. Conduct targeted Threatened flora monitoring program during next available flowering season to determine whether any impact to the population(s) has occurred.			
	Threshold Criteria: Measured groundwater level for deep monitoring bores located in areas known to support Threatened flora rise above threshold levels outlined in Table 12-8. **Table 12-8 will be amended as required following **subsequent** flora and vegetation surveys.*	**Contingency measures:** 1. Cease clearing of native vegetation in areas surrounding the impacted population (within 800 m initially). 2. Report exceedance to Regulator. 3. Prioritise rehabilitation of areas within the sub-catchment and adjacent sub-catchments of the impacted population. 4. Conduct targeted Threatened flora monitoring program during next available flowering season to determine whether any impact to the population(s) has occurred and to determine if any translocation activities would be beneficial. 5. If translocation activities are determined to be beneficial obtain appropriate licences and permits and commence relocations. 6. Implement additional actions in accordance with hydrogeologist recommendations (this may include commencing abstraction from previously installed abstraction bores).			
BBM2 Outcome 5	**Trigger Criteria:** Groundwater level rises above set trigger level for monitoring bore (see Appendix A).	**Trigger Level Actions:** 1. Conduct a hydrogeological investigation for the area including a review of groundwater levels relative to climatic and regional trends. 2. Apply minimisation actions in accordance with hydrogeologist recommendations. This may include installation of abstraction bores or prioritised rehabilitation areas within or surrounding the potentially impacted GDE in accordance with hydrogeologist recommendations.	**Indicator:** *Groundwater level rise* Targeted (GDE) Monitoring Program GDE Vegetation Condition Monitoring Program	Continuous or in response to trigger level 3-5 yearly	Summary of all groundwater monitoring data provided in AER. Notify relevant government authorities within 1 week of threshold criteria being triggered. Reporting on threshold contingency actions as required to government

Reference & Relevant outcome(s)	Trigger & Threshold Criteria	Response Actions	Monitoring	Timing / frequency of monitoring	Reporting
	Threshold Criteria: Groundwater level rises above set threshold level for monitoring bore (see Appendix A)	**Threshold Contingency Actions:** 1. Report threshold exceedance to Regulator. 2. Initiate actions in accordance with hydrogeologist recommendations which may include ceasing clearing activities, prioritising rehabilitation and / or initiation of groundwater abstraction. 3. Verify effectiveness of response actions through continued monitoring.			authorities and within the AER.
BBM3 **Outcome 5** **Outcome 6**	**Trigger Criteria:** Groundwater level decline from minimum recorded baseline[1] groundwater level exceeds trigger level (see Appendix A).	**Trigger Level Actions:** 1. Reduce abstraction rate for bores within or surrounding the impacted GDE until investigations are completed to understand cause of decline and required mitigation measures. 2. Conduct targeted monitoring to assess recovery rate of aquifer and revise Sustainable Yield from applicable abstraction bores as required. 3. Review groundwater levels relative to climatic and regional trends.	**Indicator:** *Groundwater level decline* Regional Groundwater Monitoring Program GDE groundwater verification monitoring program GDE vegetation condition assessment	Continuous logger or in response to trigger level TBA 3-5 yearly	Summary of all groundwater monitoring data provided in AER. Notify relevant government authorities within 1 week of threshold criteria being met. Reporting on threshold contingency actions as required to government authorities and within AER.
	Threshold Criteria: Groundwater level decline from minimum recorded baseline[1] groundwater level exceeds threshold level (see Appendix A). *Note: Trigger levels for groundwater decline have been determined in accordance with Froend and Loomes (2004).*	**Threshold Contingency Actions:** 1. Cease pumping from abstraction bores within or surrounding the impacted GDE. 2. Verify effectiveness of response actions. 3. Conduct a biological investigation for the GDE including a review regional trends. 4. Implement any recommended actions in accordance with external expert review.			
Groundwater					
BBM4 **Outcome 1** **Outcome 2** **Outcome 3** **Outcome 5** **Outcome 6**	**Trigger Criteria:** Groundwater abstraction for a production bore exceeds sustainable yield for the month.	**Trigger Level Actions:** • Reduce pumping rates for this bore to ensure compliance in following monthly period. • Review groundwater levels at nearby monitoring points to ensure levels remain within the expected range.	**Indicator:** *Groundwater Abstraction* Monitoring of abstraction rates against sustainable yield	Monthly	Reporting of incidents and threshold contingency actions as required to government authorities and within AER.

Reference & Relevant outcome(s)	Trigger & Threshold Criteria	Response Actions	Monitoring	Timing / frequency of monitoring	Reporting
	Threshold Criteria: Groundwater abstraction for an aquifer exceeds sustainable yield for the financial year.	**Threshold Contingency Actions:** 1. Notification of incident and planned response to relevant government authorities. 2. Investigate options for automatic alarming and / or pump shut off to ensure compliance into the future. 3. Conduct a review of the groundwater level monitoring data for the aquifer over the financial year to ensure levels remained within the upper and lower trigger levels and to identify any concerning trends. 4. Reporting on effectiveness of contingency response actions to relevant government authorities.			
BBM5 **Outcome 1** **Outcome 2** **Outcome 3** **Outcome 5**	**Trigger Criteria:** Groundwater levels do not demonstrate an observable recovery toward pre-mining levels within 5 years of rehabilitation (comparable to reference sites).	**Trigger Level Actions:** • Assess rehabilitation tree density and performance against Completion criteria. • Conduct rehabilitation management actions as required.	**Indicator:** *Groundwater Level* Regional Groundwater monitoring program	Continuous logger or in response to trigger level	Analysis of groundwater monitoring data included in AER. Reporting of incidents and threshold contingency actions as required to government authorities and within AER.
	Threshold Criteria: Groundwater levels of post mining catchments do not return to equivalent unmined catchment levels within 10 years following rehabilitation.	**Threshold Contingency Actions:** 1. Assess rehabilitation tree density. 2. Review options with relevant government authorities for treatment of rehabilitation (i.e., thinning) to improve groundwater recovery and determine an agreed action plan. 3. Implement and report on progress against agreed action plan.	Triennial aquifer reviews	3 yearly	
BBM6 **Outcome 1** **Outcome 2** **Outcome 3** **Outcome 4** **Outcome 5** **Outcome 6**	**Trigger Criteria:** Groundwater quality measures show a concerning trend during annual data review or triennial aquifer reviews.	**Trigger Level Actions:** 1. Conduct an investigation to determine potential cause of decreased water quality. 2. Implement actions to address any findings from the investigation. 3. Record findings.	**Indicator:** *TDS / EC and PH* BBM Regional Groundwater monitoring program	Continuous logger or 6 monthly field sample	Summary of water monitoring data provided within AER. Reporting on any threshold exceedance within 5 working days of becoming aware of exceedance. Reporting on threshold contingency actions as required.
	Threshold Criteria: Groundwater quality measures show a continued concerning trend following implementation of trigger level actions (allowing up to 2 years	**Threshold Contingency Actions:** 1. Conduct detailed investigations to understand required mitigation actions to prevent further decrease in water quality.	Triennial aquifer reviews	3 yearly	

Reference & Relevant outcome(s)	Trigger & Threshold Criteria	Response Actions	Monitoring	Timing / frequency of monitoring	Reporting
	from implementation for changing conditions to be observed in groundwater).	2. Report investigation outcomes and proposed mitigation actions to relevant government agencies. 3. Implement agreed mitigation actions. 4. Monitor and report on success of mitigation actions.			
Surface Water					
BBM7 **Outcome 2** **Outcome 3** **Outcome 4** **Outcome 5**	**Trigger Criteria:** Downstream surface water quality measures show a change in water quality of more than 2 SDEV from the mean when compared to upstream monitoring locations. *Note: where upstream monitoring data is unavailable a trigger of 2SDEV from mean baseline data set is applied.*	**Trigger Level Actions:** **1.** Conduct an investigation to determine potential cause of decreased water quality including a review of operational and third-party activities, weather conditions, water control infrastructure and historical water monitoring results. **2.** Implement actions to address any findings from the investigation. **3.** Verify effectiveness of any actions through ongoing surface water monitoring.	**Indicators:** *Turbidity / TSS, EC / TDS* BBM Regional Surface Water	Monthly	Summary of water monitoring data provided within AER. Reporting on any threshold exceedance within 5 working days of becoming aware of exceedance. Reporting on threshold contingency actions as required.
	Threshold Criteria: Surface water monitoring results over a 3 month period show consistent decreased water quality at downstream monitoring locations.	**Threshold Contingency Actions:** **1.** Incident investigation to be completed in accordance with site procedures. **2.** Incident to be reported to relevant government agencies including outcomes of investigation and any planned preventative actions. **3.** Implementation of agreed preventative actions.			

[1] Minimum baseline monitoring requirement for GDEs of 18 months including two winter/spring maxima.

5.2.2 BBM Objective Based Provisions

Table 5-2 provides a summary of the Management objectives for Inland Waters at the BBM.

Table 5-2: BBM objective-based provisions for Inland Waters

EPA factor/s and objective/s: Inland Waters

Objectives:

1. Minimise indirect impacts to flora and vegetation from changes in groundwater and surface water.
2. Minimise impacts on GDEs and SWDEs.
3. Minimise the risk of riverbank erosion and sedimentation
4. Minimise risk of Worsley's mining operations impacting on water quality (salinity).
5. Minimise risk of adverse impacts to hydrological regimes of the Hotham River, Marradong Brook, Murray River, Williams River and Thirty-Four Mile Brook attributable to the proposal.
6. Minimise impacts on shallow aquifers.
7. Minimise groundwater abstraction
8. Minimise risk of contamination of groundwater and surface water from chemicals and hydrocarbons
9. Minimise the risk of exposure of PASS

Key environmental values: Groundwater Dependent Ecosystems (GDEs), Surface Water Dependent Ecosystems (SWDEs), Hydrological Processes, Water Quality,

Key risks: altered groundwater levels, impacts to GDEs and SWDEs, dryland salinity, modified surface water flow regime, impacts on water quality, water contamination (hydrocarbons, chemicals, PASS)

Management Targets / Objectives	Management Actions	Monitoring	Reporting
Minimise impacts on GDEs and SWDEs	• Conduct landscape assessment and baseline flora monitoring to identify potential locations of GDEs and SWDEs. • Conduct baseline groundwater and surface water monitoring and ground truthing to verify location and boundaries of GDEs and SWDEs within highest risk impact areas as identified through modelling and FDA (i.e. potential groundwater mounding risk or salinity hotspot identified). • Define Protected Areas and associated buffers in accordance with the Protected Areas Plan. • Complete investigations into the sensitivities and tolerances of any conservation significant GDE vegetation structures vulnerable to groundwater mounding predictions. • Review and revise the water monitoring program to ensure the monitoring program intent is met for any newly identified GDEs and / or SWDEs.	• BBM water monitoring program including application of TARP requirements (Appendices A-C). • Regular hydrogeological reviews (3 yearly) for all aquifers. • Regular vegetation health assessments (3-5 yearly) for confirmed GDEs.	• Report on Protected Areas annually in 10 Year Mine Plan. • Provide flora and fauna surveys to relevant stakeholders and provide a report summary within AER. • Provide summary of water monitoring within AER. • Reporting of incidents and associated corrective actions in accordance with monitoring program TARP (see 6.1.3).
Minimise the risk of riverbank	• Apply stream buffers in accordance with the FMP (CPCWA, 2023) and *Water Quality Protection Note 6*: (Department of Water, 2006).	• Ongoing monitoring in accordance with the water	• Summary of water monitoring data provided within AER.

Management Targets / Objectives	Management Actions	Monitoring	Reporting
erosion and sedimentation	• Manage stream buffers in accordance with the PAP. • Installation of water management infrastructure (sumps, drainage lines etc.) for all operational areas including haul roads in accordance with the Bauxite Mine Site Drainage Standard (01020749) and the Trunk Haul Road Design and Construction Specification (00112148). • Obtain Bed and Banks permits under the RIWI Act for any disturbance required to stream beds and banks. • Reshape disturbed areas to match surrounding contours during progressive rehabilitation to minimise impacts on surface water drainage patterns. • Develop a CEMP with appropriate controls for all construction works (to be endorsed by applicable government authorities).	monitoring program including application of TARP requirements. • Regular inspection and maintenance of sumps.	• Reporting of incidents and associated corrective actions in accordance with applicable TARPs.
Minimise risk of Worsley's mining operations impacting on water quality (salinity).	• Minimise native vegetation disturbance and utilise existing cleared areas or areas that will be disturbed for future mining pits where possible. • Complete FDA for new mining areas to determine salinity risks. Additional salt storage investigations to be completed for high-risk areas. • Progressive rehabilitation of disturbed land. • No ground disturbance within PDWSAs until working arrangements are developed and agreed upon with regulators and the Water Corporation.	• Ongoing groundwater monitoring and associated TARPs. • Triennial aquifer reviews by hydrogeologist to understand local aquifer response to mining and abstraction programs	• Summary of water monitoring data and triennial reviews provided within AER. • Reporting of incidents and associated corrective actions in accordance with applicable TARPs.
Minimise risk of adverse impacts to hydrological regimes of the Hotham River, Marradong Brook, Murray River, Williams River and Thirty-Four Mile Brook attributable to the proposal	• Apply stream buffers in accordance with the FMP (CPCWA, 2023) and *Water Quality Protection Note 6*: (Department of Water, 2006). • Reshape disturbed areas to match surrounding contours during progressive rehabilitation to minimise impacts on surface water drainage patterns. • Obtain Bed and Banks permits under the RIWI Act for any disturbance required to stream beds and banks. • Crossing design must consider peak flow and potential flood ways. • Draft Completion Criteria for rehabilitation includes the requirement for ensuring the landform is integrated into the surrounding landscape including earthworks requirements for final pit design and that surface water management is designed to prevent prolonged surface or subsurface ponding. • The BBM Closure plan includes rehabilitation to the Hotham River Disturbance • Install and manage drainage structures in accordance with the requirements of STA-402 Site Drainage – BBM (01020749).	• Regular inspection of rehabilitation areas for pooling and erosion. • Rehabilitation earthworks monitoring and inspection following completion • During Hotham River bridge deconstruction, ensure works are undertaken in accordance with specific site procedures. • Routine inspections of sumps.	• Rehabilitation maintenance works and environmental incidents are included in the AER. • Reporting in accordance with requirements of Part V approvals.

