Balranald Mineral Sands Mine

Water Management Plan

March 2025

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Abbreviations

Abbreviation	Full Title
AWS	Automatic Weather Station
AMD	Acid and Metalliferous Drainage
ANC	Acid Neutralising Capacity
Consent	Development Consent SSD-5285
DCCEEW	Department of Climate Change, Energy the Environment and Water
DPHI	NSW Department of Planning Housing & Infrastructure
DPE-Water	NSW Department of Planning and Environment Water
EIS	Environmental Impact Statement
EMP	Environmental Management Plan
EMS	Environmental Management Strategy
EPA	NSW Environment Protection Authority
EP&A Act	NSW Environmental Planning and Assessment Act
EPBC Act	Environment Protection and Biodiversity Conservation Act 1999
EPL	Environment Protection Licence
GDE	Groundwater Dependent Ecosystem
HMC	Heavy mineral concentrate
HSEC	Health, Safety, Environment and Community
Iluka	Iluka Resources Limited
ISO	International Standard Organisation
LCC	Lost Control Card
LGA	Local Government Area
LOM	Life of Mine
LPS	Loxton Parilla Sands Formation
MOD1	Development Consent Modification 1
MPA	Maximum potential acidity
NAF	Non-Acid Forming
NPR	Neutralisation Potential Ratio
NRAR	NSW Natural Resources Access Regulator
NSW	New South Wales
OF	Olney Formation
PAF	Potentially Acid Forming
PAX	Potassium amyl xanthate
PIRMP	Pollution Incident Response Management Plan
RMP	Radiation Management Plan
POEO Act	NSW Protection of the Environment Operations Act 1997
SF	Shepparton Formation
SSD	State Significant Development
TARP	Trigger Action Response Plan
WA	Western Australia
WCP	Wet concentrator plant
WHIMS	Wet high intensity magnetic separator
WMA 2000	NSW Water Management Act (2000)
WMP	Water Management Plan
WSP	Water Sharing Plan

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1. Introduction

1.1. Purpose and scope

This Water Management Plan (WMP) has been prepared by Iluka Resources Limited (Iluka) to satisfy the requirements of Schedule 3, Condition 15 of NSW Development Consent (SSD-5285). This WMP has been prepared using the Departments *Guideline for the preparation of Environmental Management Plans* (DIPNR 2004) and the management plan requirements stated in Schedule 5, Condition 3 of NSW Development Consent (SSD-5285).

This version of the WMP is submitted prior to commencement of mining operations. It is anticipated that this Plan will be reviewed and if required, revised for approval at the following stages of project development:

1. Following calibration and validation of the groundwater model
2. Prior to cessation of mining
3. As required and appropriate for changes in legislation or if monitoring information informs levels of greater accuracy.

Should Iluka undertake construction of the open cut mining at West Balranald or at the Nepean deposit, a revised WMP will be prepared prior to commencement of construction to include management measures and monitoring relevant to the site for approval by DPHI, in accordance with Schedule 2, Condition 17 of Development Consent (SSD-5285).

The conditions of consent to which the WMP relates to and where they are addressed in the WMP is presented in Table 2.

1.2. Environmental Policy

The Iluka HSEC policy is publicly available at https://www.iluka.com/ and provides a declaration of the importance Iluka places on conducting its business safely, without detrimental health effects and with regard to the community and the value of the natural environment.

1.3. Document Structure

The remainder of this WMP is structured as follows:

- Section 2 Outlines the project description, the environmental setting is described in Appendix A.
- Section 3 Describes the community and regulator engagement including consultation with DCCEEW and EPA.
- Section 4 Describes the environmental management structure for the project and the relevant statutory requirements and policies relevant to this Plan.
- Section 5 Provides a summary of the overarching water management strategy for the project.
- Section 6 Describes the water management system and water balance.
- Section 7 Describes the surface water management measures and monitoring program.

- Section 8 Describes the groundwater and tailings management measures and groundwater monitoring program.
- Section 9 Provides a summary of the environmental inspection programs relevant to this plan.
- Section 10 Describes the exceedance and contingency protocols relevant to this Plan.
- Section 11 Describes the reporting commitment and protocols relevant to this Plan.

2. Mine description

2.1. Mine overview

The Balranald Mineral Sands Mine (the Balranald Mine) is located in south-western New South Wales (NSW). It includes construction, open-cut mining, primary processing, and rehabilitation of two linear mineral sand deposits, known as the West Balranald and Nepean deposits, located approximately 12 kilometres (km) and 66 km north-west of the town of Balranald, respectively. The Balranald Mine also includes undertaking mining of mineral ore to trial the use of underground mining methods.

Development consent (SSD-5285) was granted for the Balranald Mine by a delegate of the NSW Minister for Planning under the EP&A Act on 5 April 2016 (herein referred to as the consent). Approval was also granted under the EPBC Act (EPBC 2012/6509) by a delegate of the Commonwealth Minister for the Environment on 6 January 2017 (herein referred to as the Commonwealth approval).

On 21 December 2022, Iluka were granted approval to modify the consent (MOD1) to expand the underground mining trial which includes an additional area of disturbance to the approved Balranald Mine area to enable primary processing of the ore into heavy mineral concentrate (HMC) and transport of HMC offsite for secondary processing at Iluka's facilities

Iluka intend to construct and operate the underground mining trial for up to six years as approved, at the completion of the underground mining trial Iluka would either seek a life of mine approval for underground mining, cease operations and rehabilitate or develop the open cut mining method to extract the remainder of the ore deposit.

2.2. Site location plan

The regional setting and conceptual site layout for the Balranald Project is presented in Figure 1 and Figure 2 respectively.

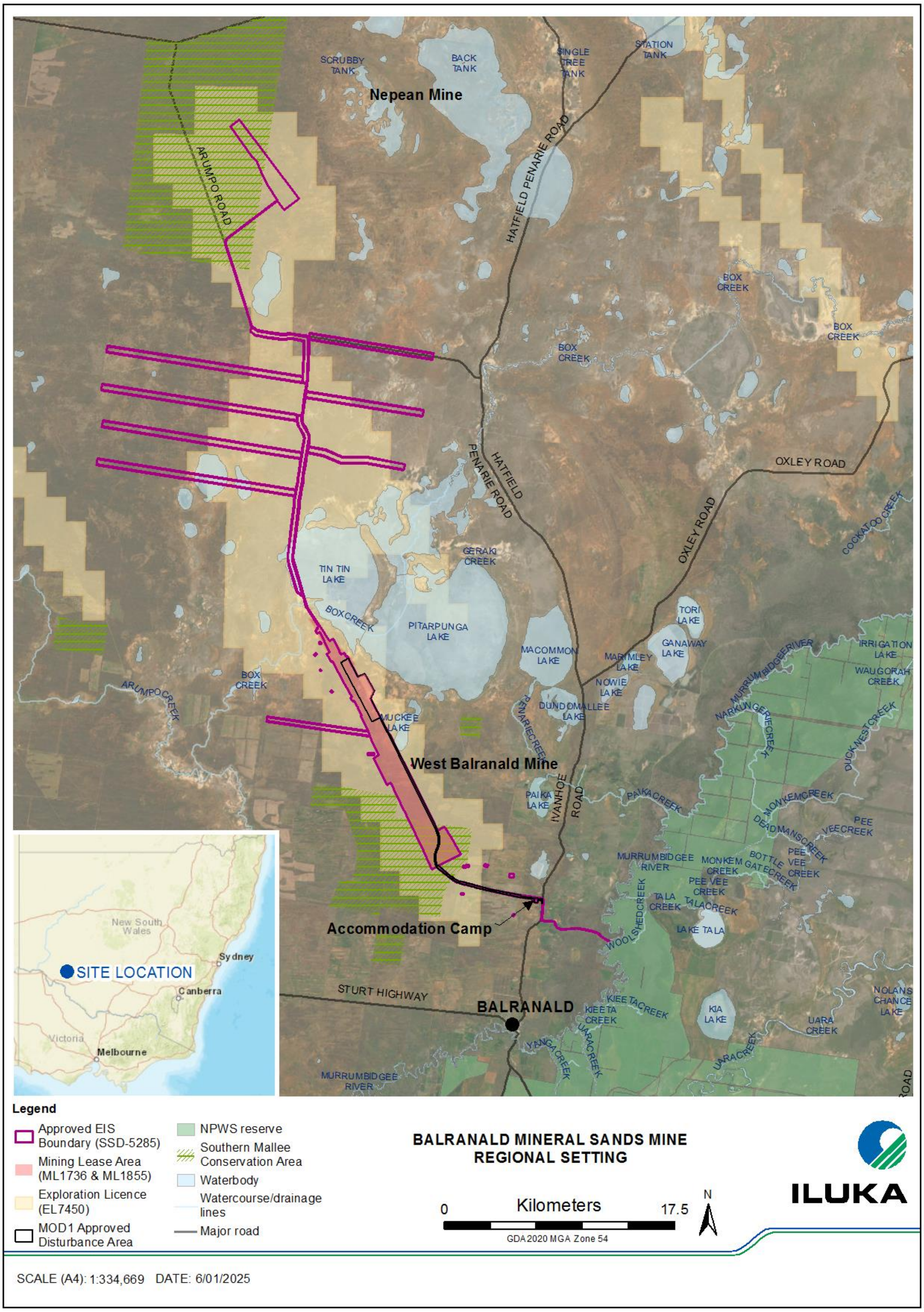


Figure 1- Regional setting

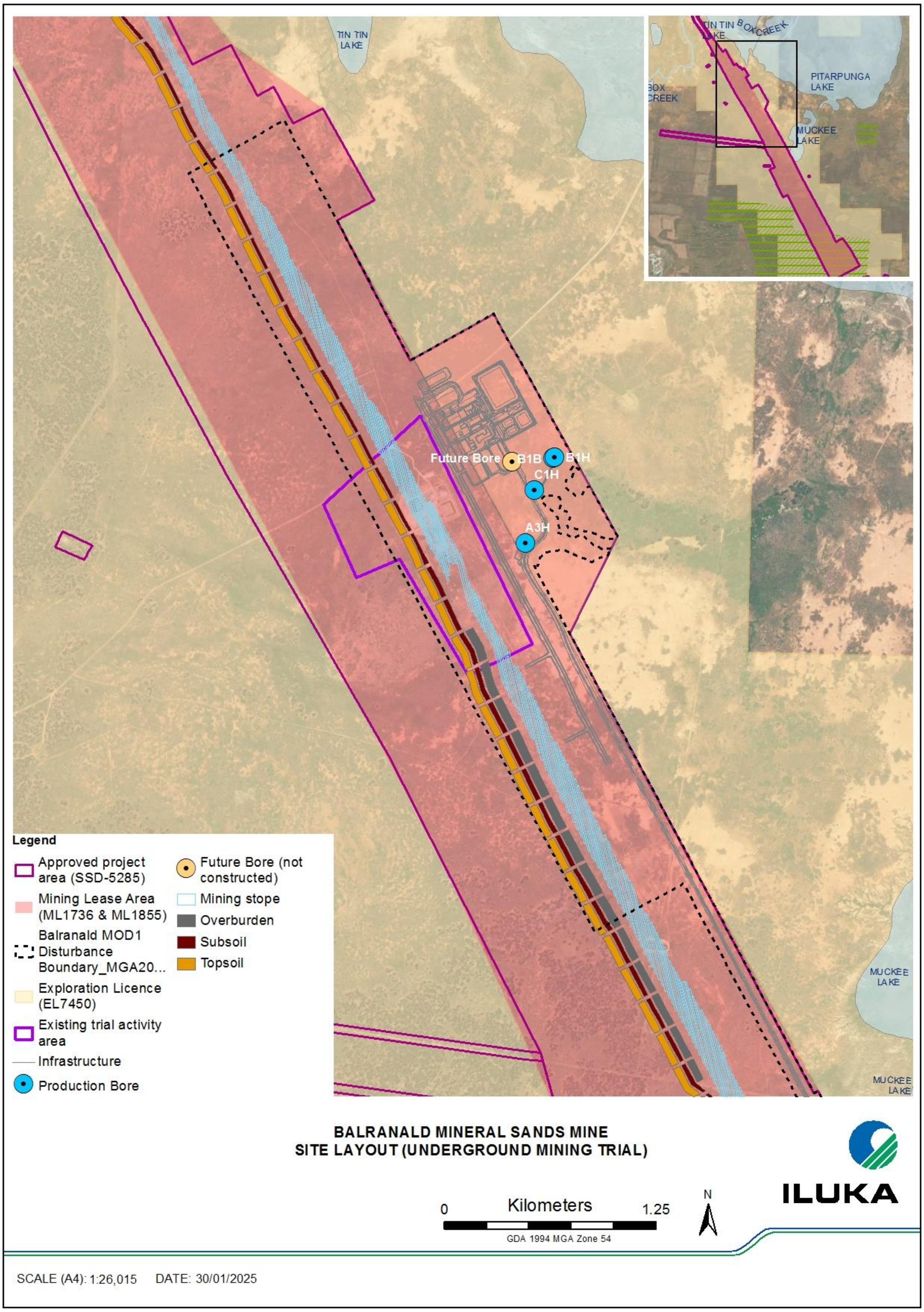


Figure 2- Underground mining general arrangement

3. Scope of works

All works will be carried out in accordance with Iluka's EMS and this WMP to manage water related risks associated with the operation of the Balranald west mine underground mining trial.

3.1.1. Operations

The underground mining trial will extract mineral ore via a process of pumping slurried ore to the surface.

The predicted processing rate is anticipated to be between 50 and 200 tph, consistent with the previous bulk sampling activity.

The processing plant has a number of components including the screening plant, wet concentrator plant (WCP), flotation plant and WHIMS plant.

The ore is concentrated through the processing plant to generate two primary product streams, magnetic HMC and non-magnetic HMC. HMC will be stockpiled on site and transported to an off-site location for processing.

Tailings generated at the processing plant will include fine clays (slimes), floatation plant tail and courser sand tails. The sand tailings will be placed on surface directly above the panels ahead of mining. The topsoil and subsoil will be pre-stripped from these areas prior to the emplacement of the sand tails and then returned for rehabilitation.

The fine sand will be reinjected underground. The mining process is depicted in Figure 4.

3.2. Timing of activities

The Balranald Mine has an operational phase of approximately six years to extend underground mining trials. Year 1 of the operational phase overlaps with the completion of the construction phase by approximately four months. The site will operate 24 hours per day, seven days per week during mining, processing and transport activities. The indicative planned sequencing of activities is presented in Figure 3.

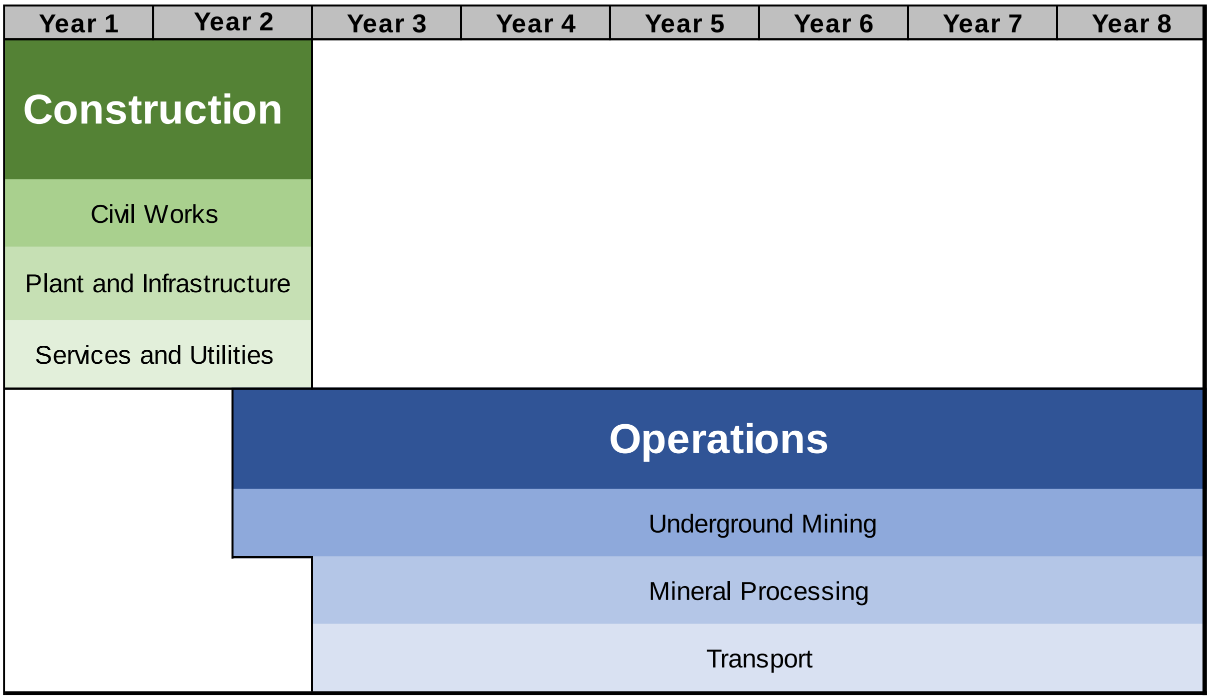


Figure 3- Sequence of site activities

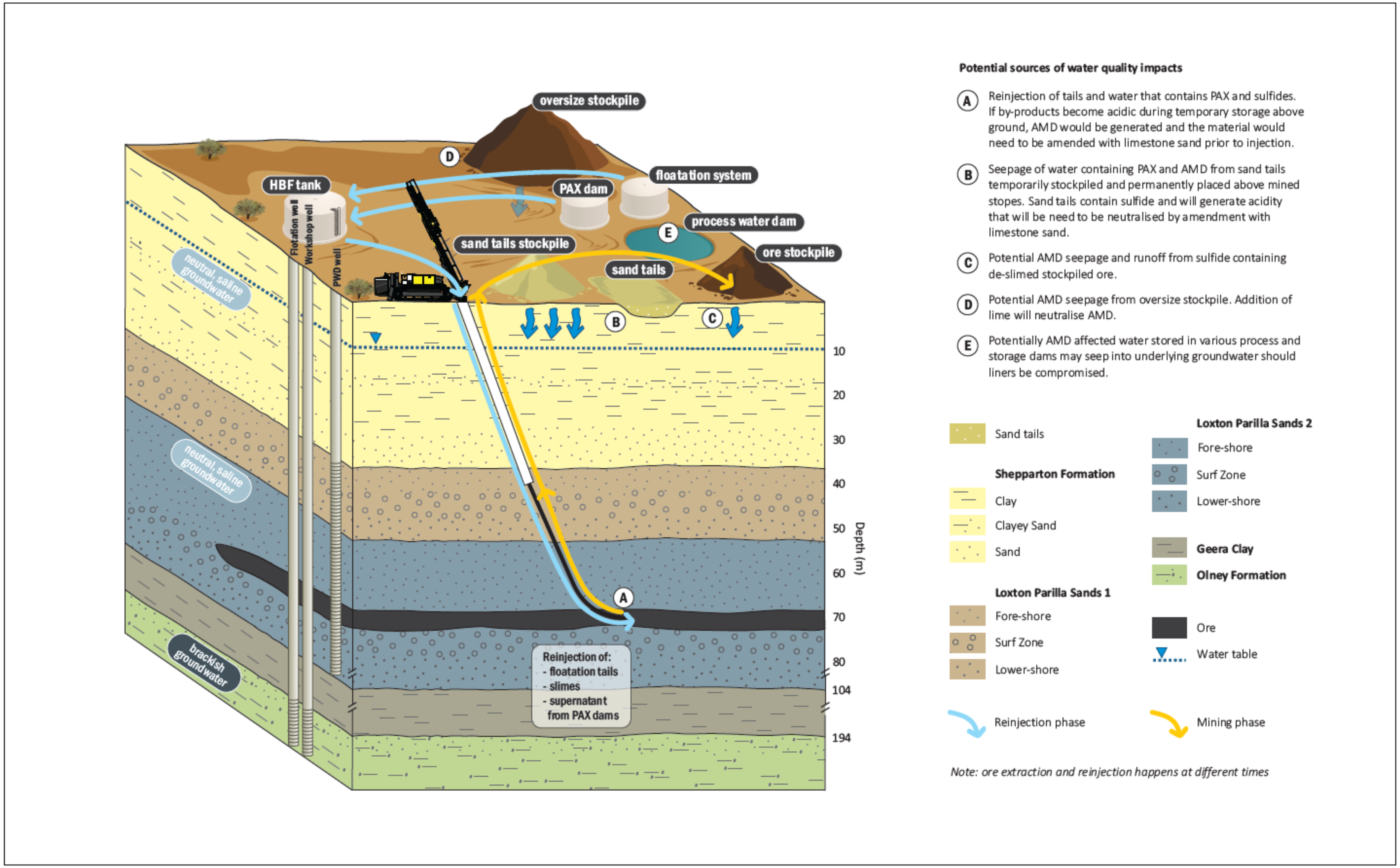


Figure 4- Mining process

4. Community and stakeholder engagement

4.1. Consultation acquired for the WMP

Iluka revised the WMP (Version 5) for the operational phase of the Balranald Mineral Sands Mine. The WMP was revised in consultation with NSW EPA and Department of Climate Change, Energy, the Environment and Water (DCCEEW) as required by Schedule 3, Condition 12(a) of Development Consent (SSD-5285).

Iluka received the following responses:

- NSW EPA email dated 20 February 2025, recommended that Iluka contact EPA directly should any necessary changes be identified to the premises' Environment Protection Licence (EPL) that may result from the proposed management plan updates.
- DCCEEW correspondence (OUT25/2976, dated 13 March 2025) provided three recommendations:
    1. The proponent should confirm if additional water supply works (eg. bores or dams) are required and update the Water Management Plan if necessary.
    2. The proponent:
        - Must ensure that Water Access Licences nominate relevant works through a dealing application prior to take occurring.
        - Should be aware that several of the listed work approvals (50WA514909, 60WA583168 & 60WA583169) have extraction limits or other conditions which may limit their use.
    3. The proponent should update the last sentence of Section 12.3 to replace the word "applicant" with "Iluka".

Iluka has amended the WMP (Version 5) to address recommendations made by DCCEEW and a consultation register is provided in Appendix B.

4.2. Communication

In accordance with Schedule 5, Condition 10 of NSW Development Consent (SSD-5285), the Iluka website will be maintained as a tool for the provision of information to stakeholders and interested parties about the environmental and community performance of the Project.

Information available on the Iluka website will be kept up to date to the satisfaction of the Secretary of the DPHI.

Stakeholder engagement is also managed in accordance with Iluka's Community and Stakeholder Engagement Plan.

External stakeholder interactions are recorded in Iluka's database to ensure a record of stakeholder interactions is maintained for the life of the operation.

4.3. Complaints

Iluka will maintain an enquiries and community complaints hotline for the Balranald Project (Phone 1800 305 993 or email balranald.community@iluka.com). The community hotline will be publicly advertised on the Iluka website Balranald engagement hub.

Community complaints will be managed in accordance with Iluka's Community and Stakeholder Engagement Plan and Environmental Management Strategy.

Iluka's Community and Stakeholder Engagement Plan for the Balranald operation provides additional requirements regarding stakeholder engagement and consultation.

In the event a complaint or enquiry is made by an external party, the nominated Iluka employee (dependent on the nature of the complaint) will be directed on the course of action in consultation with the Senior Manager.

A record of the event will be entered into the HSEC electronic management system. Any actions arising from the event will be tracked to ensure the event is dealt with appropriately.

Community inquiries and complaints will be recorded. The following information will be captured:

- the date and time;
- the method by which the complaint or inquiry was made;
- any personal details of the complainant, if provided;
- the nature of the complaint or enquiry;
- the action taken by Iluka in relation to the complaint or enquiry, including any follow-up contact with the proponent; and
- if no action was taken by Iluka, the reasons why no action was taken.

The record will be kept for at least 4 years.

The Community and Stakeholder Engagement Plan includes a grievance resolution process to enable Iluka to respond appropriately and respectfully to any issues raised by stakeholders (including internal stakeholders). The grievance resolution process is summarised in Figure 5.

A complaints and enquiry register is available on the Iluka community engagement hub website https://www.iluka.com/community-engagement/balranald/ and kept up to date on a monthly basis.

4.4. Dispute resolution

In the event of a disagreement between Iluka and a member of the community, the nominated Iluka employee (dependent on the nature of the complaint) will be directed on the course of action in consultation with the Senior Manager. Iluka will undertake the liaison to reach a resolution. Should resolution of the dispute not be reached through this primary process, either party may refer the matter to the Secretary of the DPHI for resolution.

A flow diagram summarising the dispute resolution process is presented in Figure 5.

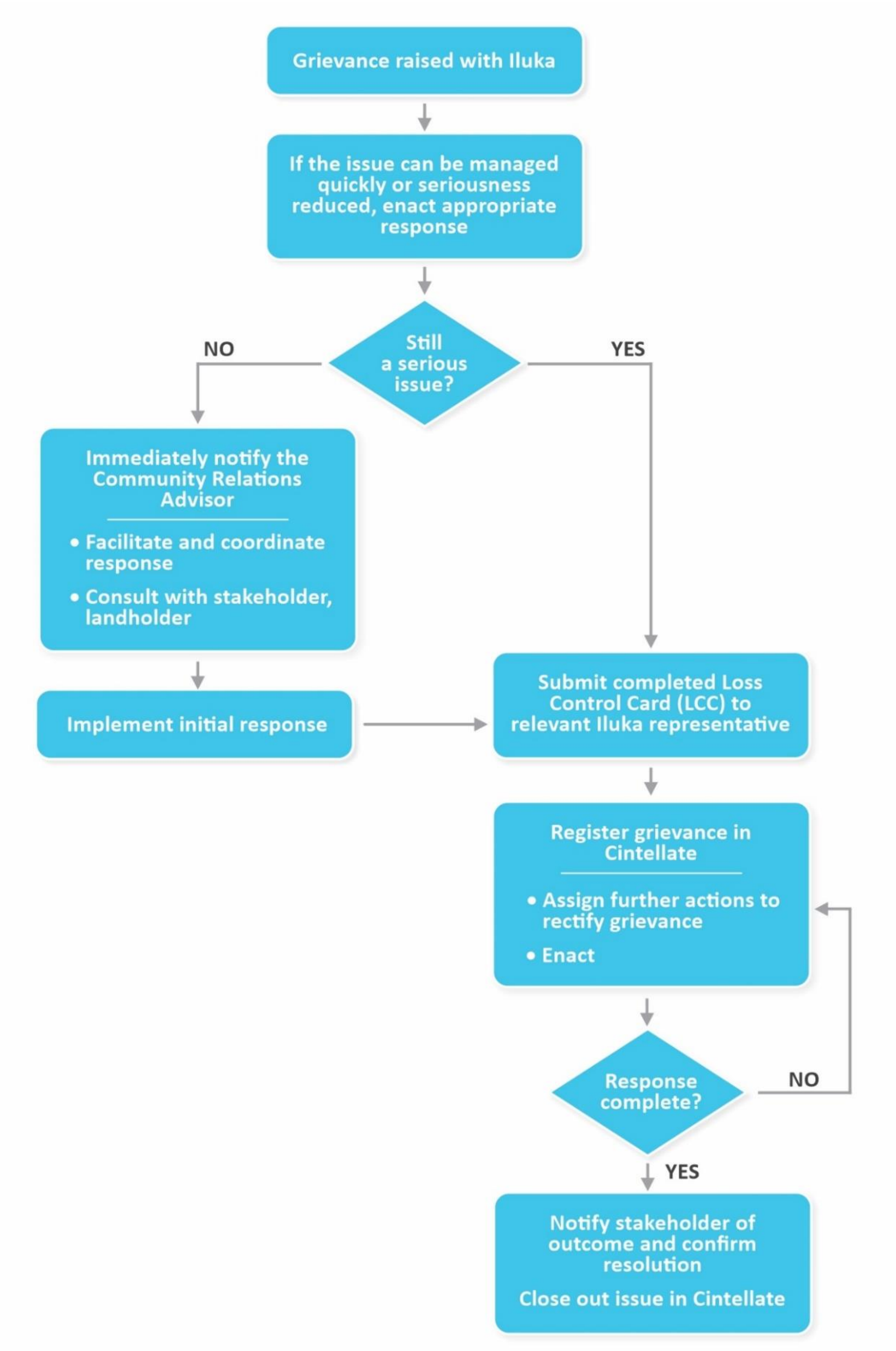


Figure 5- Summary of grievance resolution process

5. Environmental management framework

5.1. Relationship to existing EMS

Iluka's EMS has been developed to fulfil the relevant conditions in the NSW Development Consent (SSD-5285) and Commonwealth Approval (EPBC Act 2012/6509) by providing a strategic framework for environmental management of the mine including all environmental management plans (EMPs), strategies and programs prepared for the mine. The EMS establishes the overarching framework for the monitoring and environmental management of activities undertaken for the mine. The EMS incorporates the principles of continuous improvement and is consistent with the five pillars of International Standard Organisation (ISO) 14001: Environmental Management Systems. This WMP is a subordinate of Iluka's EMS.

5.2. Environmental management structure and responsibilities

All persons undertaking activities on the site are responsible for environmental management and are accountable for the following:

- complying with relevant legislation;
- complying with the EMS;
- communicating any information they become aware of in relation to environmental management; and
- taking actions to prevent and mitigate environmental impacts.

All employees and contractors within Iluka are held accountable for promoting and displaying behaviours consistent with the Iluka Plan. Table 1 defines HSEC and EMS related accountabilities.

Table 1- Roles and responsibilities for Environment and Community management

Role	Accountabilities
Operations Manager	• Develop business plans that align with wider sustainability objectives and targets. • Promote a culture of accountability and risk awareness, ensuring corrective and preventive actions are completed. • Promote active participation in Environment & Community matters in general. • Provide effective resources to implement the management system within the operation / function. • Ensure overall compliance to the EMS & HSECMS within the operation / function.
Environment, Rehabilitation and Community Relations (ERCR) Superintendent	• Provide advice/support to the environmental team for achievement of ongoing environmental compliance. • Inform and provide advice for environmental issues, non-compliances and incidents to the Operations Manager. • Support the preparation of environmental reports in compliance with corporate and regulatory requirements. • Support the review and oversee the implementation of the EMS, EMPs and procedures in accordance with corporate and regulatory requirements. • Investigate environmental incidents and endorse corrective actions in consultation with the Operations Manager.

Role	Accountabilities
	• Facilitate and review environmental risk assessments with team members and other stakeholders as required. • Oversee rehabilitation planning and implementation. • Respond to and report on community complaints in consultation with the Operations Manager. • Conduct internal compliance audits of applicable regulatory approvals, licences and other legislation for the mine. • Liaise with government regulators and other stakeholders on environment and community matters.
Environmental Advisor	• Manage the environmental monitoring database. • Collate data and prepare written reports for environmental and community performance reporting. • Implement and review the EMS, EMPs and procedures in accordance with corporate and regulatory requirements • Assist and provide advice to the Environmental Technician in collection of environmental monitoring data. • Develop procedures required for effective environmental management of the site. • Review and update management plans and procedures. • Conduct site environmental inspections and audits to identify issues and report findings to the ERCR Superintendent. • Assist in achieving compliance with regulatory requirements related to environmental management as required by the ERCR Superintendent. • Participate in the review and development of environmental risk assessments. • Conduct internal compliance audits of applicable regulatory approvals, licences and other legislation for the mine and advise the ERCR Superintendent of any non-compliances.
Environmental Technician	• Conduct the environmental monitoring required by the approved EMPs for the mine. • Follow procedures for environmental monitoring accurately and consistently. • Collect and record raw data accurately and consistently for all compliance monitoring. • Maintain calibration records of all equipment and ensure within manufacturers specifications. • Conduct site environmental inspections and report issues identified to ERCR Superintendent. • Assist with on ground environmental improvement works.
Rehabilitation Advisor	• Coordinate the planning and implementation of the rehabilitation in accordance with the Rehabilitation Management Plan and applicable procedures. • Coordinate the rehabilitation monitoring programs including engagement of specialised consultants. • Ensure that rehabilitation resources are managed effectively to ensure the success of the rehabilitation. • Prepare rehabilitation related documents and maintain the spatial data required under the Mining Act 1992. • Liaise with government regulators and other stakeholders on all rehabilitation matters.

Role	Accountabilities
Site Employees and Contractors	• Understand and comply with the Iluka EMS, HSEC policy and supporting standards • Accept accountability to ensure personal safety and the health and safety of others, and protect the environment • Identify, assess and control risks prior to undertaking any activity • Actively challenge or refuse to work in unsafe conditions or where unacceptable impact to the environment or community may occur • Intervene to prevent incidents • Actively participate in HSEC meetings, initiatives, risk assessments and monitoring programs • Report all incidents and near hits immediately • Correct or isolate hazardous situations in the workplace • Understand and follow the local emergency procedures • Comply with and suggest improvements to site documentation, processes and procedures

5.3. Legal and compliance requirements

5.3.1. NSW Environmental Planning and Assessment Act 1979

Development Consent SSD-5285 (Modification 1) was issued by NSW Department of Planning and Environment (now NSW Department of Planning, Housing and Infrastructure (DPHI) on 21 December 2022. Relevant conditions and where they are addressed in this document are provided in Table 2.