Management Targets / Objectives	Management Actions	Monitoring	Reporting
Minimise impacts on shallow aquifers	• Minimise native vegetation disturbance and utilise existing cleared areas or areas that will be disturbed for future mining pits where possible. • Groundwater modelling for new mining areas to determine groundwater mounding risks. • Regular sustainable yield testing for all production bores in the shallow and the deep fractured rock aquifer (6 yearly). • Progressive rehabilitation of disturbed land. • Additional groundwater abstraction bores installed to supply water for mining operations will target the deep fractured rock aquifer.	• Ongoing monitoring in accordance with the water monitoring program including application of TARP requirements. • Triennial aquifer reviews by hydrogeologist to understand local aquifer response to mining and abstraction programs. • Regular vegetation health assessments (3-5 yearly) for GDEs.	• Summary of water monitoring data, water abstraction and triennial aquifer reviews provided within AER.
Minimise groundwater abstraction	• Implement water efficiency measures to minimise water use for operational requirements. • Maintain abstraction to within designated abstraction limit / sustainable yield • Seek alternative sources of water (if required). • Regular (monthly) communication of groundwater abstraction rates against trigger levels / sustainable yields with relevant internal stakeholders	• Ongoing monitoring in accordance with the water monitoring program including application of TARP requirements. • Triennial aquifer reviews by hydrogeologist to understand local aquifer response to mining and abstraction programs. • Monitoring of abstraction rates against sustainable yield (monthly).	• Summary of water monitoring data, water abstraction and triennial aquifer reviews provided within AER. • Reporting of incidents and associated corrective actions in accordance with applicable TARPs.
Minimise risk of contamination of groundwater and surface water from chemicals and hydrocarbons	• Avoid storage of chemicals and hydrocarbons in PDWSAs. • Chemicals, hydrocarbons and other environmentally hazardous materials stored and handled in accordance with Dangerous Goods Safety Act 2004 and associated regulations. • Construction of fuel containment infrastructure in accordance with Australian Standards. • All spills will be managed in accordance with Spill Management Procedures and SWIs. • Collection and treatment of potentially contaminated stormwater run-off from workshops and hydrocarbon storage areas. • Contaminated soils at BBM to be placed in lined hydrocarbon storage area until removal from site by a licensed contractor.	• Ongoing monitoring in accordance with the water monitoring program including application of TARP requirements.	• BBM Licence compliance reporting. • Summary of water monitoring data provided within AER.

Management Targets / Objectives	Management Actions	Monitoring	Reporting
Minimise the risk of exposure of PASS	• Mining footprint to avoid low-lying topographical areas in the vicinity of rivers and creeks. • Stream buffers must be applied to all rivers in accordance with the FMP (CPCWA, 2023) and *Water Quality Protection Note 6*: (Department of Water, 2006). • Acid Sulphate / Potentially Acid Sulphate soil monitoring as part of risk management in disturbance areas • A CEMP must be developed with an associated ASSMP to outline the identification, sampling and management of any PASS expected to be encountered for the construction of river crossings.	• Ongoing monitoring in accordance with the water monitoring program including application of TARP requirements. • Monitoring in accordance with the ASSMP.	• Summary of water monitoring data provided within AER. • Reporting of incidents and associated corrective actions in accordance with applicable TARPs.

5.3 REFINERY

5.3.1 Refinery Outcome Based Provisions

Outcome based provisions have been developed for general operations (Table 5-3) and specifically to address Carter's Fresh Water Mussel (Table 5-4).

Table 5-3: Refinery outcome based provisions for Inland Waters

EPA factor/s and objective/s: Inland Waters, Flora and Vegetation

Outcome/s:

1. No adverse impacts to hydrological regimes and water quality of the Augustus River attributable to the proposal.
2. No adverse impacts to native vegetation within 30 m of Augustus River bank attributable to the proposal.

Key environmental values: Surface water quality and quantity

Key impacts and risks: Groundwater mounding, salinity, surface water flows.

Relevant outcome(s)	Trigger & Threshold Criteria	Response Actions	Monitoring	Timing / frequency of monitoring	Reporting
REF1 **Outcome 1** **Outcome 2**	**Trigger Criteria:** Downstream surface water quality measures at Augustus River Gauging Station (ARGS) exceed set trigger levels as defined in Appendix B.	**Trigger Level Actions:** **1.** Implement TARP Plan (refer section 5.1.3).	**Indicators:** *Turbidity, EC, Salinity, pH* Refinery Regional Surface Water	Monthly laboratory analysis EC and pH real-time (sonde)	Summary of water monitoring data provided within AER. Reporting in accordance with licence conditions.
	Threshold Criteria: Exceedance of water quality criteria as outlined in Surface Water Licence.	**Threshold Contingency Actions:** **1.** Incident investigation to be completed in accordance with site procedures. **2.** Incident to be reported to relevant government agencies including outcomes of investigation and any planned preventative actions. **3.** Implementation of agreed preventative actions.			
REF2 **Outcome 1**	**Trigger Criteria:** Environmental water release to the Augustus River does not meet required flow rate of the Surface Water Licence for a given month.	**Contingency Actions:** **1.** Report non-compliance to DWER. **2.** Conduct an investigation to determine cause of reduced flow.	**Indicator:** Surface water flow (m^3/h)		Summary of water monitoring data provided within AER and Annual Hydrological Report.

Relevant outcome(s)	Trigger & Threshold Criteria	Response Actions	Monitoring	Timing / frequency of monitoring	Reporting
	Threshold Environmental releases do not meet required flow rates for a period of 3 consecutive months.	**3.** Implement actions (as required) to address any findings from the investigation.	Refinery Regional Surface Water	Continuous	

Table 5-4: Carter's Fresh Water Mussel Outcome-Based Provisions

EPA factor/s and objective/s: Terrestrial Fauna

Outcome/s:

1. No direct impacts on Carters Freshwater Mussel (CFWM) due to Project-related activities.
2. No disturbance to native vegetation within 30 m of the Augustus River bank attributable to the proposal.
3. Indirect impacts on CFWM due to Project-related activities are minimised.

Key impacts and risks: decline in population of CFWM in FWL and Augustus River, decline in habitat quality for CFWM inside the CBME.

Relevant Outcomes	Trigger and Threshold Criteria	Response action • **Trigger level Actions** • **Threshold Contingency Actions**	Monitoring	Timing/ frequency of Monitoring	Reporting
CFWM1 Outcome 1 Outcome 2	**Trigger Criteria:** FWL CFWM Population: • Clearing occurs without an authorised internal permit within the CBME but outside the 50 m separation area for the FWL. Augustus River CFWM Population: • Clearing occurs without an authorised internal permit within the CBME but greater than 30 m from the Augustus River.	**Trigger Level Actions:** • Report internally as an incident in accordance with internal procedures. • Review management strategies and implement changes to prevent future occurrences which may include the following: o Audit and review of training and staff inductions (increase staff training and awareness to include information on 50 m or 200 m separation areas and legislative requirements, and appropriate clearing procedures). o Installation of signage where appropriate. • Review impact of unauthorised clearing and report any non-compliance to DWER within 7 days of identification. • Undertake rehabilitation of unauthorised clearing as required, in accordance with rehabilitation procedures.	**Indicators:** *verified spatial data (clearing)* Survey of clearing boundaries Internal audit against areas of clearing.	 Monthly As required during clearing.	Summary of monitoring data included in Annual Environmental Report. Incident reports. Annual Compliance Assessment Report.

Relevant Outcomes	Trigger and Threshold Criteria	Response action • Trigger level Actions • Threshold Contingency Actions	Monitoring	Timing/ frequency of Monitoring	Reporting
	Threshold Criteria: FWL CFWM Population: • Unauthorised clearing or disturbance within the 50 m separation area for the FWL. Augustus River CFWM Population: • Unauthorised clearing or disturbance within 30 m of the Augustus River.	**Threshold Contingency Actions:** • Cease clearing activities. • Undertake investigation to determine source of disturbance. • If Project-related, undertake a review to determine if impact can be minimised, develop actions to prevent recurrence and communicate findings to relevant personnel. • Suitably qualified aquatic ecologist/specialist to undertake an assessment of impact. • Rehabilitation of vegetation disturbance to be considered to re-instate fauna habitat. • Report as a non-compliance to DWER within 7 days of identification. • Investigation report to be submitted to DWER with remediation actions proposed within 28 days of incident report.			

CFWM2
Outcome 3
	Trigger Criteria:
	• Isolated occurrence of overtopping of sediment trap(s) into FWL.
		Trigger Level Actions
		• Report internally as incident.
		• Determine the source of sedimentation.
		• Where sediment deposition occurs, corrective actions will be implemented as soon as practicable:
		  ○ Conduct maintenance on the sediment trap to reduce liklihood of continued sediment discharge
		  ○ Cease land clearing
		• Investigate suitable options for translocation sites.
			Indicators: *sediment trap overtopping incident*
			• Visual inspection of sediment traps
			• Monitor TSS and Turbidity in FWL
			• Refinery Surface Water Monitoring Program
			• Carter's Freshwater Mussel Monitoinrg Program
				Monthly
				As required following overtopping
				Refer Appendix B
				Refer Appendix D
					Summary of monitoring data included in Annual Environmental Report.
					Incident reports.
					Annual Compliance Assessment Report.

	Threshold Criteria: • Continued occurrence / or overtopping of multiple sediment traps into the FWL.	**Threshold Contingency Actions:** • Report to DWER in 7 days. • Investigate impact on CFWM and remediation of water **Potential contingency action**: Translocate CFWM individuals from FWL or Augustus River if required (in consultation with DWER).			

Relevant Outcomes	Trigger and Threshold Criteria	Response action • Trigger level Actions • Threshold Contingency Actions	Monitoring	Timing/ frequency of Monitoring	Reporting

CFWM3
Outcome 1
Outcome 3
	Interim Trigger Criteria:
	Laboratory analysis for surface water quality shows results exceeding the trigger levels for any given analyte as detailed in Table 5-5
	Table 5-5.
	Note: SSGVs will be developed once 24 samples have been taken. These will replace the Interim Trigger levels.
		Trigger Level Actions:
		• Report internally as an incident.
		• Investigate the cause of the exceedance and, where found to be attributable to Project related activities, apply corrective actions as soon as practicable. Potential corrective actions may include:
		  ○ Completion of maintenance activities on drainage structures
		  ○ Ceasing of ground disturbing works until more favourable weather conditions are present
		  ○ Application of additional control measures to prevent further water quality decline.
		• Investigate suitable options for translocation sites.
		• Continue to monitor CFWM population to assess whether there has been any impact associated with the incident.
			Indicators: *Laboratory results for TSS, Salinity and Dissolved Metals*
			• Refinery Surface Water Monitoring Program
			• CFWM Water Monitoring Program
			• Monitor success of translocation (if required.
				Refer Appendix B
				Monthly for first 2 years (Refer Appendix D)
				As required
					Summary of monitoring data included in Annual Environmental Report.
					Incident reports.
					Annual Compliance Assessment Report.

	Interim Threshold Criteria: Laboratory analysis for surface water quality shows results exceeding the threshold levels for any given analyte as detailed in Table 5-5. *Note: SSGVs will be developed once 24 samples have been taken. These will replace the Interim Threshold levels.*	**Threshold Contingency Actions:** • Report as a non-compliance to DWER within 7 days of identification. • Investigate the cause of the exceedance and report findings to DWER including proposed remediation actions. • Modify operations and apply additional controls (as required) to prevent recurrence. **Potential contingency action**: Translocate CFWM individuals from FWL or Augustus River if required (in consultation with DWER).			
CFWM4 Outcome 3	**Interim Trigger Criteria:** Laboratory analysis of sediment records Mercury (Hg) >0.15 mg/kg. *Note: A SSGV will be developed once 24 samples have been taken. This will replace the Interim Trigger levels.*	**Trigger Level Actions:** • Report internally as an incident • Investigate the cause of the exceedance and, where found to be attributable to Project related activities, apply corrective actions as soon as practicable. Potential corrective actions may include: ○ Completion of maintenance activities on drainage structures	**Indicator:** *Mercury in sediment (mg/kg)* • Refinery Surface Water Monitoring Program • CFWM Sediment Monitoring Program	Monthly for first 2 years (Refer Appendix D)	Summary of monitoring data included in Annual Environmental Report. Incident reports. Annual Compliance Assessment Report.

Relevant Outcomes	Trigger and Threshold Criteria	Response action • Trigger level Actions • Threshold Contingency Actions	Monitoring	Timing/ frequency of Monitoring	Reporting
		○ Ceasing of ground disturbing works until more favourable weather conditions are present ○ Application of additional control measures to prevent further water quality decline. • Investigate suitable options for translocation sites. • Continue to monitor CFWM population to assess whether there has been any impact associated with the incident.	• Monitor success of translocation (if required.	As required	
	Interim Threshold Criteria: Laboratory analysis of sediment records Mercury (Hg) >1 mg/kg. *Note: A SSGV will be developed once 24 samples have been taken. This will replace the Interim Threshold level.*	**Threshold Contingency Actions:** • Report as a non-compliance to DWER within 7 days of identification. • Investigate the cause of the exceedance and report findings to DWER including proposed remediation actions. • Modify operations and apply additional controls (as required) to prevent recurrence. **Potential contingency action**: Translocate CFWM individuals from FWL or Augustus River if required (in consultation with DWER).			
CFWM5 Outcome 1 Outcome 3	**Trigger Criteria:** • Individual mortality of CFWM recorded at FWL. • Reduction in density of CFWM by **>20%** against baseline for Augustus River.	**Trigger Contingency Actions** • Report internally as an incident • Determine whether the changes observed in the impact sites are comparable to the observations in the reference sites. • Investigate the potential cause of the decline/death. • Where the exceedance is found to be caused by project related activities, review management measures with an adaptive management response. • Investigate suitable options for translocation sites.	**Indicator:** *CFWM mortality OR population decline* • CFWM Field Surveys (by qualified consultants)	Annual	Summary of monitoring data included in Annual Environmental Report. Incident reports. Annual Compliance Assessment Report. .
	Threshold Criteria: • **50%** reduction in CFWM known population size recorded at FWL. • **50%** reduction in CFWM density (per m^2) from baseline in Augustus River.	**Threshold Contingency Actions:** • Report as a non-compliance to DWER within 7 days of identification. • Investigate the potential cause of the population decline and report to DWER with proposed remediation actions. • Implement agreed remedial actions.			

Relevant Outcomes	Trigger and Threshold Criteria	Response action • Trigger level Actions • Threshold Contingency Actions	Monitoring	Timing/ frequency of Monitoring	Reporting
		Potential contingency action: Translocate CFWM individuals from FWL or Augustus River			
CFWM6 Outcome 3	**<u>Trigger Criteria:</u>** • Water levels recorded below 231m Australian Height Datum in FWL (AHD).	**<u>Trigger Contingency Actions</u>** • Report internally as an incident. • Review management strategies and implement changes to reduce risk of future occurrences where possible. • If decline in water levels is associated with Project-related activities, undertake a review to determine if impact can be minimised, develop corrective actions with consideration of: o Maintaining water levels to above 231m in FWL by reducing water abstraction. o Limiting the exposure of sediments for periods longer than 3 months. • Investigate suitable options for translocation sites.	**Indicator:** *FWL water level* • Monitor water levels in FWL in accordance with DWER Surface Water Licence SWL6804(4).	According to schedule of water monitoring for DWER Surface Water Licence SWL6804 (4).	Summary of monitoring data included in Annual Environmental Report. Incident reports. Annual Compliance Assessment Report.
	<u>Threshold Criteria:</u> • Water levels recorded below 225m AHD for a period of three months in FWL.	**<u>Threshold Contingency Actions:</u>** • Review impact of fluctuating water levels on CFWM population and report any non-compliance to DWER within 7 days of identification. • Undertake investigation to determine contributing factors. • Identify options available to minimise duration of impact and ensure impact period does not exceed 3 months. Implement options where operationally viable. • Apply adaptive management measures to minimise risk of recurrence and communicate findings to relevant personnel. **Potential Corrective Action:** Translocate CFWM individuals from FWL or Augustus River as required (in consultation with DWER).			

Table 5-5: Interim Trigger and Threshold Levels for CFWM - Surface Water Quality

Analyte	Unit	Interim Trigger Level	Interim Threshold Level
Water Quality			
TSS	mg/L	>8	>15
Salinity	g/L	>1.6	>3.0
Dissolved Metals:			
Mercury (Hg)	mg/L	>0.00006	>0.0006
Aluminium (Al)	mg/L	>0.027	>0.055
Cadmium (Cd)	mg/L	>0.00006	>0.0002
Copper (Cu)	mg/L	>0.001	>0.0014
Lead (Pb)	mg/L	>0.001	>0.034
Zinc (Zn)	mg/L	>0.0024	>0.008
Sediment			
Mercury (Hg)	mg/kg	0.15	1.0

Note: Site Specific Guideline Values (SSGVs) will be developed once 24 samples have been taken for each analyte. Once developed, trigger and threshold values will be replaced with the SSGVs.

5.3.2 Refinery Objective Based Provisions

Table 5-6 provides a summary of the management objectives for Inland Waters at the Refinery.

Table 5-6: Refinery objective based provisions for Inland Waters

EPA factor/s and objective/s: Inland Waters

Objectives:

1. Minimise risk of groundwater contamination from Refinery operations (including BRDAs).
2. Minimise impacts on surface water resources (i.e. FWL)
3. Minimise risk of contamination of surface water and/or groundwater from spills, chemicals or stormwater run-off
4. Minimise risk of insufficient water supply.
5. Minimise impacts on conservation significant fauna habitat
6. Minimise impacts on threatened aquatic fauna

Key environmental values: Water Quality, Threatened species

Key risks: Surface water and groundwater contamination (BRDAs, hydrocarbons, chemicals), Water supply, Impacts on Carter's Freshwater Mussel

Management Targets / Objectives	Management Actions	Monitoring	Reporting
Objective: Inland Waters:			
Minimise risk of groundwater contamination from Refinery operations (including BRDAs)	• All BRDAs to have engineered design which includes clay liners and an underdrainage system • Grout curtains installed. • Concrete bunding to be maintained for all Refinery process areas and hydrocarbon storage areas. • Maintain water management structures to ensure continued separation of the Refinery Lease Area (RLA) into two catchment areas: clean (diverted to the FWL) and dirty (diverted to the RCL) • Maintain depression bores located between BRDAs and FWL with pumping capacity to divert contaminated underflow from BRDAs to the dirty catchment if required	• Ongoing groundwater monitoring program (includes underflows) with applicable investigation trigger levels outlined in the TARP	• Summary of water monitoring data provided within Annual Hydrological Report. • Reporting of incidents and associated corrective actions in accordance with applicable TARPs.
Minimise impacts on surface water resources (i.e. FWL)	• Maintain water management structures to ensure continued separation of the Refinery Lease Area (RLA) into two catchment areas: clean (diverted to the FWL) and dirty (diverted to the RCL • BRDA engineered design • Pipe head dams • Install and maintain erosion control measures (silt / sediment traps, contouring etc) for catchment areas that feed the FWL • Installation of water management infrastructure (sumps, perimeter drains, drainage lines etc) for all operational areas including haul roads in accordance with the	• Ongoing surface water and ecological monitoring programs with applicable investigation trigger levels outlined in the TARP • Regular maintenance and inspections of water management infrastructure.	• Summary of water monitoring data provided within AER. • Reporting of incidents and associated corrective actions in accordance with applicable TARPs.

Management Targets / Objectives	Management Actions	Monitoring	Reporting
	existing Site Drainage – BBM Standard (STA-402) and the Trunk Haul Road Design and Construction Specification (00112148). • Emergency Response Plans developed for Material Risks (i.e. Catastrophic failure of BRDA).		
Minimise risk of contamination of surface water and/or groundwater from spills, chemicals or stormwater run-off	• Environmentally hazardous material releases will be managed in accordance with the Spill Management SWI (01027460). • Concrete bunding installed and maintained for all Refinery process areas and hydrocarbon storage areas • Separation of the RLA into two catchment areas: clean (diverted to the FWL) and dirty (diverted to the RCL) • Maintain Dangerous Goods Licence. • Develop and maintain a Hazardous Substance Management Procedure. Training provided to applicable personnel in accordance with the Hazardous Substance Management Procedure (00114502). • Ensure spill kits are readily available in high risk areas. • Install and maintain Oil / water separators in maintenance areas.	• Hydrocarbon and chemical analysis of selected bore monitoring programs to identify any contamination as a result of Worsley's operations • Tank Integrity Maintenance System	• Summary of water monitoring data provided within AER. • Reporting of incidents and associated corrective actions in accordance with applicable TARPs.
Minimise risk of insufficient water supply	• Identify and implement water efficiency measures to minimise water use for operational requirements. • Ensure compliance with licence to take water from FWL. • Installation of a water supply pipeline to Wellington Dam. • Development of a long-term water supply strategy	• Ongoing monitoring of groundwater and surface water with applicable investigation trigger levels outlined in the TARP	
Minimise impacts on conservation significant fauna habitat	• Define Protected Areas and associated buffers in accordance with the Protected Areas Plan. • Review and revise the water monitoring program to ensure the monitoring program intent is met for protection of vegetation that provides fauna habitat • Install monitoring bores at least two years prior to construction of BRDA4E or the commencement of contingency mining activities and collect two years of baseline monitoring then ongoing monitoring in accordance with this plan	• Ongoing groundwater monitoring and associated TARPs • Annual aquifer review	• Summary of water monitoring data and triennial reviews provided within AER. Reporting of incidents and associated corrective actions in accordance with applicable TARPs.
Minimise impacts on threatened aquatic fauna	• Apply stream buffers in accordance with the FMP (CPCWA, 2023). • Manage stream buffers in accordance with the PAP. • Disturbance of the Freshwater Lake by contingency mining activities will be avoided by maintaining a separation distance of 50 m, from the high-water mark. • Develop a monitoring program for Carter's Freshwater Mussel to assess health and potential populations within the FWL and Augustus River. This monitoring program	• Continuation of existing monitoring programs (physical, chemical and biological) to determine and identify any impacts to aquatic fauna ecosystems.	• Summary of water monitoring data provided within AER. • Summary of targeted monitoring for Carter's Freshwater Mussel will be provided within AER.

Management Targets / Objectives	Management Actions	Monitoring	Reporting
	will include consideration of mercury and other elements that may impact the health of the species. • Alternative mitigations for the Carter's Freshwater Mussel, including translocation of individuals, may be considered, if required, and will be undertaken in consultation with relevant government authorities. • Training and awareness with staff of the impact and the management measures (including new management measures identified) to reduce the potential impact CFWM.		• Reporting of incidents and associated corrective actions in accordance with applicable TARPs.

5.4 BUNBURY PORT

5.4.1 Objective Based Provisions

Table 5-7 provides a summary of the management objectives for Inland Waters at the Bunbury Port.

Table 5-7: Port objective-based provisions for Inland Waters

EPA factor/s and objective/s: Inland Waters

Outcome/s:

1. Chemicals, hydrocarbons and stormwater are managed appropriately to minimise risk of contamination of groundwater and surface water.

Key environmental values: Water Quality,

Key risks: Surface water and groundwater contamination (hydrocarbons, chemicals)

Management Targets/Objectives	Management Actions	Monitoring	Reporting
Minimise risk of contamination of surface water and / or groundwater from spills, chemicals or stormwater run-off Monitor known pre-existing hydrocarbon contamination to understand any changes	• Safe Work Instructions in place for chemical loading/unloading activities. • Dangerous Goods Licence in place. • Develop and maintain a Hazardous Substance Management Procedure. Training provided to applicable personnel in accordance with the Procedure (00114502). • Bunding and sumps in place. • Automated control and interlock systems installed. • Tank level control installed. • Ensure spill kits are readily available. • Registration of site under *Contaminated Sites Act 2003*	• Ongoing monitoring and hydrocarbon and chemical analysis of groundwater and runoff to identify any contamination as a result of Worsley's operations • Worsley Tank Integrity Maintenance System • Routine maintenance and inspections	• Summary of water monitoring data provided within AER. • Reporting of incidents and associated corrective actions in accordance with applicable TARPs.

6 REPORTING, ADAPTIVE MANAGEMENT AND REVIEW

6.1 COMPLIANCE AUDITING

Compliance to this WMP will be audited annually under MS1237 condition D2-1. Any non-compliances of the provisions set out in the WMP will be identified and registered within the internal incident, risk reporting and management system (G360) and will be reported within the AER and Compliance Assessment Report (CAR). Audit findings will be communicated internally, and actions will be assigned to relevant areas through G360. The CAR will be provided in a form suitable for publication on the South32 website and online by DWER, as required by MS1237 Condition D2-4(5).

6.2 REPORTING

6.2.1 Reporting under Ministerial Conditions:

Reporting under condition D2-(1):

"*The proponent must provide an annual Compliance Assessment Report to the CEO for the purpose of determining whether the implementation conditions are being complied with*."

Reporting under condition 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."

6.2.2 Annual Environmental Report

Worsley is required to provide an annual summary of monitoring activities by 30 September each year as part of its environmental licences. The Annual Environmental Report contains a summary of data collected over the previous financial year (1 July to 30 June). This includes a discussion of the monitoring data and other collected data against historical data (trend analysis), known standards and targets set in the licences.

Appended to the AER is the Refinery Annual Hydrological Monitoring Report which is an annual interpretation and reporting of hydrological monitoring data, including trend analysis. This report is prepared by hydrological consultants for Worsley for regulatory authorities associated with Worsley's mining and Refinery operations at Boddington and Collie, including the EMLG and the EPA.

6.2.3 Licence Reporting Requirements

Worsley is also required to adhere to the reporting conditions set out in the following licences:

- BBM EP Act Licence (L5960/1983/11)
- Refinery EP Act Licence (L4504/1981/17)
- Refinery Surface Water Licence (SWL68041(5)).

6.3 ADAPTIVE MANAGEMENT AND REVIEW

Worsley commits to maintaining a process of adaptive controls that provide the best outcome for Inland Waters. This Plan will be reviewed by Worsley on a triennial basis to assess effectiveness, ongoing relevance and incorporate improved management strategies derived from assessment of monitoring, research and positive corrective actions from incident investigations. Revised versions of this plan must be submitted to EPA Services for approval.

The review of this Plan will consider:

- Effectiveness of monitoring controls / systems;
- Monitoring report outcomes;
- Relevance to current monitoring and analysis systems and performance indicators;
- Technology improvements;
- Changes to operational activities leading to changes in the risk;
- Best practice monitoring processes;
- Actions from incident and audit outcomes;
- Changes to relevant legislation, policy, guidelines and guidance material; and
- Benchmarking against other similar operations.

7 ROLES AND RESPONSIBILITIES

Role	Responsibility
Environment Supervisor	• Ensure sufficient funds are budgeted for required external services to support this WMP. • Ensure reviews, audits, supporting surveys and studies are included in business plans.
Environment Specialists	• Ensure water and sediment monitoring is conducted in accordance with the water monitoring program described in Appendices A-C. • Verify monitoring data uploads and review and respond to trigger level exceedances. • Commission BBM Triennial Aquifer Reviews, Vegetation Condition Assessments (3-5 yearly) and Sustainable Yield Testing (6 yearly). • Report any exceedances of Sustainable Yield to relevant site personnel. • Report significant findings from external reviews and surveys to applicable internal stakeholders. • Report any incidents to relevant government authorities and conduct investigations and remedial actions as required. • Maintain site environmental training packages to ensure accuracy and sufficient content. • Review and update the WMP and associated Monitoring Plan (Appendices A-C) at least every 3 years to ensure adaptive management. • Ensure WMP is audited in accordance with the Audit schedule. • Support completion of rehabilitation works in accordance with the Mine Plan. • Commission and support investigations into the sensitivities and tolerances of any conservation significant GDE vegetation structures vulnerable to groundwater mounding predictions. • Ensure regular inspection and maintenance of water monitoring sites occurs. • Commission installation and testing of production bores, as advised by external hydrogeologists, in the event of a GDE threshold criteria being triggered.
Approvals Manager	• Develop a CEMP and ASSMP to support construction works associated with the Revised Proposal.