Table 2- Conditions from NSW Development Consent (SSD-5285) that are relevant to this WMP

Condition	Description	WMP Section
	Water Supply	
Schedule 3, Condition 11	*The Applicant shall ensure that it has sufficient water for all stages of the development, and if necessary, adjust the scale of mining operations to match its available water supply.* *Note: Under the Water Act 1912 and/or the Water Management Act 2000, the Applicant is required to obtain the necessary water licences for the development.*	*Section 8.2*
	Water Pollution	
Schedule 3, Condition 12	*Unless an EPL authorises otherwise, the Applicant shall comply with Section 120 of the POEO Act.*	*Entire document*
	Compensatory Water Supply	

Condition	Description	WMP Section
Schedule 3, Condition 13	*The Applicant must provide a compensatory water supply to the owner or leaseholder of any privately-owned land whose basic landholder water rights (as defined in the Water Management Act 2000) are adversely and directly impacted as a result of the development. This supply must be provided in consultation with DPE Water, and to the satisfaction of the Secretary.* *The compensatory water supply measures must provide an alternative long-term supply of water that is equivalent to the loss attributable to the development. Equivalent water supply should be provided (at least on an interim basis) as soon as practicable from the loss being identified, unless otherwise agreed with the landowner.* *If the Applicant and the landowner cannot agree on whether the loss of water is attributed to the development or the measures to be implemented, or there is a dispute about the implementation of these measures, then either party may refer the matter to the Secretary for resolution.* *If the Applicant is unable to provide an alternative long-term supply of water, then the Applicant must provide alternative compensation to the satisfaction of the Secretary.* *Notes:* • *The Water Management Plan (see condition 15) is required to include trigger levels for investigating potentially adverse impacts on water supplies.* • *The burden of proof that any loss of surface water or groundwater access is not due to mining impacts rests with the Applicant.*	Section 12.3
	Water Management Performance Measures	
Schedule 3, Condition 14	***Water Management Performance Measures*** *The Applicant must comply with the performance measures in Table 6, to the satisfaction of the Secretary.*	Section 6

Table 6: Water Management Performance Measures

Feature	***Performance Measure***	WMP Section
Water management – General	Minimise the use of clean water (i.e. water not in contact with disturbed areas) on site Minimise the need for make-up water from external supplies	Section 8.3
Loxton Parilla Sands and Shepparton alluvial aquifers	Negligible environmental consequences to the alluvial aquifer beyond those predicted in the EIS, including: • negligible change in groundwater levels beyond those predicted; • negligible change in groundwater quality beyond those predicted; and • negligible impact to other groundwater users levels beyond those predicted	Section 10
Construction and operation of infrastructure	Design, install and maintain erosion and sediment controls generally in accordance with the series *Managing Urban Stormwater: Soils and Construction* including *Volume 1, Volume 2A – Installation of Services* and *Volume 2C – Unsealed Roads* Design, install and maintain infrastructure within 40 m of watercourses generally in accordance with the *Guidelines for Controlled Activities on Waterfront Land (DPI 2007)*, or its latest version Design, install and maintain any creek crossings generally in accordance with the *Policy and Guidelines for Fish Habitat Conservation and Management* (DPI, 2013) and *Why Do Fish Need To Cross The Road? Fish Passage Requirements for Waterway Crossings* (NSW Fisheries 2003), or their latest versions	Section 7.1

Condition	Description		WMP Section
	Clean water diversion & storage infrastructure	Design, install and maintain the clean water system to capture and convey the 100 year ARI flood. Maximise as far as reasonable and feasible the diversion of clean water around disturbed areas on site	Section 9.2
	Sediment dams	Design, install and/or maintain the dams generally in accordance with the series *Managing Urban Stormwater: Soils and Construction – Volume 1 and Volume 2E Mines and Quarries*	Section 9.3
	Mine water storages	Design, install and/or maintain mine water storage infrastructure to ensure no discharge of mine water or saline water off-site (except in accordance with an EPL) On-site storages (including mine infrastructure dams, groundwater storage and treatment dams) are suitably designed, installed and/or maintained to minimise permeability, where practicable	Section 9.4
	Flood mitigation measures	Design, install and maintain flood mitigation measures including bunds to exclude flows from inundating the mining areas for all flood events up to and including the Probable Maximum Flood level Manage any residual downstream impacts in an appropriate manner	Section 9.2
	Overburden emplacements	Design, install and maintain emplacements to encapsulate and prevent any off-site migration of tailings, acid forming and potentially acid forming materials, and saline and sodic material Design, install and maintain emplacements to prevent off-site migration of saline groundwater seepage	Section 7
	Chemical and hydrocarbon storage	Chemical and hydrocarbon products to be stored in bunded areas in accordance with the relevant Australian Standards	Section 9.5
	Water Management Plan		
Schedule 3, Condition 15	*The Applicant must prepare a Water Management Plan for the development to the satisfaction of the Secretary. This plan must:* *(a) be prepared in consultation with DPE Water and the EPA;* *(b) include a:* *(i) Site Water Balance, that:* • *includes details of:* o *sources and security of water supply, including contingency planning for future reporting periods;* o *water use and management on site;* o *reporting procedures, including the preparation of a site water balance for each calendar year; and* • *investigates and implements all reasonable and feasible measures to minimise clean water use and to recycle water;*		Section 4.1 Section 8 Section 8.2 Section 7 Section 8.5 Section 8.3

Condition	Description	WMP Section
	(ii) Surface Water Management Plan, that includes: • *baseline data on water flows and quality in the watercourses that could be affected by the development (if available);* • *a detailed description of the water management system on-site, including the:* o *clean water diversion systems;* o *erosion and sediment controls; and* o *mine water management system, including a description on the measures that would be implemented to manage drilling fluids and muds;* • *detailed plans, including design objectives and performance criteria for the:* o *emplacement areas for tailings, acid forming and potentially acid forming materials, and saline and sodic materials;* o *reinstatement of drainage lines on the rehabilitated areas of the site; and* o *final void;* • *surface water assessment criteria, including trigger levels for investigating any potentially adverse impacts associated with:* o *the water management system;* o *surface water users supplies;* o *downstream surface water quality;* o *downstream flooding impacts; and* • *a program to monitor and report on:* o *the effectiveness of the water management system; and* o *surface water flows and water quality (if any); and* o *downstream flooding impacts;* • *reporting procedures for the results of the monitoring program; and* • *a plan to respond to any exceedances of the surface water assessment criteria, and mitigate any adverse impacts of the development;*	Section 9 n/a Section 7 Section 9.2 Section 9.3 Section 9.4 Section 10.5 n/a(1) n/a(1) Section 9.7 Section 9.8 Section 9.8.4 Section 12
	(iii) Groundwater Management Plan, that includes: • *detailed baseline data on groundwater levels, yield and quality in the region and privately-owned groundwater bores that could be affected by the development;* • *a detailed description of the groundwater management system on site;* • *detailed plans, including design objectives and performance criteria for the:* o *emplacement areas for tailings, acid forming and potentially acid forming materials, and saline and sodic materials;* o *groundwater dewatering and reinjection system; and* o *final void;* • *groundwater assessment criteria, including trigger levels for investigating any potentially adverse groundwater impacts associated with:* o *alluvial aquifers including the Loxton Parilla and Shepparton aquifers;* o *groundwater users bores;* o *groundwater dewatering and reinjection system;* o *seepage/leachate from water storages, emplacements, backfilled voids and the final void;* o *groundwater dependent ecosystems; and* o *reinjection of process water (including PAX) during the underground mining trial;* • *a program to monitor and report on:* o *groundwater inflows to the mining operations;* o *background changes in groundwater yield/quality against mine-induced changes;* o *the impacts of the development on the regional and local (including alluvial) aquifers;* o *impacts on the groundwater supply of potentially affected landowners/leaseholders;* o *groundwater levels and quality at the dewatering and reinjection sites;* o *impacts on groundwater quality as a result of reinjection of process water (including PAX) during the underground mining trial;* o *seepage/leachate from water storages, emplacements, backfilled voids and the final void;* o *groundwater dependent ecosystems; and* o *post-mining groundwater recovery;* • *a program to validate the groundwater model for the development, and compare the monitoring results with modelled predictions; and* • *a plan to respond to any exceedances of the groundwater assessment criteria, and mitigate any adverse impacts of the development.*	Section 10 Appendix D Section 10 Section 10.5 Sections 7 & 10.4 Section 10.6 Section 10.7 Section 10.3.5 Section 12

Condition	Description	WMP Section
Schedule 3, Condition 15A	*The Applicant must not commence construction until the Water Management Plan is approved by the Secretary.*	This document
Schedule 3, Condition 15B	*The Applicant must implement the Water Management Plan as approved by the Secretary.*	This document
Schedule 3, Condition 31	*The Applicant shall:* *(d) manage on-site sewage treatment and disposal in accordance with the requirements of Council and EPA; and*	Section 9.6
Schedule 5, Condition 3	***Management Plan Requirements*** *The Applicant shall ensure that the management plans required under this consent are prepared in* *accordance with any relevant guidelines, and include:* *(a) detailed baseline data;* *(b) a description of:* *- the relevant statutory requirements (including any relevant approval, licence or lease conditions);* *- any relevant limits or performance measures/criteria;* *- the specific performance indicators that are proposed to be used to judge the performance of, or guide the implementation of, the development or any management measures;* *(c) a description of the measures that would be implemented to comply with the relevant statutory requirements, limits, or performance measures/criteria;* *(d) a program to monitor and report on the:* *- impacts and environmental performance of the development;* *- effectiveness of any management measures (see c above);* *(e) a contingency plan to manage any unpredicted impacts and their consequences;* *(f) a program to investigate and implement ways to improve the environmental performance of the development over time;* *(g) a protocol for managing and reporting any:* *- incidents;* *- complaints;* *- non-compliances with statutory requirements; and* *- exceedances of the impact assessment criteria and/or performance criteria; and* *(h) a protocol for periodic review of the plan.*	Appendix D Section 5.3 Sections 9.7 and 10.6 Section 6 Sections 9.8 and 10.7 Section 12 Section 13.5 Section 14

5.3.2. NSW Protection of Environment Operations Act 1997

EPL 20795 was issued by NSW Environment Protection Authority under the NSW *Protection of Environment Operations Act 1997* (POEO Act). The EPL was varied 5 July 2023 to include groundwater monitoring requirements. EPL 20795 conditions relevant to this WMP and where they are addressed in this document are provided in Table 3.

Table 3- Relevant EPL Conditions

<table>
<tr><th>Condition</th><th>Description</th><th>WMP Section</th></tr>
<tr><td>P1.2</td><td>The following points referred to in the table are identified in this licence for the purposes of the monitoring and/or the setting of limits for discharges of pollutants to water from the point.
Water and land
<table>
<tr><th>EPA Identi-fication no.</th><th>Type of Monitoring Point</th><th>Type of Discharge Point</th><th>Location Description</th></tr>
<tr><td>17</td><td>Groundwater Monitoring</td><td></td><td>Groundwater bore labelled 'Karra Bore' identified in Figure 29 and Table 23 of the document titled 'Balranald Mineral Sands Project- West Balranald Stage 1 Consent (SSD-5285)-Water Management Plan' dated May 2023 and kept on EPA file DOC23/513414.</td></tr>
<tr><td>18</td><td>Groundwater monitoring</td><td></td><td>Groundwater bore labelled 'T01' identified in Figure 29 and Table 23 of the document titled 'Balranald Mineral Sands Project- West Balranald Stage 1 Consent (SSD-5285)-Water Management Plan' dated May 2023 and kept on EPA file DOC23/513414.</td></tr>
<tr><td>19</td><td>Groundwater monitoring</td><td></td><td>Groundwater bore labelled 'GW036673' identified in Figure 29 and Table 23 of the document titled 'Balranald Mineral Sands Project- West Balranald Stage 1 Consent (SSD-5285)-Water Management Plan' dated May 2023 and kept on EPA file DOC23/513414.</td></tr>
<tr><td>20</td><td>Groundwater monitoring</td><td></td><td>Groundwater bore labelled 'GW036866' identified in Figure 29 and Table 23 of the document titled 'Balranald Mineral Sands Project- West Balranald Stage 1 Consent (SSD-5285)-Water Management Plan' dated May 2023 and kept on EPA file DOC23/513414.</td></tr>
<tr><td>21</td><td>Groundwater monitoring</td><td></td><td>Groundwater bore labelled 'WB01' identified in Figure 29 and Table 23 of the document titled 'Balranald Mineral Sands Project- West Balranald Stage 1 Consent (SSD-5285)-Water Management Plan' dated May 2023 and kept on EPA file DOC23/513414.</td></tr>
<tr><td>22</td><td>Groundwater monitoring</td><td></td><td>Groundwater bore labelled 'WB02' identified in Figure 29 and Table 23 of the document titled 'Balranald Mineral Sands Project- West Balranald Stage 1 Consent (SSD-5285)-Water Management Plan' dated May 2023 and kept on EPA file DOC23/513414.</td></tr>
<tr><td>23</td><td>Groundwater monitoring</td><td></td><td>Groundwater bore labelled 'LPSPB03' identified in Figure 29 and Table 23 of the document titled 'Balranald Mineral Sands Project- West Balranald Stage 1 Consent (SSD-5285)-Water Management Plan' dated May 2023 and kept on EPA file DOC23/513414.</td></tr>
<tr><td>24</td><td>Groundwater monitoring</td><td></td><td>Groundwater bore labelled 'T03' identified in Figure 29 and Table 23 of the document titled 'Balranald Mineral Sands Project- West Balranald Stage 1 Consent (SSD-5285)-Water Management Plan' dated May 2023 and kept on EPA file DOC23/513414.</td></tr>
</table>
</td><td>Section 10.7.4</td></tr>
</table>

<table>
<tr><th>Condition</th><th>Description</th><th>WMP Section</th></tr>
<tr><td>L1.1</td><td>Except as may be expressly provided in any other condition of this licence, the licensee must comply with section 120 of the Protection of the Environment Operations Act 1997.</td><td>Entire document</td></tr>
<tr><td>M2.1</td><td>For each monitoring/discharge point or utilisation area specified below (by a point number), the licensee must monitor (by sampling and obtaining results by analysis) the concentration of each pollutant specified in Column 1. The licensee must use the sampling method, units of measure, and sample at the frequency, specified opposite in the other columns:</td><td>Section 10.7.4</td></tr>
<tr><td>M2.3</td><td>Water and/ or Land Monitoring Requirements
POINT 17,18,19,20,21,22,23,24
<table>
<tr><th>Pollutant</th><th>Units of measure</th><th>Frequency</th><th>Sampling Method</th></tr>
<tr><td>Aluminium (dissolved)</td><td>micrograms per litre</td><td>Yearly</td><td>Representative sample</td></tr>
<tr><td>Arsenic (dissolved)</td><td>micrograms per litre</td><td>Yearly</td><td>Representative sample</td></tr>
<tr><td>Cadmium (dissolved)</td><td>micrograms per litre</td><td>Yearly</td><td>Representative sample</td></tr>
<tr><td>Chromium (dissolved)</td><td>micrograms per litre</td><td>Yearly</td><td>Representative sample</td></tr>
<tr><td>Cobalt (dissolved)</td><td>micrograms per litre</td><td>Yearly</td><td>Representative sample</td></tr>
<tr><td>Copper (dissolved)</td><td>micrograms per litre</td><td>Yearly</td><td>Representative sample</td></tr>
<tr><td>Electrical conductivity</td><td>microsiemens per centimetre</td><td>Yearly</td><td>Representative sample</td></tr>
<tr><td>Iron (dissolved)</td><td>micrograms per litre</td><td>Yearly</td><td>Representative sample</td></tr>
<tr><td>Lead (dissolved)</td><td>micrograms per litre</td><td>Yearly</td><td>Representative sample</td></tr>
<tr><td>Manganese (dissolved)</td><td>micrograms per litre</td><td>Yearly</td><td>Representative sample</td></tr>
<tr><td>Nickel (dissolved)</td><td>micrograms per litre</td><td>Yearly</td><td>Representative sample</td></tr>
<tr><td>pH</td><td>pH</td><td>Yearly</td><td>Representative sample</td></tr>
<tr><td>Uranium</td><td>micrograms per cubic metre</td><td>Yearly</td><td>Representative sample</td></tr>
<tr><td>Zinc (dissolved)</td><td>micrograms per litre</td><td>Yearly</td><td>Representative sample</td></tr>
</table>
POINT 19,20,21,22,23
<table>
<tr><th>Pollutant</th><th>Units of measure</th><th>Frequency</th><th>Sampling Method</th></tr>
<tr><td>Standing Water Level</td><td>metres</td><td>Quarterly</td><td>In situ</td></tr>
</table>
</td><td>Section 10.7.4</td></tr>
</table>

5.3.3. NSW Water Management Act 2000

Water Sharing Plans (WSPs) are statutory documents established under the *Water Management Act 2000* (WMA 2000) that apply to individual water source areas and contain the rules for sharing and managing the water resources of NSW. The WMA 2000 outlines the requirements for the taking and trading of water through water access licenses (WALs), water supply works and water use approvals.

There are a number of surface and groundwater WSPs that relate to water sources in and surrounding the mine area; two are applicable to the current mine activities being the Water Sharing Plan for the MDB Porous Rock Groundwater Source 2020 and Murrumbidgee Regulated River Water Source. The Balranald Mine lies within the Western Murray Porous Rock Groundwater Source. Further information about this WSP and the Balranald Mine can be found in the Balranald Project Water Impact Assessment (EMM, 2015).

Iluka have constructed the approved Murrumbidgee fresh water supply pipeline and pump,. River water will be used for selected activities that specifically require fresh water.

Water extraction from the Murrumbidgee river would be regulated by the Water Sharing Plan for the Murrumbidgee Regulated River Water Source 2016. Iluka hold 101 shares of Murrumbidgee Regulated River Water Source under Water Access Licence WAL41857. Water Supply Works Approval 40MW416854 is nominated to this Water Access Licence for the extraction of surface water.

5.3.4. NSW Aquifer Interference Policy

The NSW Aquifer Interference Policy (AIP) was finalised in September 2012 and clarifies the water licensing and approval requirements for aquifer interference activities in NSW, including the taking of water from an aquifer in the course of carrying out mining.

The NSW AIP requires that potential impacts on groundwater sources, including their users and GDEs, be assessed against minimal impact considerations, outlined in Table 1 of the Policy. If the predicted impacts meet the Level 1 minimal impact considerations, then these impacts will be considered as acceptable. The adopted Level 1 minimal impact considerations for the mine are discussed further below and are outlined in Table 4.

The minimal impact thresholds outlined in the AIP will be used to assess the potential impacts to groundwater resulting from the Balranald Mine. This is in accordance with the Minister's requirements for approval and administration of the WMA 2000.

The AIP's 'minimal impact considerations' are employed to assess impacts to water table levels, water pressure levels and water quality across a range of different groundwater system types. The AIP divides groundwater sources into 'highly productive' or 'less productive' based on the yield (>5 L/s for high yielding) and water quality (<1,500 mg/L total dissolved solids for high yielding). Thresholds are set in the AIP for the different groundwater sources for the different minimal impact considerations.

The groundwater within the Western Murray Groundwater Source in the MDB Porous Rock WSP in the vicinity of the Balranald Mine is classified as 'less productive', based on the very high salinity levels. The categories of less productive groundwater sources include alluvial, porous rock and fractured rock. The greater water source is classified as a 'porous rock' water source, therefore the minimal considerations for porous rock units of less productive groundwater systems have been adopted for the Balranald Mine.

Table 4- Minimal Impact Criteria for adopted for the Balranald Mine (after EMM, 2022).

Impact level	Watertable	Water pressure	Water quality
Level 1 impact (ie less than minimal)	Less than or equal to 10% cumulative variation in the water table, allowing for typical climatic 'post-water sharing plan' variations, 40 m from any: a) high priority groundwater dependent ecosystem; or b) high priority culturally significant site. Listed in the schedule of the relevant water sharing plan. A maximum of a 2 m decline cumulatively at any water supply work.	A cumulative pressure head decline of not more than a 2 m decline, at any water supply work.	Any change in the groundwater quality should not lower the beneficial use category of the groundwater source beyond 40 m from the activity.
Level 2 impact (ie greater than minimal)	If more than 10% cumulative variation in the water table, allowing for typical climatic 'post-water sharing plan' variations, 40 m from any: a) high priority groundwater dependent ecosystem; or b) high priority culturally significant site. Listed in the schedule of the relevant water sharing plan if appropriate studies demonstrate to the Minister's satisfaction that the variation will not prevent the long-term viability of the dependent ecosystem or significant site. If more than a 2 m decline cumulatively at any water supply work, then make good provisions should apply.	If the predicted pressure head decline is greater than requirement 1 above, then appropriate studies are required to demonstrate to the Minister's satisfaction that the decline will not prevent the long-term viability of the affected water supply works unless make good provisions apply.	If condition 1 is not met then appropriate studies will need to demonstrate to the Minister's satisfaction that the change in groundwater quality will not prevent the long-term viability of the dependent ecosystem, significant site or affected water supply works.

Source: AIP DPI Water 2012.

Notes: 'Post-WSP'– refers to the period after the first WSP in the water source begins, including the highest pressure head (allowing for typical climatic variations) within the first year after the first WSP begins.
'Appropriate studies' on the potential impacts of watertable changes greater than 10% are to include an identification of the extent and location of the asset, the predicted range of watertable changes at the asset due to the activity, the groundwater interaction processes that affect the asset, the reliance of the asset on groundwater, the condition and resilience of the asset in relation to watertable changes and the long-term state of the asset due to these changes.
All cumulative impacts are to be based on the combined impacts of all 'post-WSP' activities within the water source.

5.3.5. Water Licencing and Approvals

Iluka's Water Access Licences (WALs) are listed in Table 5 and water works approvals are provided in Table 6. State significant developments are exempt from the requirement to obtain a water supply works approval under the WMA 2000, if proposed works have been previously assessed in a Groundwater Impact Assessment for the Consent or any future modification of the Consent. Two miscellaneous works approvals have been created to permit nomination of water supply works for licenced water extraction. Other water supply works approvals held by Iluka and any extraction limits are also listed in Table 6.

All production bores used to extract groundwater will be linked to a nominated works approval to permit water extraction under one or more of the WALs held by Iluka. Any production bores not approved under the Consent or a future modified Consent will be subject to a new Water Supply Works Approval under the WMA 2000.

The groundwater bore labelled "Future Bore" (Figure 2) will be installed as a standby saline water source within the LPS Formation to support mining, processing and site operation. The additional bore is not proposed to increase the total demand for hyper saline groundwater or change the maximum licensable abstraction from the Western Murray Porous Rock Groundwater Source. Instead, it will act as an alternative water supply for operations in the event the main pumps are not available. Prior to the construction of this bore it will be assessed under a future modification of the Consent.

Iluka hold four WALs to permit extraction of groundwater and one WAL for the extraction of water from the Murrumbidgee River. All water extracted as part of the mining process will be accounted for under a WAL, even though the majority of this water will be reinjected. Water will be extracted in accordance with the available allocation and the carryover and record keeping conditions stated in the WALs.

Table 5- Water access licences

WAL number	Water Source	Entitlement Volume (ML)
WAL31101 (60AL583095)	Western Murray Porous Rock Groundwater Source	50
WAL44602 (60AL583681)		4,233
WAL44970 (50AL514844)		1,117
WAL41857 (40AL417267)	Murrumbidgee Regulated River Water Source	101 (General Security)

Table 6- Works approvals and monitoring bore licences

Approval / licence number	Issue date	Expiry date	Linked WAL	Water Source	Listed Works
60MW583326	18/5/2016	17/5/2026	WAL44602, WAL31101	Covers all groundwater works extracting water from the Western Murray Porous Rock Groundwater Source	All works previously assessed under Consent SSD-5285 and subsequent Modifications of Consent. (B1H & B1B)
40MW416854	18/5/2016	17/5/2026	WAL41857	Covers all surface water works extracting water from the Murrumbidgee Regulated River Water Source	Construction of water supply pipeline and placement of temporary surface water pump.
50WA514909*	17/09/2024	16/09/2034	WAL44602	Western Murray Porous Rock Groundwater Source	Production bores A3H, C1H (630ML/Yr limit each)
60WA583168	27/11/2013	26/6/2026	WAL31101		Karra Bore (50ML/Yr limit)

Note: *A 71W Application to nominate this Work to WAL44602 was submitted 11 March 2025.

5.4. Training and awareness

Iluka have a standard for training and awareness *(Group Standard 3:Training and Awareness)* to ensure employees and contractors are appropriately trained and are competent to perform their work.

Inductions (excluding visitor induction) shall be undertaken every two years or more frequently as required. The Iluka induction and a Balranald Mine specific induction shall be undertaken prior to commencement of works.

Processes and procedures are developed and implemented by the operation to identify, prioritise and plan the fulfilment of training needs commensurate with HSEC risks. Processes shall include (at a minimum):

- development of a training needs analysis, including the identification of training needs for all employees and contractors within the area, operations, mine or function;
- delivery of training and maintaining currency;
- methods and criteria for the determination of competency; considering training, education, skills and experience; and
- evaluation of the effectiveness of training processes and programs.

Training attendance, inductions and competency shall be recorded. Employee and contractor records shall be maintained and attendance recorded in the Iluka Training Management System.

Iluka maintain a training platform, which requires employees to undertake specific training programs periodically.

5.5. Environmental risk assessment

A risk-based framework was adopted for the groundwater assessment to categorise and characterise risk in-line with the National Water Commission's (NWC) mining risk framework (NWC 2010). The groundwater risk assessment framework uses a source-pathway-receptor model to characterise the significance of a water-affecting activity, grouping these as either 'direct' or 'indirect' impacts (EMM, MOD1 report).

All water related risks have been collated into an Aspects and Impacts register for the Balranald Mine. Mitigation measures have been developed to minimise impacts to water as low as reasonably practicable during the operation phase of mine. The risk assessment will be reviewed throughout different stages of mining or when a potential hazard is identified to ensure that adaptive management is being applied effectively and appropriate controls are adopted. Appendix C provides a summary of the aspects and impacts register relevant to this Plan.

6. Water Strategy and Performance Measures

The water management strategy is based on the separation of water from different sources based on anticipated water quality, as follows:

- Saline groundwater extracted from the Loxton Parilla Sands (LPS) and brackish water sourced from the Olney Formation will be used to satisfy mine water demands, and partially reinjected into the LPS during the mining process. This use of saline groundwater minimises the need for river water from the Murrumbidgee River. Water efficiency will be maximised at all stages of operations, where practical, to minimise groundwater take.

- Mine affected water, comprising processing water and runoff collected in the processing area (including run of mine (ROM) pad and tailings and mining by-product stockpiles) is contained within the ore processing area and returned to the process for reuse.
- Process water quality will be monitored and managed to minimise its influence on groundwater quality when recirculated into the ground for mining.
- The potential for AMD generation from ore and waste streams will be mitigated and minimised via dedicated handling and storage measures and infrastructure, and where it cannot be minimised, it will be mitigated via limestone neutralisation.
- A comprehensive monitoring strategy will be used to assess the performance of the water system and the influence of mining activities on the nearby groundwater system. Monitoring in the initial stages of mining will be used to calibrate and validate the groundwater model.
- Flood risk is mitigated via comprehensive flood modelling and construction of flood bunds and diversion structures.
- Potable water would be produced by a potable water treatment plant.
- Sewage would be managed via an approved package waste treatment system serviced by Iluka personnel or a licenced contractor as required.
- An adaptive management framework will be applied to all aspects of water management in accordance with Iluka's EMS and via future revisions of this WMP.
- Water data and information will be transparently reported via the Annual Review.
- Water performance measures (from Schedule 3 Condition 14) and the management and mitigation measures implemented to address these, are provided in Table 7. Implementation of these measures is described in further detail in Sections 9 and 10 of this document.

6.1. Environmental management measures

The water management performance and management measures that will be implemented are outlined in Table 7.

Table 7: Water performance and management measures

Feature	Performance Measure (SSD-5285 Schedule 3 Condition 14)	Management and Mitigation Measures
Water management – General	- Minimise the use of clean water (i.e., water not in contact with disturbed areas) on site - Minimise the need for make-up water from external supplies	- Process area bunded to divert clean water around it - water captured from processing area is reused to offset demand for groundwater - mine water is reused as much as possible to minimise demand for external water - Hypersaline and brackish groundwater (low beneficial use) used preferentially over river water extraction (high beneficial use) - Training and awareness of environmental hazards and controls for site personnel, including water efficiency
Loxton Parilla Sands and Shepparton alluvial aquifers	Negligible environmental consequences to the alluvial aquifer beyond those predicted in the EIS, including: · negligible change in groundwater levels beyond those predicted; · negligible change in groundwater quality beyond those predicted; and · negligible impact to other groundwater users levels beyond those predicted	- groundwater monitoring program and data review against investigation triggers - groundwater model review process to confirm / validate EA predictions - treatment of tailings to mitigate and minimise infiltration of seepage water - Minimise PAX reinjected underground - Stockpiles located on an engineered hardstand that diverts surface runoff to the diversion drains.
Construction and operation of infrastructure	- Design, install and maintain erosion and sediment controls generally in accordance with the series Managing Urban Stormwater: Soils and Construction including Volume 1, Volume 2A – Installation of Services and Volume 2C – Unsealed Roads - Design, install and maintain infrastructure within 40 m of watercourses generally in accordance with the Guidelines for Controlled Activities on Waterfront Land (DPI 2007), or its latest version - Design, install and maintain any creek crossings generally in accordance with the Policy and Guidelines for Fish Habitat Conservation and Management (DPI, 2013) and Why Do Fish Need To Cross The Road? Fish Passage Requirements for Waterway Crossings (NSW Fisheries 2003), or their latest versions	- Installation of stormwater infrastructure in accordance with the hydrology assessment recommended design. - routine inspection and maintenance of drainage and erosion control - hydrology assessment completed and identified no permanent watercourses in the mining operations area. - Murrumbidgee pipeline and pumping infrastructure constructed in accordance with Guidelines for Controlled Activities on Waterfront Land (DPE 2022) - Use of any existing surface water infrastructure for extraction of water from the Murrumbidgee River.
Clean water diversion & storage infrastructure	Design, install and maintain the clean water system to capture and convey the 100 year ARI flood. Maximise as far as reasonable and feasible the diversion of clean water around disturbed areas on site	- Flood levee designed to 1% AEP 72-hour event - water diverted around operations.

Feature	Performance Measure (SSD-5285 Schedule 3 Condition 14)	Management and Mitigation Measures
Sediment dams	Design, install and/or maintain the dams generally in accordance with the series Managing Urban Stormwater: Soils and Construction – Volume 1 and Volume 2E Mines and Quarries	- Sediment control designed according to NSW blue book. - routine inspection of drainage, sediment control and dams.
Mine water storages	- Design, install and/or maintain mine water storage infrastructure to ensure no discharge of mine water or saline water off-site (except in accordance with an EPL) - On-site storages (including mine infrastructure dams, groundwater storage and treatment dams) are suitably designed, installed and/or maintained to minimise permeability, where practicable	- process plant area bunded to 1% AEP 72-hour event. - process plant drainage and rainfall runoff capture dams designed to 1%% AEP 72-hour event. - all process water dams are lined - surface and groundwater monitoring program to detect any leakage - routine inspection and maintenance of water infrastructure - automated shut-off system to prevent overflow/spill for process water dams - Training and awareness of environmental hazards and controls for site personnel including water pollution
Flood mitigation measures	- Design, install and maintain flood mitigation measures including bunds to exclude flows from inundating the mining areas for all flood events up to and including the Probable Maximum Flood level - Manage any residual downstream impacts in an appropriate manner	- Flood mitigation bunds constructed around the processing plant areas in accordance with the hydrology assessment recommended design. - Culverts will be constructed along access road to permit passage of flood flows.
Overburden emplacements	Design, install and maintain emplacements to encapsulate and prevent any off-site migration of tailings, acid forming and potentially acid forming materials, and saline and sodic material. Design, install and maintain emplacements to prevent off-site migration of saline groundwater seepage	- Sand tailings will be disposed of in pre-stripped area above the mining panels, encapsulated with 2 m of inert material, and covered with subsoil and topsoil. - Sand tailings containing PAF material will be amended with limestone to neutralise acid and metalliferous drainage.
Chemical and hydrocarbon storage	Chemical and hydrocarbon products to be stored in bunded areas in accordance with the relevant Australian Standards	- Chemical and hydrocarbon products will be stored in bunded areas in accordance with: *AS1940-2004 The storage and handling of flammable and combustible liquids* *AS 3780:1994 Australian standard for the storage and handling of corrosive substances* *AS 1692:1989 Australian standard for tanks for flammable and combustible liquids* - routine inspection and maintenance of bunding and storage areas - Training and awareness of environmental hazards and controls for site personnel

7. Site Water System

Production bores will be used for the operations phase of the mine (location shown in Figure 18). Water is stored in the process water pond and or tanks. Its primary uses are for processing, dust suppression, material conditioning and miscellaneous uses such as wash down. Potable water is imported to site or produced on site using a package Reverse Osmosis (RO) water treatment plant.

The mine water management system comprises the mining system (groundwater injection and recovery), a series of dams within the processing plant area and sediment dams located downstream from soil stockpiles and disturbed areas. The preliminary layout of the process plant areas is shown in Figure 6 and Figure 7, and a simplified conceptual layout of the site water system is provided in Figure 8. Water storages are summarised in Table 8.

Mining will involve mining drill rigs located along the strike of the ore body. Each will use high pressure to mobilise the ore, which is then recovered at an anticipated rate of 50 to 200 tonnes per hour. The combined ore is pumped to the processing plant which concentrates the ore to generate two primary product streams; magnetic Heavy Mineral Concentrate (HMC) and non-magnetic HMC.

Each plant has its own water circuit. Flotation water contains PAX, a chemical used to separate iron sulfide from the ore. Flotation circuit overflow is sent to a series of PAX destruction dams to reduce the PAX concentration. This water is reused back in the flotation process and excess water is combined with other mine water and recycled as part of the mining process. The desliming and thickening process also produces fine material which is reinjected underground.

Hypersaline groundwater supply and other process waters are stored in the process water dam from where it is distributed for various uses. Brackish water is used for purposes where a lower salinity is required such as gland seal water and dust suppression.

Sand tailings is a by-product generated in the ore processing plant. This is dewatered as much as practicable prior to being trucked and deposited on prepared areas overlying mining panels, that exist ahead of mining. Lime is added to sand tailings to neutralise any potential acidity.

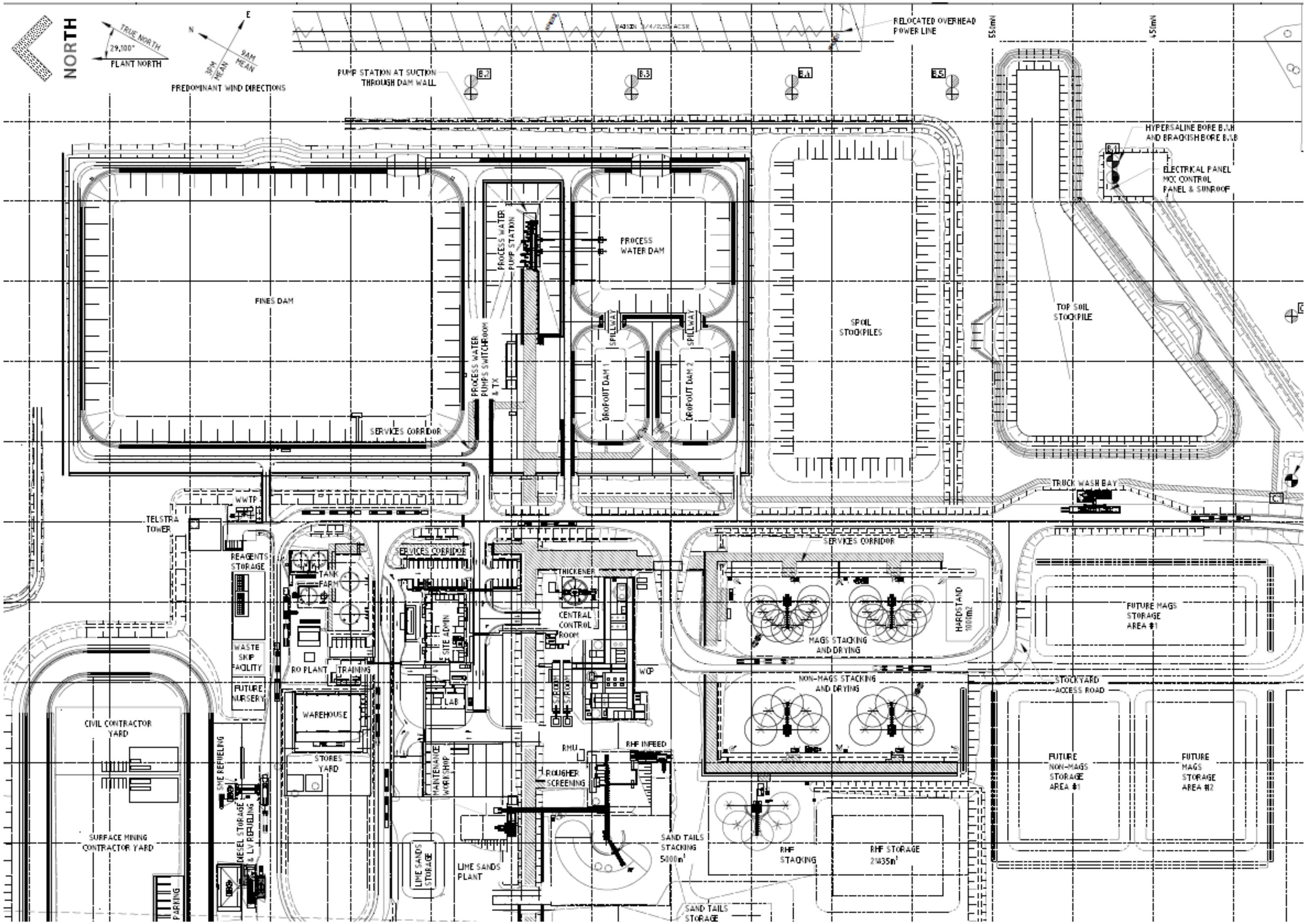


Figure 6- Plan view of the ore processing plant and water infrastructure.