Superintendent Mine Production Planning	• Ensure mine clearing is minimised through Mine Planning processes. • Review and amend operational plans in response to exceedances of threshold criteria to minimise further impacts on inland waters.
Superintendent Mine Development Planning	• Ensure the Protected Areas, Protection Commitment and Biodiversity Areas of Interest mapping layers are maintained in Mine Planning Software. • Oversee the preparation of the 10 Year Mine plan.
Superintendent Execution - Mining Services	• Conduct progressive rehabilitation in accordance to plan.
Maintenance Supervisor	• Conduct regular inspection and maintenance of the mine drainage network. • Conduct regular inspections and maintenance on water supply infrastructure.
Principal Approvals	• Commission FDA analysis in advance of mining for new mining areas. • Commission salt storage assessment where FDA indicates further assessment is required. • Devise new water monitoring programs (based on expert advice) and provide these to the Environment Specialists for implementation in new mining areas. • Commission desktop and field monitoring to allow assessment of potential GDEs and SWDEs in new mining areas. • Define Protected Areas in accordance with Protected Areas Plan (01013619). • Apply for Bed and Banks Permits as required.
Specialist GIS (Environment)	• Maintain environment mapping layers for the business in Arc GIS.
Superintendents Execution (Refinery Process Areas)	• Ensure regular inspection and maintenance of process area bunds.
Superintendent Execution - BRDA Construction & Operations	• Ensure BRDA construction is in accordance with engineered design. • Ensure regular inspection and maintenance of BRDAs and supporting infrastructure. • Conduct regular inspection and maintenance of Refinery freshwater drainage network (sumps etc). • Maintain depression bores.
Principal Business Planner	• Develop and implement a long-term water supply strategy which includes investigation of water efficiency improvements.
Process and Analysis Engineer	• Maintain a site water balance. • Monitor and maintain water levels within the RCL and FWL at a safe level.
Superintendent Execution - Mining	• Application of dust suppressants.
All Staff and Contractors	• Report all spills and emergencies. • Follow Spill Management SWIs. • Complete mandatory and task specific environmental training.

8 STAKEHOLDER CONSULTATION

Stakeholder consultation in association with this WMP is outlined in Table 8-1.

Table 8-1: Stakeholder Consultation Summary

Stakeholder	Comments/Advice	Response
DWER	As summarised within the Response to submissions.	Key recommendations incorporated into this WMP.
	Further modifications to provisions required to ensure suitability and measurability.	Changes incorporated to address comments.
	Further amendments required in line with draft conditions received in EPA Report 1768.	Changes incorporated to meet new requirements.
	Review of draft version 5.5 identified minor modifications to be made.	Modifications made to document as requested and provided for final review as version 5.6.
DCCEEW	As summarised within the Response to submissions.	Key recommendations incorporated into this WMP.
	Additional advice received during stop clock. Amendments required to Table 5-1 and Table 5-2.	Amendments included where possible. Response sent to DCCEEW where this was not possible.
	Advice received on version 5.5. Request to include additional information from Threatened Species Management Plan for Carter's Freshwater Mussel and to specify that historic data will be included in considerations for baseline determination where available.	Information included in this WMP and provided for final review as Version 5.6.
Water Corporation	Comments regarding operations in PDWSAs and development of Working Arrangements	WMP includes commitment that mining and exploration activities are excluded from RPZs
Peel Harvey catchment Council	Request to increase monitoring program suite to include TSS.	Requested analysis incorporated into surface water monitoring program.
	Additional detail regarding sump design requested.	Minimum design requirements for sumps included in WMP.

9 DEFINITIONS, TERMS AND ABBREVIATIONS

Term	Description
AER	Annual Environmental Report
ASSMP	Acid Sulfate Soils Management Plan
BBM	Boddington Bauxite Mine
BRDA	Bauxite Residue Disposal Area
BTC	Bauxite Transport Corridor
CAR	Compliance Assessment Report
CBME	Contingency Bauxite Mining Envelope
CEMP	Construction Environmental Management Plan

CFWM	Carter's Freshwater Mussel
DBCA	Department of Biodiversity, Conservation and Attractions
DEMIRS	Department of Energy, Mines, Industry Regulation and Safety
DoE	Department of Environment (Now DCCEEW)
DWER	Department of Water and Environment Regulation
EMLG	Environmental Management Liaison Group
EP Act	*Environmental Protection Act 1986*
EPA	Environmental Protection Authority
ERD	Environmental Review Document
FDA	Flux Density Analysis
FMP	Forest Management Plan
FWL	Freshwater Lake
GDE	Groundwater Dependent Ecosystem
MNES	Matters of National Environmental Significance
MS719	Ministerial Statement No. 719
PASS	Potential Acid Sulfate Soils
PDWSA	Public Drinking Water Source Area
PEC	Priority Ecological Community
Project Area	Includes current operations within the BBM, Refinery and Bunbury Port and operations as proposed in the Revised Proposal.
RCL	Refinery Catchment Lake
The Refinery	Worsley Alumina Refinery
RPZ	Reservoir Protection Zone
RLA	Refinery Lease Area
RIWI Act	*Rights in Water and Irrigation Act 1914*
Sensitive Area Sumps	Sumps that are required to prevent run-off into environmentally sensitive areas, are located in areas where run-off is not allowable under licence conditions or prevent release of treated water which poses an unacceptable risk to the business shall be considered Sensitive Area Sumps. Examples of these include: • Sumps adjacent to protected areas (ie. Tunnell Road Heath) • The large sump which prevents run-off to flow out of the Maintenance compound • Sumps preventing run-off from a confirmed or uninterpretable dieback area into a Dieback-free area • Sumps, which in the event of an overflow, discharge onto private land
SEP	Solar Evaporation Pond
SSGV	Site-Specific Guideline Value
SWDE	Surface Water Dependent Ecosystem
TARP	Trigger and Action Response Plan

TDS	Total Dissolved Solids
TSS	Total Suspended Solids
WA	Western Australian
WMDE	Worsley Mining Development Envelope
WMP	Water Management Plan
Worsley	South32 Worsley Alumina Pty Ltd
Worsley State Agreement	*Alumina Refinery (Worsley) Agreement Act 1973*
WRC	Water and Rivers Commission

10 REFERENCES

00112148	Trunk Haul Road Design and Construction Specification
0011450	Hazardous Substance Management Procedure
01012523	Biodiversity and Forest Management Plan
01013619	Protected Areas Plan
01020749	Site Drainage - BBM Standard, STA-402
01027460	Spill Management SWI
200000338	Threatened Species Management Plan
200000484	Protected Areas Implementation and Management Procedure
200001092	Flora and Vegetation Management Plan
	Alumina Refinery (Worsley) Agreement Act 1973 (WA)
	Country Areas Water Supply Act 1947
	Contaminated Sites Act 2003 (WA)
	Environmental Protection Act 1986 (WA)
	Explosives and Dangerous Goods (Dangerous Goods Handling and Storage) Regulations 1992 (WA)
	Ministerial Statement No. 719
	Rights in Water and Irrigation Act 1914 (WA)
	Metropolitan Water Supply Sewerage and Drainage Act 1909 (WA)
	Metropolitan Water Supply Sewerage and Drainage Bylaws 1957 (WA)
	Water Agencies Powers Act 1984 (WA)
	Water Corporation Act 1995 (WA)
	ANZECC (2000) Australia and New Zealand *Guidelines for Fresh and Marine Water Quality*. October 2000.
	Bureau of Meteorology (BoM) (2020a). *Climate Data Online*. http://www.bom.gov.au/climate/data/
	Bureau of Meteorology (BoM) (2020b). *Groundwater Dependent Ecosystems Atlas*. http://www.bom.gov.au/water/groundwater/gde/

	Conservation and Parks Commission of Western Australia (2023). *Forest Management Plan 2024-2033*, Government of Western Australia.
	Croton, J.T. (1991). *Relationships of groundwater levels and salt storages to the geomorphology of the Intermediate Rainfall Zone of the northern jarrah forest*, Environmental Research Bulletin No. 24. Alcoa of Australia Ltd.
	Croton, J.T. and Dalton, J.A. (2004). *Soil salt storages and salinity risk assessment for the Boddington Bauxite Mine*, Water & Environmental Consultants reports to Worsley Alumina Pty Ltd.
	Croton, J.T. and Dalton, J.A. (2007). *Summary of soil salt storages for Boddington bauxite mine*, Water & Environmental Consultants reports to Worsley Alumina Pty. Ltd.
	Croton, J.T. and Dalton, J.A. (2008). *Proposed Groundwater Monitoring for Marradong Timber Reserve Mine Area*, Water & Environmental Consultants Confidential Report to Worsley Alumina Pty. Ltd.
	Croton, J.T., Mauger, G. W. and Dalton, J.A. (2020). *Review of the Piezometer Network at the Boddington Bauxite Mining,* Water & Environmental Consultants (WEC) reports to Worsley Alumina Pty Ltd.
	DCCEEW 2024, Environmental Management Plan Guidelines. URL: https://www.dcceew.gov.au/sites/default/files/documents/environmental-management-plan-guidelines.pdf
	Department of Environment (2005). South Dandalup Dam Catchment Area, South Dandalup Pipehead Dam Catchment Area Drinking Water Source Protection Plan. Water Resource Protection Series WRP 55.
	Department of Environment Regulation (DER – now DWER) (2015a). *Identification and investigation of acid sulfate soils and acidic landscapes.*
	Department of Environment Regulation (DER – now DWER) (2015b). *Treatment and management of soils and water in acid sulfate soil landscape*.
	EPA (2024) *Instructions: How to prepare Environmental Protection Act 1986 Part IV environmental management plans*. URL: https://www.epa.wa.gov.au/sites/default/files/Forms_and_Templates/Preparing%20Environmental%20Protection%20Act%201986%20PIV%20environmental%20management%20plans.pdf
	Froend, R., Loomes, R, Horwitz, P, Bertuch, M, Storey, A. and Bamford, M. (2004). *Study of Ecological Water Requirements on the Gnangara and Jandakot Mounds under Section 46 of the Environmental Protection Act – Task 2 Determination of Ecological Water Requirements*. Prepared for The Waters and Rivers Commission. September 2004.
	GHD Group Pty Ltd (GHD) (2012). Refinery Water Balance Strategy. *Investigation into Key Strategic Projects Ensuring Refinery Operational Security*, June 2012.
	GHD Group Pty Ltd (GHD) (2020). *Hotham Bauxite Groundwater and Surface Water Studies*, Unpublished report prepared for South32 Worsley Alumina.
	Green, K.A., Croton, J.T. and Dalton J.A (2021). *Boddington Bauxite Mine Triennial Aquifer Review July 2017-June 2020,* Water & Environmental Consultants (WEC) reports to Worsley Alumina Pty Ltd.
	Green, K.A., Croton, J.T., Dalton, G.T. and Dalton J.A (2023). *Salinity Risk Assessment for Hotham North Mining Area Using Flux Density Analysis,* Water & Environmental Consultants (WEC) report to South32 Worsley Alumina Pty Ltd.
	Grigg (2017). Hydrological response to bauxite mining and rehabilitation in the jarrah forest in south west Australia. Journal of Hydrology: regional Studies Volume 12, August 2017, Pages 150-164. URL: https://www.sciencedirect.com/science/article/pii/S2214581816301665
	Golder Associates (2004). *Worsley Alumina's Bauxite Mining Lease Area 258SA Stream Flow and Salinity Analysis*, Unpublished report prepared for Worsley Alumina Pty Ltd, Nov 2004.

	Johnston, C.D. (1981). *Salt content of soil profiles in bauxite mining areas of the Darling Range, Western Australia*, CSIRO Australia, Division of Land Resources Management Technical Paper No. 10:1-19.
	Mattiske Consulting Pty Ltd (2021). *Assessment of Flora and Vegetation on Worsley Mine Expansion Primary Assessment Area.* Unpublished report prepared for South32 Worsley Alumina Pty Ltd, September 2021.
	Mcfarlane et. al (2020). Runoff and groundwater responses to climate change in South West Australia. Journal of the Royal Society of Western Australia, Volume 103, 2020 Pages 9–27. URL: https://www.rswa.org.au/publications/journal/103/RSWA 103 p9-27 McFarlane et al.pdf
	Slessar, G.C., Murray, N.J. & Passchier, T. (1983). *Salt storage in the bauxite laterite region of the Darling Range, Western Australia*, Environmental Research Bulletin No. 16, Alcoa of Australia Ltd.
	Stokes, R.A., Stone, K.A. & Loh, I.C. (1980). *Summary of soil salt storage characteristics in the northern Darling Range*, Water Resources Branch, Public Works Depart. W.A., Tech. Rep. No. WRB 94.
	Strategen Environmental Review (2005). Worsley Alumina Environmental Review and Management Program.
	Strategen (2008). Audit Program - Ministerial Statements No. 719 and 751. Unpublished Report for Worsley Alumina Pty Ltd, Jan 2008
	Tsykin, E.N. & Croton, J.T. (1988). *General salt storage terrain relationships for the Darling Range, W.A.* Environmental Research Note No. 14. Alcoa of Australia Ltd.
	Tsykin, E.N. & Slessar, G.C. (1985). *Estimation of salt storage in the deep lateritic soils of the Darling Plateau, Western Australia*, Australian Journal of Soil Research 23: 533–41.
	Water and Rivers Commission Water, (2000a). *Quality Protection Guidelines (2-11)*
	Water and Rivers Commission (WRC) (2000b). *Environmental Water Provisions Policy for Western Australia*, Water and Rivers Commission, Statewide Policy No. 5.
	WRM (2014). Augustus River Ecological Monitoring Program, Milestone Report – Aquatic Fauna Baseline Survey.
	Worley Parsons (2011). Worsley Alumina Water Balance Strategy.
	Worsley (2007). WAPL Proposed Water Supply Strategy
	Worsley (2022). Worsley Mine Expansion (Revised Proposal) Environmental Review Document. June 2022.
	Worsley (2024). Worsley Mine Expansion (Revised Proposal) Response to Submissions Document. March 2024.

11 DOCUMENT CONTROL

Version Control

Version	Change	Date
5.0	Initial version prepared for submission with Worsley Mine Expansion Revised Proposal ERD EPA Assessment #2216 and EPBC Reference #2019/8437	27/10/2021
5.1	Amended in response to submissions.	15/03/2023
5.2	Amended sections 5.3.4.2, 5.7.2 and Table 6 in response to EPA Services comments regarding GDEs and Surface Water Trigger and Threshold Criteria. Tables in Section 6 layout changed to landscape. Inclusion of Aluminium Stewardship Initiative.	12/06/2023
5.3	Updated water monitoring programs. Inclusion of CFWM monitoring program. Baseline monitoring period increased to 18 months. Mining Activities within PDWSAs removed, Table 6 outcome-based provisions amended to address comments received from regulators. Reference to ASI removed.	5/12/2023
5.4	Table 6 and 7 updated to include additional management provisions for groundwater and surface water respectively. Appendix A updated to include additional regional groundwater monitoring location.	07/03/2024
5.5	Incorporate Recommended Conditions received in EPA Report 1768. Amend Appendix A to reflect updated monitoring program. Update of References to Forest Management Plan 2024-2033 from Draft version to final. Amend Table 5-1 and Table 5-2 to address required outcomes in Draft Ministerial Statement Conditions and additional information request from DCCEEW. Inclusion of section 4.5. Update layout to meet updated EPA Management Plan Template.	09/09/2024
5.6	Remove reference to Threatened Species Management Plan. Inclusion of relevant information from Threatened Species Management Plan for Carter's Freshwater Mussel within this WMP. Amend referencing, display errors and minor changes identified during EPA-S review of previous version. Implemented feedback from DCCEEW.	14/11/2024
5.7	Amended all references to Ministerial Statement and associated conditions to match the requirements of MS1237. Included Carter's freshwater mussel Regional Reference locations in Appendix D. Revised some actions in Table 5-4. Modified internal review circulation list.	10/01/2025
6.0	Signatures placed and document finalised	17/01/2025
	Minor changes – no version change (included updating table D2 to remove DO and ammonium and correcting a typo "Ar" to "As"	10/02/2025

Reviewer Circulation

Role	Name	Endorsed	Date
Environmental Supervisor	Craig Kimpton	✓	10.02.2025
Manager Production Planning	Cameron McKean	✓	10.02.2025

Approval Circulation

Role	Name	Approved	Date
Manager EH & A	Claire Reid	✓	10.02.2025
General Manager (Mine and Materials)	Trever Stockil	✓	10.02.2025

12 APPENDICES – WATER MONITORING PROGRAMS

12.1 APPENDIX A: BBM WATER MONITORING PROGRAM - PAA

12.1.1 Monitoring Programs

The water monitoring programs and associated trigger levels described in Table 12-1 to Table 12-8 are up to date as of August 2024. Regular reviews of all monitoring programs are conducted to ensure that stated outcomes and objectives are met. Changes may be required should monitoring sites fail or new mining areas become operational. Changes to the monitoring program will be determined in consultation with external experts to ensure suitability and will be included in the Annual Environmental Report.

Table 12-1: BBM Regional Groundwater Monitoring Program

Frequency	Analysis Required	Analysis	Sites Monitored
Continuous	Water Level (WL)	Logger	A04, B01, B04,F06-D, H13D, K04, K05, K14, M01, M01/18, M03, M04,M06, MP03, MP10, MP17 MP21, MP26, SW01, N01, N04, N05, N07, N10, P12, Q03,Q05,Q07, Q09, Q11, T05, T07C, T06C, T11, To be established1[2]: H12D Logger to be installed: K14, Q01, Q02, Q07, Q08
6 monthly (peak summer and peak winter)	pH, Electrical Conductivity (EC), Total Dissolved Solids (TDS), Alkalinity, Silicon as SiO_2, Fluoride Nutrients: Total P, NOx, NH_3, NH_4+, Total N Major cations and Anions: Ca, Mg, Na, K, Fe, Cl, SO_4, Total Metals: As, Cd, Cr, Pb, Ni, Zn, Hg, Mn, Se, Al, Fe,	Lab	A04, B01, B04, E01/04,F06-D, H13D, K04, K05, K13, K14, M01, M01/18, M03, M04, M06, MP03, MP10, MP14, MP17, MP21, MP26, MP27, N01, N04, N05, N07, N10, P12, Q01, Q02, Q03, Q05, Q06, Q07, Q08, T05, T06C, T07C, T11, T11A To be established[2]: H12D
	WL, EC, Temp °C, pH and Dissolved Oxygen (DO)	Field	
In accordance with NBG monitoring program			NBG Monitoring Locations2F[3]: PISWPZ3A, RNSWPZ3A, WD8BR5
In response to trigger/alert	WL EC	Field Field/LabF[4]	As required

Table 12-2: Hydrocarbon Bores Monitoring Program

Frequency	Analysis Required	Analysis	Sites Monitored
Biannually	Total Recoverable Hydrocarbons (TRH) in accordance with the BBM Licence (L5960)	Lab	HMB01/03, HMB02/03

[2] Monitoring locations to be installed as per recommendations in Green et. al. 2023.
[3] Information supplied historically under pre-established information sharing arrangement
[4] If field data confirms trigger exceedance lab analysis work should progress.

Table 12-3: Production Bore Monitoring Program

Frequency	Analysis Required	Analysis	Sites Monitored
Annual	pH, EC, TDS, Alkalinity, Silicon as SiO_2, Fluoride N Major Cations and Anions: Ca, Mg, Na, K, Fe, Cl, SO_4. Filtered Metals: Al, As, Cd, Cr, Fe, Hg, Mn, Ni, Pb, Se, Zn.	Lab	E01/06, K01, K06, K07, K08, K09, M01/08, M01/11, M01/18, M02/08, M03/09, SE01/01, SE01/03, SE01/04, SE02/03, SE02/06, T07A, T08, T10, T12, T13, T14, SE02/01, SE03/01, M02/09, M03/08
	WL, EC, Temp °C, pH and DO	Field	

Table 12-4: Targeted GDE Groundwater Monitoring Program

Frequency	Analysis Required	Analysis	Sites Monitored
All monitoring points within this program are also sampled in accordance with the BBM Regional Groundwater Monitoring Program (Refer Table 12-1).			
Continuous (Quarterly download)	WL, EC	Logger	Locations will be reviewed on an annual basis and provided within the AER. Current targeted (GDE) monitoring locations and associated trigger levels are provided in Table 12-8.
Quarterly	WL, EC	Field	

Table 12-5: BBM Surface Water Monitoring Programs

Program	Frequency	Analysis Required	Analysis	Sites Monitored
Regional Surface Water	Monthly	EC, pH, DO, Temp °C and Turbidity TSS Calculated values: TDS	Field Lab#	S07, S11, S15, S16, S18, S21, S24, S31, S32, S33, S38, S39, S42, S43, S50, S55*
	In accordance with NBG monitoring program			NBG Monitoring Locations[5]: WHBK10, HBBK14, 34BK110
Livestock Dams	Monthly	EC, pH, DO, Temp °C and Turbidity	Field	D02, D03

* S55 – site to be established
# Lab analysis only required if field monitoring method fails

Table 12-6: BBM Recycled Water Monitoring Program (accordance with the EP Act Licence (L5960-1983-11 3.6.1)

Program	Frequency	Analysis Required	Analysis Type	Sites Monitored
Treated Hydrocarbon Contaminated Wastewater	Monthly	pH, TDS, TRH, Cr, Cu and Zn	Lab	ANP01, KD01

[5] Information supplied historically under pre-established information sharing arrangement (see 13.1.1)

12.1.2 Monitoring Program Trigger Levels

Table 12-7: BBM Water Monitoring Program Trigger Levels

Monitoring Program	Analyte	Unit	Trigger Level	
Groundwater				
Targeted GDE Groundwater	Water Level (increase)	mbgl	• Refer to Table 12-8 for trigger and threshold levels. • Concerning trend identified during annual monitoring data review.	
	Water Level (decrease)	mbgl	• Refer to Table 12-8 for trigger and threshold levels. • Concerning trend identified during annual monitoring review undertaken in association with the Annual Environmental Reporting process.	
Regional Groundwater	Water Level	mbgl	• Concerning trend identified by hydrogeologist within the triennial aquifer review of groundwater monitoring data. • Concerning trend identified during annual monitoring review undertaken in association with the Annual Environmental Reporting process.	
	TDS	mg/L		
Surface Water			**Lower Trigger Level**	**Upper Trigger Level**
Livestock Dams	TDS	mg/L	N/A	4000
Regional Surface Water	EC, Turbidity, TSS, TDS	Various	Downstream monitoring point water quality is inferior to upstream water quality and is >2SDEV from the mean upstream monitoring point. Where upstream monitoring point is not available use mean baseline.	
S42[6]	TDS	mg/L	N/A	TBD[7]

[6] Used to support Targeted Perched Aquifer – *C. hopperiana* monitoring program.
[7] 12 months baseline monitoring period required to establish trigger level.

Table 12-8: Targeted GDE Groundwater Monitoring Program - Trigger Levels

Deep fractured rock aquifer monitoring							
Bore ID	Historic Range	Screen Interval (mbgl)	Groundwater Rise (mbgl)		Groundwater Decline (mbgl)		Risk to be managed
			Trigger Level	Threshold Level	Trigger Level	Threshold Level	
A04	12.8 - 24.3	Unknown (40m depth)	9.6	6.4	N/A	N/A	Groundwater mounding
B01	0.8 -13.4	Unknown (13.5m depth)	0.7	0.6	15.4	15.9	Ground water mounding and groundwater decline
H12D*	TBA	TBA	TBA	TBA	N/A	N/A	Groundwater mounding
H12S	TBA	TBA	TBA	TBA	N/A	N/A	Groundwater mounding
H13D	Dry	24 – 30	TBA	TBA	N/A	N/A	Groundwater mounding
H13S	Dry	3 – 6	TBA	TBA	N/A	N/A	Groundwater mounding
MP21	19.8 - 24.6	23.57 - 29.57	14.85	9.9	N/A	N/A	Groundwater mounding
P12	1.7 - 10.1	6.4 - 25.0	1.5	1.3	10.85	11.35	Ground water mounding and groundwater decline
Q03	2.4 - 3.5	8.2 - 32.2	2.2	1.8	4.25	4.75	
Q05	2.9 - 9.8	20.73 - 38.73	2.6	2.2	10.55	11.05	
Q06	>27.5**	14.83 - 26.83	20.6	13.8	N/A	N/A	Groundwater mounding (Interaction with perched aquifer)
Q07	24.3 - 26.4	16.05 - 34.05	18.2	12.15	N/A	N/A	
Q08	19.4 - 24.6	24.76 - 42.76	14.6	9.7	N/A	N/A	
T05	1.1 - 11.1	28.0 - 41.5	1	0.8	11.85	12.35	Ground water mounding and groundwater decline
T07C	2.6 – 15.4	Unknown (91.4 m depth)	2.3	1.95	16.15	16.65	
T11	3.8 - 16.1	Unknown (31.9 m depth)	3.4	2.9	17.1	17.6	
T11A	3.7 - 15.3	13.03 - 25.03	3.3	2.8	16.3	16.8	
Perched Aquifer - C. hopperiana							
	Historic Range	Screen Interval (mbgl)	TDS Trigger Level (mg/L)		TDS Threshold Level (mg/L)		Risk to be managed
Q09***	TBA	3 - 6	TBA		TBA		Perched Aquifer
Q11***	TBA	4 - 7	TBA		TBA		

* Bores to be installed in FY25 and baseline monitoring conducted for 2 years prior to setting trigger and threshold levels. Bauxite mining operations will not commence in these areas within the next 5 years.
** Dry since installation at depth of 27.5m.
*** Installed in June 2024. Dry since installation.

12.1.2.1 *Commentary on Targeted Monitoring Program (Potential GDEs) Trigger Levels*

Groundwater Rise

Groundwater Rise trigger levels are defined based on the Risk Matrix included as Table 12-9. This Risk Matrix shows risk level increasing with increased groundwater levels at different rates depending on the baseline groundwater conditions at the monitoring site. The risk level is described in terms of the potential impacts to vegetation at the site with the described groundwater rise. In this way areas that have lower available unsaturated soil profile have a higher risk of impact associated with inundation of the root zone and therefore impacts on vegetation condition with rises in the groundwater table.

Table 12-9: Groundwater Mounding Risk Table:

	Decrease in depth to GW (mbgl) in %				
Baseline Depth to GW (highest recorded (mbgl))	**10%**	**25%**	**50%**	**75%**	**90%**
40	36	30	20	10	4
20	18	15	10	5	2
10	9	7.5	5	2.5	1
5	4.5	4	2.5	1.25	0.5
2	1.8	1.5	1	0.5	0.2

Risk Level	Description
Negligible	No basis to expect that GDEs would be impacted
low	Low level impacts possible but no expected mortality, full recovery expected
mod	Moderate level impacts, potential for some mortality (<20%), potential for lasting impacts in limited areas
high	Impacts expected, individual flora mortalities likely (<50%), potential for lasting impacts
very high	Vegetation mortality, loss of ecosystem function, lasting impacts

Groundwater Decline

Groundwater Decline trigger levels are defined based on the approach applied by Froend and Loomes et. al. (2004) for Wetlands noting that the GDEs within the PAA are not usually representative of wetlands. The potential GDEs represent riparian vegetation and heaths which in some cases appear to be associated with perched aquifers as the groundwater levels measured in some instances exceed 20 mbgl and are therefore highly unlikely to support a GDE. Given this, locations where groundwater levels are >20 mbgl have not been assigned trigger or threshold values.

Table 12-10: Groundwater Decline Risk Table:

Highest Recorded Baseline Groundwater Level (mbgl)	Increase in depth to GW (mbgl)	
	Trigger Level (m) [8]	Threshold Level (m) [9]
0-3	0.75	1.25
3-6	1.0	1.5
6-10	1.5	2
10-20 [10]	2	2.5

12.1.3 Additional Baseline Monitoring Information – Newmont Boddington Gold

Additional water monitoring information has historically been provided by Newmont Boddington Gold (NBG) under a pre-established information sharing arrangement. This information provides useful baseline information for future operations within the northern section of the WMDE. Additional Worsley monitoring sites will be established in this area prior to mining activities commencing.

[8] Corresponding with terrestrial vegetation (phreatophytic vegetation) low risk category of impact from the framework developed by Froend and Loomes et. al. (2004).
[9] Corresponding with the terrestrial vegetation (phreatophytic vegetation) moderate risk category of impact from the framework developed by Froend and Loomes et. al. (2004).
[10] This category is not covered by Froend and Loomes et al (2004) and has been extrapolated and applied. Areas under these conditions are considered unlikely to support GDEs.