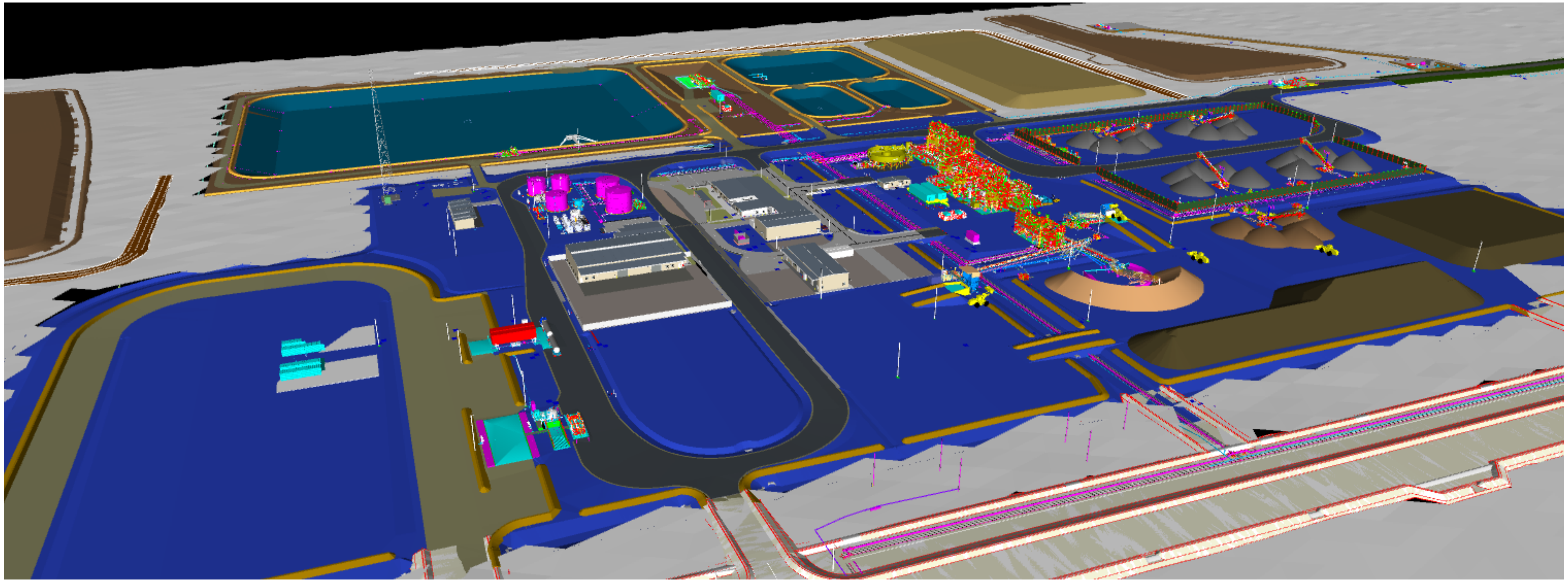


Figure 7- Conceptual three-dimensional view (looking from the west) of the ore processing plant and water infrastructure.

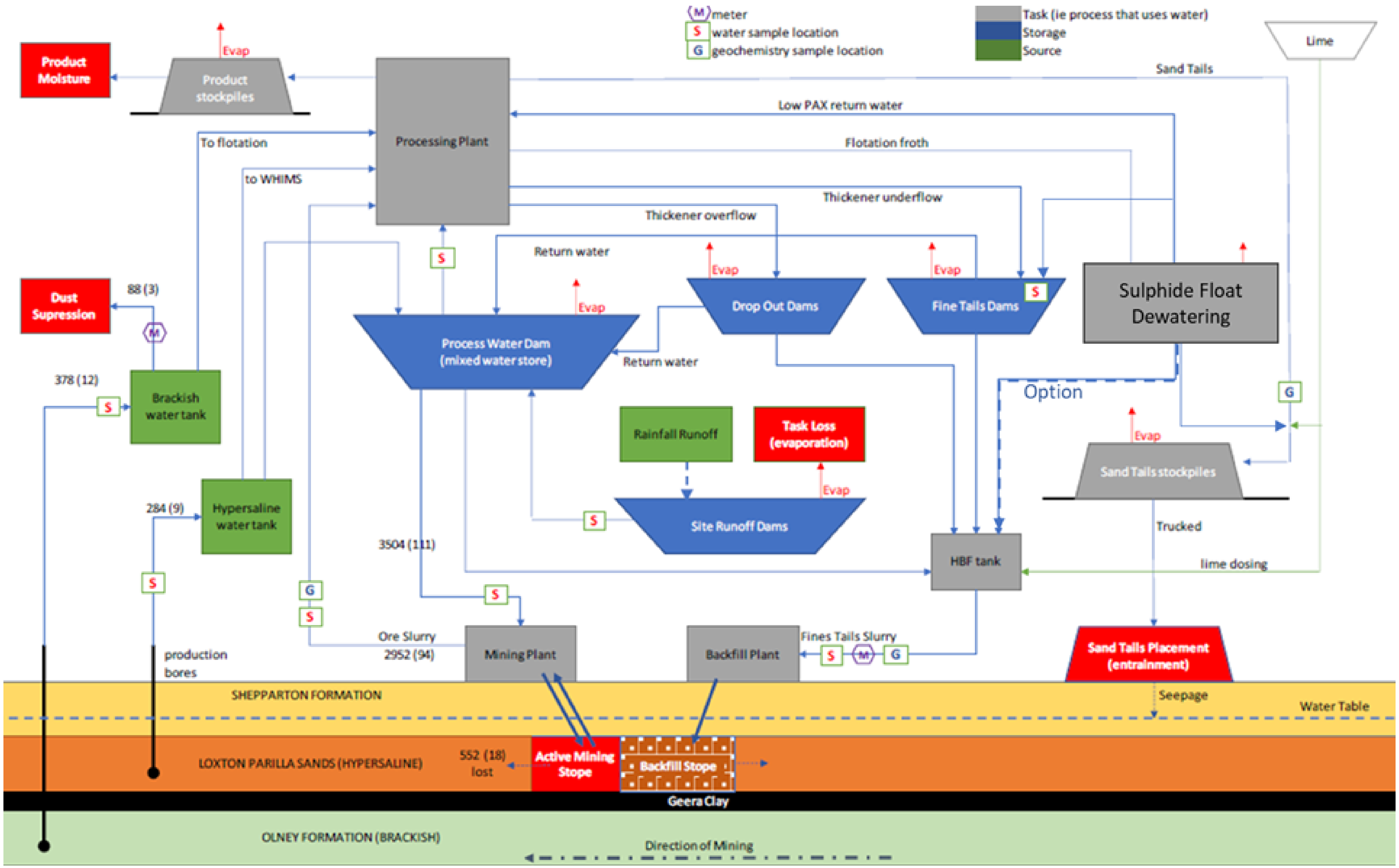


Figure 8- Simplified site water system schematic

Table 8- Mine water storage dams

Dam	Description
Operations Phase	
Site Runoff Dams	Lined dam to collect runoff from the ore processing areas. Designed to store a 1:100 year 72-hour rainfall event plus additional freeboard. This dam is maintained in a nominally empty state at all times to ensure that adequate freeboard is available to capture rainfall runoff to within its design capacity.
Process Water Dam (PWD)	Lined dam to collect runoff from the ore processing areas. Designed to store a 1:100 year 72-hour rainfall event plus additional freeboard. The PWD is the main receiver and source of process water for a range of streams within the processing facility, mining and backfilling.
Drop Out Dams (DODs)	Lined dam to collect runoff from the ore processing areas. Designed to store a 1:100 year 72-hour rainfall event plus additional freeboard. The drop out dams function as additional solids capture facilities before discharging back into the PWD These are periodically dredged and the fine material is sent to the HBF tank for underground backfill. There are two DODs, one Duty and one Standby
Fines Dam	Dams to collect runoff from the ore processing areas. Designed to store a 1:100 year 72-hour rainfall event plus additional freeboard. The sulfide dam stores flotation overflow (froth) that contains predominantly fine, iron sulfide minerals. These are stored under a water cover to prevent them from oxidising and generating acidic conditions. The fine material is sent to the HBF tank for underground backfill.

7.1. Construction of infrastructure

Infrastructure will be constructed generally in accordance with the EA. In accordance with SSD-5285 Schedule 3 Condition 14, the following guidelines will be adopted where relevant:

- any infrastructure within 40 metres (m) of watercourses will be designed, installed and maintained generally in accordance with the Guidelines for controlled activities on waterfront land (DPE, 2022), or its latest version; and

- any creek crossings will be designed, installed and maintained generally in accordance with the Policy and Guidelines for Fish Habitat Conservation and Management (Department of Primary Industries, 2013) and Why Do Fish Need to Cross the Road? Fish Passage Requirements for Waterway Crossings (Fairfull, S. and Witheridge, G., 2003), or their latest versions.

8. Water Balance

8.1. Water Demand

Water will be required for processing, dust suppression and material conditioning. Brackish groundwater will be used for activities that specifically require fresher water.

Saline water will not be used in undisturbed areas where there is a risk of topsoil contamination.

The predicted water demand for operations and corresponding sources are shown in Table 9. The primary water demand is for mining, where it is estimated that 3,400 ML/year is required to mobilise the ore. The majority of this water (2,864 ML/year, or 84%) is directly recovered as part of the mining process. The remaining demand for mining is sourced from production bores from the hypersaline LPS aquifer which also hosts the ore. Hence the water lost during mining is essentially returned to the aquifer.

The other demands are for ore processing (714 ML/year entrained in tailings and products), dust suppression (85 ML/year), evaporation from dams (64 ML/year) and reagent make-up (26 ML/year).

Table 9- Estimated water demands and sources (EMM, 2022).

Demands		Sources				
Water use	Volume	Hyper saline groundwater Imported	Brackish groundwater Imported	Ore body groundwater Recovered with ore	Floc and reagents Imported	Potable water truck Imported
Mining						
Mining water supply	3,400	536	-	2,864		-
Processing	714	616	68	-	26	-
Water in Tails	*689*					
Water in Product	*26*					
Site operation						
Dust suppression	85	-	85	-	-	-
Evaporation from dams	60	64	-	-	-	-
Potable use	15	-	-	-	-	15
Total demand	**4,274**	**1,216**	**153**	**2,864**	**26**	**15**

8.2. Sources and Security of Supply

The Balranald Mine will source its water from groundwater for mining operations. This is anticipated to provide all water requirements for the duration of the mine. Iluka's water works approval and access licences are described in Section 5.3.5.

Water is sourced from production bores located in the LPS Formation (nominally 20 L/sec each) and Olney Formation (nominally 12 L/sec each). The site is located in a low rainfall region. Any rainfall captured in the ore processing areas will drain into runoff dams. This water is not considered suitable for discharge and will be pumped back into the process water dam to offset the need for groundwater extraction.

Water supply reliability presents a low risk for mining, due to the high productivity of the groundwater formations. In accordance with SSD-5285 Schedule 3 Condition 11, activities will be modified in the event that water supply is not available.

In the event that groundwater allocations are restricted within the water source, Iluka may, as a contingency in accordance with SSD-5285 Schedule 3 Condition 15(b)(i), temporarily trade groundwater allocation on the open water market to maintain availability of its water supply.

8.3. Water Efficiency Measures

In accordance with SSD-5285 Schedule 3, Condition 15(b)(i), water is reused at every stage of the process to minimise the need for clean water. The primary purpose of maximising water reuse is to minimise extraction of groundwater from the Western Murray Porous Rock water source, thus minimising the potential impact from groundwater drawdown.

The primary form of reuse is direct recovery of water during mining operations where the majority of water injected for mining is recovered. Other reuse includes clay fines thickener overflow water and sumps that capture and recover water from ore and tailings stockpiles.

8.4. Metering and monitoring

Australian Standard, pattern approved meters are installed at water extraction points, where required under any relevant Water Supply Works Approval conditions, in accordance with the NSW DCCEEW Non-Urban Metering Framework. Flow meters will also be installed at other locations within the site water system to track key water transfers and water efficiency.

8.5. Water Accounting and Reporting

In accordance with SSD-5285 Schedule 3 Condition 15(b)(i), an annual water account will be developed and reported in the AEMR for each calendar year. This water account will include:

- Licenced water extraction
- Summary of reconciled water balance
- Water consumption
- Water efficiency

Water consumption will be compared against EA predictions (Section 8.1).

9. Surface Water Management

Due to the flat landscape and hydrological setting of the mine site, and the long distance to any receiving surface water systems, the surface water risks for mine are considered low. Surface water management measures are associated with managing localised flooding, segregation and containment of process water within the processing plant, localised erosion and sediment control.

The following sections outline the surface water management aspects in accordance with SSD-5285 Schedule 3 Condition 15(b)(ii).

9.1. Baseline Data

Due to the hydrological setting of the Balranald Mine (Appendix A), there is no baseline data available for local flow or surface water quality to satisfy the requirements of SSD-5285 Schedule 3, Condition 15(b)(ii).

9.2. Clean Water and Flood Diversion

A flood impact assessment was completed by WRM (2015) which considered flooding events from overflow from the Lachlan River into Box Creek. More recently, Worley (2022) focused on local flooding events. The Worley assessment (2022) included a two-dimensional TUFLOW flood model to assess on-site flood characteristics for both existing and post-development conditions. The Worley modelling was based on the following design storm events (Worley, 2022):

- Simulation of the 30 minute, 1 hour, 3 hour, 6 hour, 12 hour and 72 hour duration storms for both the 1% annual exceedance probability (AEP) and 5% AEP design events. The shorter duration storms are expected to result in higher peak flood levels along overland flow paths due to the higher rainfall intensity and flow rates, while the longer duration storms are expected to result in higher peak flood levels in the local depressions due to the higher total runoff volumes.

- Adoption of a temporal pattern with a relatively even distribution of rainfall throughout the storm duration.

The 72-hour duration storm was chosen as the upper limiting duration for design flood modelling following a review of historical rainfall records at the nearby gauges at Balranald (RSL) (gauge no. 049002) and Oxley (Walmer Downs) (gauge no. 049055). The two gauges are located 14 km and 40 km from the mine boundary, respectively. The Balranald (RSL) gauge has been recording daily rainfall totals since 1879. The Oxley (Walmer Downs) gauge has been recording daily rainfall totals since 1922.

The available rainfall records show that the longest storm durations recorded were no more than 72 hours. The Balranald (RSL) gauge recorded a three-day rainfall event in June 1963, while the Oxley (Walmer Downs) gauge recorded a three-day rainfall event in February 2011.

The construction of the proposed works is predicted to have negligible impacts on the existing flood behaviour within the mine boundary. In accordance with SSD-5285 Schedule 3, Condition 15(b)(ii) and based on the flood modelling, a series of flood diversion berms will be constructed to divert the 1% AEP 72-hour storm event. The flood mitigation measures will be designed to exclude flows up to the probable maximum flood level. The berms are located to the western side of the mining area (Figure 12) and around the north and eastern side of the processing plant area (Figure 6) to provide protection from the 1% AEP event with an additional 500 mm freeboard. A typical cross-section is shown in Figure 9.

The local flood modelling (Worley, 2022) showed that the site access road is predicted to remain largely flood-free during the 1% AEP event. Some minor overtopping is predicted at three locations but is not predicted to be greater than 0.1 m depth and with relatively low flood velocities of 0.8 m/sec. The magnitudes of these depths and velocities constitute a H1 flood hazard category according to ARR 2019, which means that the inundation is “generally safe for people and vehicles” (Smith et al., 2014). Water is not expected to remain ponded on the road surface following the end of the storm event.

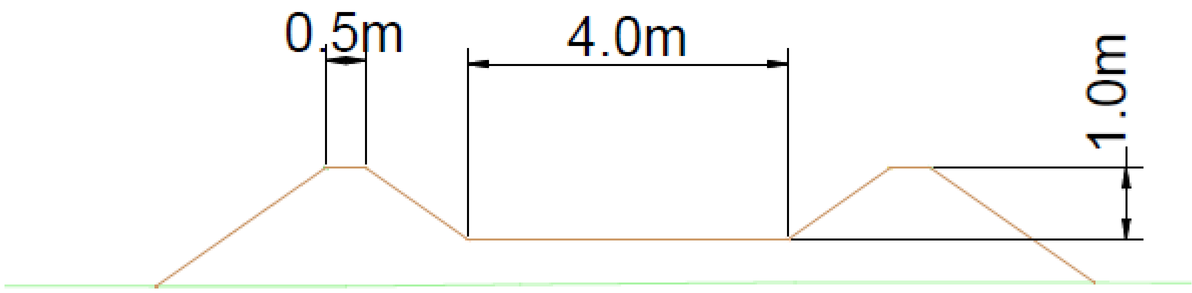


Figure 9- Typical cross-section of flood diversion berm

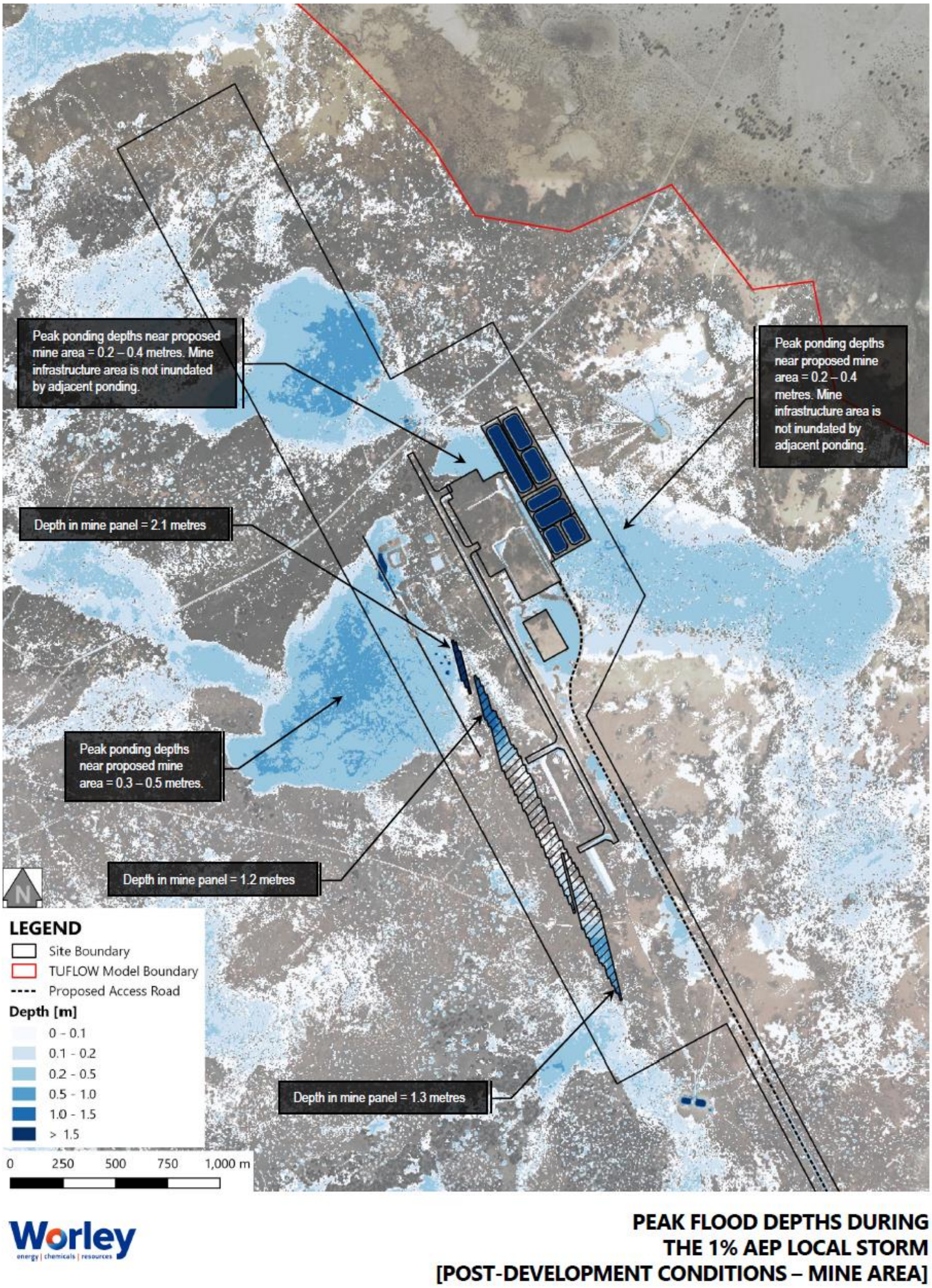


Figure 10- Peak flood depths for 1% AEP 72-hour scenario (Worley, 2022). Location of flood protection berms are shown west of the mining area.

9.3. Erosion and Sediment Control

Due to the hydrological setting of the Balranald Mine there is low risk of erosion and sediment impacts on receiving waterbodies. The following sections describe the erosion and sediment controls to be implemented in accordance with SSD-5285 Schedule 3 Condition 15(ii).

Erosion and sediment controls will be implemented for the mine development area, designed generally in accordance with the principles described in the series Managing Urban Stormwater: Soils and Construction including Volume 1 (Landcom, 2004) and Volume 2E Mines and Quarries (DECC, 2008) and Volume 2A – Installation of Services and Volume 2C – Unsealed Roads, including the following measures:

- minimising surface disturbance and restricting access to undisturbed areas;
- use of Iluka’s Site Disturbance Permit process that includes specification of area specific erosion and sediment controls;
- installing appropriate erosion and sediment controls prior to disturbance of any land and around soil stockpile areas;
- storing soil stockpiles at appropriate distances from watercourses;
- soil stockpile batters constructed at a minimum slope of 1:3
- stabilise soil stockpile surfaces with vegetation or hydromulch as soon as practicably possible if required;
- construction of surface drains to control and manage surface runoff;
- reducing the flow rate of water across exposed surfaces and in areas where water concentrates (e.g., through use of coir logs or cross ripping);
- construction of sediment dams to contain runoff up to a specified design criteria; and
- treating rehabilitation areas to promote infiltration (e.g. cross ripping ripping);

Temporary sediment traps and sediment filters (e.g., sediment fences) will be installed where required downslope of disturbance areas in accordance with Landcom (2004). The temporary erosion and sediment control systems will remain in place until all earthwork activities are completed and the disturbed area is rehabilitated. All water conveyance structures (i.e., channels and diversions) will be designed and constructed to safely convey flow resulting from a 5% annual exceedance probability (AEP) rainfall event.

Sediment control dams will be constructed in areas of high risk such as downstream of soil stockpiles. These dams will be designed in accordance with Type-D sediment dams described in Landcom (2004). The dams will be sized to capture a 1% AEP 72-hour storm event. Drainage lines and sediment dams will be inspected monthly or following 20 mm rainfall (over 24-hours) to check for capacity and integrity. If required to maintain design criteria, sediment will be removed from the sediment dams to maintain their design storage capacity.

9.4. Mine Water Management

Mine water includes process water, which is used for ore processing, mining operations and drilling muds and fluids. Process water quality has the potential to be influenced by extracted groundwater from production bores, process chemical additives (including PAX) and acid and metalliferous drainage and neutralisation reactions within ore, product and tailings stockpiles. As described in Section 7, process water will be reused for underground mining, where a portion of the water will be lost to the hypersaline LPS Formation. Some residual process water will also be contained within sand tailings that will be disposed of in trenches which has the potential to seep into the Shepparton Formation, which host the water table.

Management of process water quality is required to ensure that it is suitable for ore processing and groundwater reinjection, and the mine water management system must prevent discharge of mine water to receiving surface water systems.

9.4.1. Process plant runoff

All runoff from process plant infrastructure areas and including ore, product and tailings stockpiles will be captured and contained within the site runoff dams (see Figure 6 and Section 7) or the process dams. Their design runoff containment volumes be reinstated as soon as practicable following a rainfall event. Captured water will be returned to the process water dam for reuse.

9.4.2. Temporary storage of sulfidic materials

Ore and product stockpiles will be stored on compacted, low-permeability hardstand areas. Drainage from these areas will report to sumps and be returned to the process water dam for reuse.

Slimes which have the highest potential to generate AMD, will both be disposed of sub-aqueously via the underground mining backfilling process. Below the water table, these materials cannot oxidise due to the absence of air. Prior to underground deposition, these materials will be temporarily stored at the surface within dedicated ponds (refer to Figure 6) which will prevent and minimise contact with air and subsequent oxidation of sulfidic materials.

The fines and slimes ponds will be periodically dredged and the treated materials deposited into the underground stopes within the LPSs aquifer or blended with course sand tailings and amended with lime prior to backfilling.

A Trigger Action Response Plan (TARP) for maintaining the process water pH to within 6 to 8.5 is provided in Section 12.1.3

9.4.3. Drilling Fluids and Muds

The drilling of mining and reinjection drillholes will involve the use of drilling muds. In accordance with SSD-5285 Schedule 3, Condition 15(b)(ii), the following measures will be implemented to manage drilling fluids and muds:

- Drilling fluids and muds will be contained within a closed system consisting of sumps located adjacent to each mining plant drill pad.

- The drilling muds will be a water-based fluid containing primarily bentonite and polymers. The drilling fluids have been assessed as environmentally benign (LWC, 2017).

9.5. Chemical and Hydrocarbon Management

Chemicals and hydrocarbons will be handled and stored in a manner to prevent spills and leaks to the environment, in accordance with Australian Standards, including:

- AS1940-2004 The storage and handling of flammable and combustible liquids
- AS 3780:1994 Australian standard for the storage and handling of corrosive substances
- AS 1692:1989 Australian standard for tanks for flammable and combustible liquids

Control measures for chemical and hydrocarbon management will include:

- Bunding and permanent and temporary storage tanks and containers;
- Routine inspection and maintenance of bunded areas;
- Spill response kits and equipment available;
- Spill and incident response procedures (see Section 13.5); and
- Training and awareness for relevant roles relating to storage, handling and spill response.

Material incidents relating to chemical and hydrocarbon spills will be reported in accordance with the protocols in Section 13.5.

9.6. Waste Water Management

A package wastewater treatment plant will be constructed and operated for the duration of the operations phase of mine. The Wastewater treatment system will be managed in accordance with the Recycled Water Management Plan.

There are no surface water criteria or limit conditions in SSD-5285 or EPL20795. Due to the hydrological setting of the development, there is no background data available with which to develop site specific surface water quality assessment criteria. ANZECC/ARMCANZ (2000) water quality criteria for livestock, and irrigation water for radionuclides have been selected as interim performance criteria for comparative purposes only (Table 10) with any surface water quality data collected outside of the processing plant area. These criteria will be updated, if possible, if surface water quality data becomes available in the future.

The southern end of the West Balranald deposit is approximately 10 km to the north of the Murrumbidgee River. The confluence of the Murrumbidgee and the Murray rivers is approximately 30 km to the south-west of the deposit. The proximity of the West Balranald deposit to the Murrumbidgee and Murray Rivers necessitates that the Surface Water Assessment considers these significant water bodies.

The Murrumbidgee and Murray Rivers in the vicinity of the mine area contain fresh water supplies that are frequently used for purposes such as town water supply and irrigation, however this is not considered further as no water will be discharged to these rivers.

Table 10- Provisional surface water assessment criteria

Parameter	ANZECC/ARMCANZ (2000) Guideline value/investigation trigger values
pH	6-9(1)
Total Dissolved Solids (mg/L)	4,000 (beef cattle) (1)
Calcium (mg/L)	1000(1)
Sulphate (mg/L)	1000(1)
Aluminum (mg/L)	5(1)
Arsenic (mg/L)	0.5(1)
Cadmium (mg/L)	0.01(1)
Cobalt (mg/L)	1(1)
Chromium (mg/L)	1(1)
Copper (mg/L)	1 (cattle) (1)
Mercury (mg/L)	0.002(1)
Nickel (mg/L)	1(1)
Lead (mg/L)	0.1(1)
Uranium (mg/L)	0.2(2)
Zinc (mg/L)	20(1)
Gross alpha (Bq/L)	0.5(2)
Gross beta (excluding K-40) (Bq/L)	0.5(2)
Ra-226 (Bq/L)	5(2)
Ra-228 (Bq/L)	2(2)

Notes: 1. Preliminary guideline value derived from ANZECC/ARMCANZ (2000) livestock drinking water guideline.

2. Preliminary guideline value derived from ANZECC/ARMCANZ (2000) irrigation water guideline.

9.7. Surface Water Monitoring Program

Objectives of the surface water monitoring program are to:

- Track process water quality to:
- Identify the need for pH correction of the process water; and
    - Characterise the water quality being reinjected underground, to enable calibration of the hydrogeochemical model (Section 10.3.2).
- Monitor background concentrations

.

9.7.1. Surface water monitoring

Due to the lack of permanent watercourses within the mine area and the mine does not discharge to any watercourses, no hydrological monitoring is planned. Should flooding events occur, field observations will be recorded (if safe to do so) to support any future flood modelling and assessment.

The regional hydrology is characterised by infrequent flows in Box Creek and flooding of dry lakes. In the event of such flooding, opportunistic sampling will be conducted at Box Creek upstream and downstream of the mine if the sampling sites can be safely accessed. Indicative surface water sampling locations are shown on Figure 11. These samples will be analysed for Suites 1 and 2 (as listed in Table 11) to provide background and downstream water quality.

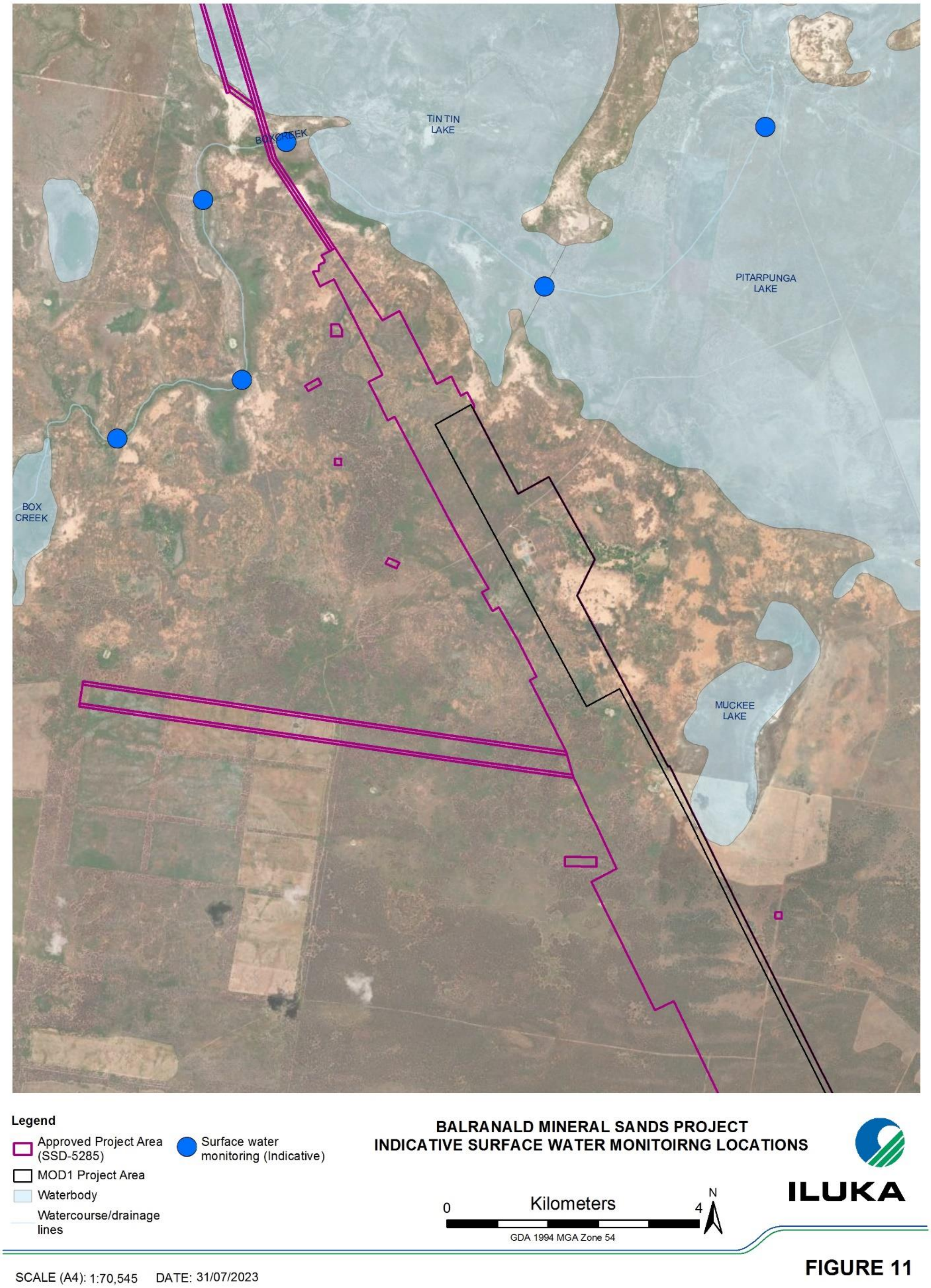


Figure 11- Indicative surface water monitoring locations

9.7.2. Process water monitoring

Process water monitoring will be undertaken at key locations in the processing plant to inform AMD treatment activities and monitor the process water quality. Table 11 provides the monitoring locations and frequencies, and Table 12 provides the analytical suites.

Table 11- Process water quality monitoring schedule

Location	Purpose	Frequency	Parameters (refer to Table 12)
Operations phase			
Process Water Dam	Monitor general trends in process water quality.	Monthly, (quarterly for Ra226/228)	Suite 1, 2, 3 and Suite 4
Sand Tails Stockpile sump	Monitor water quality of leachate from sand tailings stockpiles to ensure that lime dosing is effective.	Monthly	Suite 1
HBF tank	Characterise the WQ of reinjection water	Monthly	Suite 1, 2 and 3
PAX destruction ponds (inflow and outflow)	Measure the effectiveness of PAX destruction	Monthly	Suite 1, 3
Slimes Pond	Monitor pH	Weekly field parameters	Suite 1
Site Runoff Dam(s)	Monitor trends in rainfall runoff water quality from the ore processing areas	Monthly	Suite 1

The field and laboratory parameters that will be collected for the monitoring programs within this WMP are grouped into the following suites (as shown in Table 12):

- Water level, measured in the field manually or via a data logged level logger or VWP.
- Suite 1 – Physical water quality parameters measured in the field (pH, EC, ORP, temperature)
- Suite 2 – Major and trace element chemistry, dissolved metals. This suite will provide detailed characterisation of the salinity and metals in the water to enable assessment of groundwater interactions in the mining and transition zones and comparison with Site Specific Trigger Levels (SSTLs) at compliance monitoring locations.
- Suite 3 – PAX and PAX breakdown products. This suite will permit measurement of the migration of PAX from the mining area.
- Suite 4 – Radionuclides. Iluka is obliged to analyse and monitor for Naturally Occurring Radioactive Materials (NORM). These elements can be concentrated within heavy mineral deposits associated with monazite sands and include isotopes of uranium, thorium, radium and potassium. Two of the short-lived daughter isotopes including Ra-226 and Ra-228 are commonly monitored by Iluka, due to their high mobility under certain environmental conditions and detrimental impact to ecosystems and humans following uptake (IAEA, 2014). Th, U, Ra-226 and Ra-228 will be monitored periodically.

Table 12- Field and laboratory analytical suites

Suite	Purpose	Parameters(1)
Level	Measure static water head in the groundwater system	Standing water level (SWL). Vibrating Wire Piezometers (VWPs) and water level data loggers (in selected bores) will be deployed.
Suite 1	General water quality characteristics	pH, EC, oxidation reduction potential (ORP), temperature
Suite 2	Water characterisation, detect changes in salinity and potential AMD impacts	Major ions, Alkalinity (if pH >4.5), acidity (if pH<4.5) Dissolved metals (As, Fe, Al, Mn, Zn, Cu, Pb, Ni, Co, Cd, Cr, Th, U)
Suite 3	PAX migration	PAX & PAX breakdown products
Suite 4	Radionuclides	Ra-226 and Ra-228 Gross alpha and gross Beta

9.7.3. Monitoring procedures and QAQC

Water quality monitoring will be undertaken in accordance with the Australian Guidelines for Water Quality Monitoring and Reporting (ANZECC and ARMCANZ, 2000a) and Approved Methods for the Sampling and Analysis of Water Pollutants in NSW (DEC, 2004). Analytical methods will be consistent with EPA Approved methods for the sampling and analysis of water pollutants in NSW (EPA, 2022).

All laboratory analyses will be performed by a National Association of Testing and Analysis (NATA) accredited laboratory.

9.7.4. Data evaluation and reporting

Data will be entered and stored in Iluka's environmental database system. Data will be reviewed promptly once received and relevant data compared with the process water performance criteria. A summary of process water quality results will be reported annually in the Annual Review.