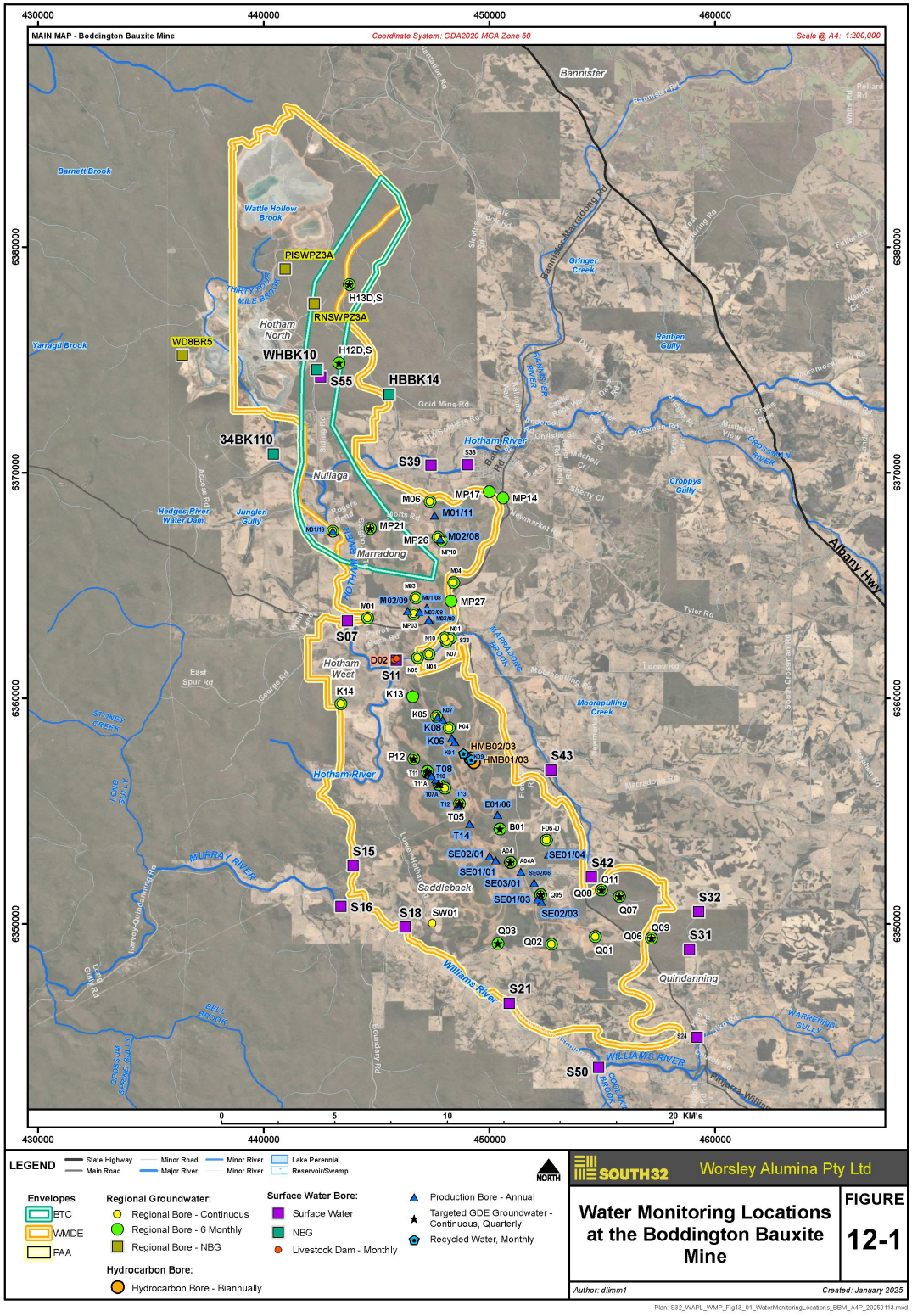

Figure 12-1: Water monitoring locations at the BBM.

12.2 APPENDIX B: REFINERY WATER MONITORING PROGRAM

Table B1: Refinery Groundwater Monitoring Program

Program	Frequency	Analysis Required	Analysis Type	Sites Monitored
Groundwater	Real-time (6 hour interval)	Water Level (WL), EC, Temp °C	Down Bore Sensor	Background: R25B, SVM24, NVM28f RCL and Refinery: NVM01f, NVM02z, M117s, M116z, M112f, M113z, M114s, M111s PHDs: SVM36, SVM60, SVM54, SVM55, NVM12f, NVM11s, NVM10z
	Biannually[11]	pH, EC, Alkalinity, K, Na, Ca, Mg, Fe, Al, Cl, SO_4, Sb, As, Cd, Cr, Cu, Pb, Mn, Ni, Se, Zn, and Hg *(Calculated Results: TDS, NA/CL, HCO_3, CO_3, OH)*	Lab	
	In response to trigger / alert	WL, EC, Temp °C, pH and DO	Field[12]	As Required
		pH, EC, Alkalinity, K, Na, Ca, Mg, Fe, Al, Cl, SO_4, Sb, As, Cd, Cr, Cu, Pb, Mn, Ni, Se, Zn, and Hg *(Calculated Results: TDS, NA/CL, HCO_3, CO_3, OH)*	Lab[13]	

Table B2: Refinery Surface Water Monitoring Programs

Program	Frequency	Analysis Required	Analysis Type	Sites Monitored
Regional Surface Water[14]	Real time[15]	Water level, flow rate, DO, pH, EC, and Temp °C	Sonde	ARGS
	Weekly[16]	Water Level volume[17]	Field (level gauge)	FWL
	Monthly	Temp °C.[18], EC, pH, Turbidity	Field	ARGS, FWL Pump, FWL Scour Valve, FWLUF1, FWLUF2, FWLUF3
		EC, pH, Na, Cl, TSS, Salinity g/L	Lab.	
	Quarterly[19]	SO_4, K, Ca, Mg, Fe, Al, Alkalinity (as $CaCO_3$),	Lab	Reference sites: HAR1, BRR1,

[11] Biannual sampling campaign of select groundwater monitoring bores as recommended by GRM.
[12] Initial investigation to confirm anomalous reading.
[13] If field data confirms trigger exceedance lab analysis work should progress.
[14] Refinery SWL only requires sampling to be conducted for FWL Pump Station and ARGS.
[15] Water level, DO and Temp for ARGS only.
[16] Licence condition that this is done at a weekly frequency however, Worsley have the ability to collect it in real time.
[17] FWL level only.
[18] Temp for ARGS only.
[19] DO and DO% saturation for ARGS only during quarterly sampling.

B3: Refinery Water Monitoring Program Trigger Levels [20]:

Regional Surface Water			
Analyte	**Unit**	**Minimum Action Level**	**Maximum Action Level**
Aluminium	mg/L		0.2
Chlorine	mg/L		400
Dissolved Oxygen	%	90	
Electrical Conductivity	uS/cm	120	300
Iron	mg/L		0.3
Manganese	mg/L		0.1
Nitrate as N	mg/L		0.7
Nitrate as NO3	mg/L		0.7
pH	pH unit	6.5	8
Sodium	mg/L		300
Sulfate	mg/L		400
Total Alkalinity as CaCO3	mg/L		500
Turbidity	NTU		20

Groundwater				
Analyte	**Unit**	**Warning**	**Trigger**	**Threshold**
EC (PHDs, RCL and Refinery)	uS/cm	75th percentile	75th Percentile plus 10%	75th percentile plus 20%
Water Level (Background)	Mbgl	N/A	N/A	N/A
Water Level (PHDs)	Mbgl	95th percentile	Water level in monitoring bore becomes lower than PHD water level	Water level in monitoring bore is lower than PHD water level for >3 months
Water Level (RCL and SEPs)	Mbgl	95th percentile	<4 mbgl	<3mbgl

All triggers are monitoring site specific.

In addition to the above the following 3 step verification process is applied to identify and detect possible liquor contamination in groundwater:

1. An increasing trend in groundwater EC levels, using 2019 sampling record as a baseline dataset.
2. An increasing trend in the Alkalinity/TDS ratio.
3. An increasing trend of the Na/Cl concentration ratio.

Where a 20% increase in EC is observed over a 2 year period in conjunction with increasing trends in Alkalinity/TDS ratio and Na/Cl concentration ratio this will represent a threshold exceedance.

[20] These trigger and threshold levels do not apply to surface water sites FWLUF1-3 (used only periodically for underflow diversion) BRR1 and HAR1 (reference sites).

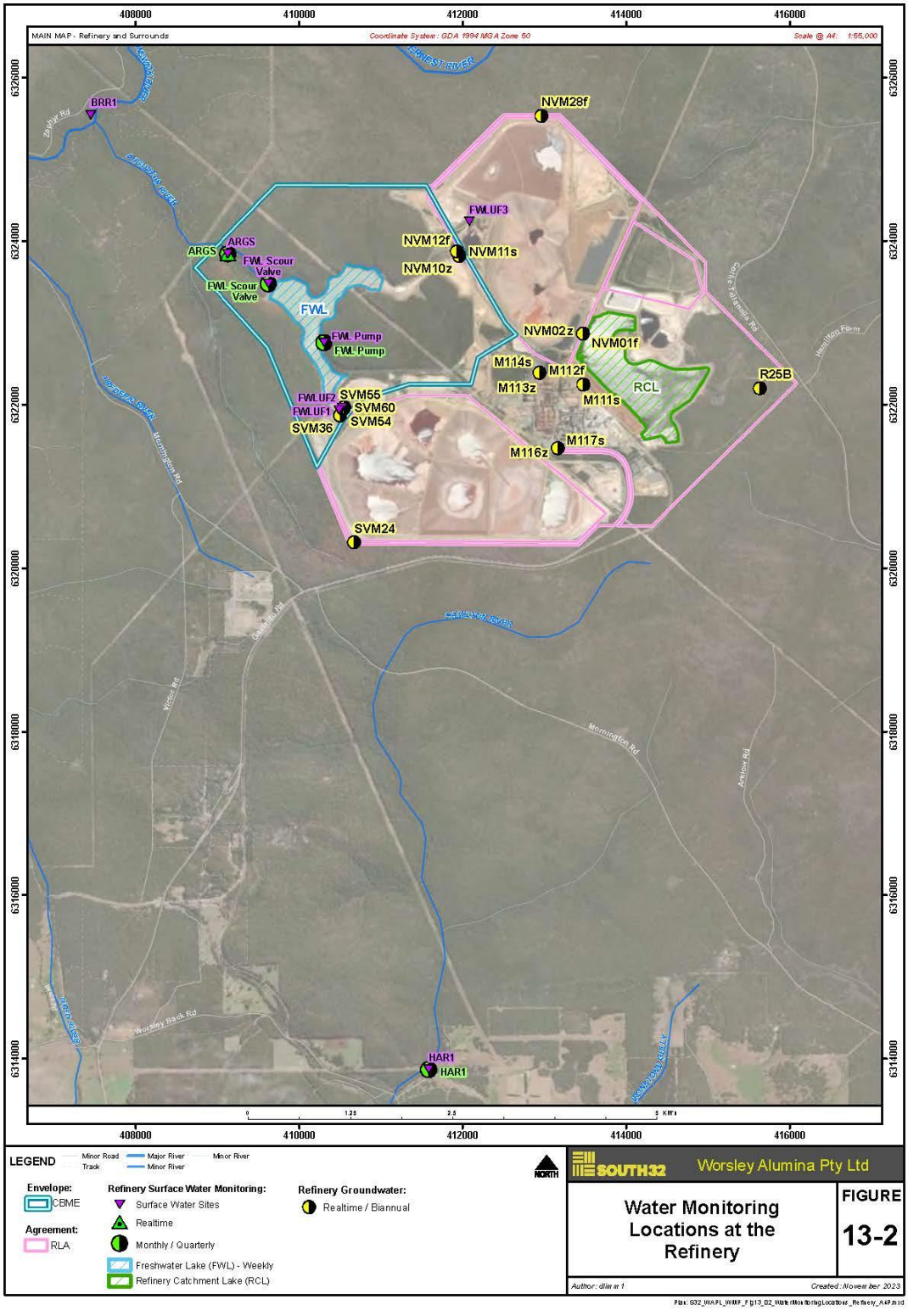

Figure 12-2: Current and historical water monitoring locations for the Refinery.

12.3 APPENDIX C: BUNBURY PORT WATER MONITORING PROGRAM

Table C1: Proposed Bunbury Port Groundwater Monitoring Program

Program	Frequency	Analysis Required	Analysis Type	Sites Monitored
Groundwater	Real-time (6-hour interval)	Water Level, EC and Temp °C	Down Bore Sensor	B17A, B21A
	In response to trigger / alert	Water Level (WL), EC, Temp °C, pH and DO	Field	As required
		pH, EC, Alkalinity, K, Na, Ca, Mg, Fe, Al, Cl, SO_4, Sb, As, Cd, Cr, Cu, Pb, Mn, Ni, Se, Zn, and Hg *(Calculated Results: TDS, NA/CL, HCO_3, CO_3, OH)*,	Lab	

Table C2: Proposed Bunbury Port Surface Water Monitoring Program

Program	Frequency	Analysis Required	Analysis Type	Sites Monitored
Surface Water	At the time of release[21]	EC and pH	Field	Caustic Tank Bund

[21] Bunbury Port to test the water in caustic tank bund and record the results prior to releasing into environment.



Figure 12-3: Current and historical water monitoring locations for the Bunbury Port.

12.4 APPENDIX D: CARTERS FRESHWATER MUSSEL MONITORING PROGRAM

D1 Surface Water and Sediment Monitoring Programs

D1.1 Surface Water Monitoring Program

Worsley Alumina Refinery are required to regularly monitor water levels and quality at specified frequencies at two locations within the CBME; the FWL Pump Station and Augustus River Gauging Station. Water levels are measured on a weekly basis at the FWL Pump Station and are continuously logged at the Augustus River Gauging Station (ARGS) as described in Appendix B. Appendix B also outlines the suite of water quality parameters monitored on a monthly or biannual basis at both sites. The existing surface water monitoring program will be complimented by additional monitoring as described in Table D1. This includes several additional parameters measured on a monthly basis for Site-Specific Guideline Value (SSGV) development and to detect exceedances in accordance with the Outcome-based Provisions outlined in Table 5-4.

At each site water quality parameters will be measured in situ using a portable, hand-held water quality meter with results recorded. The meter will be calibrated following appropriate standards. Water samples will be collected for laboratory analyses according to supplier instructions and using the bottles provided. The samples will be analysed for basic parameters and nutrients, anions and cations, and dissolved metals as outlined in Table D1. All water samples will be stored and kept cool following collection and transported to a NATA-accredited laboratory for analysis, with the accompanying chain of custody documentation.

Table D1: Carter's Freshwater Mussel Water Quality Monitoring

Program	Frequency	Analysis Required	Analysis Type	Sites Monitored
Carter's Freshwater Mussel	Reference Sites: Annual All other sites: Monthly (for 2 years) then annually	pH, Salinity/EC, Temp., DO*	Field	FWL1, FWL2, FWL3, FWL4, FWL5, AR1, AR2, AR3
		pH, TDS/EC*, Turbidity, TSS*, Total P*, NOx*, NH_3*, NH_4+*, Total N* **Anions and cations:** Alkalinity, HCO_3, CO_3, Cl, Ca, Na, K, Mg, SO_4, Mn, S, Se, Si **Dissolved Metals:** Al*, As, B, Ba, Cr, Cd*, Co, Cu*, Fe*, Pb*, Hg*, Mo, Ni, U, V, Zn*	Lab	Reference Sites: LR Dam_21, RR10, RR2
Threshold Exceedance Monitoring	Weekly	TBD based on exceedance. Weekly monitoring until recovery below threshold value.	Field/Lab	As required

*Note: * indicates analytes for which SSGVs will be developed.*

D1.2 Sediment Monitoring Program

Sediment quality will be assessed at all sites by scraping the top 2 cm of sediment into a sterilised glass jar (excluding voids), with nitrile gloves to avoid contamination. Jars will be sealed and kept cool for the duration of the field survey and couriered to a NATA-accredited laboratory for the analysis of the suite of parameters outlined in Table D2.

Table D2: Carters Freshwater Mussel Sediment Monitoring Program

Program	Frequency	Analysis Required	Analysis Type	Sites Monitored
Carter's Freshwater Mussel	Reference Sites: Annual All other sites: Monthly (for 2 years) then annually	pH, EC*, Moisture Content (%), TOC, Total Kieldahl Nitrogen, NOx*, Total N*, Total P*, N-NH_3*, NO_3* **Anions and Cations:** Cl, HCO_3, CO_3, S-SO4, Na, Ca, K, Mg. **Dissolved Metals**: Al*, As, Bo, Cd*, Co, Cr, Cu*, Hg*, Mn, Mo, Ni, Pb*, Se, U, V and Zn	Lab	FWL1, FWL2, FWL3, FWL4, FWL5, AR1, AR2, AR3 Reference sites: LR Dam_21, RR10, RR2
Threshold Exceedance Monitoring	Weekly	TBD based on exceedance. Weekly monitoring until recovery below threshold value.	Lab	As required

*Note: * indicates analytes for which SSGVs will be developed.*

D1.3 Site-Specific Guideline Values (SSGVs) Development

At present Interim Trigger and Threshold values will be used as described in Table 5-5. Development of SSGVs will be achieved by analysing long-term water and sediment quality data. A minimum of two years of monthly sampling or 24 data records will be collated, outliers removed, and upper and lower trigger values derived, traditionally comprising 20th and 80th percentiles following methods outlined in *Australian and New Zealand Guidelines for Fresh and Marine Water Quality. Australian and New Zealand Governments and Australian state and territory governments* (ANZG, 2018).

Once developed, water and sediment quality data from FWL and Augustus River can be compared to the SGGVs, in relation to CFWM. This will assist in informing South32's understanding of potential impacts associated with the Revised Proposal, and subsequent monitoring and management of the species.

D2 Other CFWM Monitoring Programs

D2.1 CFWM Sampling

Prior to sampling CFWM, a Fauna Taking (Biological Assessment) Licence must be obtained from the Department of Biodiversity, Conservation and Attractions (DBCA). Survey methods for CFWM sampling should follow methods developed by Dr Michael Klunzinger (Klunzinger, 2011). Visual inspection of all survey sites should be conducted prior to establishment of new monitoring transects to detect the presence of CFWM. These have already been established for some FWL and Augustus River sites during the baseline survey (Stantec, 2021).

Two techniques may be used for CFWM sampling, depending on water depth; peripheral and / or deepwater sampling (Table D4). Peripheral sampling will occur at sites of wadable depth, while deepwater sampling will occur at deeper sites, such as central parts of FWL. At peripheral sites where evidence of CFWM is detected, such as presence of dead shells on shorelines or visual observations in water, CFWM sampling should be conducted. Additional dive or drone surveys should be conducted to target areas of the FWL that are beyond wadable depths. This should consist of targeted searches for CFWM by a qualified dive team or a remote underwater drone.

At each monitoring site, qualitative observations of key in-stream habitat types and substrate composition will also to be noted, as well as riparian habitat to assist in the assessment of variation in species distribution, density and population structure.

The start and end point of each monitoring reach not previously sampled, as well as each individual quadrat will be marked using a handheld GPS, with coordinates recorded, to support the ongoing monitoring program during life of mine operations.

Table D4: Carters Freshwater Mussel Sampling Methods

Sampling Technique	Monitoring Method
Peripheral	• A standardised 50 m long monitoring reach running perpendicular to the shore will be established, to a maximum water depth of one metre. • Ten 1 m^2 quadrats will be deployed, constructed of PVC piping, and placed randomly along the monitoring reach on the lake/stream bed. • Mussel specimens will be collected using hand (tactile) foraging or sieving within each quadrat. • Encountered CFWM will be transferred into a 20 L bucket containing water from the site. • Each living CFWM will be measured (to the nearest 0.01 mm) for maximum shell length using calipers, and then gently replaced in the quadrat of collection. • Presence of deceased mussels and shell fragments will be recorded at each site.
Deepwater	• Targeted search for CFWM will be conducted by a qualified dive team or remote underwater drones. • Searches within the sediments will occur for a maximum duration of two hours across a 30 m linear transect perpendicular to the shoreline. • A specific search pattern will be followed, with tactile searching of the sediments occurring at 2 m intervals from the shoreline to a maximum distance of approximately 20 m from the from the shoreline. • Specimens encountered will be collected by divers and taken to shore for identification using expertise and appropriate taxonomic guides. • Each living CFWM will be measured (to the nearest 0.01 mm) for maximum shell length, and gently replaced by divers to the approximate location of collection.

D2.2 Freshwater Fish Sampling

Methods used to monitor fish will comply with South-West Index of River Condition (SWIRC) methods recommended by DWER and as described by Storer *et al.* (2020). Fish should be surveyed using fyke nets and beach seine nets, as appropriate, following methods outlined in Table D5.

Fyke nets should comprise a dual 10 m leader/wing (7 mm mesh, 1.5 m drop) and a 5 m hooped net (75 cm diameter semi-circular opening, 10 mm mesh), and be deployed at all sites as a 'passive' technique. This will capture any fish as they swim into the net. Although these nets are traditionally used in rivers and creeks, for the purpose of the Program, they will also be set in shallow areas on the perimeter of FWL and any regional reference dam sites. At Augustus River and any regional reference river sites, fyke nets should be set facing upstream and downstream, blocking the entire channel and capturing fish in both directions. Additionally, a beach seine net will be used to complement the fyke nets where suitable, capturing smaller individuals.

Table D5: Sampling methods for fish sampling

Sampling Technique	Monitoring Method
Fyke nets	• Two fyke nets will be set at each site in shallow areas, in opposite directions, submerged sufficiently to allow fish to swim into the net, but allowing air to reach any by-catch. • Nets will be deployed for three 24-hour stints, set in the morning and emptied the following morning. • Captured fish will be emptied into buckets of water from the site, identified to species following nomenclature of Allen et al. (2002), measured for standard length (SL mm), checked for CFWM larvae on fins, health and reproductive status, and released alive to sampling location. • Floating platforms will be placed in each fyke net, to form air pockets and allow by-catch, such as tortoises and other aquatic fauna to breathe.
Beach seine nets	• A beach seine net will be walked out into the water sites with shallow banks, perpendicular from shore, and fish herded in the direction of the net. • The net will be walked into shore, capturing the fish and pulled into land. • Captured fish will be emptied into buckets of water from the site, identified to species following nomenclature of Allen et al. (2002), measured for standard length (SL mm), checked for CFWM larvae on fins, health and reproductive status, and released alive to sampling location.

Table D6: Targeted Carters Freshwater Mussel and Fish Monitoring Program

Program	Frequency	Analysis Required	Analysis Type	Sites Monitored
CFWM Peripheral Sampling	Annually (Early Spring)	CFWM population analysis	See D2.1	FWL1, FWL, 2, FWL3, FWL4, FWL5, ARG1, ARG2, ARG3 Reference sites: LR Dam_21, RR10, RR2
CFWM Deepwater Sampling	Annually (Early Autumn)	CFWM population analysis	See D2.1	Dive 2, Dive 4, Dive 5
Freshwater Fish Sampling	Biennially (Early Spring)	Assess presence of suitable fish host species Assess presence of CFWM larvae on fish	See D2.2	FWL1, FWL, 2, FWL3, FWL4, FWL5, ARG1, ARG2, ARG3 Reference sites: LR Dam_21, RR10, RR2

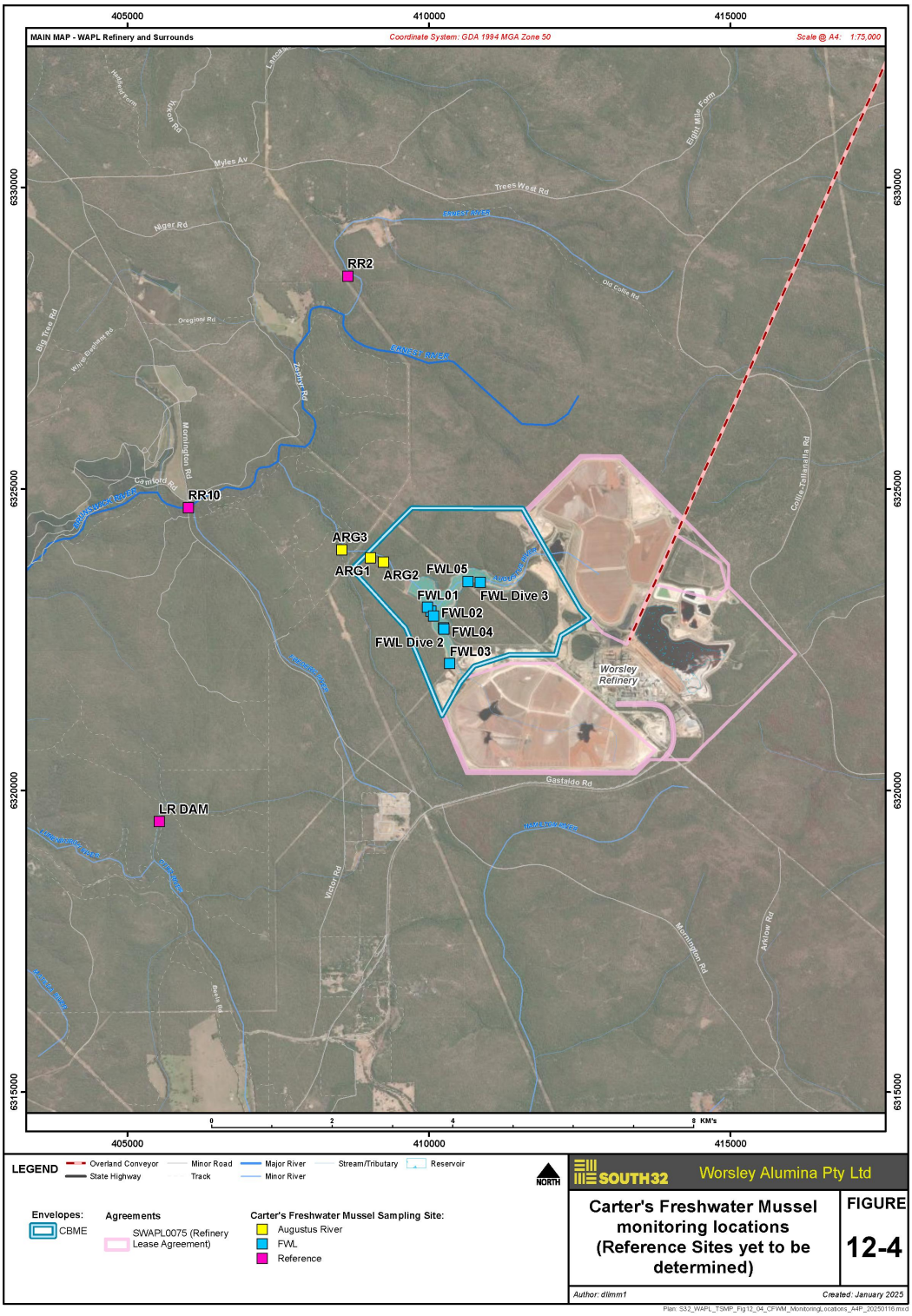

Figure 12-4: Carter's Freshwater Mussel monitoring locations.

D3 Data Analysis

A range of statistical and spatial analyses will be applied to determine trends in water level, water quality, and sediment quality, relative to CFWM distribution, density, and population structure, as well as fish presence and population dynamics. Data analyses may include, but shall not be limited to:

- calculation of average CFWM density (individuals per m^2) per site;
- determining statistically significant differences in CFWM density between sites and waterbodies using an appropriate technique (typically ANOVA);
- determining spatial and temporal mussel population structure (length-frequency distributions), with mussel age inferred from published literature (where possible);
- summarising water and sediment quality data at each site (tabular form), and undertaking multivariate analysis on these parameters spatially and temporally (PCA analysis) using the software package PRIMER v7;
- providing comparison of water quality parameters from each reporting period against baseline conditions, triggers and thresholds, SSGVs when available, and ANZG (2018a) DGVs; and
- determining spatial and temporal trends in freshwater fish host, if present.