10. Groundwater Management

Groundwater management at the Balranald Mine will focus on preventing and minimising groundwater contamination associated with process chemicals and AMD, and monitoring groundwater drawdown from production bores and the migration and dissipation, caused by the potential mounding of the process chemical plume during operations and post-mining.

The following sections outline the groundwater management aspects in accordance with SSD-5285 Schedule 3 Condition 15(b)(iii).

10.1. Baseline data

Baseline groundwater data including water levels, water chemistry and aquifer hydraulic properties are provided in Appendix D.

10.2. Sensitive Receptors

10.2.1. Private bores

Several landholders in the area rely on groundwater, sourced from the brackish Lower Renmark Group Aquifer (part of the Olney Formation), for stock, irrigation, and domestic use. These landholder bores are located throughout the Balranald Mine area and shown in Figure 12.

The only aquifer with beneficial use is the Olney Formation due to its brackish salinity. This water is used for livestock drinking purposes. Within the Balranald Mine vicinity, bores that could be impacted by mine related activities are summarised in Table 13.

The Balranald Mine will source a portion of its production water from the Olney Formation. The groundwater impact assessment (EMM, 2022) conducted modelling that predicted the drawdown in the Olney Formation from the production bores, with none of the private landholder bores were shown to be impacted in the modelling.

Table 13- Third party bore locations.

Local Name	Easting(1)	Northing(2)
HD1	726,012	6,185,773
T01	722,791	6,201,029
T02	729,721	6,195,973
T03	732,061	5,189,404

Notes: 1. MGA2020 Zone 54H

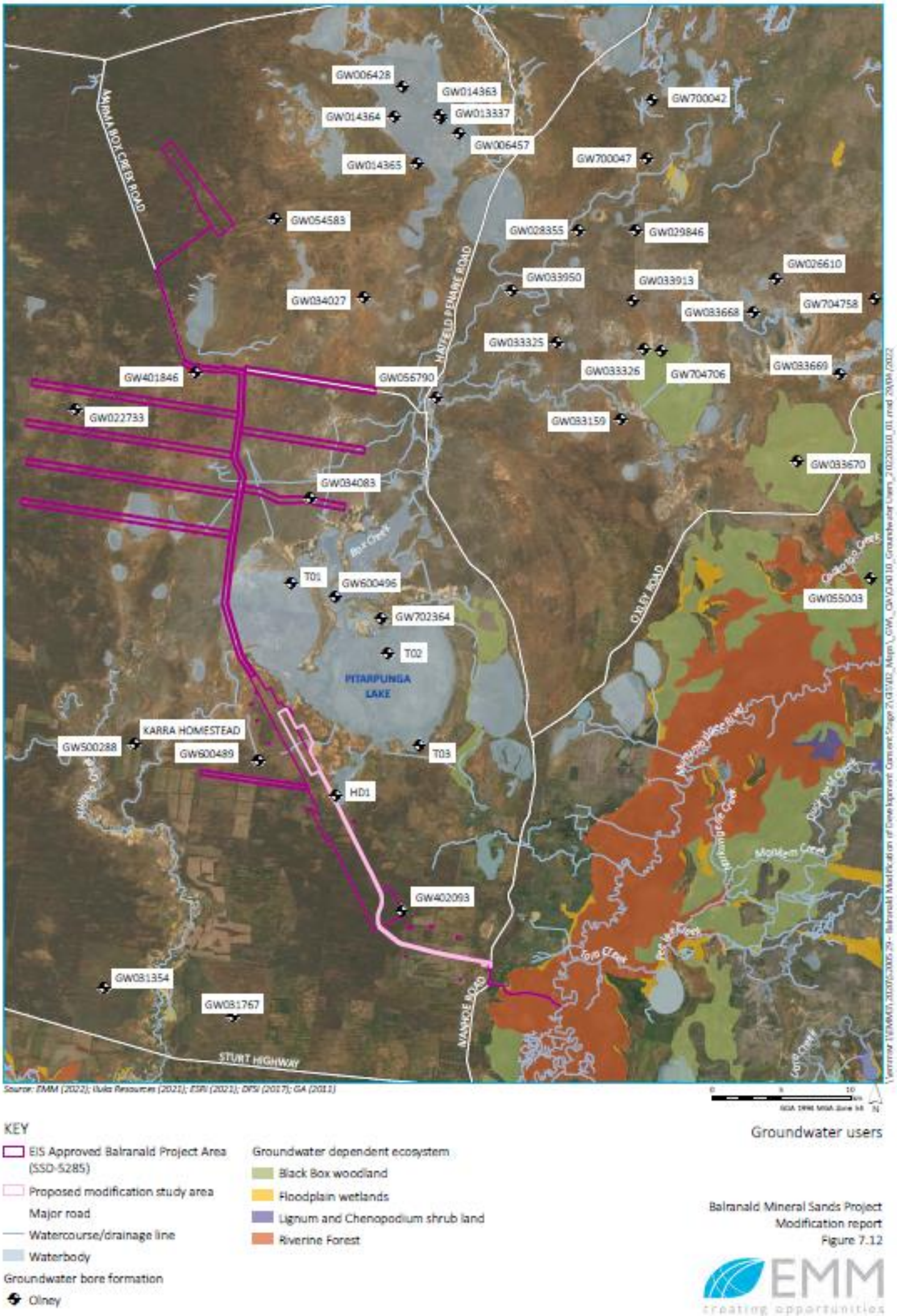


Figure 12- Private bore location map (EMM, 2022).

10.2.2. Groundwater Dependent Ecosystems

The baseline investigations (SKM 2011), undertaken as part of the pre-feasibility study (PFS), identified the occurrence of ecosystems that potentially rely on groundwater in the vicinity of the Balranald Mine area (i.e. GDEs). This investigation mapped and characterised ecosystems that potentially rely on groundwater into two broad categories:

- wetlands and vegetation associated with the Murrumbidgee, Lachlan and Murray River Floodplain environments, as per the Lower Murrumbidgee Groundwater WSP for the vegetation to the south and west of the Murrumbidgee River; and
- vegetation (primarily Black Box woodland) outside the floodplain and permanent streams, in topographic depressions where the water table may be shallow enough and not too saline for vegetation use.

The study found that potential groundwater reliance associated with both of these environments is likely to be only opportunistic. Groundwater use of vegetation in the region is influenced by two main factors: the depth of the water table and groundwater salinity. The ecosystems that potentially rely on groundwater associated with the floodplain environments include the high value River Red Gum forests and the Great Cumbung Swamp. The Black Box woodlands away from the floodplain are less significant assets in terms of their ecological value, but they provide locally valuable shade and shelter for fauna (and stock) in a landscape sparsely populated by trees (WRM, 2015).

Rainfall and the periodic flooding of the Murrumbidgee River are more likely sources of water for vegetation (URS 2012). Thus, floodplain environments are considered to have a low susceptibility to altered groundwater conditions due to the close presence of the Murrumbidgee River, a flow regulated water source. Further from floodplains, vegetation may have a greater reliance on groundwater as there are no permanent water bodies in these environments.

In 2014, an investigation was undertaken to establish whether the Black Box vegetation was accessing water from the Shepparton Formation (CDM Smith 2015). This study found that rainfall and episodic surface water (irregular flooding and/or pooling from heavy rainfall) provided the dominant water source for Black Box, although there was some potential for these trees to use groundwater opportunistically to supplement their water needs. Previous studies have shown Black Box to be a hardy, resilient species capable of sustaining droughts and quite saline conditions (up to 60,000 µS/cm). The River Red Gum is more tolerate to water logging than the Black Box community.

The spatial distribution of ecosystems that rely on groundwater, updated from the baseline investigation to include the areas of Black Box that were mapped in 2014 by CDM Smith (EMM 2015), is shown on Figure 13 (after EMM, 2022).

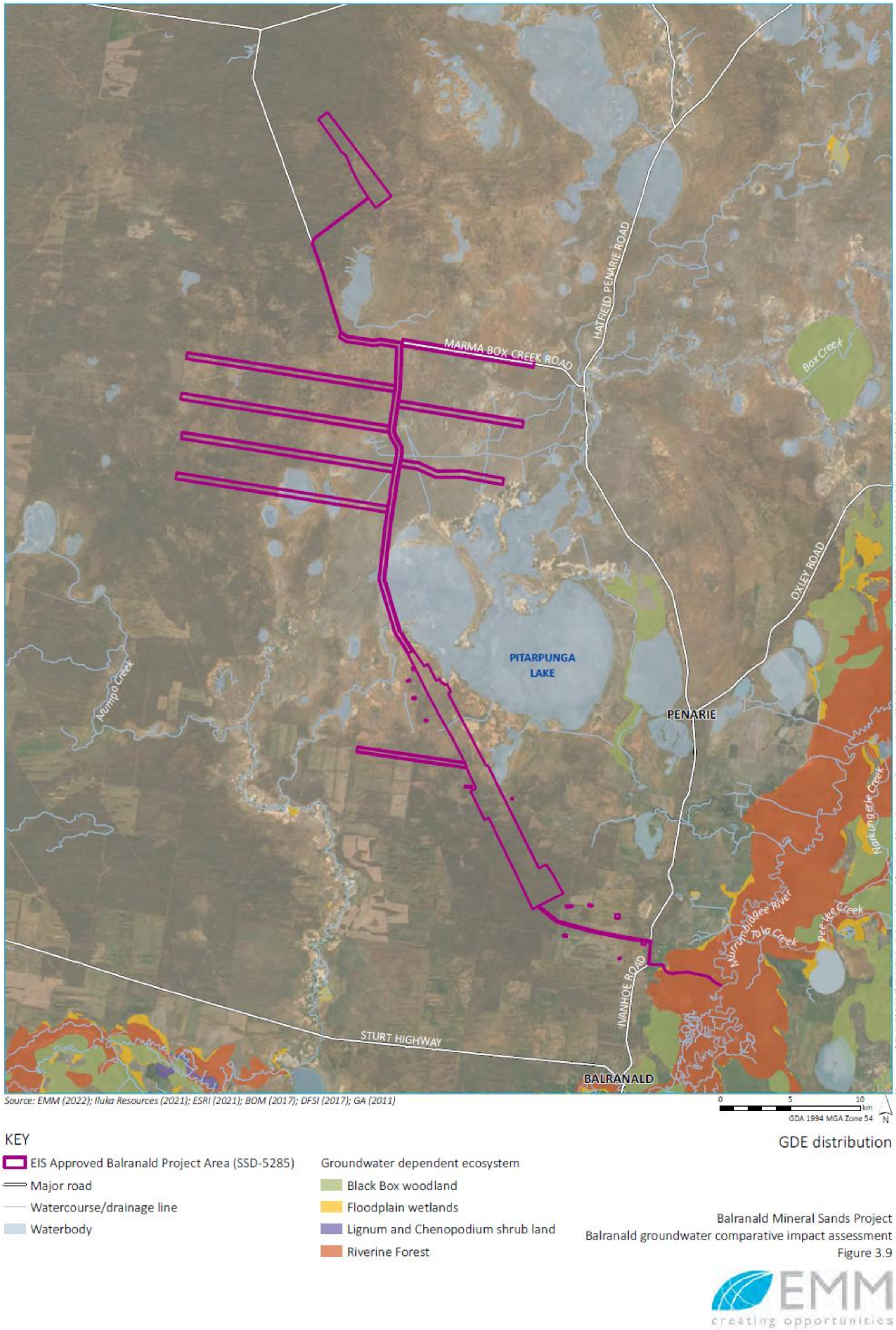


Figure 13- Mapped GDEs (EMM, 2022).

10.2.3. Aquatic ecosystems

There are no aquatic ecosystems within the area affected by PAX injection to the LPS, and PAX impacted groundwater will not migrate and discharge to the ecosystems associated with the Murray and Murrumbidgee Rivers (approximately 23 km to the east). The risk to aquatic ecosystems is therefore considered negligible (EMM, 2022).

10.3. Groundwater Assessments

The following sections outline the current conceptual hydrogeological and hydrogeochemical models, and the structure and predictions of the corresponding numerical groundwater flow model. The models include description of some of the possible impacts from mine, that are managed with measures described in other sections of this Plan. The conceptual and numerical models represent successive iterations of conceptualisation, which are based on progressive collection of data, numerous studies and data reviews assessments. Iluka will continue to refine and improve the understanding of the groundwater system as additional information becomes available.

More detailed information about the site conceptualisation and modelling methods and results can be found in the Groundwater Impact Assessment to support Modification 1 (EMM, 2022).

10.3.1. Conceptual Models

A series of conceptual models have been developed to describe the following (after EMM, 2021):

- The underground mining process and how it interacts with the surrounding aquifer water pressures, quality and integrity.

- The overall conceptual model including groundwater stresses, sources and sinks likely to develop during progressive mine development and rehabilitation including both surface and underground activities.

- A focused geochemical conceptual model, which identifies potential sources of AMD and processing chemicals that may impact groundwater quality.

10.3.2. Conceptual Hydrogeological Model

The overall conceptual model related to how the groundwater affecting activities interact with the surrounding environment is summarised in Figure 14 (EMM, 2022). The main features include:

- Groundwater supply bores are shown to the left of Figure 14 . Up to four production bores will target the LPS, which will direct saline water to the process water dam (PWD) to support mining and processing activities. Up to two production bores will target the deeper Olney Formation to supply brackish water to the flotation dam and workshop. These activities have the potential to cause drawdown within the targeted aquifers. Drawdown within the LPS may encourage water associated with reinjected slimes to migrate towards the production bores and indirectly take from the overlying Shepparton Formation, (SF) which could cause water table drawdown. Drawdown within the Olney Formation could induce saline water to migrate downwards from the overlying Geera Clay and drawdown to nearby third-party bores. However, numerical modelling (Section 10.3.4) predicts minimal interaction between mine reinjection water and production water supply. A monitoring program is designed to manage any such interaction.

- Seepage from sand tails is assumed to occur for approximately 10 days and to be located one mine panel or approximately 155 m ahead of active mining. Emplacement of sand tails in advance of the mining front is aimed to induce subsidence. Seepage from sand tails may cause water table mounding and migration of seepage water. Sand tailings will be dewatered as much as practicably possible prior to placement ahead of mining.

- Mining the stopes is estimated to cause four metres of subsidence. Subsidence can cause increased hydraulic conductivity within the units and may manifest as depressions or 'sink holes' at land surface.

- The slimes fraction of the tailings and water will be deposited into the cased ends of the previously mined stopes, including those stopes used in previous underground mining trials. Slimes injection will occur across 1 to 3 stopes simultaneously and will occur approximately 50 m behind the active mining stopes.

- During the commissioning phase excess groundwater may be required to be re-injected into existing stope access holes or existing groundwater injection bores. Re-injection water will be monitored as per Sections 9.7.2 & 10.6.

- Slime injection may cause increased groundwater pressure to occur initially in the LPS, which may cause the injected water and any solutes to emanate away from the stopes being backfilled. If hydraulic connectivity has been increased due to subsidence, groundwater pressure could also increase in the overlying SF, potentially causing short-term water table mounding.

- The mining and backfilling process will not significantly impact on the underlying Geera Clay and Olney Formation, the latter only being affected by extraction of brackish water for the mine water supply.

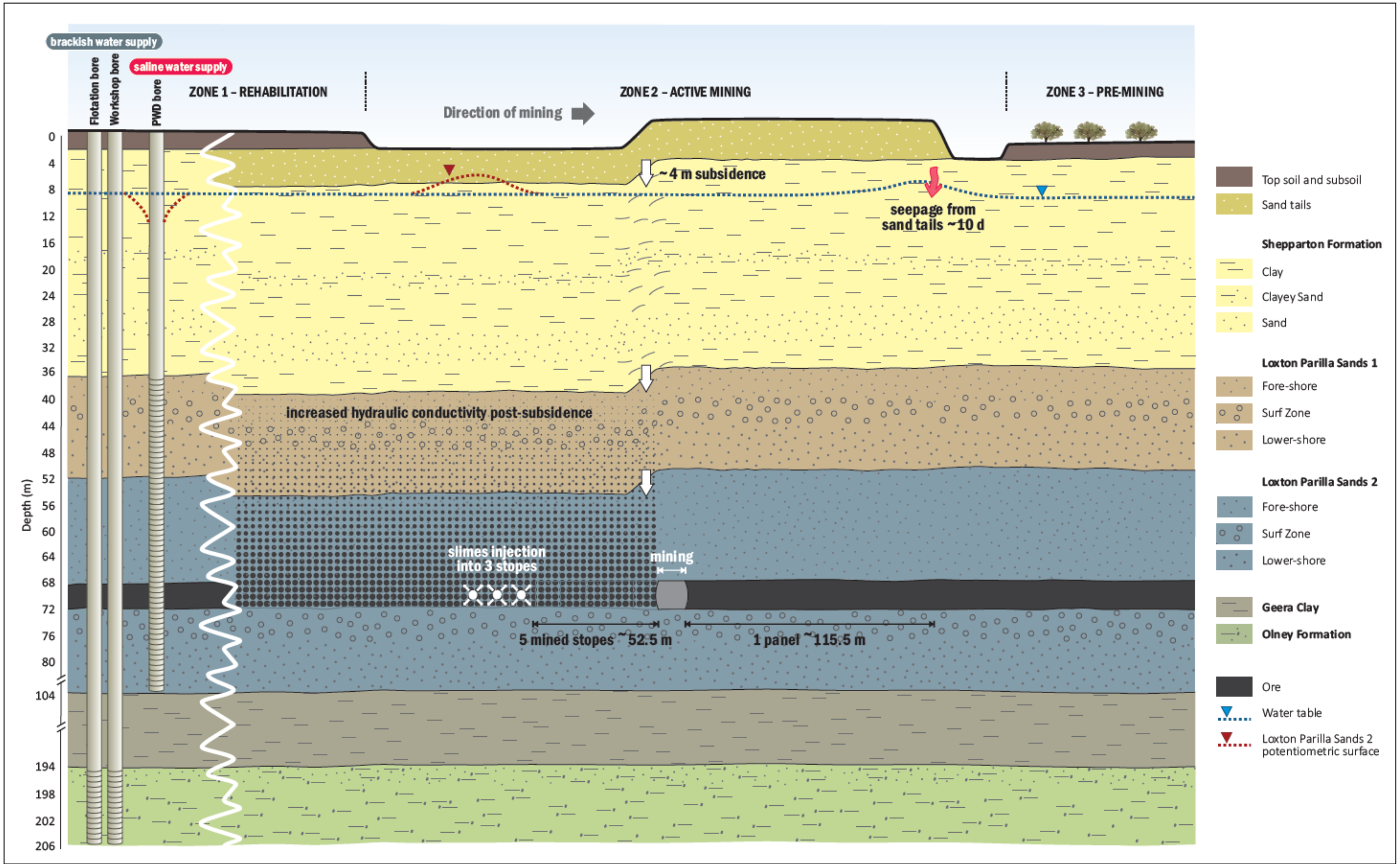


Figure 14- Groundwater-affecting activities conceptual model (EMM, 2022).

10.3.3. Geochemistry and processing conceptual model

A conceptual geochemical model of the groundwater system and potential sources of contamination that may affect groundwater quality is presented in Figure 4 (after EMM, 2022; Earth Systems (2020, 2021a, b, c, 2022). Key concepts that relate to water quality and geochemistry include:

- Groundwater in the SF and LPS aquifers is saline to hypersaline and has near neutral pH. Due to the high salinity, the water is not suitable for human consumption, irrigation or stock watering.
- Since groundwater in the Olney Formation is less saline than groundwater in the LPS and SF aquifers, injecting water originating from the deeper formation into the LPS aquifer is not considered to pose a risk to water quality in the LPS or SF aquifers.
- Oxidation of reducing minerals such as pyrite does not occur naturally in the SF and LPS aquifers because the dissolved oxygen concentration is limited, and the groundwater is not in contact with oxygen in the atmosphere. Oxidation of these minerals may occur when the ore is brought to the surface during mining. This process (referred to as AMD) can generate acidic water and liberate heavy metals. This will be minimised by adding limestone to the screened and de-slimed ore, products, by-products and wastes (namely sand tailings) that contain sulfide minerals as required.
- Process chemicals will be added during ore processing. Potassium amyl xanthate (PAX), used in the flotation circuit to remove sulfide minerals, is expected to last a few days in the natural environment (NICNAS, 1995) and is not expected to bioaccumulate (Earth Systems 2021b, c, 2022b).
- A portion of the PAX will biodegrade in storage dams and tanks and some PAX will sorb to surfaces of solids. It was assumed for the groundwater impact assessment, that 50% of the PAX will sorb to fine-grained tailings and has a current estimated half-life of eight weeks. Once injected into the LPS aquifer, PAX will also sorb to aquifer solids and will continue to degrade which will reduce the mobility of PAX and will consume PAX from the groundwater.
- Flotation tails will be mixed with supernatant water from the PAX dams in the HBF tank and will be re-injected into the ore body. Sulfides will be concentrated in the waste during the flotation process and will be returned to the LPS and are not expected to further oxidise because of the limited dissolved oxygen underground.

The monitoring programs (Section 10.7), groundwater flow model review and recalibration process (Section 10.3.5) are intended to continually improve the understanding of the geochemical model.

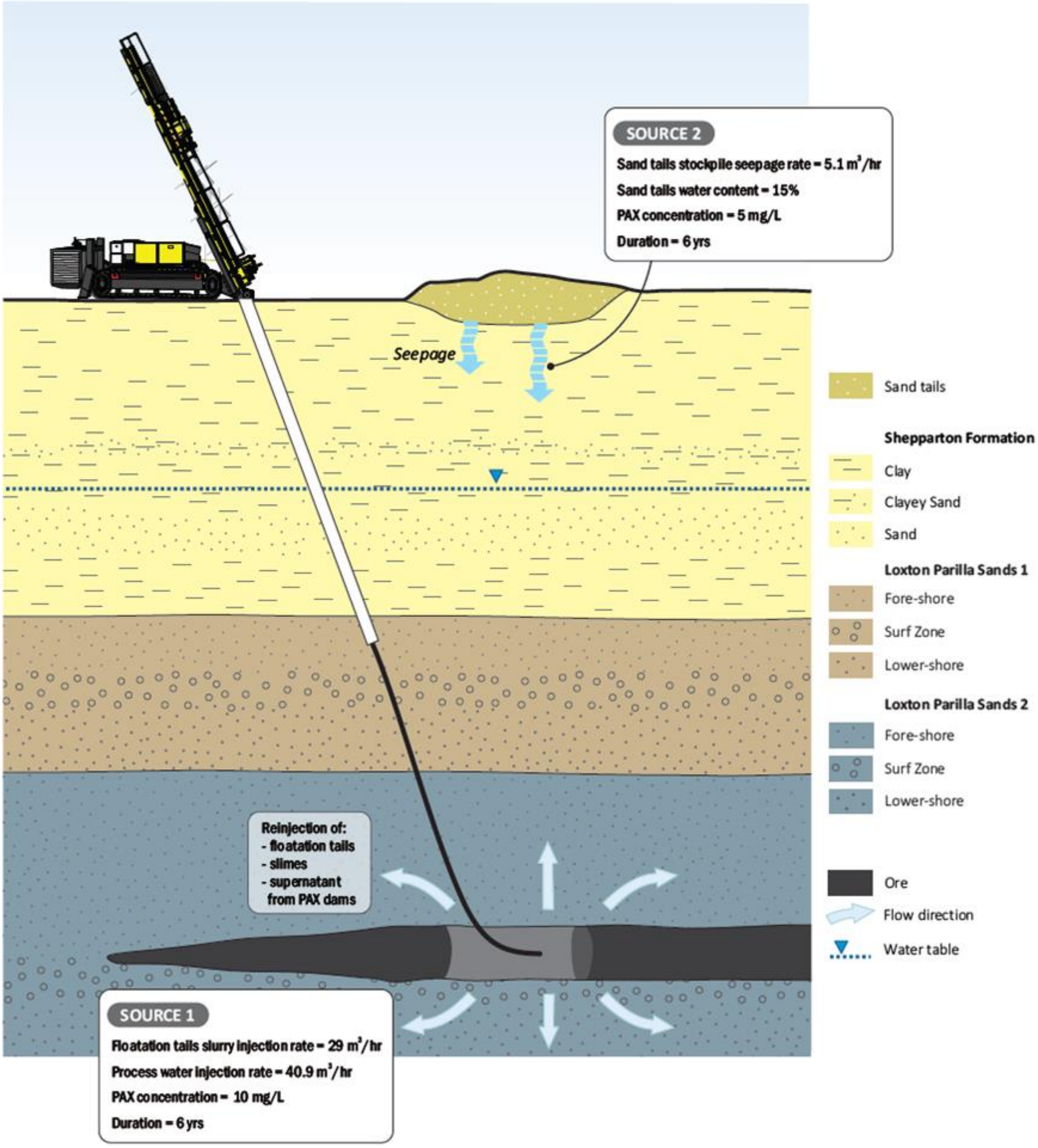


Figure 15- PAX source conceptual model (after EMM, 2022).

10.3.4. Numerical groundwater model

A 'BAL3.0' groundwater model was developed for MOD1 (EMM, 2022).For the full details regarding the groundwater model, refer to the MOD1 groundwater impact assessment (EMM, 2022). The model domain and grid are shown in Figure 16.

The MOD1 groundwater model was peer reviewed by HydroGeoLogic (2022) who concluded that the BAL3.0 groundwater modelling has been conducted consistent with best practice methods and a Class 2 model confidence level is well justified, confirming its fitness for mining project impact assessment and groundwater management purposes.

The key aspects of the model predictions were the potential for groundwater mounding near mining operations, groundwater drawdown in the Olney Formation and LPS from pumping of the mine water supply bores and the potential extent and migration of water quality impacts from PAX reinjection into the LPS aquifer.

The groundwater drawdown model was updated (EMM, 2025) following the construction of four production bores (Figure 17 & Figure 18). Based on the location and pumping regime, the construction and operation of the bores is not considered to have a material change in the outcomes of the groundwater impact assessment presented for MOD1, including potential impacts on groundwater quantity (drawdown or mounding), sensitive receivers or quality.

The numerical model predicted the following (after EMM, 2022 and updated 2025):

- Mining activities would result in short-term and localised variations in groundwater levels in both the SF and LPS Formations. Mounding in the LPS is expected to be less than 1 m in the vicinity of the stopes and not extend beyond a few hundred metres (based on 0.2m drawdown).
- Mounding due to seepage of water from sand tailings is predicted to be insignificant.
- In the Olney Formation, 0.2 m drawdown from production water supply would extend to approximately 15km from the processing areas. Of the private bores identified (Section 10.2.1), the maximum drawdown of < 1.2m is observed at the Karra Homestead bore, which is located 4 km SSW of the mine site. A drawdown of greater than 2 m (threshold defined by the AIP for minimal impact) is localised to near the site and does not reach any third-party bores (Figure 17)
- In the LPS Formation, drawdown from production water supply would extend to approximately 2 km from the processing areas (modelled drawdown in the LPS Formation during mining (EMM, 2022 and later updated 2025)).
- The largest predicted drawdown responses at a GDE location was at GDE8 (Figure 15). At this location, potential GDEs are associated primarily with Black Box trees along Box Creek, located directly north-east of the West Balranald footprint. The GDE class and impact assessment framework developed for the mine indicated that Blackbox in this region is likely a Class 4 GDE, which has a ‘low’ level of dependence on the occurrence of groundwater. In addition, drawdowns of up to 5 m may have a ‘low’ impact on GDE health. Given the modelled drawdown for MOD1 shows drawdown less than 0.1 m at this location, the risk to terrestrial impacts is considered low to insignificant.

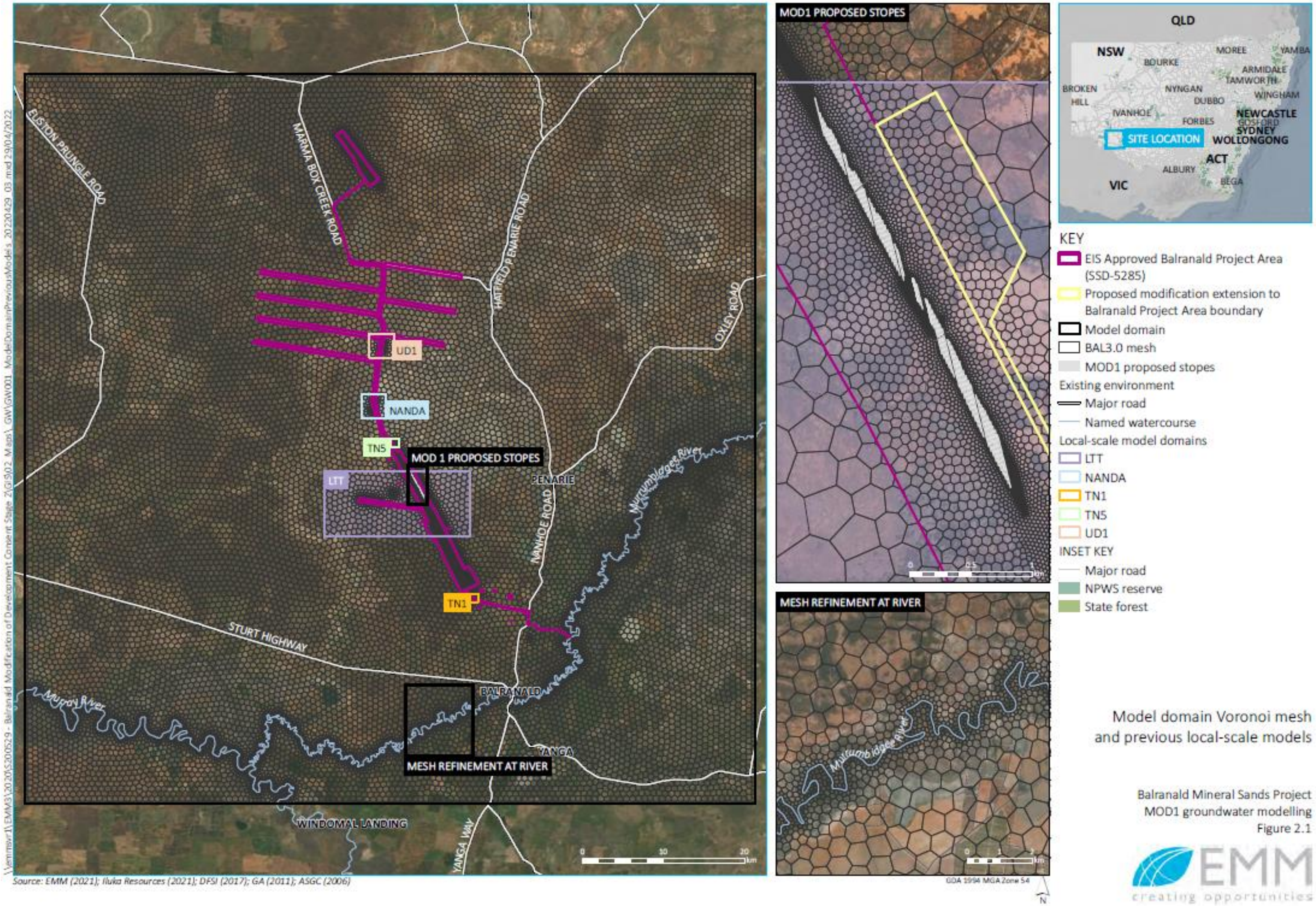


Figure 16- Balranald numerical model domain and grid (after EMM, 2022).

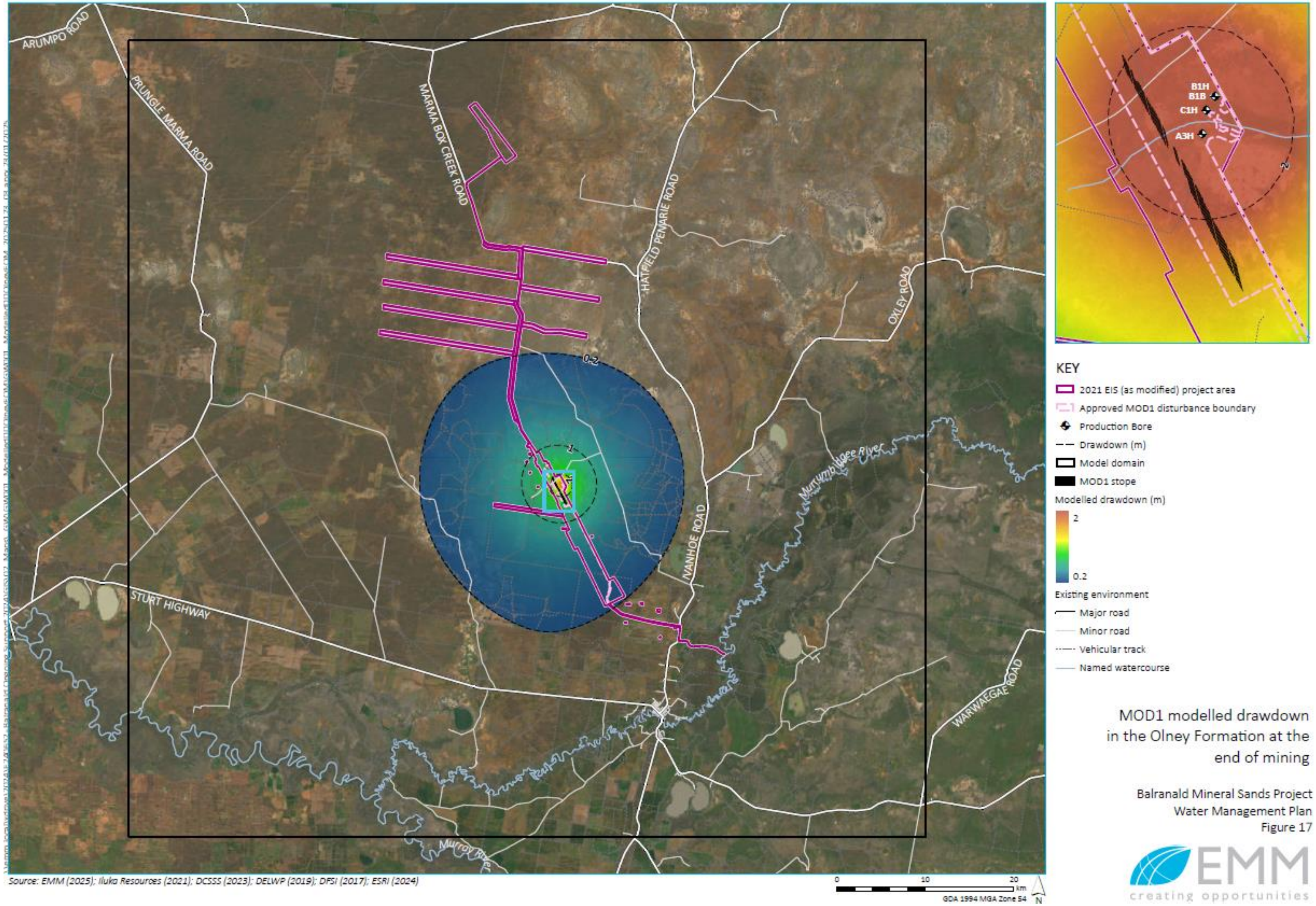


Figure 17- Modelled drawdown in the Olney Formation at the end of mining (after EMM, 2025).

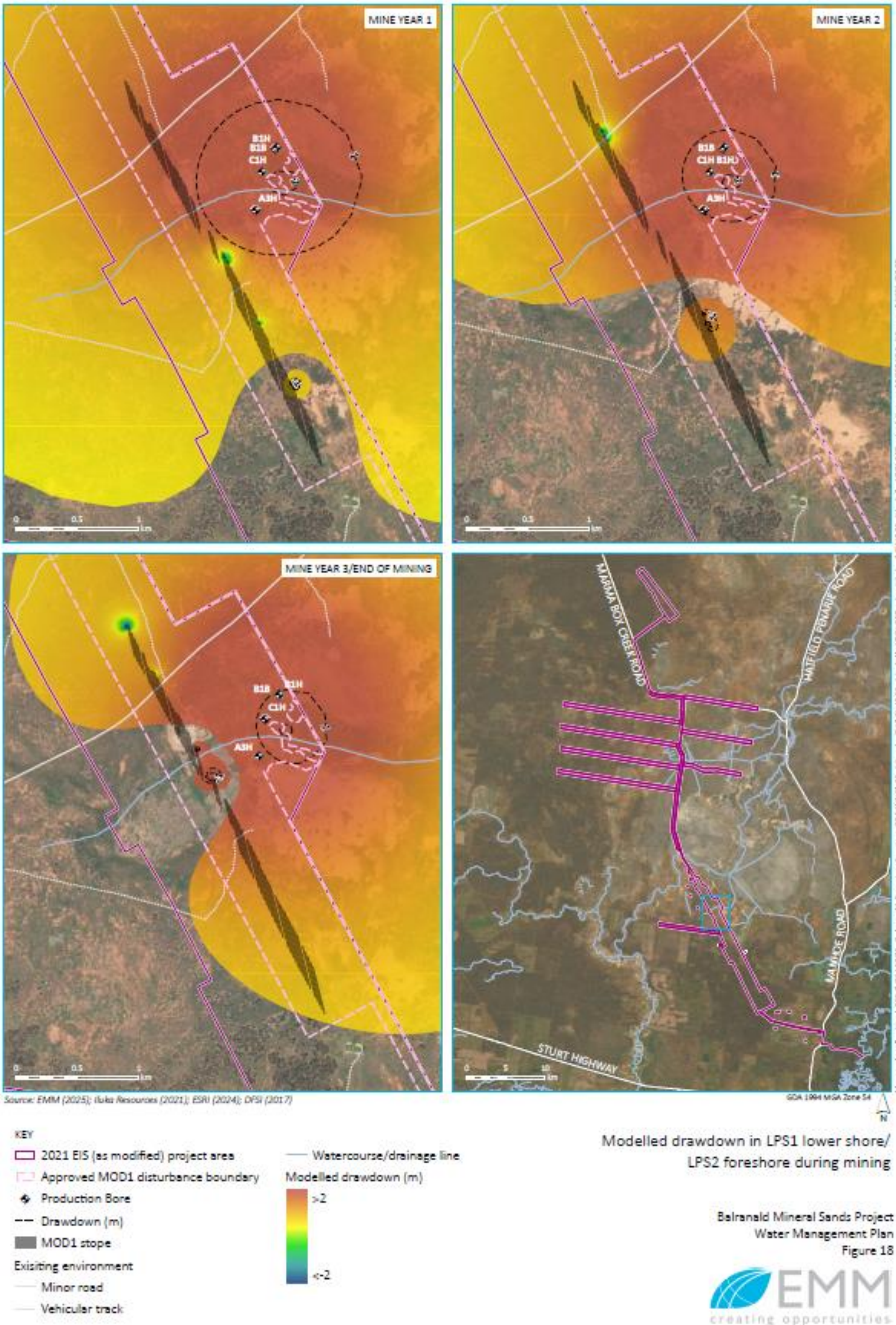


Figure 18: modelled drawdown in the LPS Formation during mining (EMM, 2025)

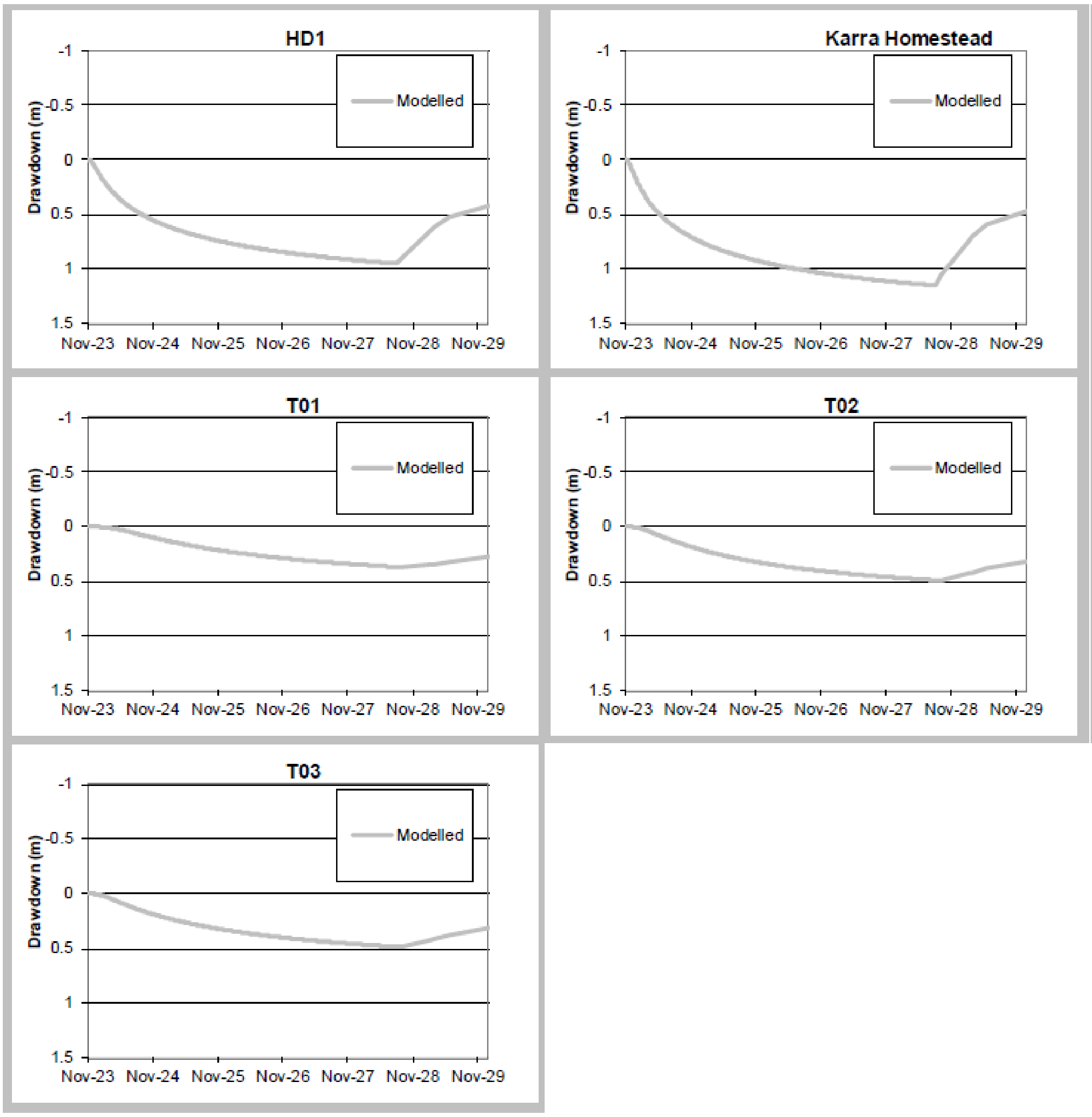


Figure 19: Modelled hydrographs at Olney Formation third party bores. Refer to Section 10.2.1 and Figure 12 for bore locations.

The dispersion of PAX in the surrounding groundwater system was also modelled (EMM, 2022) and later updated (EMM, 2024). PAX will be reinjected into the LPS Formation via the recirculation of process water for mining, and also potentially from residual process water contained in sand tailings that may seep into the SF. PAX is commonly used in mining and has been shown to break down in water storage dams and in mining process circuits (EMM, 2022). A conservative rate of PAX breakdown was applied during the MOD1 groundwater assessment, assuming a PAX half-life of 12 weeks (Earth Systems, 2020). Model simulations were performed during operations, at cessation of mining and up to 100 years following cessation of mining. The MOD1 groundwater assessment report (EMM, 2022) provides additional detail about the modelling methods, results and further scenarios for post-mining conditions, including a conservative scenario in which PAX does not degrade.

The numerical model predicted that with the 12-week half-life applied, the PAX concentration did not extend past the mine boundary. Figure 20 and Figure 21 show the modelled PAX concentration in the Shepparton and LPS Formations, respectively at various mine stages.

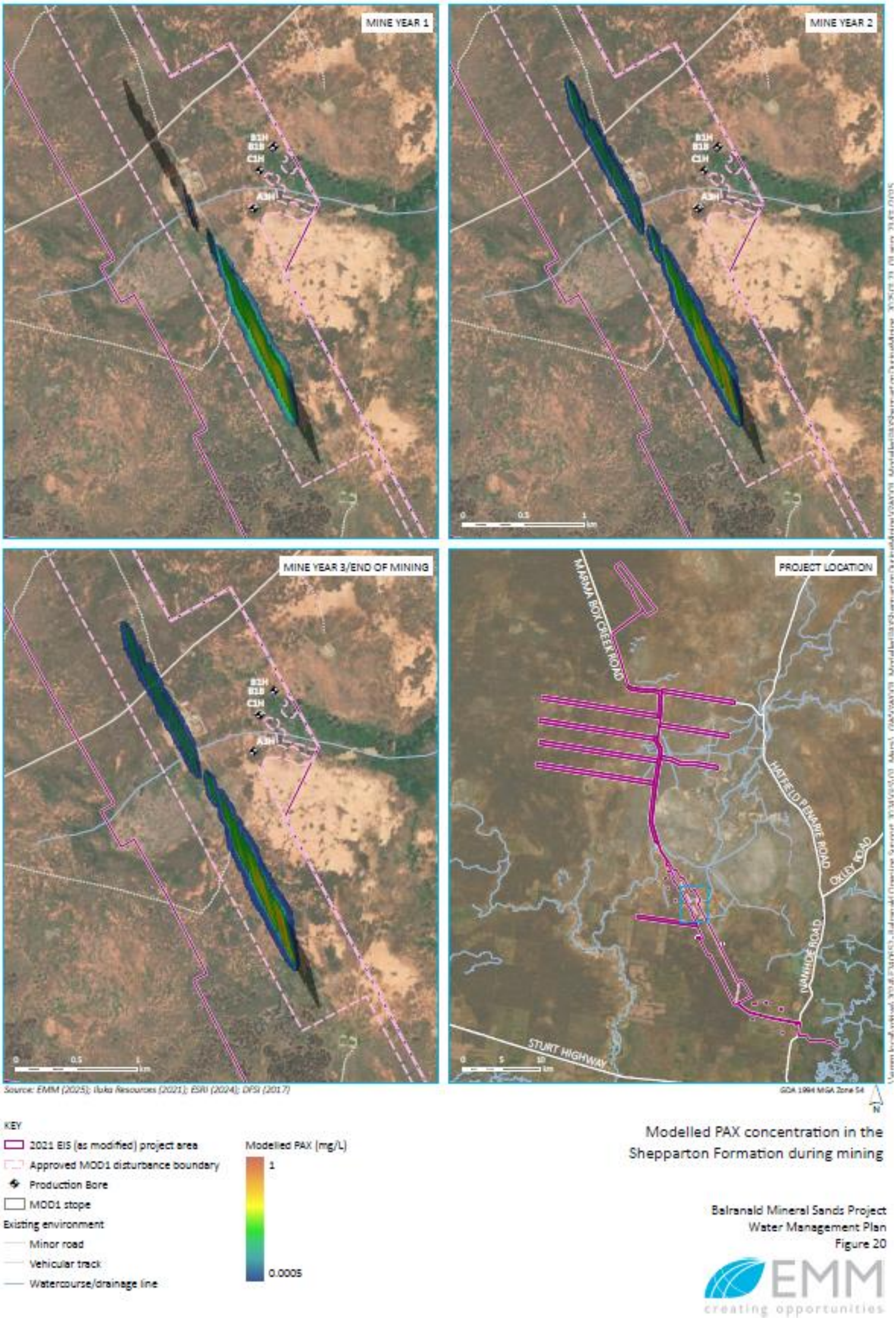


Figure 20: Modelled PAX concentration in the Shepparton Formation, PAX half-life of 12 weeks

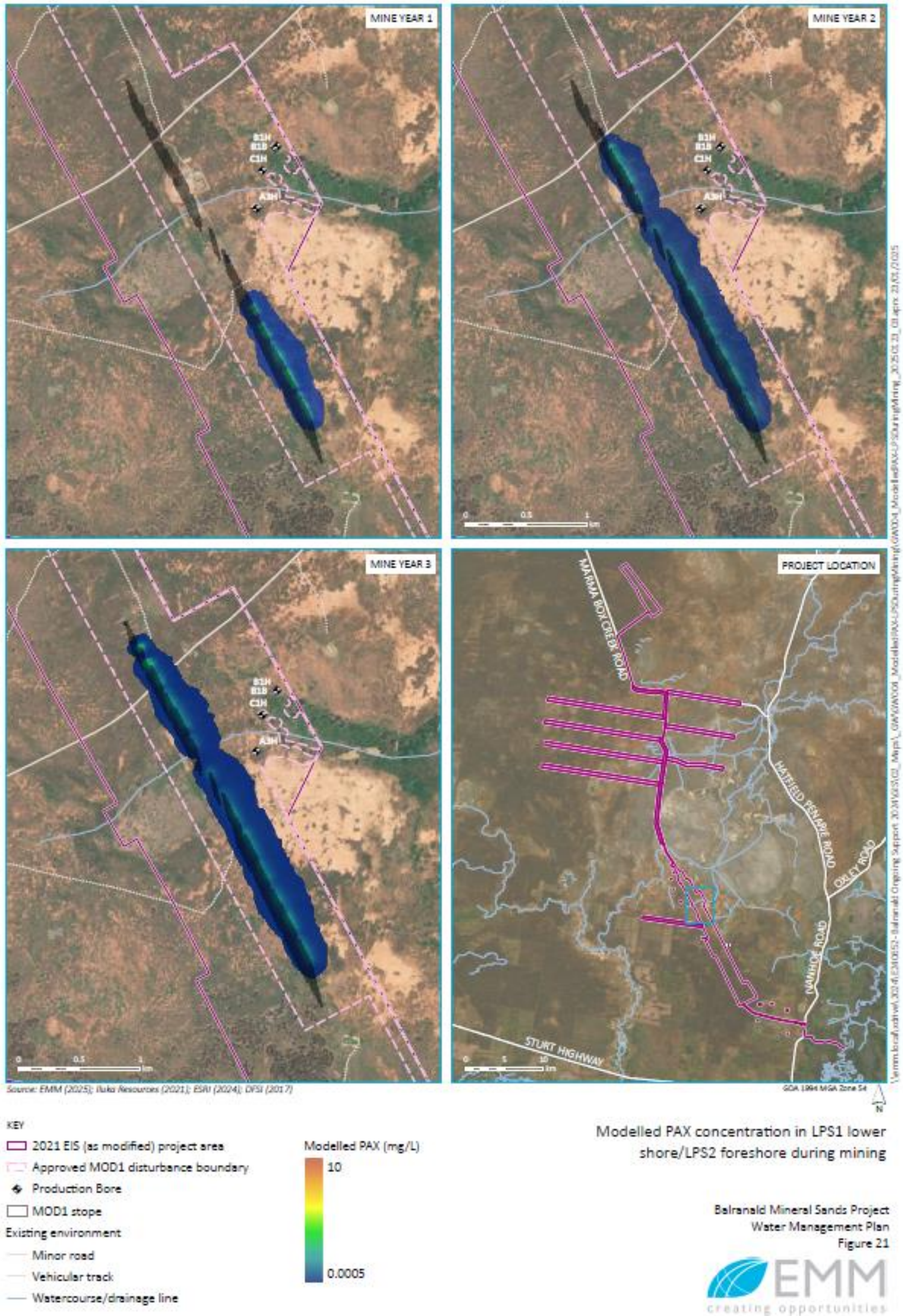


Figure 21: Modelled PAX concentration in the Loxton Parilla Sands Formation, PAX half-life of 12 weeks

10.3.5. Protocol for model review and update

The groundwater model will be progressively updated as new information becomes available, in accordance with SSD-5285 Schedule 3, Condition 15(b)(iii). Iluka will engage a specialist external consultant to review and if required revise the groundwater model, including the solute transport component, after nominally 6-12 months of data is collected, depending on the results of the monitoring program, and following the commencement of mining. The groundwater model will be reviewed and if necessary recalibrated every two years during life of mine. The groundwater model will be peer reviewed by an independent specialist consultant in accordance with SSD Groundwater Modelling Guidelines.

10.4. Groundwater Reinjection Management

Mine water reinjected underground during mining will contain residual process chemicals (namely PAX) and has the potential to contain salinity and AMD from stored product and stockpiles within the processing plant. The mining process also has the potential to cause localised groundwater pressure variations.

The groundwater reinjection pressure will be monitored in real-time via the mine control room. Vibrating wire piezometers will be installed in close proximity to mining and reinjection to monitor local groundwater pressures. Hydraulic Operating Conditions (HOCs, see Section 10.6.1) will be used to establish adaptive boundary conditions to minimise and prevent impacts.

Process water quality will be monitored and maintained (see Section 9.7.2) to neutralise any AMD derived from ore, product and tailings stockpiles.

10.5. Tailings and AMD Management

It is anticipated that approximately 50-60 tonnes per hour of sand and float tailings will be generated from ore processing activities. In accordance with SSD-5285 Schedule 3, Condition 15(b)(iii), the objectives of sand tails management are to:

- Minimise the rate of AMD generation using encapsulation
- Mitigate AMD generated from sand tailings placed above the groundwater table using limestone amendment.

Sand tails will be amended with limestone sand to neutralise any AMD that is anticipated to be generated when it is deposited above the mining area. The limestone sand will be added via a conveyor system at the sand tailings stockpiles, before the tailings is trucked to its disposal location.

The sand tailings will be placed into the pre-stripped areas ahead of the progression of mining and above the ore body area, as shown in plan view in Figure 22. The pre-stripped areas will be nominally 2.5m deep, which will allow the sand tailings to be placed below the natural ground surface. Once placed, sand tailings will be promptly covered with the material excavated from the 2.5m deep pits (nominally 2 m of overburden, 0.4m of subsoil and 0.1 m of topsoil). This cover will minimise the rate of sulfide mineral oxidation within the sand tailings.

Iluka has calculated that a conservative limestone dosing ratio is sufficient to neutralise any acidity in the sand tailings. A dosing ratio of 2:1 corresponds to limestone with an acid neutralisation capacity twice that of the maximum potential acidity of the sand tailings (i.e. a safety factor of 2). This dosing rate is more conservative than regulatory guidance provided in the NSW Acid Sulfate Soils Manual (Stone et al., 1998) which recommends a safety factor of at least 1.5.

Iluka will conduct geochemical test work to optimise the limestone dosing ratio after the commencement of mining. Should a lesser dosing ratio be deemed acceptable after sufficient testing and an informed risk assessment, an update will be included in a future revision of this management plan.

Representative samples of the ore being processed will be collected at a minimum rate of one sample every twelve hours and analysed for total sulfur content. The sulfur measurements will be used to calculate the limestone sand rate required to achieve an NPR of 2 in the sand tails.

To ensure that the sand tails are sufficiently neutralised prior to disposal, the following monitoring will be undertaken:

- Rinse pH testing – A rinse pH test (1 part material: 5 parts water) will be undertaken from the combined process residue stack. The sample will be a composite, comprised of 5-10 sub-samples from locations representative of the entire stack.
- Seepage pH testing – Visual inspections of drainage from the combined process residue stacks should be conducted when seepage is occurring. If significant iron staining is visible, then seepage samples will be collected and analysed for pH.
- NPR validation testing – Samples will be collected from the combined process residue stacks and tested for ANC and total sulfur. These results will be used to calculate the NPR of the residue stacks.

The frequency and SSTLs for these tests are outlined in Table 14. An exceedance protocol in relation to these SSTLs is provided in Section 12.1.5.

Table 14 - AMD management monitoring

Analysis	**Frequency**	**SSTL**		
		Green	**Yellow**	**Red**
Rinse pH testing	Daily until 3 months of pH>6 results, then reduced to weekly	pH≥6	pH ≥ 5 and <6	pH<5
Seepage pH testing	Daily while seepage is occurring	pH≥6	pH ≥ 5 and <6	pH<5
NPR validation testing	Daily until 3 months of NPR>2, then reduced to weekly	NPR>2	1.5 < NPR ≤ 2	NPR≤1.5

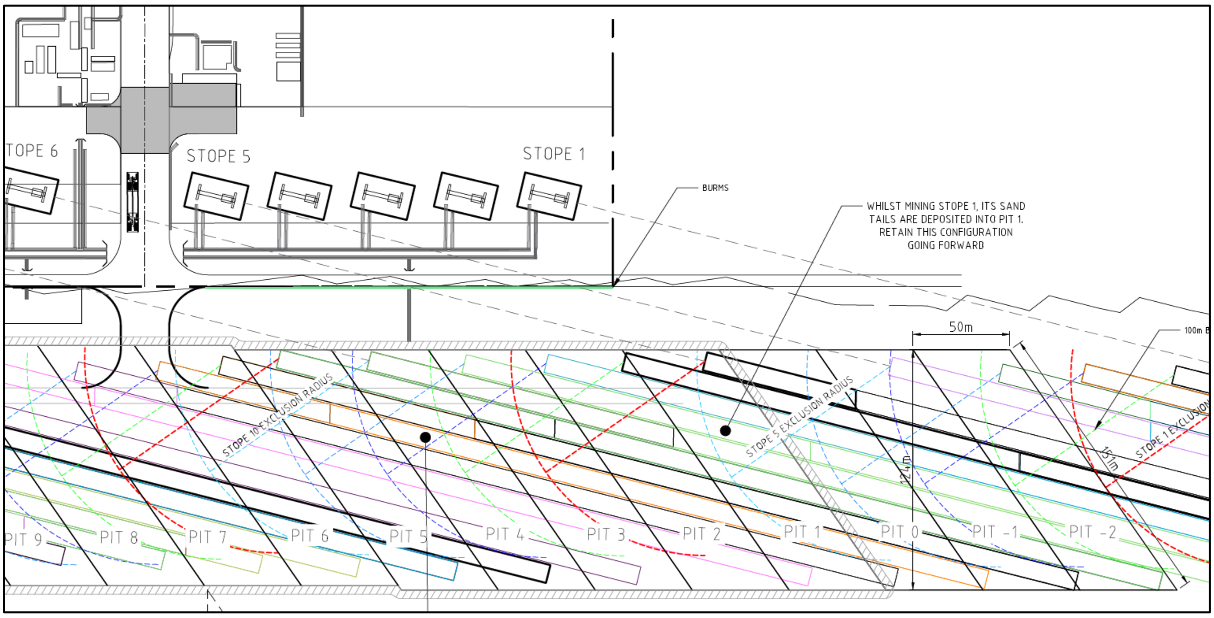


Figure 22: General arrangement of sand tailings pits relative to mine stopes.

10.6. Groundwater Assessment Criteria

In accordance with SSD-5285 Schedule 3 Condition 15(iii), this section describes the groundwater assessment criteria, including trigger levels for investigating any potentially adverse groundwater impacts associated with:

- alluvial aquifers including the LPS and Shepparton Formations;
- groundwater bore users;
- groundwater dewatering ;
- seepage/leachate from water storages, tailings, emplacements, backfilled voids and the final void. While voids are described in Condition 15, these do not apply to the underground mining trial approved under MOD1.
- groundwater dependent ecosystems; and
- reinjection of process water (including PAX) during the underground mining trial.

10.6.1. Groundwater Reinjection

Hydraulic pressures

The Hydraulic Operating Conditions (HOCs) framework was established as part of the T3 groundwater management plan (EMM, 2019). The HOCs represent the historical maximum pressures that have been experienced within the aquifers during previous hydrogeological field programs, without any adverse impacts being observed and were developed as follows:

- Shepparton Formation: HOCs were determined based on the rooting depths of nearby vegetation. Away from the Murrumbidgee River and associated floodplain region, vegetation relies predominantly on rainfall and soil water storages within the SF, with root system depths of around 5 mBGL. Therefore, due to the high salinity of groundwater in the SF, groundwater level rise into the root zone should be avoided (EMM, 2020).

- Loxton Parilla Sands Formation: Water level trigger levels for the LPS Formation have been defined for the upper-most facie of this unit, which lies directly below the SF. These HOCs have been set to avoid over-pressurising, and thus compromising the integrity of the overlying SF layer, but more specifically, the bentonite clay layer existing at the base of the SF.

These HOCs were initially developed based on past hydrogeological field programs which involved large scale reinjection activities (Iluka 2015; Iluka 2016). These were applied for the duration of the T3 trial, where at no point during the trial did the pressures exceed these values (EMM, 2021). These HOCs have been adopted as preliminary HOCs for the ongoing underground mining trial. The HOC framework is intended to be adaptive and will be reviewed and improved following the initial stages of mining.

An exceedance protocol in response to the HOCs is provided in Section 12.1.1.

Table 15- Initial Hydraulic Operating Conditions (HOCs, after EMM, 2020).

Parameter	Shepparton Formation			Loxton Parilla Sands Formation		
	Green	Yellow	Red	Green	Yellow	Red
Depth to Groundwater (mounding)	<8 mBGL	≤8 to >6 mBGL	≤6 mBGL	<15 mAGL	≥15 to <20 mAGL	≥20 mAGL

Notes: mBGL = metres below ground level; mAGL = metres above ground level

Water quality

To minimise the potential for changes to surrounding groundwater quality, the water quality of reinjected water will be maintained in accordance with the performance criteria in Table 16:

Table 16- Process water reinjection performance criteria

Monitoring Location	Parameter	Yellow investigation / action trigger (Leading indicator)	Red Investigation / Action Trigger (compliance)
HBF Tank	pH	Less than 7.0 or greater than 8.0	Less than 6.5 or greater than to 8.5.

10.6.2. Groundwater quality

Groundwater modelling (Section 10.3.4) has predicted that the groundwater system in the vicinity of mining activities will change due to aquifer mixing and injection of PAX. The MOD1 groundwater assessment (EMM, 2022) predicted no impacts to beneficial uses of the groundwater from these anticipated changes in groundwater quality. Hence, management of groundwater impacts is based on monitoring and assessment of groundwater quality to confirm that changes in groundwater quality remain within predicted values.

The management framework (described in Table 17 uses two operational zones (referred to as Mining Zone and Transition Zone in Figure 23) to monitor and evaluate anticipated changes in groundwater quality and one compliance zone (representing background groundwater conditions). The compliance zone establishes an area where any changes to the background groundwater quality would be considered greater than predicted in the Environmental Assessment and require a response.

SSTLs have been established for the compliance zone based on background water quality data collected at the site prior to operations and data that was collected during or after trial operations from the compliance (unaffected) zone only. These SSTLs were established using the DES (2021) guidelines for groundwater trigger derivation and are summarised in Table 18. The SSTLs are targeted to field parameters (EC, pH and ORP) due to these parameters being well understood for the main aquifers on-site. Any occurrence of AMD is expected to impact these parameters, making them a suitable warning for potential impacts. Individual SSTL trigger values have been derived for nearby third-party bores using the same methodology so that any changes in groundwater quality can also be identified in these bores.

Limit A trigger values are equal to the 80th percentile of the baseline dataset (and the 20th percentile for ORP and pH), while the Limit B trigger values are equal to the 95th percentile of the baseline dataset (and the 5th percentile for ORP and pH). An SSTL exceedance occurs when five consecutive exceedances of the Limit A trigger value are measured, or when three consecutive exceedances of the Limit B trigger value are measured. An SSTL exceedance will trigger the response measures outlined in Section 12.1.2, including a review of the collected laboratory data to look for evidence of metal mobilisation and examine potential causes of the exceedance, mining-related or otherwise.

SSTLs will also be used for comparison with data in the mining and transition zone where changes are expected, and as a leading indicator to potential changes at the compliance zone. However, in these two zones (the Mining and Transition Zones) the SSTLs will not be used to assess compliance. Where SSTLs are exceeded in the compliance zone, actions will be put in place to reduce the potential impact to groundwater quality.

As PAX is not present in the background water, any detected PAX (greater than 0.1 mg/L) will trigger the response measures outlined in Section 12.1.2. This PAX concentration was selected because it represents the laboratory limit of detection.

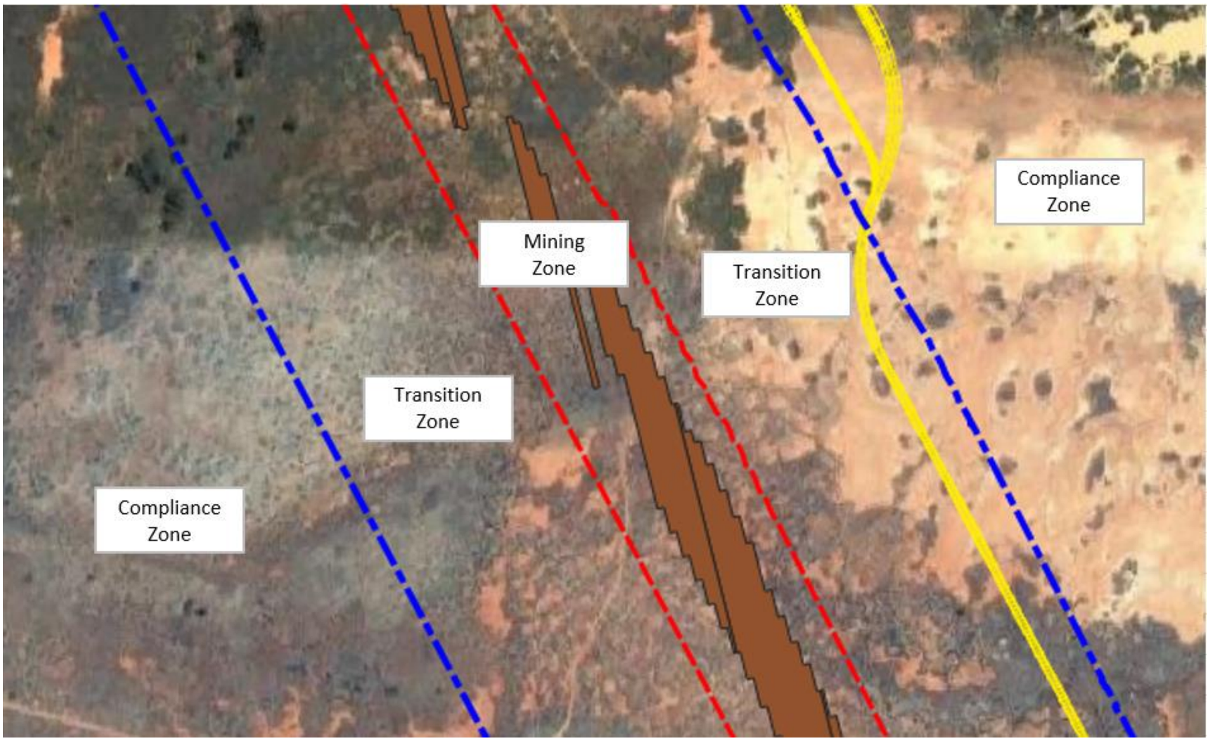


Figure 23: Groundwater quality management framework zones

Table 17- Groundwater management framework

Groundwater management zone	Purpose	Description
Zone 1 Mining Zone	Operational	Adjacent and surrounding the mining area including the stope footprint and extending 50 m in all directions. Required to understand immediate changes in groundwater head and quality in the vicinity of mining activities. Large changes in water quality relative to baseline are anticipated and this zone will be monitored for operational purposes and to refine and calibrate the groundwater model. This zone provides a leading indicator for potential changes in Zone 2.
Zone 2 Transition Zone	Operational	Largely non-mining areas (other than processing plant) and spans from 50 to 400m away from the stopes in all directions. Required to understand changes in water quality at various distances form the mine stopes and to track the migration of PAX away from the stopes. Some changes in water quality relative to baseline are anticipated and this zone will be monitored for operational purposes and to refine and calibrate the groundwater model.

Groundwater management zone	Purpose	Description
		This zone provides a leading indicator for potential changes in Zone 3.
Zone 3 Background Zone	Compliance	Non-mining areas greater than 400 m from the stopes in all directions. No material changes in groundwater quality are predicted at these locations and any change would constitute an impact beyond that predicted in the Balranald MOD1 groundwater assessment and hence constitute a non-conformance with this WMP.

Table 18- Groundwater quality trigger values

Category	Level A Trigger			Level B Trigger		
	EC (µS/cm)	pH (pH units)	ORP (mV)	EC (µS/cm)	pH (pH units)	ORP (mV)
Karra Bore	9,436	7.55 – 7.83	-120.2 – -39.3	10,211	7.21 – 7.94	-161.2 – 40.1
T01	8,879	7.37 – 7.68	-92.6 – 10.7	9,213	6.95 – 7.80	-139.0 – 105.2
T02	7,041	7.31 – 7.65	-84.9 – 25.0	7,233	6.97 – 7.80	-135.2 – 73.6
T03	6,149	7.29 – 7.66	-68.5 – 18.2	6,273	7.06 – 7.89	-110.7 – 69.5
HD1	7,462	7.30 – 7.73	-94.2 – 2.40	7,798	6.86 – 7.83	-109.2 – 52.2
SFM bores	63,244	6.40 – 7.06	-147.3 – 66.5	68,516	6.04 – 7.60	-210.7 – 131.6
LPS bores	55,200	6.54 – 6.92	-198.4 – -8.6	58,837	5.96 – 7.17	-237.9 – 84.2

10.6.3. Aquifer drawdown

The closest sensitive receptors identified (Section 10.2) include the Karra homestead bore and the Blackbox community to the east of the mine area (GDE4). The maximum predicted drawdown (Section 10.3.4) was 1.2 m at the Karra homestead bore and 0.1m at the location of GDE4. In accordance with SSD-5285 Schedule 3 Condition 15(iii), these values have been assigned as investigation trigger levels (Table 19) at conservative locations within the monitoring network to provide a leading indicator of any potential impact.

Table 19- Groundwater drawdown investigation trigger levels

Bore ID	Nominal Coordinates(1)		Investigation Trigger Level(1)
	Easting	Northing	
MBO035	723967	6188596	>1.5m drawdown in the Olney Formation
MBO018	724338	6187859	
WB102	724967	6186395	>1.2m drawdown in the Olney Formation
WB103	720630	6194507	
WBMB10	717804	6187437	

Notes: 1. Trigger levels defined as the approximate value where the drawdown is greater than that predicted in the Balranald MOD1 groundwater assessment (see Section 10.3.4).

10.7. Groundwater monitoring programs

This section provides the groundwater monitoring program to be implemented during the operations phase of the Balranald Mine.

In accordance with SSD-5285 Schedule 3, Condition 15(b)(iii), several monitoring programs will be implemented throughout the life of the mine. The groundwater monitoring strategy is as follows:

- Conduct relatively intensive monitoring during the initial stages of mining and groundwater reinjection(Panels 1 and 2), to collect sufficient data to enable robust validation, and if required, re-calibration of the hydrogeological model. Model calibration is anticipated to occur after 6-12 months of mining operations (depending on monitoring results). Therefore, monitoring programs presented below are developed for the initial two years of mining operations.
- Based on the model calibration, the groundwater monitoring programs will be reviewed and updated with a focus on compliance with predicted impact levels.
- Monitoring bores will be progressively installed as the mine progresses.
- Due to the nature of the mining activity, where mining will initially progress along a six-kilometre ore body, the monitoring program is required to be flexible and allows for the frequency of monitoring to be adjusted so that it is focused near the active mining areas where changes in groundwater are expected. At monitoring locations where mining is no longer active and groundwater quality has stabilised, the frequency of monitoring will be decreased and may cease in certain locations.
- Monitoring data will be quality controlled and reported transparently.

Groundwater monitoring has been split into several monitoring programs related to different operational phases and potential environmental risks, and as outlined in SSD-5285 Schedule 3, Condition 15(b)(iii). The monitoring programs and their respective objectives are outlined in Table 20 and discussed below:

- Construction and commissioning phase monitoring program. This is intended to collect additional baseline data prior to mining and monitor aquifer drawdown from the water supply bores. This monitoring program will cease at the end of construction.
- Mining Zone monitoring program. This will use a combination of Vibrating Wire Piezometers (VWPs) and monitoring wells to monitor groundwater head within close proximity to mining operations (Figure 24). This monitoring will be compared with established hydraulic operating conditions (see Section 10.6.1).