D4 Reporting

Water levels and water quality are reported on an annual basis, in the Worsley Alumina Refinery Annual Hydrological Report (AHR) and Compliance Assessment Report (CAR). An annual technical report will also be prepared for CFWM monitoring (including biennial fish monitoring), summarising key findings, for the life of the Revised Proposal. This will be appended to annual regulatory reporting, as required. This annual technical report should compare findings against the provisions included in this WMP. Where exceedances of triggers or thresholds occur, these must be reported and actioned in accordance with Table 5-4.

D5 CFWM Translocation Contingency Action

Translocation may be required as a corrective action if exceedances of environmental criteria occur for:

- water levels in FWL;
- TSS in FWL or Augustus River downstream;
- metals including Hg, Al, Cd, Cu, Pb and Zn in FWL or Augustus River; and/or
- salinity (as EC) in FWL or Augustus River.

The suggested methods and check frequency for translocation of the CFWM are outlined in Table D7, if required.

A suitable translocation site, with favourable habitat will be selected, consulting DBCA where required. Approval is also required from the DWER and DBCA prior to translocation being undertaken. Frequent checks should be conducted initially after the relocation, with CFWM checked for responsiveness on each occasion. Following this, annual mark-and-recapture surveys should be undertaken at the translocation site for up to 15 years, to assess the condition and health of the population. Monitoring conducted in summer/autumn will provide an indication of recruitment success.

Table D7: Sampling methods and check frequency for CFWM translocation.

Technique	Methods & Frequency
CFWM Translocation	• Habitat and water quality assessment will be conducted to confirm suitability of the site for translocation of CFWM. • The timing of relocation from the FWL will avoid the spawning/brooding period of the species (July-November) (Klunzinger 2008, PhD Thesis, Murdoch University). • individuals should be collected by hand via a combination of raking, wading and scuba diving), and placed in buckets of water from FWL, mixed 50:50 with water from relocation site, to provide some acclimatisation prior to release (Paice & Beatty, 2021). • At the selected relocation site, each individual mussel's tag number and release location should be recorded using a GPS. • Mussels should be removed from buckets, measured to the nearest 1-mm shell length (SL) and marked with numbered passive integrated transponder (PIT) tags (Hallmark Print) (Kurth et al., 2007). • Responsiveness checks should be conducted initially after the relocation. • Annual mark-and -recapture surveys should be undertaken to assess the condition and health of the population.
Responsiveness Check Frequency	• Daily during initial 3 days; • Weekly during following 2 months; • Fortnightly during following 3 months; • Monthly during following 2 months.
Mark – and -recapture Survey Frequency	• Annual up to 15 years at translocation site

D6 References

ANZG. (2018). Australian and New Zealand Guidelines for Fresh and Marine Water Quality. Australian and New Zealand Governments and Australian state and territory governments.

Klunzinger, M. W., Strebel D., Beatty, S. J., Morgan, D. L., & Lymbery, A. J. (2011). Baseline assessment of freshwater mussel populations wthin the urban waterways renewal project.

Stantec. (2021). Carter's Freshwater Mussel Baseline Monitoring Program.

Storer, T., O'Neill, K., Christie, E., Galvin, L., & van Looij, E. (2020). The South West Index of River Condition, Module 2–method summary: collection and analysis of aquatic biota. In: River Science Technical Series, report.

12.5 APPENDIX E: TABLE OF MONITORING LOCATIONS

BBM

Table E1: BBM Surface Water Monitoring Locations (GDA94, MGAz50)

Monitoring Site	Easting	Northing
S07	443694	6363438
S11	445873	6361697
S15	443952	6352581
S16	443405	6350771
S18	446261	6349855
S21	450872	6346476
S24	459200	6344967
S32	459271	6350540
S33	448206	6362671
S38	449027	6370352
S39	447411	6370349
S42	454520	6352072
S43	452726	6356826
S50	454841	6343625
S55*	442515	6374246
D02	445780	6361714
D03	445880	6361776
WHBK10**	442345	6374575
HBBK14**	445541	6373481

* Monitoring site yet to be established, indicative location only pending confirmation of site accessibility.
** Newmont Boddington Gold monitoring site.

Table E2: BBM Groundwater Monitoring and Production Bore Locations (GDA94, MGAz50)

Monitoring Site	Easting	Northing	Production Bore	Easting	Northing
A04	450911	6352729	E01/06	450353	6354846
A04A	450924	6352731	K01	448462	6358070
B01	450449	6354218	K06	448324	6358246
F06-D	452515	6353723	K07	447913	6359055
HN12D & H12S***	TBD	TBD	K08	447690	6359169
HN13D & H13S***	443769	6377719	K09	449107	6357430
K04	448202	6358694	M01/08	447227	6364028
K05	447640	6359202	M01/11	447557	6368116
K13	446587	6360084	M01/18	443050	6367413
K14	443406	6359755	M02/08	447813	6367060
M01	444595	6363565	M03/09	447298	6363480
M01/18	443050	6367413	SE01/01	450274	6352817
M03	446722	6364460	SE01/03	452129	6351105
M04	448411	6365126	SE01/04	452601	6353083
M06	447361	6368725	SE02/01	449990	6353005
MP03	446639	6363764	SE02/03	452301	6350986
MP10	447864	6367014	SE02/06	451985	6351830
MP14	450588	6368888	SE03/01	451383	6352311
MP17	449988	6369164	T07A	447747	6356197
MP21	444714	6367539	T08	447613	6356406
MP26	447714	6367139	T10	447420	6356565
MP27	448288	6364313	T12	448568	6355230
N01	448247	6362676	T13	448656	6355328
N04	447311	6361958	T14	449125	6354435
N05	446816	6361805			
N07	448092	6362522			
N10	448007	6362690			
P12	446653	6357321			
Q01	454690	6349436			
Q02	452738	6349105			
Q03	450369	6349134			
Q05	452265	6351299			
Q06	457180	6349365			
Q07	455751	6351215			
Q08	454950	6351499			
Q09	457183	6349372			
Q11	454946	6351494			
SW01	447463	6350025			
T05	448666	6355332			
T06C	448019	6356020			
T07C	447750	6356194			
T11	447251	6356708			
T11A	447234	6356764			
HMB01/03*	449295	6357158			
HMB02/03*	449145	6357329			
PISWPZ3A**	440934	6379049			
RNSWPZ3A**	442229	6377510			

* Hydrocarbon monitoring bore.
** Newmont Boddington Gold monitoring bore.
*** Nested monitoring bores yet to be installed

REFINERY

Table E3: Refinery Surface Water Monitoring Locations (GDA94, MGAz50)

Monitoring Site	Easting	Northing
ARGS	409339	6323598
FWL Pump	410302	6322761
FWL Scour Valve	409739	6323398
FWLUF1	410487	6321936
FWLUF2	410526	6321967
FWLUF3	412080	6324244
HAR1	411584	6313868
BRR1	407451	6325547

Table E4: Refinery Groundwater Monitoring Locations (GDA94, MGAz50)

Monitoring Site	Aquifer	Easting	Northing
SVM36	Fractured	410499	6321865
SVM60	Fractured	410552	6321970
SVM54	Zersatz	410539	6321947
SVM55	Shallow	410539	6321953
NVM12f	Fractured	411930	6323873
NVM11s	Shallow	411958	6323817
NVM10z	Zersatz	411957	6323817
NVM10f	Fractured	413466	6322866
NVM02z	Zersatz	413467	6322867
M117s	Shallow	413161	6321468
M116z	Zersatz	413162	6321466
M112f	Fractured	412939	6322387
M113z	Zersatz	412938	6322387
M114s	Shallow	412936	6322388
M111s	Shallow	413472	6322244
R25B	Fractured	415634	6322197
SVM24	Fractured	410669	6320314
NVM28f	Fractured	412961	6325529

PORT

Table E5: Port Monitoring Locations (GDA94, MGAz50)

Monitoring Site	Easting	Northing
B17A	376067	6312423
B21A	376186	6312578
Caustic Tank Bund	376041	6312684

12.6 APPENDIX F: RISK ASSESSMENT

Risk Identification				Risk Evaluation and Control Effectiveness Assessment			
Location	Risk Event	Causes (Direct & Contributing)	Expected Impact / Consequences	Controls (preventative and mitigating)	Severity	Likelihood	Risk Rating
Refinery	Reduced water quality in FWL (potential impacts on Carter's Freshwater Mussel)	Loss of containment of chemicals, hydrocarbons or process liquors within the freshwater catchment Failure of sediment controls in freshwater drainage lines Increased erosion and overland flow caused by mining activities in CBME	Potential impacts on Carter's Freshwater Mussel within FWL and Augustus River. Non-compliance with DWER licence (quality of FWL not suitable for release).	Separated catchments, Contaminated and Freshwater, and associated protection infrastructure (Pipehead dams, RCL, BRDA design etc) Worsley Tank Integrity Maintenance System (TIMS) Auditing to Australian Standards 3780 and Codes Drainage control structures (sediment traps, sumps, drain scour protection) Annual preventative maintenance and inspection of drainage lines and silt traps 50 m exclusion zone for FWL for mining in the CBME Process bunds Portable barriers to freshwater drains Spill Response Procedures FWL discharge shut off valve Monitoring program for FWL water and sediment (described in WMP)	Moderate	Likely	Medium
BBM	Rising groundwater table	Clearing of native vegetation	Localised vegetation deaths Increased salinity in waterways and groundwater Change in vegetation structure (soil profile moisture regime changes)	Triennial aquifer reviews Regular Tunnell Road Heath Health Assessments Groundwater Modelling Monitoring and management of clearing gap under Rehabilitation Commitment Progressive Rehabilitation Groundwater abstraction Water Management Plan and associated monitoring programs	High	Unlikely	Medium
BBM	Falling groundwater table	Abstraction of groundwater Rehabilitation with native vegetation Drying climate	Localised vegetation deaths Change in vegetation structure (soil profile moisture regime changes)	Groundwater monitoring program Triennial aquifer reviews Regular Tunnell Road Heath Health Assessments Groundwater Modelling as part of Grade Control Modelling Process Monitoring and management of clearing gap Groundwater abstraction (within sustainable yields)	High	Rare	Low
All	Indirect impacts on waterways from dust	Construction and operation activities	Decreased water quality (i.e. increased turbidity)	Dust suppression (water and / or chemical) on haul roads and open areas Dust suppression in fixed plant Progressive Rehabilitation Apply stream buffers Manage stream buffers in accordance with the PAP.	Minor	Unlikely	Low

Risk Identification				Risk Evaluation and Control Effectiveness Assessment			
Location	**Risk Event**	**Causes (Direct & Contributing)**	**Expected Impact / Consequences**	**Controls (preventative and mitigating)**	**Severity**	**Likelihood**	**Risk Rating**
	Uncontrolled discharge of stormwater	Significant rainfall event Poorly maintained /designed sumps	Localised short duration increased turbidity Sedimentation	Apply stream buffers Manage stream buffers in accordance with the PAP. Installation of water management infrastructure (sumps, drainage lines etc.) in accordance with Bauxite Mine Site Drainage Standard (01020749) and the Trunk Haul Road Design and Construction Specification (00112148). Bed and Banks permits (where required) Reshape disturbed areas to match surrounding contours during progressive rehabilitation CEMP with appropriate controls for all construction works Drain and sump maintenance and inspection (cleared during summer) Biodiversity and Forest Management Plan (01012523)	Minor	Likely	Low
All	Water or soil contamination from spills	Fuel/Oil loss during refuelling or unloading Exposure to fuel/Oil during loading / unloading of bulk quantities outside of bunding / secondary containment Hydraulic line break in field	Localised minor impacts on soil and water	Planned maintenance Operator pre-start checks Spill trays and spill kits available Bunded areas Workshop with sealed surface Spill management SWI (01027460) and training Load restraint (drums) Humeceptor ® at workshop hardstand Bunded fuel farm, tanks and pumps Coordination of unloading and loading activities. Hazardous Materials & Spills Management Procedure Training in accordance with Hazardous Substance Management Plan Clearance to Work Worsley Tank Integrity Maintenance System (TIMS) Auditing to Australian Standards AS1940 and Codes Material Safety Data Sheets (Chemalert) Bunded areas	Minor	Likely	Low
	Groundwater contamination from hydrocarbons	Storage of bulk hydrocarbons	Localised contamination of groundwater	Hydrocarbon bore monitoring program Double lined storage facilities Above ground fuel storage Worsley Tank Integrity Maintenance System (TIMS) Bunding	Minor	Unlikely	

Risk Identification				Risk Evaluation and Control Effectiveness Assessment			
Location	**Risk Event**	**Causes (Direct & Contributing)**	**Expected Impact / Consequences**	**Controls (preventative and mitigating)**	**Severity**	**Likelihood**	**Risk Rating**
Refinery	Catastrophic failure of BRDA Dam Embankment	Inadequate design, construction, operation or maintenance	Significant contamination of land and water.	TSF Emergency Preparedness & Response Plan BRDA's are designed and constructed under guidance of registered Geotechnical Civil Engineers. BRDA Earthworks Specification and design drawings Regular auditing, inspections and maintenance for structural integrity	Major	Rare	Medium
Refinery	Contamination of Groundwater – Tailings storage	Liquor leaching through BRDA floor that does not report to the underflow network	Localised groundwater contamination	BRDA's are designed and constructed under guidance of registered Geotechnical Civil Engineers. BRDA Earthworks Specification and design drawings Capacity to divert under drainage to contaminated catchment if contamination is detected. Strict quality control procedures during construction. Groundwater, surface water and underflow monitoring	Moderate	Unlikely	Low
Refinery	Inability to meet ecological release requirements from FWL	Drying climate Decreased freshwater catchment Increased freshwater consumption	Non-compliance with licence Decreased flow in Augustus River and associated impacts on habitat	Strategic water source planning Water efficiency improvement projects	Minor	Possible	Low
BBM	Contamination of water from exposure of PASS	Exposure of PASS during construction activities	Localised impacts on surface water and soils	Mining footprint to avoid low-lying topographical areas in the vicinity of rivers and creeks. Stream buffers applied to all rivers Acid Sulphate / Potentially Acid Sulphate soil monitoring as part of risk management in disturbance areas CEMP and associated ASSMP for the construction of river crossings.	Minor	Unlikely	Low

Risk Reference Tables:

Qualitative measure of likelihood (after controls are 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

Qualitative measure of consequence (with controls in place)	
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

	Consequence				
	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**