1. Water supply drawdown monitoring program. This program will use monitoring wells screened within the LPS and Olney Formation (OF) to measure the drawdown caused by extraction of production water and assess the potential for impacts to private water supplies and/or GDEs. Monitoring results are compared with performance criteria in Section 10.6.3.

- Groundwater quality monitoring program is intended to monitor:
  a. the chemical composition of water being reinjected;
  b. track the migration and degradation of PAX;
  c. confirm that sand tailings seepage has negligible impact to groundwater quality;

d. confirm that there is no leakage to the underlying OF; and

- radiation levels within close proximity to mining areas.

  This monitoring program will use monitoring wells in the LPS and SF to monitor anticipated changes in water quality surrounding the mining area. A SSTL framework and TARPs are established in this Plan to ensure that the changes in groundwater quality remain within those predicted. This monitoring program is intended to be both progressively implemented and adaptive and will be updated (via resubmission of this Plan), following recalibration of the numerical hydrogeological model.

- Regional & background monitoring program. This monitoring program continues on from exiting regional monitoring and will operate for operations and post-mining to collect long-term background data. Monitoring bores will be located outside the extent of predicted groundwater impacts and up-hydraulic gradient within the groundwater systems.

- Post-mining monitoring program. This will use selected monitoring wells to continue monitoring after cessation of mining to continue to track the migration and degradation of PAX within the groundwater system. This monitoring program will be developed prior to the end of mining and updated in a future revision of this Plan.

The following sections outline further detail about each groundwater monitoring program. Note that some bores are used in multiple monitoring programs.

Table 20- Summary of groundwater monitoring programs

MP#	Project Phase	Monitoring Program Name	Monitoring Purpose	Analytical Suites (see Table 12)	Operations phase TARP
1	Mining	Mining – Zone Monitoring Program	Monitor changes in groundwater head surrounding mining activities.	SWL, loggers (selected)	HOC (Section 10.6.1) and TARP (Section 12.1.1)
2	Construction / Mining	Water Supply Drawdown Monitoring Program	To ensure that excessive drawdown does not occur at private bores and GDE locations	SWL	SSTL and TARP (Section 12.1.4)
3	Mining	Mining - Groundwater Quality	Monitor anticipated changes in water quality due to salinity, AMD and PAX reinjection. Confirm that these changes remain within the predicted and approved changes. Confirm no leakage to OF	SWL, Suite 1, Suite 2, Suite 3	SSTL (Section 10.6.3) and TARP (Section 12.1.2)
4	Mining	Mining – AMD Management	Ensure sand tailings are appropriately neutralised with limestone before deposition	AMD suite (Table 14)	SSTL (Section 10.5) and TARP (Section 12.1.5)
5	All	Regional Monitoring Program	Monitor background and regional hydraulic gradients and water quality.	SWL, Suite 1, Suite 2	n/a
6	Post-mining	Post-mining Monitoring Program	Monitor post-closure environmental conditions, PAX degradation	SWL, Suite 1, Suite 2, Suite 3, Suite 4	n/a

Notes: SWL = Standing water level.

10.7.1. Mining zone hydraulic pressure

As described in Section 10.3.1, mining operations are anticipated to produce localised changes in groundwater head. A combination of real-time and data-logged monitoring will be used to ensure that mining and reinjection activities remain within the defined HOCs. VWPs will be installed within the mining panels (Figure 24). Each set of VWPs will include one screened within the SF and one within the LPS. VWPs will be monitored in real-time and include automated alarms to alert operators to elevated groundwater head.

Only VWPs within the active mining areas will be used to assess compliance against HOCs and trigger any immediate response actions. Monitoring wells laterally adjacent to each stope will be used to record trends in groundwater head via data level loggers.

This monitoring program will commence at the start of mining operations and is intended to be adaptive and may be updated and optimised if required following the initial stages of mining activities.

Monitoring bore locations are provided in Table 21 for Mining panels 1&2. Locations will be optimised based on site specific conditions. Iluka may use existing monitoring bores located close to any of the proposed monitoring locations.

Table 21- VWP and monitoring bore locations (Years 1-2) used for mining and reinjection groundwater pressure monitoring.

ID	Screened aquifer			Instrumentation	Frequency of data collection	Coordinates[1]	
	SFM	LPS	OF			Easting	Northing
MBL019		✓		Low flow sampling pump (manual)	Monthly	724473	6187912
MBL025		✓				724287	6188269
MBL036		✓				724091	6188631
MBS063	✓					723894	6190338
MBL005		✓		Level Logger[2]	6-hourly level logger, downloaded monthly[3]	724376	6187398
MBS005	✓					724382	6187387
MBL015		✓				724139	6187815
MBS015	✓					724144	6187807
MBL033		✓				723872	6188338
MBS033	✓					723870	6188330
MBL035		✓				723967	6188596
MBS035	✓					723971	6188585
BH-M22D		✓				723683	6188855
BH-M22S	✓					723683	6188855
MBO018			✓	Level Logger[2]	6-hourly level logger, downloaded monthly[3]	724338	6187859
MBL018		✓				724341	6187844
MBS018	✓					724349	6187831
MBL024		✓		Low flow sampling pump (remote)	Monthly	724148	6188243
MBS024	✓					724153	6188235
MBO035			✓			723963	6188601
MBL007		✓		Low flow sampling pump (remote)	Monthly	724315	6187556
MBS007	✓					724314	6187567
MBL017		✓				724228	6188050
MBS017	✓					724232	6188040
MBL020		✓				724089	6187958
MBS020	✓					724096	6187947
MBL031		✓				723992	6188516
MBS031	✓					723994	6188510
MBL034		✓				723848	6188455
MBS034	✓					723852	6188449
MBL040		✓				723777	6188889
MBS040	✓					723780	6188882
VWP001	✓	✓		Vibrating Wire Piezometer (VWP)	Real-time groundwater pressure[3]	724490	6187406
VWP002	✓	✓				724367	6187458
VWP003	✓	✓				724497	6187582
VWP004	✓	✓				724320	6187578
VWP005	✓	✓				724398	6187742
VWP006	✓	✓				724270	6187812
VWP007	✓	✓				724153	6187849
VWP008	✓	✓				724258	6188012
VWP009	✓	✓				724056	6188029
VWP010	✓	✓				724168	6188186

VWP011	✓	✓				724042	6188247
VWP012	✓	✓				723916	6188307
VWP013	✓	✓				724024	6188469
VWP014	✓	✓				723859	6188465
VWP015	✓	✓				723935	6188646
VWP016	✓	✓				723811	6188698
VWP017	✓	✓				723679	6188846
VWP018	✓	✓				723774	6188880

Notes: 1. Specific bore locations may be optimised based on field conditions.
2. Level loggers will only be deployed to bores adjacent to active mining panels at any given time.
3. Active mining areas only

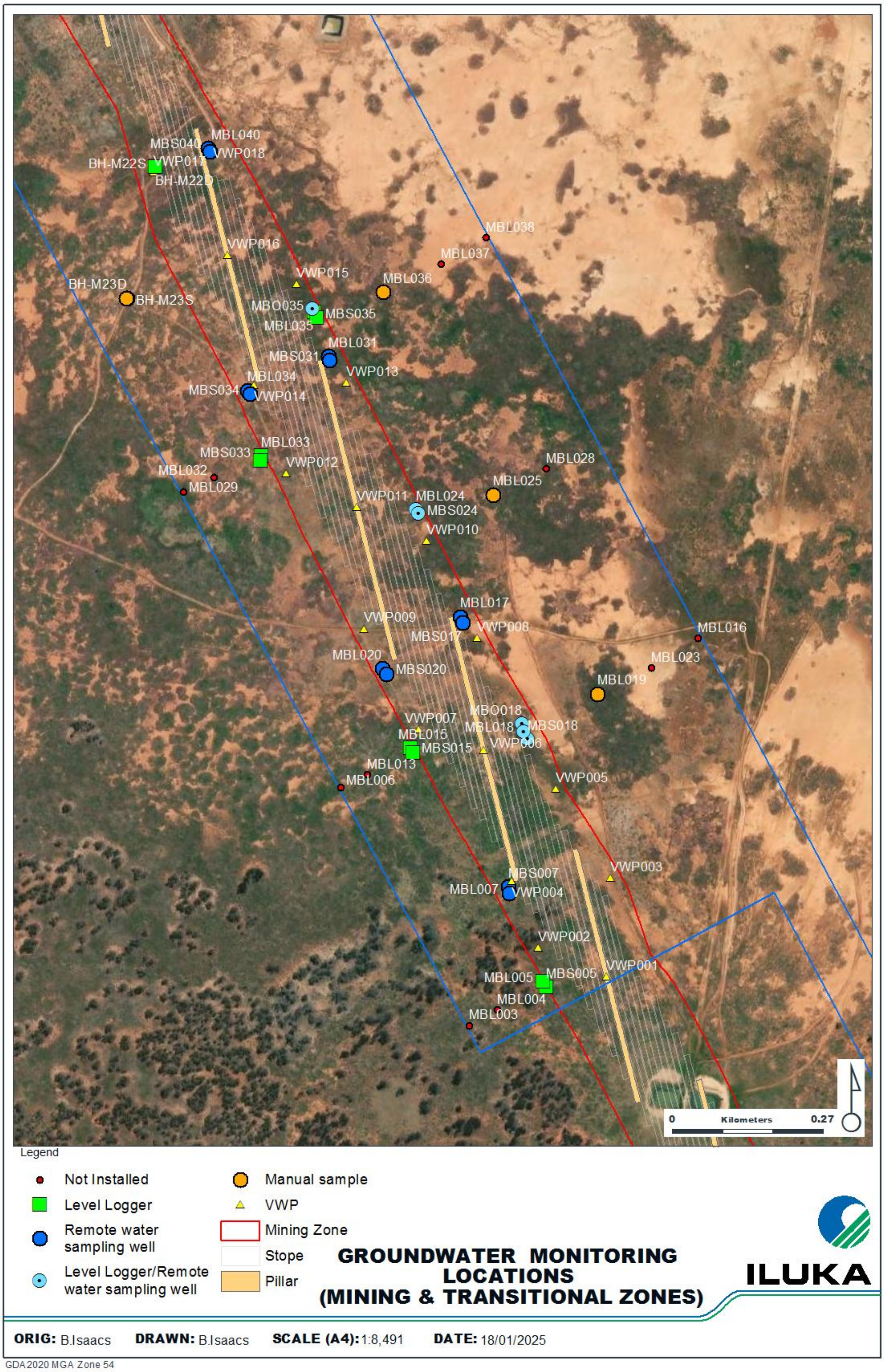


Figure 24- Mining and transitional zone monitoring program (years 1-2 of mining)

10.7.2. Water supply drawdown

Production water supply will be derived from bores constructed in the LPS and OF. Groundwater levels will be monitored in both formations at varying distances from the production bores. The results will be compared with the groundwater model predictions (see Section 10.3). Table 22 lists the monitoring bore locations for the bore water supply monitoring program. Figure 25 & Figure 26 shows the nominal bore locations relative to the modelled groundwater drawdown contours.

Table 22- Production water supply groundwater monitoring program.

ID	Screened aquifer		Frequency of data collection	Coordinates	
	LPS	OF		Easting	Northing
WB102		✓	Monthly SWL	724967	6186395
WB103		✓		720630	6194507
WBMB10		✓		717804	6187437
MBO018		✓		724338	6187859
MBO035		✓		723967	6188596
WB40	✓			721167	6193438
WB27	✓			724905	6186386
BH25-D	✓			723239	6189004
BH20-D	✓			723677	6189208

10.7.3. Groundwater quality

Mining activities and sand tails disposal has the potential to affect groundwater quality as described in Section 10.3. An adaptive monitoring program will be implemented to monitor changes in groundwater quality and compare these to predictions for modelled parameters. An SSTL framework has been established in Section 10.6 to trigger investigation and mitigation actions if water quality exceeds predicted impacts. The initial groundwater monitoring program will be more intensive and focus on the area where ore will be mined in the first 12-18 months of operations surrounding Panels 1 & 2. (Table 21 and Figure 24), to permit robust calibration of the groundwater model.

Groundwater monitoring bores have been located to form transects, perpendicular to and along the strike of the ore body. Transects will contain bores located adjacent to the mining panels, spaced within the transition zone on either side of the ore body where the PAX plume is anticipated to migrate. Compliance bores (linked with the SSTL framework) will be located at 400 m distance from the strike of the ore body, where PAX is not anticipated to reach based on the assessed groundwater impacts. The minimum distance of 50m from the ore body is defined by a safety exclusion zone established around the surface subsidence area above the ore body. Selected bores will be constructed within this exclusion zone using a remote sampling technique developed during the T3 mining trial. This technique will be used to locate monitoring bores nominally up to 50 m within the safety exclusion zone. These selected bores will be screened within the SFM with the primary purpose of monitoring potential water quality impacts related to infiltration of residual process water contained in sand tailings (Figure 27 & Figure 28). Selected bores will also be screened in the OF to confirm that the process chemicals do not leak to this lower aquifer.

Water quality data will be collected monthly in the mining and transition zones for the first 12 months of monitoring, then the frequency of data collection reviewed following analysis of these results.

The monitoring program is intended to be adaptive and additional monitoring bores will be installed on an as-needed basis in the following circumstances:

1. PAX concentrations at existing monitoring bores exceed the modelled concentrations (as noted in Table 23).

- An exceedance of the field parameter SSTLs values (Table 18) occurs and a follow-up investigation of the laboratory data shows evidence of metal mobilisation.

These additional monitoring bores will be installed of a confirmed exceedance within the transition zone to ensure continuous data collection and compliance. The locations of the additional monitoring bores will be chosen based on where the exceedance occurred, with initial location estimates provided in Table 23.

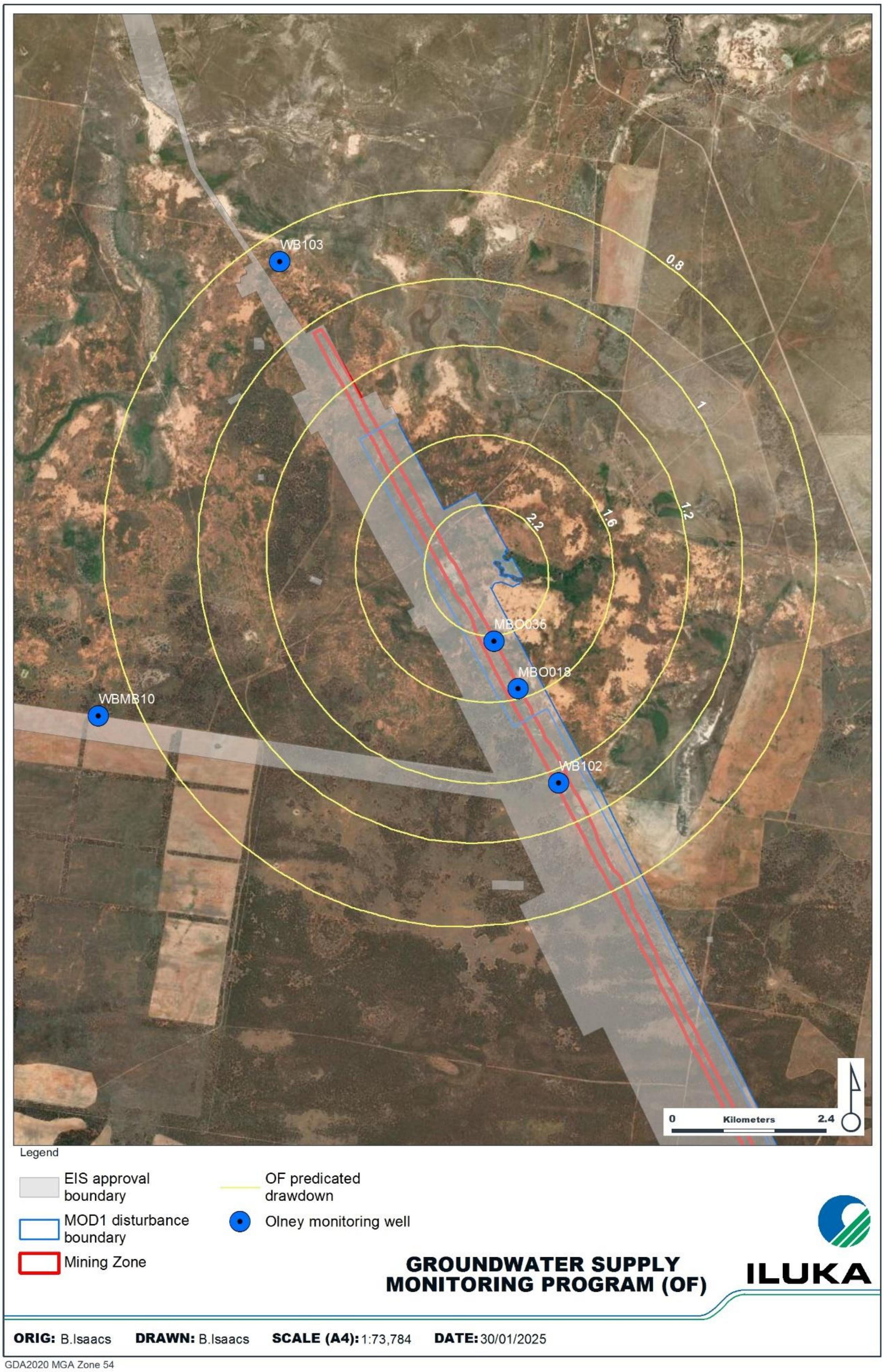


Figure 25- Production water supply monitoring program (OF)

Figure 26- Production water supply monitoring program (LPS)

Table 23- Groundwater quality monitoring program for mining, transitional and compliance zones

ID	Groundwater management zone	Timing of installation and analysis	Screened aquifer			Parameters Frequency of data collection[2]	Coordinates[1]	
			SFM	LPS	OF		Easting	Northing
MBS007	Mining Zone	Existing	✓			SWL, Suite 1, Suite 2, Suite 3 - Monthly near active mining area, then quarterly[2] Suite 4 – Annual **(mining zone only)**	724314	6187567
MBL007				✓			724315	6187556
MBS017			✓				724232	6188040
MBL017				✓			724228	6188050
MBS018			✓				724349	6187831
MBL018				✓			724341	6187844
MBO018					✓		724338	6187859
MBS020			✓				724096	6187947
MBL020				✓			724089	6187958
MBS024			✓				724153	6188235
MBL024				✓			724148	6188243
MBS031			✓				723994	6188510
MBL031				✓			723992	6188516
MBS034			✓				723852	6188449
MBL034				✓			723848	6188455
MBO035					✓		723963	6188601
MBS040			✓				723780	6188882
MBL040				✓			723777	6188889
MBS005	Transition Zone	Existing	✓				724382	6187387
MBL005				✓			724376	6187398
MBS015			✓				724144	6187807
MBL015				✓			724139	6187815
MBL019				✓			724473	6187912

MBL025				✓			724287	6188269
MBS033			✓				723870	6188330
MBL033				✓			723872	6188338
MBL036				✓			724091	6188631
BH-M23S			✓				723631	6188620
BH-M23D				✓			723632	6188620
MBL004		if PAX >0.1 mg/L or field parameter SSTL exceedance occurs at MB005		✓			724294	6187347
MBL013		if PAX >0.1 mg/L or field parameter SSTL exceedance occurs at MB015		✓			724061	6187768
MBL023		if PAX >2 mg/L or field parameter SSTL exceedance occurs at MB019		✓			724570	6187960
MBL028		if PAX >2 mg/L or field parameter SSTL exceedance occurs at MB025		✓			724381	6188315
MBL032		if PAX >0.5 mg/L or field parameter SSTL exceedance occurs at MB033		✓			723787	6188300
MBL037		If PAX >3 mg/L or field parameter SSTL exceedance occurs at MB036		✓			724194	6188681
MBL003	Compliance Zone	if PAX >0.1 mg/L or field parameter SSTL exceedance occurs at MB004		✓			724243	6187319
MBL006		if PAX >0.1 mg/L or field parameter SSTL exceedance occurs at MB013		✓			724014	6187746
MBL016		if PAX >0.1 mg/L or field parameter SSTL exceedance occurs at MB023		✓			724654	6188012
MBL029		if PAX >0.1 mg/L or field parameter SSTL exceedance occurs at MB032		✓			723732	6188274
MBL038		if PAX >0.1 mg/L or field parameter SSTL exceedance occurs at MBL037		✓			724273	6188729
MBS063	Process Plant	Existing	✓				723894	6190338

Notes: 1. Specific bore locations may be optimised based on field conditions. 2. In line with the adaptive management framework, this plan allows for the monitoring frequency to be adapted on an ongoing basis as the mining plant progresses and/or water quality results indicate that the conditions have stabilised.

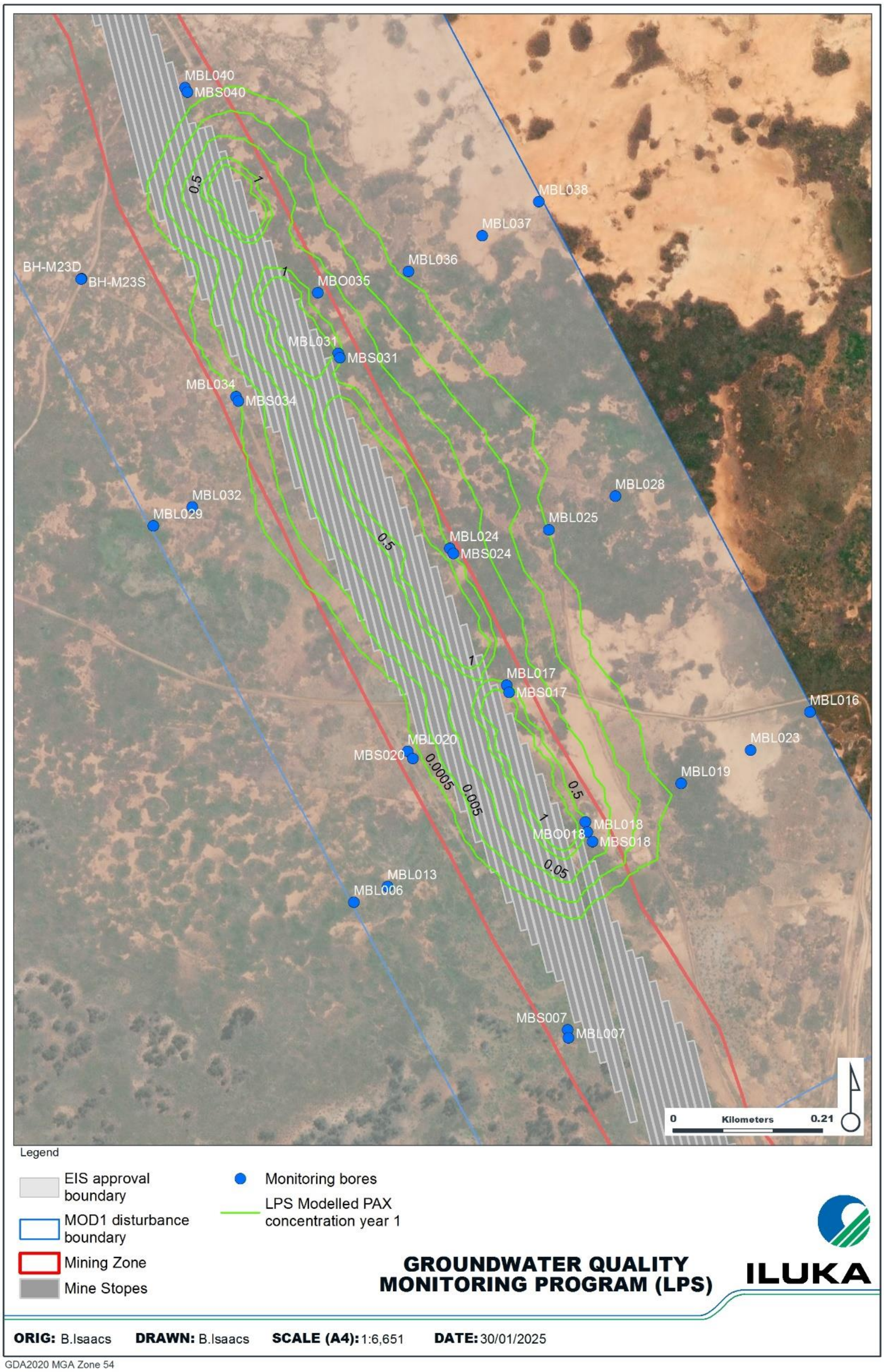


Figure 27- Initial groundwater quality monitoring program showing modelled PAX concentration at the end of year 1 of mining in LPS.

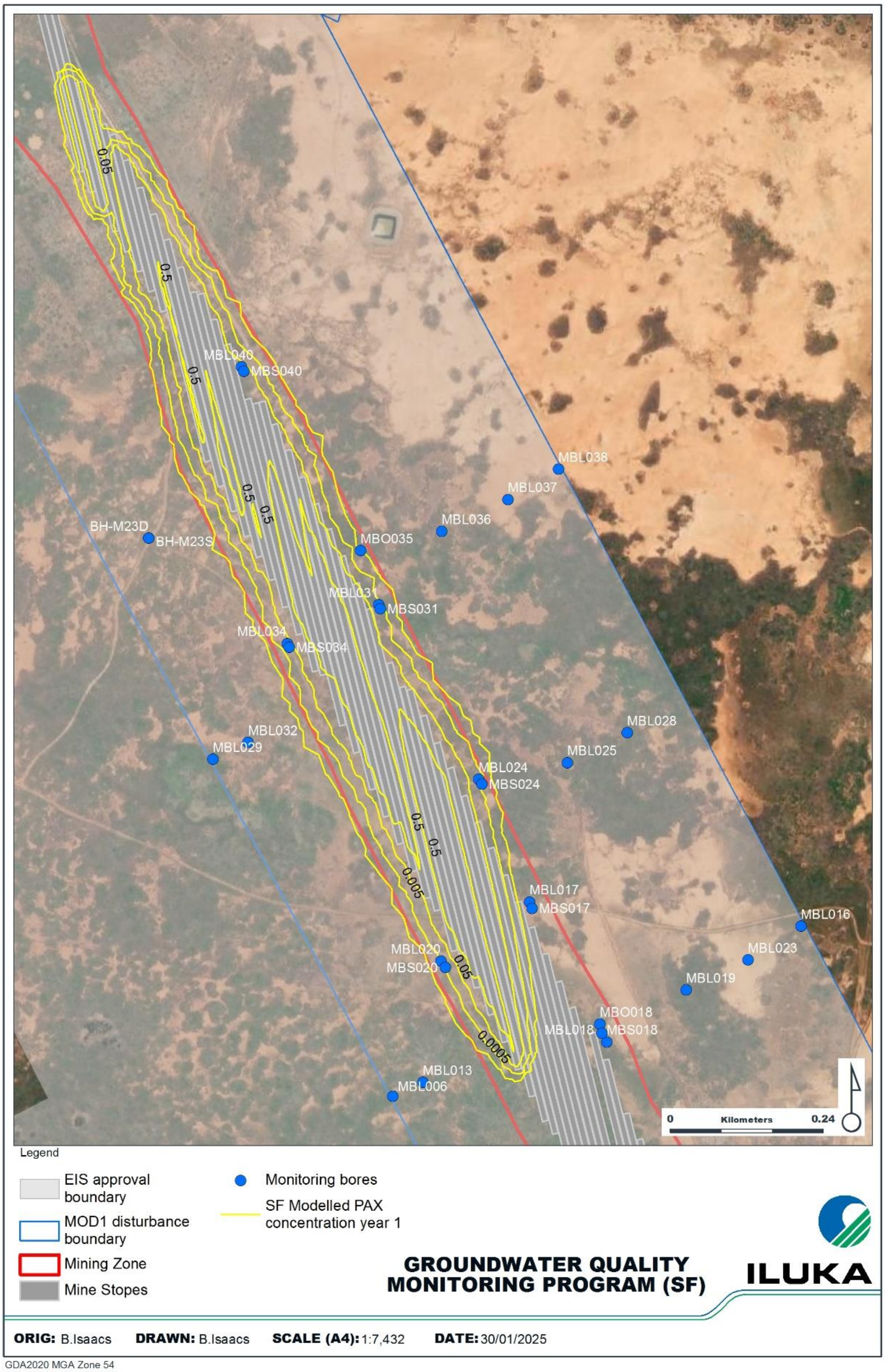


Figure 28- Initial groundwater quality monitoring program (top) showing modelled PAX concentration at the end of year 1 of mining in SF.

10.7.4. Regional and background

A regional monitoring program will be implemented throughout the duration of the Balranald Mine to gather information on trends in background water quality and regional groundwater levels and trends in the regional groundwater flow regime. The HOC and SSTL framework will not be used to assess changes in groundwater level and quality at these locations. Bores have been located up-hydraulic gradient within the groundwater system and utilise existing bores to maintain continuity of long-term data records that currently exist. The bores selected represent a selection of the bores used in the T3 regional monitoring network and form part of the ongoing GMEs.

Table 24- Regional groundwater monitoring program

ID	Screened aquifer			Frequency of data collection	Analytical Suites	Coordinates	
	SFM	LPS	OF			Easting	Northing
Karra Bore[1]			✓	- SWL quarterly; - Water quality Annually	SWL (excl Karra Bore, T01, T03), Suite 1, Suite 2	720430	6188310
T01[1]			✓			722791	6201032
GW036673(1)	✓					711680	6189281
GW036866(1)	✓					734900	6203463
GW036866(2)		✓				734900	6203463
WB01	✓					730399	6175412
WB02		✓				730402	6175415
LPSPB03		✓				724893	6186351
T03[1]			✓			732044	6189404

[1] SWL not possible due to bore pump head works preventing access to well.

Figure 29: Regional monitoring bores.

10.7.5. Post-mining

A post-mining groundwater monitoring program will be developed at the later stages of the operations phase of mine based on monitoring results and groundwater model validation and calibration and included in a revised version of this plan.

10.7.6. Monitoring Procedures and QAQC

Iluka will maintain a groundwater bore register to store relevant construction details for all monitoring bores. Groundwater monitoring will be undertaken using a combination of low-flow sampling methods and/or collection via passive samplers (Hydrasleeves). Standard operating procedures (SOPs) for these methods are provided in Appendix E, which are consistent with the following Australian/New Zealand Standards:

- AS NZS 5667.1, 1998 – Water Quality Sampling – Part 1 Guidance on the design of sampling programs, sampling techniques and the preservation and handling of samples.
- AS NZS 5667.11, 1998 – Water quality - Sampling guidance on sampling of groundwaters.

Water quality monitoring equipment and groundwater level loggers will be calibrated, and calibration records maintained. Field blank and duplicate water quality samples will be collected, and results compared with parent samples.

All laboratory analyses will be performed by a NATA accredited laboratory.

10.8. Bore Development Procedures

Bore development is to be undertaken in accordance with the bore development Standard Operating Procedure (SOP) provided in Appendix E. This SOP has been developed using external expert advice (EMM, 2020) based on guidance in the Minimum Construction Requirements for Water Bores in Australia, 4th Edition (NUDLC 2020). The SOP includes a template for the collection of bore development details.

10.9. Data management and reporting

Data will be entered and stored in Iluka's environmental database system. Data will be reviewed promptly once received and relevant data compared with applicable performance criteria.

Monitoring data will be presented in the Annual Review. In accordance with SSD-5285 Schedule 3, Condition 15(b)(iii), the following will be reported:

- A summary of groundwater level data near mining operations and comparison with HOCs.
- A summary of groundwater quality data with focus on PAX migration / degradation and comparison with modelled predictions, within the mining, transition and compliance zones, including a comparison of bore water quality data with SSTLs.
- A summary of groundwater drawdown data from production bores and comparison with modelled predictions, and relative to the location of any private landholders/leaseholders and GDEs.
- A summary of any significant trends in regional / background changes in groundwater level and water quality relative to changes within mining areas.
- Post mining water level recovery (after the completion of mining activities).

11. Environmental Inspections

Environmental inspections will be carried out to identify environmental hazards and to assess the effectiveness of water management measures and controls. Table 25 outlines the inspection program.

Inspections will be documented in the form of a checklist and any hazards or non-conformances will be reported using Iluka's incident reporting system. Any actions arising from the inspections will be allocated as soon as reasonably practical and tracked electronically until closed out.

Table 25- Water management inspection program

Inspection area	Details of inspection	Timing/frequency	Responsibility
Mine water pipeline	Pipeline integrity Spills / leaks	Monthly	Environmental Advisor
Process water dams	Dam integrity Minimum freeboard Liner / spillway condition Leaks/ spills	Monthly	
Flood mitigation berms	Integrity	Monthly	
Sediment control structures (including temporary measures)	Condition and effectiveness of control Design freeboard is available	Monthly, or after 20 mm rainfall	
Mining Unit Plant / Drilling pads	Sump liner integrity, design freeboard available Spills or leakage	Monthly	
Chemical and Hydrocarbon storage areas	Bund integrity and capacity available Spills or leaks Spill kits available and stocked	Monthly	
Processing plant	Spills and leaks Drainage and sumps clear Any chemical drums containers stored in appropriate areas	Monthly	
Waste water treatment plant	Spills/leaks General operating condition	Daily	
RO plant	Spills/leaks	Monthly	

12. Adaptive Management

To facilitate continuous improvement of the environmental management system, the following sections outline protocols and procedures that will be followed in the event that an exceedance of the WMP assessment criteria or other unforeseen impact occurs.

The approach to management of groundwater during the underground mining trial will be adaptive. The adaptive management approach will allow for the use of the monitoring data to address the risks and impacts to the groundwater system and allow for ongoing environmental impact assessment to vary (if, appropriate) the trigger criteria should impacts be identified as negligible. This is especially the case for developing flexible operational hydraulic triggers, which will vary along the orebody/strike due to the inherent heterogeneity within the subsurface system. Any variation in trigger criteria will be approved via resubmission of this WMP.

12.1. Exceedance of performance criteria

This WMP has been developed to manage and monitor water-related risks associated with the Balranald Mine, to minimise the likelihood of exceedances of the performance criteria detailed in the project's operating approvals and licences. In accordance with SSD-5285 Schedule 5 Condition 2, if an exceedance of these criteria and/or performance measures occurs, Iluka will, at the earliest opportunity:

- Take all reasonable and feasible steps to ensure that the exceedance ceases and does not recur.
- If the exceedance constitutes an environmental incident or emergency, then this will be managed via the Pollution Incident Response Management Plan (PIRMP) and the protocols stated in Section 13.5.
- Undertake an investigation into the cause of the exceedance and contributing factors.
- Consider all reasonable and feasible options for remediation (where relevant) and
- Communicate and submit a report to regulator and community stakeholders as required, describing the nature of the exceedance, investigation outcomes and any remediation options or actions, if required.
- Implement remediation measures as directed by the EPA or Planning Secretary.

The following investigation, assessment and notification protocols will be followed in the event of an exceedance of the stated performance criteria within this WMP.

12.1.1. HOC Exceedance

An adaptive exceedance protocol in response to an exceedance of the hydraulic operating conditions is provided in Table 26.

Table 26- HOC exceedance protocol

Exceedance condition (detected by real-time monitoring at VWPs). Refer to Table 14 for HOC values.		**Action**	**Response**
Green	Normal Operations	Continue monitoring	Normal Operations, no action required.
Yellow	Leading indicator	- Control room operator, as soon as practically possible, to: - validate data, check for data / instrument errors - If data valid, notify the Mining and Environment Superintendents. - Closely monitor trends and if trend is increasing, adjust mining operations to decrease the reinjection pressure and bring values back within the Green operating thresholds.	
Red	Non-compliance SF only, following 72-hours of sustained exceedance above red HOCs	- Environmental incident (loss Control Card) logged in Incident Management System. - Within 7 days (Schedule 5 Condition 6), Environment Superintendent to: - Notify Operations Manager - Notify DCCEEW and EPA. - As soon as practically possible, Operations Manager to: - modify operations to reduce the groundwater pressures and bring the pressures back to within the green operating conditions.	- Incident investigation to identify cause and corrective actions. - If required, investigate environmental impacts and remediation options. - if required, and where no material environmental harm has occurred, review and update the HOC criteria and resubmit this WMP for approval.

12.1.2. Water Quality SSTL Exceedance

An adaptive exceedance protocol linked with the groundwater quality SSTL triggers (section 10.6.2) is presented in Table 27.

Table 27- Water Quality SSTL exceedance protocol

Exceedance condition (detected by routine water quality monitoring as outlined in Section 10.7.)		**Action**	**Response**
Green	Normal Operations	Continue monitoring	Normal Operations, no action required.
Yellow	Leading indicator (Exceedance within transition zone bores)	- As soon as practically possible, Environment Advisor to: - notify Environment Superintendent. - Review data quality and validate. - Review laboratory data to check for evidence of metal mobilisation and determine potential causes for the exceedance. - If required, conduct additional sampling to further investigate. - Notify Operations Manager	- Increase the frequency of monitoring. - If evidence of metal mobilisation is found, or if PAX concentrations are greater than modelled, install additional monitoring bores as outlined in Table 23.
Red	Non-compliance (Compliance bores only, as described in Section 10.6)	- Environmental incident (loss Control Card) logged in Incident Management System. - Within 7 days (Schedule 5 Condition 6) Environment Superintendent to: - Notify DCCEEW and EPA.	- Incident investigation to identify cause and corrective actions. - Engage an expert to assess any potential environmental impacts and, if required, remediation options. Provide the report to DCCEEW and EPA. - if required, and where no material environmental harm has occurred, review and update the SSTL criteria and resubmit this WMP for approval.

12.1.3. Process Water Reinjection Exceedance

An adaptive exceedance protocol linked with the process water reinjection triggers is provided in Table 28.

Table 28- Process water reinjection exceedance protocol

Exceedance condition (detected by routine process water quality monitoring as outlined in Section 10.6.1).		**Action**	**Response**
Green	Normal Operations	Continue monitoring	Normal Operations, no action required.
Yellow	Leading indicator (detected via real-time process water monitoring and/or process water sampling).	- As soon as practically possible, Processing Plant Operator to: - notify Environment Superintendent. - Validate data by checking for instrument faults, subsequent readings, including additional sampling if required. - Notify Surface Mining and Concentrating Superintendent - As soon as practically possible, Ore Processing Superintendent to: - Dose the process water with neutralising agent to bring the process water pH into the green operating threshold.	- If required, increase the frequency of monitoring.
Red	Non-compliance Confirmed after 48 hours of consecutive monitoring rounds with exceeded values and validated data.	- Environmental incident (loss Control Card) logged in Incident Management System. - Within 7 days (Schedule 5 Condition 6) Environmental Superintendent to: - Notify DCCEEW and EPA. - Surface Mining and Concentrating Superintendent to take immediate action to prevent and/or minimise ongoing exceedance of the criteria.	- Incident investigation to identify cause and corrective actions. - Engage an independent expert to assess any potential environmental impacts and, if required, remediation options. Provide the report to DCCEEW and EPA. - if required, and where no material environmental harm has occurred, review and update the SSTL criteria and resubmit this WMP for approval.

12.1.4. Aquifer drawdown exceedance

If groundwater drawdown trigger levels exceed the levels stated in Table 19, the following investigation protocol will be used.

- The potential exceedance will be promptly reported to the Environment Superintendent and Operations Manager.
- Groundwater data will be verified with additional monitoring and supporting data from other bores.
- Once the data is verified and the exceedance is confirmed, DPHI will be notified in writing within 7 days (Schedule 5 Condition 6) and provided with the available information and any management or mitigation actions undertaken.
- Within 30 days, a specialist hydrogeologist will be engaged in consultation with DCCEEW to undertake an assessment of groundwater impacts relative to EA predictions.
- Any further assessment, management and mitigation measures in response to the exceedance will be developed in consultation with DPHI. Any potential impact to private water supply will be handled in accordance with SSD-5285 Schedule 3 Condition 13 (see Section 11.2).

12.1.5. Rinse/seepage pH and NPR exceedance

An adaptive exceedance protocol linked with AMD management triggers is provided in Table 29.

Table 29- Rinse/seepage pH and NPR exceedance protocol

Exceedance condition (detected by routine AMD monitoring as outlined in Section 10.5).		**Action**	**Response**
Green	Normal Operations	Continue monitoring	Normal Operations, no action required.
Yellow	Leading indicator	- As soon as practically possible, Environmental Advisor to: - notify Environment Superintendent. - Review data quality and validate. Undertake repeat testing on individual samples to identify location of low pH samples - If required, conduct further testing to determine NPR of areas that have pH<6. - Notify Operations Manager	- Add limestone to the stack to achieve an NPR of 2 and retest. - Review limestone dose rates and other QA/QC data to identify the issue.
Red	Non-compliance Confirmed after repeat testing and validated data.	- Environmental incident (loss Control Card) logged in Incident Management System. - Repeat testing to identify locations of low pH samples. - Determine NPR of areas that have a pH<6. -Add limestone to the stack to achieve an NPR of 2 and retest. - Within 7 days (Schedule 5 Condition 6) Environment Superintendent to: - Notify DPHI and EPA.	- Incident investigation to identify cause and corrective actions. - Review limestone dose rates and other QA/QC data to identify the issue. Provide the report to DPHI and EPA. -Update procedures if necessary to prevent recurrence of exceedances and resubmit this WMP for approval.

12.2. Unforeseen Impacts

In the event that any unforeseen failure of the water management system occurs, or unforeseen surface water or groundwater impacts are detected, the following general response procedure will be initiated:

- As soon as practically possible, check and validate the data/information which indicates an unforeseen impact, this may involve resampling.
- If required, instigate environmental incident procedures, including DPHI and EPA notifications.
- Review the unforeseen impact, including consideration of:
  - Any other relevant monitoring data; and
  - Current operational activities and land management practices;
- Provide a preliminary investigation report to DPHI, EPA and relevant agencies within 7 days of identifying the unforeseen impact.
- If required, and nominally within 30-60 days, depending on the nature of the issue and regulator consultation required, commission an independent investigation by an appropriate specialist into the unforeseen impact.
- Implement appropriate contingency/remedial/monitoring measures, in consultation with DPHI and any other relevant agencies.
- Communicate results of investigation and subsequent contingency and remedial measures to government agencies as required.
- Review and update this WMP and resubmit to DPHI for approval.

12.3. Compensatory Water Supply

In accordance with SSD-5285 Schedule 3 Condition 13, Iluka will provide a compensatory water supply to the owner or leaseholder of any privately-owned land whose basic landholder water rights (as defined in the Water Management Act 2000) are adversely and directly impacted as a result of the Balranald Mine. This supply will be provided in consultation with DCCEEW, and to the satisfaction of the Secretary.

The compensatory water supply measures will provide an alternative long-term supply of water that is equivalent to the loss attributable to the development. Equivalent water supply will be provided (at least on an interim basis) as soon as practicable from the loss being identified, unless otherwise agreed with the landowner.

If Iluka and the landowner cannot agree on whether the loss of water is attributed to the development or the measures to be implemented, or there is a dispute about the implementation of these measures, then either party may refer the matter to the Secretary for resolution.

If Iluka is unable to provide an alternative long-term supply of water, then Iluka must provide alternative compensation to the satisfaction of the Secretary.

13. Compliance Monitoring and Reporting

13.1. Compliance Monitoring

Compliance for the Balranald Mine is to be achieved by:

- adherence to conditions of the Development Consent, EPA Licence, Mining Lease conditions and corporate policies;
- annual compliance reporting in the Annual Review;
- review of the EMPs within 3 months of an Annual Review, a reportable incident, an Independent Environmental Audit or modifications to the conditions of the Consent;
- regular compliance auditing (both internal and external)
- revision of risk assessments periodically or after a reportable incident or a new hazard is identified;
- identification of performance against criteria and/or performance measures; and
- implementation of corrective measures to rectify a non-compliance or performance issue.

Compliance with all approvals, plans and procedures will be the responsibility of all personnel (staff and contractors) employed on or in association with the mine.

Iluka maintains an electronic database system for the management of obligations, stakeholder interactions and compliance monitoring. Each compliance source and its associated obligations are periodically audited for compliance by the responsible person. Actions can be assigned to any obligation to ensure compliance is met, automatic email alerts prompt the actioners to undertake the required tasks.

Iluka also maintains an electronic database system for the storage and management of environmental monitoring data. Compliance reports can be generated from the database and compared against known performance criteria or trigger levels. Monitoring schedules and alerts can be setup to notify environmental staff of required monitoring events.

Iluka environmental staff undertake scheduled environmental inspections of work areas to identify environmental hazards, which are reported and managed via Iluka's electronic inspection management system.

In accordance with Schedule 5, Condition 6A of the Consent, non-compliances will be reported to DPHI within seven (7) days of becoming aware of the non-compliance. Notification will be in writing via the Departments Major Projects Website and detail the reasons for the non-compliance and what actions have been, or will be, undertaken to address the non-compliance.

13.2. Environmental reporting

13.2.1. Annual Review

In accordance with Schedule 5, Condition 4 of the Development Consent (SSD-5285), Iluka will submit an Annual Review to DPHI before 31 March each year for the previous year.

The Annual Review will specifically address the following aspects of Condition 4, which directly relate to water:

- include a comprehensive review of the monitoring results and complaints records of the development over the previous calendar year, which includes a comparison of these results against:
- the relevant statutory requirements, limits or performance measures/criteria;
    - the monitoring results of previous years; and
    - the relevant predictions in the EIS;
- identify any non-compliance over the last year, and describe what actions were (or are being) taken to ensure compliance;
- identify any trends in the monitoring data over the life of the development;
- identify any discrepancies between the predicted and actual impacts of the development, and analyse the potential cause of any significant discrepancies; and
- describe what measures will be implemented over the next year to improve the environmental performance of the development.

13.2.2. Annual EPA Return

Environment Protection Licence (20795) requires the inclusion of a monitoring and complaints summary in Iluka's Annual Return that is completed and supplied to the EPA not later than 60 days after the end of each reporting period. Water quality is required to be reported to the EPA as part of the Annual Return.

Water quality information included in the Annual Return includes:

- a statement of compliance;
- a monitoring and complaints summary including;
    - an analysis and interpretation of monitoring results; and
- actions to correct identified adverse trends.

The Annual Review and Annual EPA Return and any water quality monitoring results will be published on the Iluka website in accordance with Schedule 5, Condition 10 of the Development Consent (SSD-5285).

13.3. Other environmental reporting

In accordance with Schedule 5, Condition 3 of NSW Development Consent (SSD-5285), Iluka has developed protocols for managing and reporting the following:

- incidents;
- complaints;
- non-compliances with statutory requirements; and
- exceedances of the impact assessment criteria and/or performance criteria.

Environmental reporting requirements including timing, submission and distribution methods are summarised in Table 30.

In accordance with Schedule 5, Condition 7 of NSW Development Consent (SSD-5285), Iluka will provide regular reporting on the environment and community performance of the Balranald Mine on the Iluka website community engagement hub (https://www.iluka.com/community-engagement/balranald/)

Table 30- Environmental reporting requirements

Report	Frequency	Distribution	Distribution Method
Incident Report	Notification immediately when becoming aware and reported via DPHI Major Projects Portal.	DPHI and any relevant agencies	Planning Portal/ Email
Annual Review	Annually by 31 March each year.	DPHI and any relevant agencies	Planning Portal/Iluka website
Annual Return	Annually by 8 August (60 days from end of reporting period)	NSW EPA	eConnect EPA /Iluka website
Independent Environmental Audit Report	Every 3 years (Commencing within 1 year of the commencement of construction)	DPHI	Planning Portal/Iluka website
Annual Rehabilitation Report & Forward Program	Annually by 1 March (60 days from end of reporting period)	NSW Resources Regulator	Regulator Portal/Rehabilitation Portal/Iluka website

13.4. Environmental auditing

Within 1 year of the commencement of construction and every three years thereafter, a full Independent Environmental Audit will be undertaken, as required by Schedule 5, Condition 8 of NSW Development Consent (SSD-5285). The Independent Environmental Audit will include consultation with all relevant agencies and will be conducted by a suitably qualified experienced and independent team of experts whose appointment has been endorsed by the Secretary of the DPHI.

The Independent Environmental Audit will:

- assess the environmental performance of mining and assess whether it complies with the requirements of all relevant approvals;
- review the adequacy of any approved strategy, plan or program required under all relevant approvals; and
- recommend measures or actions to improve the environmental performance of mining and/or any strategies, plans or programs required under the relevant approvals.

A copy of the Independent Environmental Audit along with the response to any recommendations contained in the audit report, will be provided to the Secretary of the DPHI and made available on the Iluka website.

13.5. Environmental incident and emergency management

13.5.1. Environmental incidents

An incident is defined as a set of circumstances that causes or threatens to cause material harm to the environment, and/or breaches or exceeds the limits or performance measures/criteria in NSW Development Consent (SSD-5285).

Following the Group Guideline -Hazard Incident Emergency Classification (GUI1135), incidents of serious actual or potential consequence must be immediately notified to the Environment, Rehabilitation and Community Relations (ERCR) Superintendent (or equivalent environment representative) and site Operations Manager or their delegate.

The ERCR Superintendent (or equivalent environment representative) shall then:

- Determine if the incident is a 'notifiable incident' for notification to a Regulator.
- Consult with the Operations Manager or their delegate and the Environment Manager to agree on incident classification and notification requirements.
- Complete the notification within the legislated timeframes.
- Determine if the incident is a 'reportable incident' for inclusion in reports to the Regulator.

The reporting of incidents will be conducted in accordance with Schedule 5, Condition 6 of NSW Development Consent (SSD-5285) and in accordance with the protocol for industry notification of pollution incidents under Part 5.7 of the Protection of the *Environment Operations Act, 1997*.

Iluka will immediately notify the Department and any other relevant agencies immediately after the authorised person becomes aware of the incident and set out the location and nature of the incident. The DPHI can be notified of incidents via the Major Projects Website https://pp.planningportal.nsw.gov.au/major-Projects and the NSW EPA can be notified by telephoning the hotline on **131 555.**

The incident report will:

- describe the date, time and nature of the exceedance/incident;
- identify the cause (or likely cause) of the exceedance/incident;
- describe what action has been taken to date; and
- describe the proposed measures to address the exceedance/incident.

13.5.2. Environmental emergencies

Iluka will maintain a Pollution Incident Response Management Plan (PIRMP) for the Balranald Mine in accordance with Condition R1.1 of Environment Protection Licence 20795. The PIRMP outlines the process for responding to environmental emergencies in a timely and effective manner and adopting appropriate measures for the control and recovery from emergencies. Where appropriate, environmental emergency response procedures will be integrated with the Balranald Emergency Control and Response Plan.

Preparedness for emergencies by staff, personnel, contractors and service providers will be undertaken in accordance with on-site training requirements whereby personnel will be appropriately trained in the use of emergency response equipment and procedures, and will be made aware of their responsibilities should such an event occur. A list of external agencies that may be required in the event of an emergency is presented in Table 31.

Table 31- External agency contact details

Name	Contact details	Location
Police	000 03 5898 4980	Balranald
Ambulance	000	Balranald
NSW Rural Fire Service	000	Balranald
Fire and Rescue NSW	000 03 5020 1577	Balranald
NSW Volunteer Rescue Squad	03 5020 1966	Balranald
Hospitals	03 5071 9800	Balranald Multi-Purpose Health Service
	03 5033 9300	Swan Hill District Hospital (emergency)
	03 5022 3333	Mildura Base Hospital (emergency)
NSW State Emergency Service	13 25 00	www.ses.nsw.gov.au
NSW Poisons Information Centre	13 11 26 (24-hour hotline)	www.poisonsinfo.nsw.gov.au
NSW Environment Protection Authority(EPA)	13 15 55	www.epa.nsw.gov.au
NSW Resources and Energy – ResourcesRegulator	1300 814 609	www.resourcesregulator.nsw.gov.au
SafeWork NSW	13 10 50	www.safework.nsw.gov.au
Balranald Shire Council	03 5020 1300	Balranald

14. WMP review and revision process

In accordance with Schedule 5, Condition 5 of Development Consent (SSD-5285), the WMP will be reviewed within 3 months of the submission of:

- the Annual Review;
- a reportable incident;;
- an Independent Environmental Audit; and
- any modification to the conditions of the Consent.

Where the review leads to revisions in any document, a revised document will be submitted to the Secretary of the DPHI within 4 weeks of the revision occurring.

15. References

DES 2021, Using monitoring data to assess groundwater quality and potential environmental impacts. Version 2. Department of Environment and Science (DES), Queensland Government, Brisbane.

EMM Consulting Pty Ltd (EMM), 2015 Balranald Mineral Sands Project, Environmental Impact Statement

EMM Consulting Pty Ltd, 2019 Balranald bulk sampling activities historical groundwater assessment and summary report, prepared for Iluka Resources Limited, October 2019.

EMM Consulting Pty Ltd, 2021 Balranald Mineral Sands Project- Hydrogeological assessment of the T3 mining trial, prepared for Iluka Resources Limited, dated February 2021.

EMM Consulting Pty Ltd, 2022 Balranald Groundwater Comparative Impact Assessment in support of Modification No. 1.

EMM Consulting Pty Ltd, 2022 Balranald Mineral Sands Project – Modification of Consent (SSD-5285) Surface Water Assessment.

EMM Consulting Pty Ltd, 2024 Balranald Project – Groundwater modelling for process change and surface tailings emplacement.

EPA, 2022. Approved methods for the sampling and analysis of water pollutants in NSW https://www.epa.nsw.gov.au/-/media/epa/corporate-site/resources/water/22p3488-approved-methods-for-water-in-nsw.pdf?la=en&hash=19C9070D145112CD4B8317E5EFCAFBD1C0575A50

Stone, Y., Ahern, C.R., and Blunden, B., 1998. Acid Sulfate Soils Manual 1998. Acid Sulfate Soil Management Advisory Committee, Wollongbar, NSW, Australia.

Worley, 2022. Balranald Mineral Sands Project Definitive Feasibility Study – Flood Impact Assessment

Appendix A- Project Environmental Setting

The summarises the environmental setting of the project, relevant to this WMP. More detailed information is available in the environmental assessment documentation for the project.

Topography

The regional setting and approved EIS project area are shown in Figure 1.

The topography across the project area is mostly flat with only minor fluctuations in elevation observed. Across the project expanse the elevation rises from 62 m Australian Height Datum (AHD) in the south, at the West Balranald deposit to 100 m AHD in the north, at the Nepean deposit.

The southern half of the West Balranald deposit gently undulates from 62 to 70 m AHD. The terrain of the Nepean mine is slightly more undulating with elevations ranging from 64 m AHD in the southeast corner to a maximum height of 100 m AHD in the centre west. The Nepean mine terrain gently slopes to a low of approximately 86 m AHD to the north of the project area. The basement fault structure has a material impact on the topography of the area and the change in elevation at the Nepean deposit is a result of basement faulting (EMM, 2015).

Land Use

Land uses within the Balranald Local Government Area (LGA) comprise mostly of agricultural pastoral activities with some fruit growing. Grazing utilises approximately 95% of all agricultural land with dryland cropping comprising a minor portion of agricultural activities at 1%. The primary crops grown are cereals for grain, mainly wheat and barley. Irrigation occurs over only 0.4% (approximately 8,000 ha) of the total agricultural area (ABS 2011).

The Yanga National Park and Murrumbidgee River are approximately 13 km south-east of the West Balranald deposit. Mungo National Park and Willandra Lakes Region World Heritage Area (WLRWHA) are approximately 39 km from the northern extent of the West Balranald deposit.

No substantial mining land use currently exists within the Balranald LGA, although there are several mineral titles. A small gypsum mining operation is located to the east of the project area. An approved mineral sands mine, known as the Atlas-Campaspe Mineral Sands Project, is located approximately 40 km north of MOD1, with approval granted in 2014. This project is currently under construction and operations are expected to commence in 2022.

Climate

The project area is characterised as semi-arid, with hot dry summers and cold winters. Climatic data from the Bureau of Meteorology's (BoM) weather station at Balranald town (BoM station: 049002) indicates monthly mean minimum temperature ranges from 3.5 degrees Celsius (°C) to 16.4°C and the monthly mean maximum temperature ranges from 15.7°C to 33°C. Temperature data at this station has been collected from 1907 until present.

Rainfall data from the Balranald BoM station reports the average monthly rainfall at 27 mm; the rainfall record commenced in 1879. As seen in Figure A1 mean monthly rainfall is evenly distributed throughout the year, with the highest median rainfall over spring and the lowest median rainfall over summer.

WRM (2015) reports that evaporation at Balranald is greater than rainfall for all months, monthly pan evaporation averages 159 mm. Evaporation greatly exceeds rainfall in warmer months, this is highest in January where the maximum monthly mean pan evaporation is 301 mm and the mean monthly rainfall is 22.3 mm. At Mildura Airport (BoM station number 076031) (approximately 160 km northwest), the average, monthly evaporation is 182 mm and the annual evapotranspiration is 350 mm (Jacobs 2015).

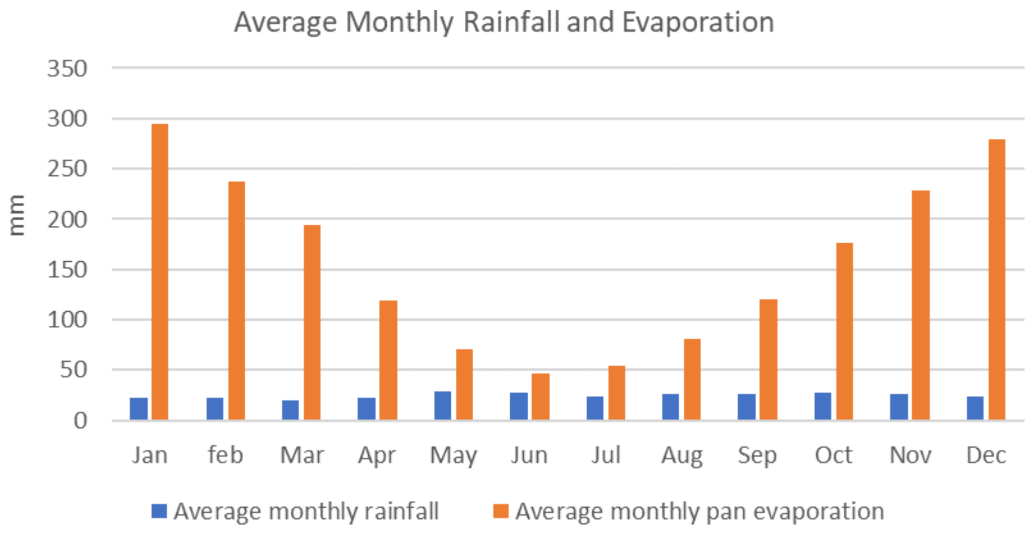


Figure A1: Average monthly rainfall and pan evaporation (1889-2021; SILO, 2022)

Hydrology

On a regional scale, the Murrumbidgee and Murray rivers are the major permanent surface water features in the vicinity of the Balranald Project area. The Lachlan River terminates at the Great Cumbung Swamp, approximately 48 km east of the Balranald Project, a major permanent surface water feature in areas upstream of Balranald. The Murrumbidgee and Murray rivers provide key water resources for large populations within the Murray Darling Basin including town water supplies, agriculture and the environment. The Murrumbidgee River occurs about 10 km south of the Balranald Project, and flows in a south-westerly direction, to its confluence with the Murray River about 40 km to the south-west of the Balranald township.

Locally, the main surface water feature within the Balranald Project area is Box Creek, which is an ephemeral watercourse (and does not intercept the watertable) and a tributary of the Murray River. Almost all of the Balranald Project is located within the Box Creek catchment, however the creek only flows during and immediately following heavy local rainfall or large flooding events. Flow has only occurred in Box Creek on occasions in the last 60 years (WRM, 2015). Permanent surface water flows are confined to the major rivers and their associated backwaters outside of the Balranald Project area.

Due to the dry climate, flat landscape, and large areas of permeable soils, there is little locally derived runoff in the MOD1 project area and no permanent surface water sources. Extremely heavy local rainfall events are capable of filling local depressions, including dry relic beds and creating temporary flow in drainage features, such as Box Creek.

During Lachlan River flood conditions, Merrowie Creek (Figure A2) may receive flood waters. If flood conditions are high and sustained, flood waters may traverse Merrowie and Middle creeks to Tarwong Lake, located 96 km NE from the MOD1 project area. From Tarwong Lake, flood waters may flow along Box Creek for approximately 150 km, through a number of typically dry ephemeral lakes before reaching Muckee, Pitarpunga and Tin Tin Lakes.

Muckee, Pitarpunga and Tin Tin Lakes lie to the north and east of the MOD1 project area. If these lakes become full (they are typically dry), water will drain to the Box Creek outlet of Tin Tin Lake to the west of the MOD1 project area and flow south to Arumpo Creek and then to the Murrumbidgee River, approximately 30 km south-west of the MOD1 project area.

The majority of the MOD1 project area drains into dry lakes or depressions; very little to no local runoff enters Box Creek (WRM, 2015) (see Figure XX).

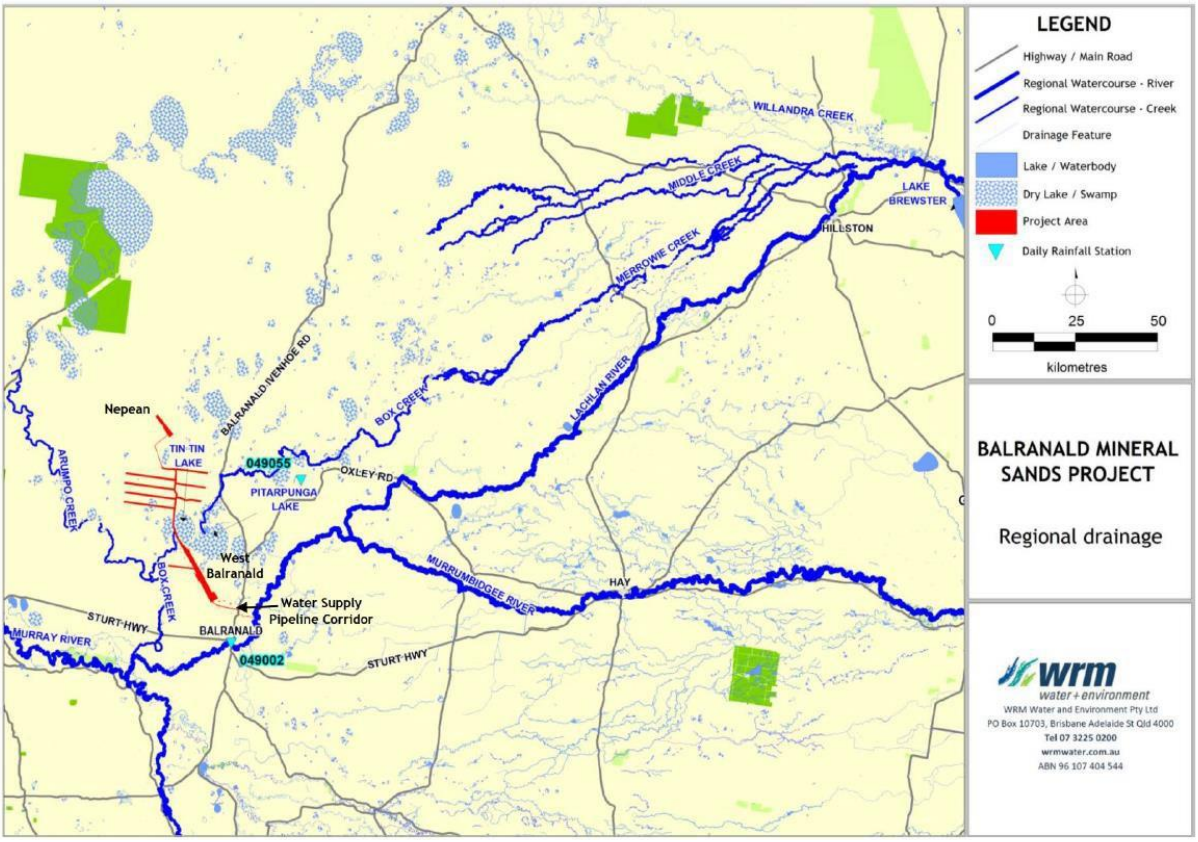


Figure A2: Regional surface water features and project area (WRM, 2015)

Geology

The Balranald Project is located in the centre of alluvial sediments of the Murray Basin, within the central west of the Riverine Plain. Subregions within the Murray Basin are defined by surface geomorphology and the presence of the Ivanhoe Block and associated structures. Within the project area the basal unit of the Murray Basin, which directly overlies the basement rocks (comprising Proterozoic and Palaeozoic rocks), is the Olney Formation; a geological unit deposited during the Paleogene to the mid-Miocene periods. The Olney Formation sediments are predominantly continental, but marginal marine units such as the Geera Clay, interfinger through the middle sequence to the east of the project area.

In the eastern end of the Murray Basin, the Olney Formation is overlain by the Calivil Formation which is in turn overlain by the Shepparton Formation. In the west, the Olney Formation is overlain by the Loxton-Parilla Sands Formation which is in turn overlain by aeolian sands of the Shepparton Formation. The Calivil Formation laterally interfingers and grades into the Loxton-Parilla Sands at the eastern edge of the Riverine Plain. The regional stratigraphy system of the Murray Basin is conceptually shown on Figure A3.

Within the project area, the combined thickness of the Murray Basin sediments ranges from 250 m to 290 m, with the local geology summarised in Table A1. The Shepparton Formation and Loxton-Parilla Sands range in thickness between 60 m to 100 m, while the Geera Clay and Olney Formation have a combined thickness of 190 m. The basement structure has significant influence on the geologic structure of both the overlying geology and associated groundwater flow in the project area (Kellett 1991 and 1994).

Table A1: Local geology of the Balranald Area (after EMM, 2022)

Age	Group	Unit	Lithology
Pre-Tertiary		Basement rock	
Eocene to Early Oligocene	Lower Renmark Group	Olney Formation	Unconsolidated to poorly consolidated, blue-grey/dark-brown carbonaceous sand and silt.
Oligocene to Middle Miocene	Middle Renmark Group	Olney Formation	Unconsolidated to poorly consolidated, dark-grey, blue, or black carbonaceous clay or silty sand. Commonly pyritic and ligneous.
Late Oligocene to Middle Miocene	Murray Group	Geera Clay	Poorly consolidated, plastic to friable, dark greenish-grey or black silt and clay. Potentially glauconitic, pyritic, calcareous, carbonaceous, or fossiliferous. Local sandy and dolomitic hardbands.
Middle Miocene	Upper Renmark Group	Olney Formation	Unconsolidated to poorly consolidated, brown-grey, carbonaceous, medium to fine sand with interbedded silt. Micaceous and pyritic.
Late Miocene to Early Pliocene	Wunghnu Group	Calivil Formation	Interbedded clay, silty clay, silt and fine to coarse-grained quartz sand, reef quartz and metasediment gravel. Minor ligneous clay.
Late Miocene to Pliocene		Loxton-Parilla Sands	Unconsolidated to weakly cemented, yellow-brown, fine to coarse, well to poorly-sorted, quartz sand and sandstone. Minor clay and silt.
Quaternary (Holocene)		Floodplain Sediments: (Coonambidgal Formation)	Exists within the Murray River floodplain. Unconsolidated, grey, brown, micaceous silty clay, silt, polymictic sand and gravel.

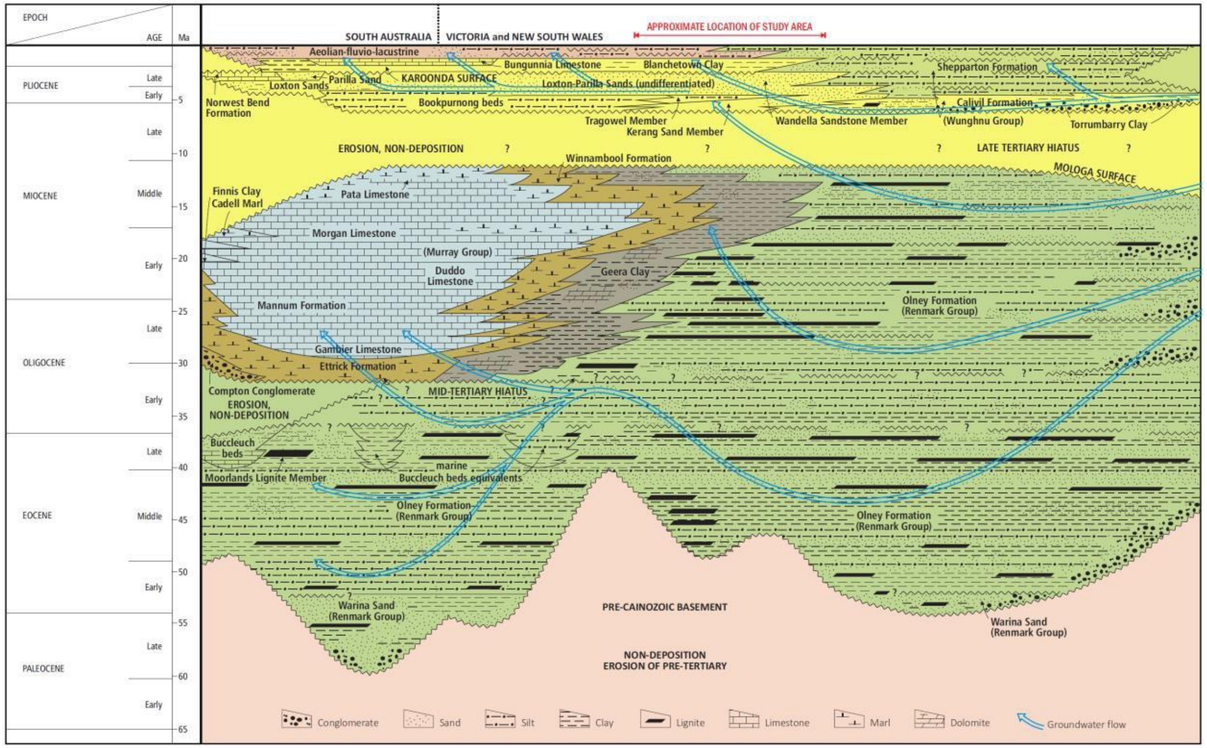


Figure A3: Aquifer systems of the Murray Basin (EMM, XX, after Evans and Kellet, 1989 and Brown and Stephenson, 1991).

Hydrogeology

The Murray Basin is a closed groundwater basin that has regional aquifer systems, confining layers and permeability barriers to groundwater flow. There are three regional groundwater systems within the Basin: Riverine (eastern and southern), Mallee–Limestone (southwestern) and Scotia (northwestern) (EMM, 200 after Evans and Kellet 1989). The dominant groundwater flow direction is from east to west, although flow tends to converge in the centre of the western boundary of the Riverine province. In the east, the Murray Basin alluvial sediments are targeted for fresh water supplies, with the Lower Lachlan, Lower Murrumbidgee and Lower Murray Groundwater Management areas providing over 550,000 ML of groundwater rights to users in these three areas alone. However, in a westerly direction the water quality becomes increasingly saline, sediments become finer, and average bore yields decline.

Within the project area groundwater resources are too saline for purposes such as irrigation and town water supplies. Extractive water use in the Balranald Project area is typically only for stock watering via groundwater bores.

Groundwater in the project area (Figure A4) is associated with the Shepparton Formation, Loxton Parilla Sands and Olney Formation. The Geera Clay is an aquitard with low yields and is not targeted for water supply.

The Shepparton Formation consists of a thick layer of unconsolidated to poorly consolidated clayey sand and silty clays with interbedded sand lenses. This unit is highly variable across the West Balranald deposit and drilling has defined two dense clay layers (locally up to 4 m to 6 m thick). Moderately to strongly iron cemented rock layers are also present within the sand dominant lenses between the clay layers. The thickness of the unit varies from approximately 19 m at the northern end to more than 36 m through central and southern areas of the West Balranald deposit.

The upper Loxton-Parilla Sands marine sequence (referred to as LPS1) varies in thickness along the strike of the deposit from 16–20 m in the north to more than 60 m at the southern end. The sequence typically consists of three upper beach facies: foreshore, surf zone and lower shore; the different facies have varying horizontal hydraulic conductivities. A marine transgression marks the boundary between the LPS1 and the lower (older) marine sequence. The lower marine sequence (LPS2) is host to the West Balranald deposit and also consists of three facies (foreshore, surf zone and lower shore) with the mineral sands deposit typically lying within the foreshore facies of LPS2. Explorative drilling along the length of the West Balranald deposit confirmed the presence of confining Geera Clay along the strike of the West Balranald mine below the LPS2.

Within other geologic units, sediments are observed to be heterogeneous in nature and can act as localised and temporal aquifers. The Olney Formation is the regionally extensive early-Tertiary lacustrine system, specifically underlying the wider Balranald Project, and consists of the Upper, Middle and Lower Renmark Group.

The Palaeozoic rocks of the Lachlan Fold Belt underlie the Murray Basin sediments and form the basement to the basin. The basement contains structures such as ridges and troughs that have influenced deposition of the sediments and therefore also influence the hydrogeology of the Murray Basin.

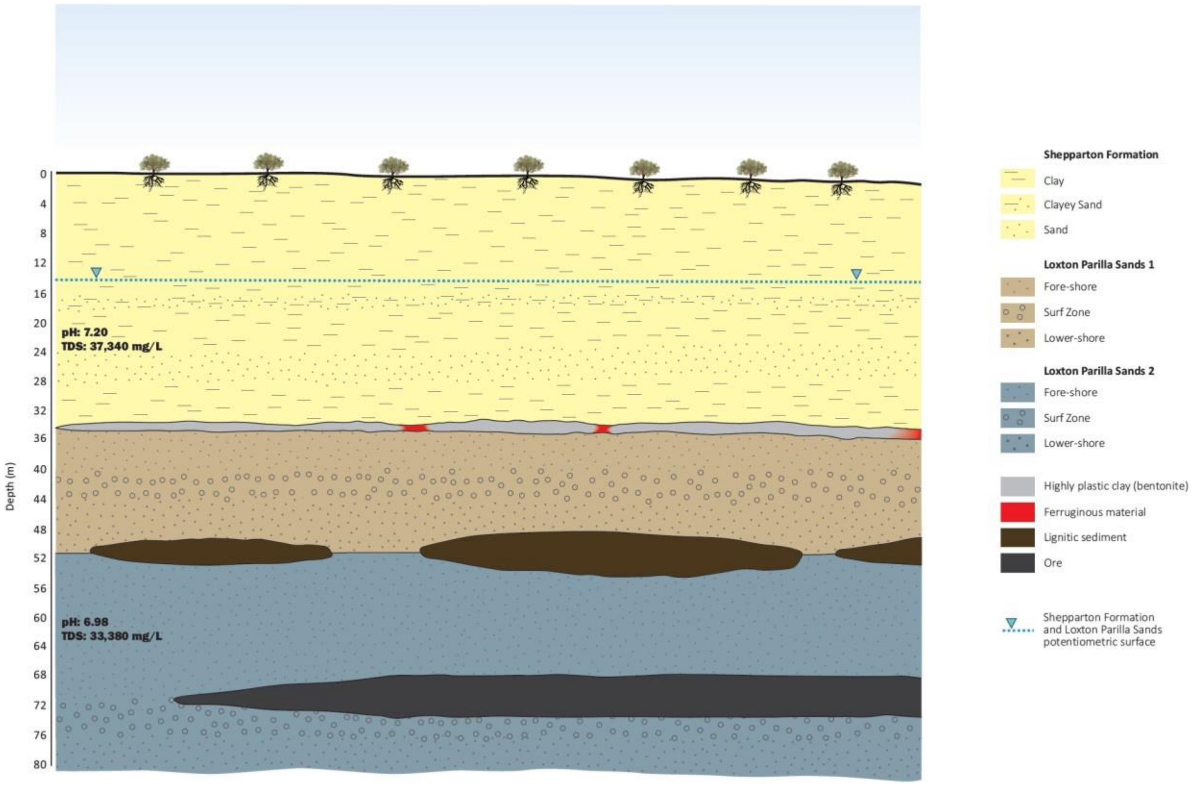


Figure A4: Conceptualised hydrostratigraphy in the T3 bulk sampling activity area (after EMM, 2022).

Regional groundwater level measurements taken during 2014 and part of previous detailed feasibility studies (prior to any large-scale site activities), were used to develop plan-view unstressed potentiometric surfaces (i.e. groundwater level contours). Figure A5 shows the unstressed (ie. Natural conditions) potentiometric surface for the Shepparton Formation (SFM) (0.5m interval), Loxton-Parilla Sands (LPS) (0.5m interval) and Olney Formation (OFM) (1m interval). These potentiometric surfaces suggest (EMM, 2022):

- The potentiometric surfaces for the SFM and LPS are near identical under natural/unstressed conditions, with the SFM hosting the water table across the West Balranald deposit. At Nepean, the water table is hosted within the LPS.
- Local groundwater occurring at elevations greater than 52 mAHD prevail at the southern end of the West Balranald deposit. Groundwater levels between 48 and 49 mAHD dominate further north.
- The local groundwater flow direction is from the south-east to the north-west.
- Groundwater heads recorded within the Olney Formation range from 63 mAHD at the southern end of the West Balranald deposit, to 57 mAHD to the west. The prevailing groundwater flow direction in this unit is from east to west, and consistent with the historical groundwater maps produced by Kellet (1989, 1994).

On a regional scale, the Ivanhoe Block impedes westerly throughflow in the Riverine Plain as the regional aquifer either thins out over the rising basement block or is truncated by it. At the boundary of the Ivanhoe Block flow lines in the deeper aquifers are deflected north and south, and flow lines in the shallower aquifers on top of the ridge line are forced to converge. The Geera Clay also forms a hydraulic barrier to lateral flow in the middle Olney Formation, forcing westerly groundwater flow lines in the middle and upper Olney Formation to converge.

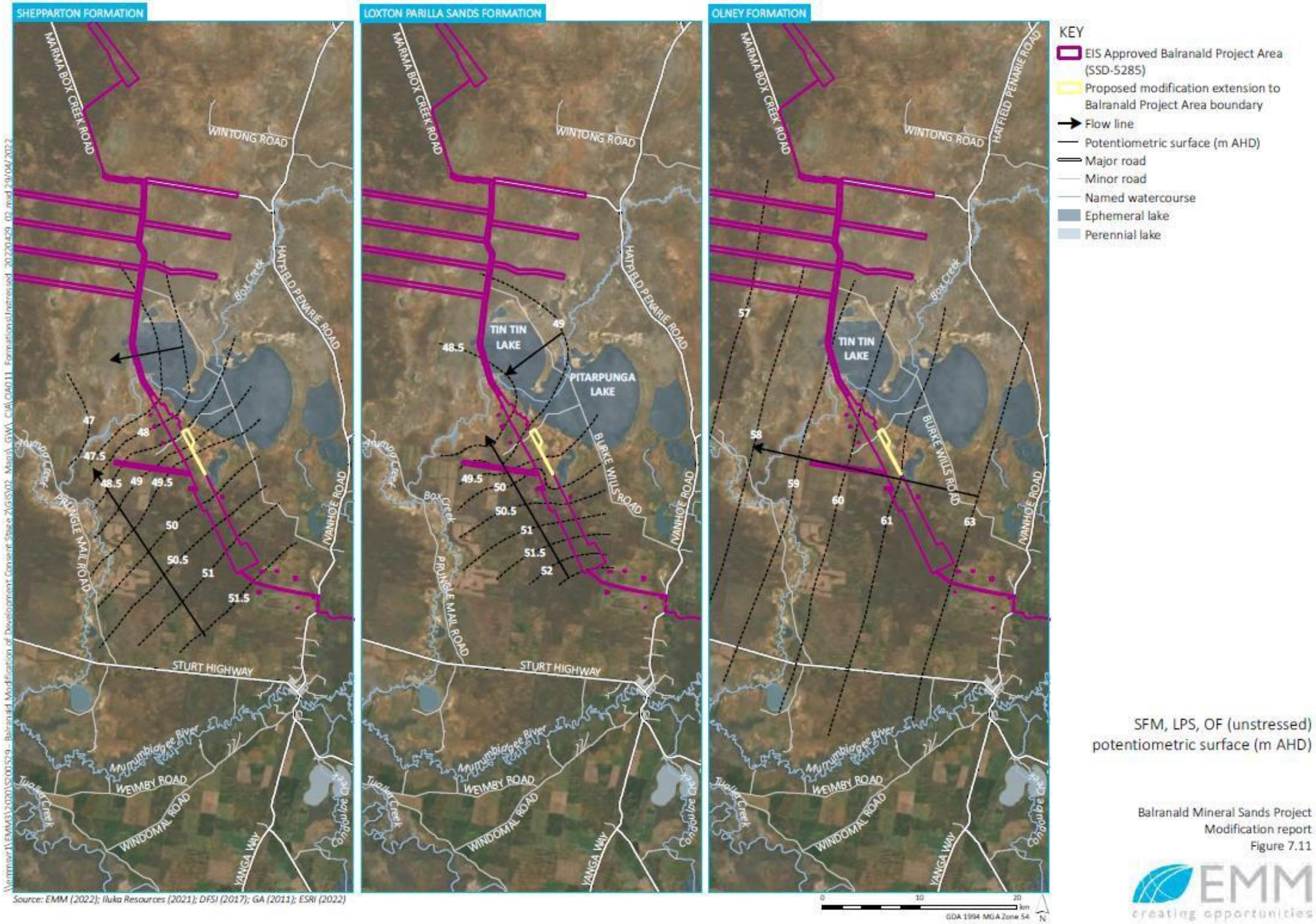


Figure A5: Baseline groundwater contours in the project area (EMM, 2022).

Appendix B- Record of consultation

Table B1: Water Management Plan consultation register.

DATE	OUTGOING / INCOMING	ORGANISATION	CONTACT MADE BY	CONTACT TO	CONTACT TYPE	COMMENTS
4/4/2023	Incoming	NSW EPA	NSW EPA	Iluka	Letter (DOC23/7200853-3)	No issues or comments raised in relation to this WMP.
6/4/2023	Incoming	NSW DPE-Water	NSW DPE-Water	Iluka	Letter (OUT23/5223)	DPE-Water made two recommendations: 1. Ensure that administrative requirements for water licencing are met prior to taking water. Iluka has included the latest information regarding the dealing applications in this version of the WMP. Once completed, dealings and licencing information will be included in subsequent versions of this WMP. 2. Inclusion of additional groundwater baseline data and specific timeframes around actions proposed for trigger exceedances or unforeseen impacts. Iluka has amended Appendix D and Section 12 accordingly.
24/10/2023	Incoming	NSW EPA	NSW EPA	Iluka	Email	No issues or comments raised in relation to this WMP.
30/10/2023	Incoming	NSW DPE-Water	NSW DPE-Water	Iluka	Letter (OUT23/17749)	DPE-Water made three recommendations: ○ The proponent should confirm what water sources the reference "…..if required other licensed off-site sources of fresh water will be used during the construction phase…." refers to. ○ The proponent should update the Water Management Plan to include: • a plan of the pipeline route from the site to the

						Murrumbidgee River • a plan of the location of the proposed pumping infrastructure, including Lot/DP details, pump, pipe and intake location, and point where pipeline trenching commences • details of the pipeline diameter, pump intake pipe diameter and pump capacity. ○ The proponent should update Table 7 to amend the date for the Guidelines for Controlled Activities on Waterfront Land from "DPI 2007" to "DPE 2022".
20/02/2025	Incoming	NSW EPA	NSW EPA	Iluka	Letter (DOC25/119528)	It is recommended that Iluka contact EPA directly should any necessary changes be identified to the premises' Environment Protection Licence (EPL) that may result from the proposed management plan updates.
13/03/2025	Incoming	DCCEEW	DCCEEW	Iluka	Letter (OUT25/2976)	DCCEEW made 3 recommendations: 1. The proponent should confirm if additional water supply works (eg. bores or dams) are required and update the Water Management Plan if necessary. 2. The Proponent: • Must ensure that Water Access Licences nominate relevant works through a dealing application prior to take occurring. • Should be aware that several of the listed work approvals (50WA514909, 60WA583168 & 60WA583169) have extraction limits or other conditions which may limit their use. 3. The proponent should update the last

						sentence of Section 12.3 to replace the word "applicant" with "Iluka".

Appendix C- Aspects and Impacts Register

Table C1: Aspects and impacts register relevant to this Water Management Plan

Ref#	Construction / Project Activity	Potential impacts / risks	Management and mitigation measures	Likelihood	Consequence	Mitigated Risk Ranking
CONSTRUCTION						
C1	Bore water supply (Olney formation)	- Over extraction of groundwater - groundwater level drawdown	- Metering according to DPE framework - Adequate water entitlement held to meet anticipated requirements - Extraction according to WAL & WSP Rules - Tracking extraction vs Allocation - model to predict drawdown and no impact identified - Monitoring program to measure drawdown	E	MO	L
C2	Construction of infrastructure	- Sedimentation of waterways - surface water contamination from chemical and hydrocarbon spills. - groundwater contamination from chemical and hydrocarbon spills. - Flooding	- Construction ESCP as per NSW Blue Book (to be included in Contract) - minimal hydrocarbon exposure (diesel). Negligible chemical exposure (general construction, small quantities) - Diesel tanks in self-contained bunds - Chemical and hydrocarbon storage and management according to Australian Standards (to be included in contract) - Environmental inspections of work areas - Emergency Response Procedures (PIRMP) - Flood assessment - Construction Environmental Management Plan - Spill kits and response procedure - Construction sequence to be optimised to manage environmental risks (e.g. flood levees). - environmental inspections of work areas - temporary water storages built to appropriate standards (Iluka standards)	D	MI	M

Ref#	Construction / Project Activity	Potential impacts / risks	Management and mitigation measures	Likelihood	Consequence	Mitigated Risk Ranking
C3	Top soil stripping and stockpiling	- sedimentation of waterways	- Construction ESCP in accordance with NSW Blue Book - soil stockpiles to be stabilised - environmental inspections of work areas	D	MI	M
C4	Site Access Roads	- Sedimentation of water ways - Flood inundation	- Flood model and assessment - Road design including culverts at low points - Contractor ESCP to be developed - Multiple stockpiles to be stabilised	D	MO	M
OPERATION						
O1	Site Access Roads	- Sedimentation of water ways - Flood inundation	- Flood model and assessment - Culverts at low points - ESCP (minimise disturbance area)	D	MI	M
O2	Top soil stripping and stockpiling	- sedimentation of waterways	- mining sequence optimised to minimise the amount of soil stockpiled - ESCP - soil stockpiles to be stabilised - progressive rehabilitation of disturbed areas as mining progresses	D	MI	M

Ref#	Construction / Project Activity	Potential impacts / risks	Management and mitigation measures	Likelihood	Consequence	Mitigated Risk Ranking
O3	Drilling and use of drilling muds for underground mining	- impacts to groundwater quality from drilling muds	- Specialist review (LWC, 2017) concluded environmentally benign. - Drilling muds contained within a closed mud system - inspection program	C	MI	M
O4		- Sedimentation of waterways from runoff from drill pads	- Drill pad ESCP - Drill pads progressively rehabilitated as mining progresses	C	MI	M
O5	Underground mining and backfilling: - removal of ore as slurry - Reinjection of process water, flotation tails, fine sands and supernatant from PAX dam	- changes to water access and quality for GDEs - changes to surface and groundwater interaction for watercourses, swamps and springs that receive baseflow - Changes to water access and quality for private bores	- groundwater model predicts no impacts to GDEs watercourses or swamps - groundwater model and validation, review process defined in WMP - groundwater drawdown monitoring program, with TARP to trigger model and impact assessment review of impacts outside of EA predictions	D	MO	M
O6		- Water table drawdown, aquifer depressurisation, changed groundwater flow paths, local induced flows, indirect take from the overlying Shepparton Formation. - Groundwater pressure increase within the LPS and/or water table mounding in the SFM.	- extracted under net-zero stope pressure conditions. Conditions monitored using VWPs installed in panels and monitored continuously via a central control room. - Groundwater monitoring program and data reviews to understand aquifer interactions. - Hydraulic Operating Conditions (HOCs) and TARP to investigate and/or modify operations if exceeded.	D	MI	M

Ref#	Construction / Project Activity	Potential impacts / risks	Management and mitigation measures	Likelihood	Consequence	Mitigated Risk Ranking
O7		- Introduction of PAX to LPS aquifer, PAX migration with groundwater flow, causing loss of beneficial use of groundwater due to PAX contamination	- aquifer has low beneficial use. Third party users are outside of model predicted impact area - optimisation of ore processing to minimise PAX usage - Conservative transport and fate modelling shows limited migration post mining. - PAX transport and fate model validation and calibration after xx months - groundwater level and quality monitoring program with TARP to review impact assessment if impacts outside EA predictions - Sorption onto particles is anticipated to remove PAX - Process water monitoring program to quantify PAF reinjection and rate of natural degradation - Groundwater monitoring will be undertaken post-operations to continue to monitor PAX plume migration and degradation.	D	MO	M
O8		- Introduction of AMD to LPS aquifer, acid migration with groundwater flow, localised dissolution of native metals present in aquifer solids and returning sulfide minerals to LPS aquifer. Potential for sulfides to have oxidised and generate acidity which is injected with the tails into the LPS aquifer. - the above causing loss of beneficial use of groundwater due to PAX contamination	- Slimes/fines to remain submerged in lined pond. - Flotation tails and sand fines will be amended with lime as needed to neutralise acidity. - Geochemistry monitoring program to characterise sulfide concentration of ore and waste as mining progresses. - Oxygen is limited in the groundwater and sulfide oxidation is unlikely to occur in the aquifer. - Treatment of PAF prior to reinjection if required (in HBF tank) - Groundwater model review and calibration process defined in WMP.	E	MO	L

Ref#	Construction / Project Activity	Potential impacts / risks	Management and mitigation measures	Likelihood	Consequence	Mitigated Risk Ranking
O9		- Process water salinity changing the beneficial reuse 'of the groundwater	- Use of lower salinity water for process (brackish water) - Water quality assessment shows salinity will be lower than baseline (due to mixing of water with OF water). - Groundwater monitoring program	E	MI	L
O10		- Impact to aquatic and terrestrial ecosystems located in close proximity to mine	- mining occurs within LPS which is not connected to the local ecosystems - groundwater model review and calibration process defined in WMP - monitoring program and TARP for review of impact assessment if impacts are outside of EA predictions	E	MO	L
O11	Stope development and progression	- Changes to the aquifer properties	- Modelling shows no lasting effect on groundwater levels or flow as a result of mine progression. - groundwater model and validation, review process defined in WMP	B	NE	M
O12		- Subsidence causing increased recharge / altered drainage in subsidence areas	- Subsidence model and impact assessment complete - Groundwater assessment predicts negligible impact due to changed aquifer properties. - Mining method anticipated to result in uniform subsidence - Preloading of sand and rehab materials ahead of mining.	B	NE	M
O13	Sand tailings stockpiles and re-placement ahead of mining	- sedimentation of waterways - contamination of groundwater from seepage / leachate - contamination of surface water from seepage/leachate	- Geochemistry monitoring program to characterise material being placed. - encapsulation of the sand tailings within the subsidence zone, then covered with topsoil. - Material amendment with lime. Lime dosing infrastructure conservatively constructed to deliver up to 3:1 lime to sulfide acidity equivalent. - Additional test work to be conducted to optimise lime dosage rate. - Groundwater quality monitoring program	D	MO	M

Ref#	Construction / Project Activity	Potential impacts / risks	Management and mitigation measures	Likelihood	Consequence	Mitigated Risk Ranking
O14	Ore / oversize / product stockpiles / reactive overburden stockpiles	- surface water contamination from mine affected runoff - groundwater contamination from leachate / seepage	- stockpiles constructed on compacted base with drainage sumps, water returned to process. - geochemistry monitoring program for material characterisation - drainage and containment dams for ore processing area, no discharge (except in accordance with EPL). Site runoff dams maintained to contain 1:100 year rainfall runoff event. - routine inspection and maintenance of drainage system	D	MO	M
O15	Ore Processing Operations	- removal of catchment area from waterways - site inundation from flooding - interference with natural flooding	- detailed flood modelling completed (DFS) - Diversion of clean water around project as much as possible. Clean water diversion must convey a 1:100 year event (assumed 72hr) - Flood levees around the processing plant.	E	SI	M
O16		- spill of process water onto ground leading to groundwater infiltration	- Processing infrastructure areas over bunded concrete pads - engineered designs for all process water ponds, including pond liners. - Process area stormwater pond maintain freeboard for 1:100 year 72 hour event at all times, managed by Water Management Plan. - Level sensors and alarms for pond high levels - Weather forecast and TARP to ensure adequate freeboard	C	MI	M
O17		- Surface / groundwater contamination from chemical and hydrocarbons	- Chemical and hydrocarbon storage and handling designed to AS. - spill response equipment available on site. - Oil and grease separator to treat contaminated water. - Chemical and hydrocarbon management plan developed, including spill and response procedures	C	MI	M

Ref#	Construction / Project Activity	Potential impacts / risks	Management and mitigation measures	Likelihood	Consequence	Mitigated Risk Ranking
O18	Water Balance / Supply, sourced from Olney Formation 12L/sec and LPS Formation 12L/sec	Insufficient water supply to meet mining / ore processing requirements	- Groundwater bores tested to provide sufficient yield - highly permeable aquifer with excess available water allocation - production bores constructed with redundancy (duty and standby bores & pumps) - Acquire sufficient WAL to ensure adequate water supply.	E	SI	M
O19		- Induced saline water from the overlying LPS	- Geera Clay acts as competent barrier between the more saline LPS and Olney Formation and thus intermixing is not expected - Small volume relative to overall sustainable extraction limit for groundwater source.	E	MI	L
O20		- drawdown on third party bores	- Operate in accordance with WAL, WA and WSP rules and conditions. - Groundwater model predicts <2m drawdown at all neighbouring bores - GW model review and calibration process defined in WMP - Groundwater level monitoring program (to include bores in the vicinity of 3rd party bores) with TARP to review impact assessment if impacts outside of EA predictions.	E	MO	L
O21		- Recirculation of PAX contaminated water if production bores intercept mine reinjection water	- Groundwater model predicts limited recirculation of the water - PAX recirculation has no impact on operations - groundwater monitoring program to measure PAX in LPS production bores. - GW model review and calibration process defined in WMP	B	NE	M
O22		- Altered baseflow in local and regional watercourses	- groundwater model predicts no baseflow impact to local and regional watercourses - GW model review and calibration process defined in WMP	D	MO	M

Ref#	Construction / Project Activity	Potential impacts / risks	Management and mitigation measures	Likelihood	Consequence	Mitigated Risk Ranking
O23		- indirect impact to Aquatic GDEs	- No GDEs within modelled impact zone - Model review and calibration process defined in WMP	D	MO	M
O24		- indirect impact to terrestrial GDEs	- Closest GDE community (Black Box) north east of the mine has very low estimated drawdown <0.1m - Model review and calibration process defined in WMP	D	MO	M
O25		- interaction with Atlas Campaspe Mine	- Modelling shows no impact / interaction - Model review and calibration process defined in WMP	D	MO	M
O26	Waste water (sewage)	- surface / groundwater contamination with untreated waste water.	- Separate council approval for waste water treatment plant. - operation and maintenance of plant in accordance with manufacturer and council conditions. - Monitoring program in accordance with OEM to ensure plant is operating correctly.	D	MI	M
O27	Operation of Reverse Osmosis Plant	- Brine management - Drinking water quality (not considered in environmental RA)	- pump brine back into the process water. - replacing salt from the formation where it came from as much as practical. - Potable water quality monitoring program in accordance with OEM	D	NE	L

Appendix D- Groundwater Baseline Data

Groundwater Chemistry

Pre-development groundwater baseline water data has been collected from existing near-mining, third-party and regional monitoring bores within a 3 km radius of the Balranald mine site (EMM, 2019). The baseline data was collected from 2011–2015 and used to summarise the local groundwater chemistry surrounding the site. Tables D1, D2, and D3 present statistical analyses summarising the baseline groundwater chemistry of the SFM, the LPS, and the Lower Renmark Group (LRG) respectively (the LRG is used to represent the OF). As local third-party groundwater users predominately utilise the LRG for irrigation purposes, the ANZECC (2000) trigger values for irrigation are displayed in these tables for comparison purposes only.

Table D1: Shepparton Formation groundwater quality statistical summary (EMM, 20xx)

Statistic	pH	Total Alkalinity (mg/L $CaCO_3$)	Total Dissolved Solids (mg/L)	Ca (mg/L)	Mg (mg/L)	Na (mg/L)	K (mg/L)	SO_4 (mg/L)	Cl (mg/L)	Al (mg/L)	As (mg/L)	Cu (mg/L)	Fe (mg/L)	Li (mg/L)	Mn (mg/L)	Mo (mg/L)	Ni (mg/L)	Sr (mg/L)	U (mg/L)	Zn (mg/L)
Number	96	95	96	96	96	96	96	96	96	96	27	96	93	96	96	27	27	96	96	96
Minimum	3.85	177	19700	340	710	6800	19	1800	12300	0.003	0.001	<LOR	0.003	0.010	<LOR	<LOR	<LOR	7.320	<LOR	0.003
Lower Fence[1]	6.16	223	19700	340	710	6800	19	1800	12300	0.003	0.001	<LOR	0.003	0.010	0.001	0.001	0.001	9.213	<LOR	0.003
Quartile 1 (25th percentile)	6.85	328	33675	502	1200	9088	35	3600	15575	0.005	0.001	0.005	0.240	0.061	0.093	0.002	0.005	14.950	0.003	0.020
Median	7.13	359	39650	598	1530	11200	42	4245	20200	0.025	0.004	0.012	0.630	0.088	0.270	0.004	0.010	16.950	0.012	0.033
Quartile 3 (75th percentile)	7.30	398	43650	657	1750	13000	66	4801	23000	0.050	0.010	0.018	3.570	0.1218	0.591	0.010	0.017	18.775	0.025	0.072
Upper Fence[2]	7.98	503	57200	890	2550	16200	113	6603	30500	0.118	0.024	0.038	8.565	0.211	1.338	0.022	0.035	24.513	0.059	0.151
Maximum	8.10	570	57200	1100	2550	16200	115	9309	30500	28.90	0.028	0.071	10.400	0.368	6.200	0.053	0.057	32.900	0.229	0.244
IQR[3]	0.46	70	9975	155	550	3913	31	1201	7425	0.045	0.009	0.013	3.330	0.060	0.498	0.008	0.012	3.825	0.023	0.053
Number of Upper Outliers[4]	2	4	0	2	0	0	1	8	0	19	2	2	2	6	15	1	3	2	9	3
Number of Lower Outliers[5]	8	8	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	5	0	0
ANZECC[6]	4 - 9	N/A	5 000	N/A	N/A	N/A	N/A	N/A	N/A	5	0.1	0.2	N/A	2.5	0.2	0.01	0.2	N/A	0.01	2

Notes:

1. Lower fence is defined as the 25th percentile minus 1.5 multiplied by the IQR;
2. Upper fence is defined as the 75th percentile plus 1.5 multiplied by the inter IQR;
3. IQR = Inter Quartile Range, which represents 50% of the data between the 25th and 75th percentile (ie. IQR = Q3-Q1);
4. Upper outliers are defined as data that fall between the upper fence and the maximum;
5. Lower outliers are defined as data that fall between the lower fence and the minimum; and
6. ANZECC (2000) guideline value for irrigation and general water use.

Table D2: Loxton Parilla Sands Formation groundwater quality statistical summary (EMM, 20xx)

Statistic	pH	Total Alkalinity (mg/L $CaCO_3$)	Total Dissolved Solids (mg/L)	Ca (mg/L)	Mg (mg/L)	Na (mg/L)	K (mg/L)	SO4 (mg/L)	Cl (mg/L)	Al (mg/L)	As (mg/L)	Cu (mg/L)	Fe (mg/L)	Li (mg/L)	Mn (mg/L)	Mo (mg/L)	Ni (mg/L)	Sr (mg/L)	U (mg/L)	Zn (mg/L)
Number	173	173	173	173	173	173	173	173	173	173	36	173	164	173	173	36	36	173	173	173
Minimum	6.19	207	8870	105	225	3200	10	500	5240	0.005	<LOR	<LOR	0.025	0.017	0.064	<LOR	<LOR	2.990	<LOR	0.003
Lower Fence[1]	6.30	252	8870	105	225	3200	10	500	5240	0.005	0.001	<LOR	0.025	0.017	0.064	0.001	0.001	2.990	<LOR	0.003
Quartile 1 (25th percentile)	6.93	376	18500	276	594	5330	31	991	10000	0.005	0.001	0.003	0.450	0.087	0.220	0.001	0.001	6.260	<0.001	0.013
Median	7.16	427	33000	368	1100	9000	40	2460	16600	0.025	0.001	0.005	1.370	0.112	0.427	0.001	0.002	9.480	0.003	0.029
Quartile 3 (75th percentile)	7.35	458	38000	556	1420	11000	52	3680	19400	0.050	0.008	0.008	4.120	0.155	0.620	0.003	0.004	14.600	0.005	0.080
Upper Fence[2]	7.98	582	48200	848	2659	14200	84	6170	26000	0.118	0.018	0.016	9.625	0.257	1.220	0.006	0.009	27.110	0.012	0.181
Maximum	8.40	914	48200	848	1930	14200	110	6170	26000	0.340	0.045	0.058	12.300	0.279	1.650	0.010	0.010	33.300	0.027	1.100
IQR[3]	0.42	83	19500	280	826	5670	21	2689	9400	0.045	0.007	0.006	3.670	0.068	0.400	0.002	0.003	8.340	0.005	0.068
Number of Upper Outliers[4]	10	16	0	0	0	0	5	0	0	22	2	9	4	1	11	4	4	1	30	19
Number of Lower Outliers[5]	1	18	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
ANZECC[6]	4 - 9	N/A	5 000	N/A	N/A	N/A	N/A	N/A	N/A	5	0.1	0.2	N/A	2.5	0.2	0.01	0.2	N/A	0.01	2

Notes:

1. Lower fence is defined as the 25th percentile minus 1.5 multiplied by the IQR;
2. Upper fence is defined as the 75th percentile plus 1.5 multiplied by the inter IQR;
3. IQR = Inter Quartile Range, which represents 50% of the data between the 25th and 75th percentile (ie. IQR = Q3-Q1);
4. Upper outliers are defined as data that fall between the upper fence and the maximum;
5. Lower outliers are defined as data that fall between the lower fence and the minimum; and
6. ANZECC (2000) guideline value for irrigation and general water use.

Table D3: Lower Renmark Group (OF) baseline groundwater quality statistical summary (EMM, 20xx)

Statistic	pH	Total Alkalinity (mg/L $CaCO_3$)	Total Dissolved Solids (mg/L)	Ca (mg/L)	Mg (mg/L)	Na (mg/L)	K (mg/L)	SO4 (mg/L)	Cl (mg/L)	Al (mg/L)	As (mg/L)	Cu (mg/L)	Fe (mg/L)	Li (mg/L)	Mn (mg/L)	Mo (mg/L)	Ni (mg/L)	Sr (mg/L)	U (mg/L)	Zn (mg/L)
Number	209	32	117	58	58	58	58	55	51	47	21	21	42	21	51	21	21	15	14	1
Minimum	5.70	379	2490	21	28	793	16	1	1180	<LOR	<LOR	<LOR	0.009	0.041	0.006	<LOR	<LOR	0.818	<LOR	<LOR
Lower Fence[1]	6.72	379	2490	21	28	793	16	1	1180	<LOR	0.001	0.001	0.009	0.041	0.006	0.001	0.001	0.818	<LOR	<LOR
Quartile 1 (25^{th} percentile)	7.29	400	3570	35	47	1073	23	1	1570	0.020	0.001	0.001	0.330	0.051	0.014	0.001	0.001	0.958	0.001	<LOR
Median	7.50	432	4349	40	59	1235	27	1	1840	0.050	0.001	0.001	0.660	0.060	0.020	0.001	0.001	1.160	0.001	<LOR
Quartile 3 (75^{th} percentile)	7.67	445	5675	53	70	1565	29	2	2400	0.115	0.001	0.002	1.533	0.075	0.038	0.001	0.001	1.940	0.001	<LOR
Upper Fence[2]	8.24	511	8833	81	104	2304	37	4	3645	0.256	0.001	0.003	3.336	0.111	0.075	0.001	0.001	2.830	0.001	<LOR
Maximum	9.63	603	10265	120	160	2530	49	35	4280	1.980	0.006	0.003	7.390	0.158	0.091	0.001	0.004	2.830	0.001	<LOR
IQR[3]	0.38	45	2105	18	23	493	6	1	830	0.095	0.000	0.001	1.203	0.024	0.025	0.000	0.000	0.983	0.000	<LOR
Number of Upper Outliers[4]	5	2	2	3	8	4	7	9	7	5	5	0	2	2	4	0	3	0	0	0
Number of Lower Outliers[5]	5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0
ANZECC[6]	4 - 9	N/A	5 000	N/A	N/A	N/A	N/A	N/A	N/A	5	0.1	0.2	N/A	2.5	0.2	0.01	0.2	N/A	0.01	2

Notes:

1. Lower fence is defined as the 25th percentile minus 1.5 multiplied by the IQR;
2. Upper fence is defined as the 75th percentile plus 1.5 multiplied by the inter IQR;
3. IQR = Inter Quartile Range, which represents 50% of the data between the 25th and 75th percentile (ie. IQR = Q3-Q1);
4. Upper outliers are defined as data that fall between the upper fence and the maximum;
5. Lower outliers are defined as data that fall between the lower fence and the minimum; and
6. ANZECC (2000) guideline value for irrigation and general water use.

Groundwater radionuclides

There are four Ra isotopes naturally present in the environment: ^{226}Ra of the uranium decay series, ^{228}Ra and ^{224}Ra of the thorium decay series and ^{223}Ra of the actinium decay series. Of these, ^{226}Ra and ^{228}Ra have relatively long half-lives (1600 and 5.75 years, respectively). Radium is of significance due to its high mobility in the environment under a number of common environmental conditions and the tendency of Ra to accumulate in bone following uptake into the body. The concentrations of Ra in waters and the mobility of Ra through the environment are generally controlled by interaction with surfaces by adsorption through ion exchange. Radium generally is quite soluble in saline groundwater compared to other long-lived natural radionuclides, such as thorium and lead-210.

Land & Water Consulting Pty Ltd (LWC) was engaged to undertake a Baseline Groundwater Monitoring for the activity site. A total of 18 groundwater wells were gauged and sampled (October 2014) for water quality including radionuclide analysis. A summary of the radionuclide analytical results is presented in **Tables 17 & 18** with the certified laboratory analytical reports saved in TRIM1752668. Location of the monitoring wells are provided in **Figure 15**.

Table 17: Overview of Radionuclide Data for the Shepparton Formation

PARAMETER	UNIT	PRE-MONITORING MAXIMUM REPORTED (JUNE 2014)	POST-MONITORING MAXIMUM REPORTED (MAY 2015)	SAMPLE (32MM WELL DIAMETER)
Total Metals				
Uranium	mg/L	0.043	0.045	BH – M1 (14-2126-15)
Thorium	mg/L	0.011	0.018	BH – M5 (14-2126-02)
Gross Radioactivity Concentration				
Gross Alpha	Bq/L	3.71	2.93	BH – M6 (14-2126-11)
Gross Beta	Bq/L	2.42	1.797	BH – M5 (14-2126-02)
Uranium (U-238) Series				
Uranium-238	Bq/L	0.54	0.56	BH – M1 (14-2126-15)
Thorium-234	Bq/L	0.315	0.361	BH – M1 (14-2126-15)
Radium-226	Bq/L	0.271	0.335	BH – M4 (14-2126-19)
Lead-210	Bq/L	0.16	0.097*	BH – M6 (14-2126-11)
Thorium (Th-232) Series				
Thorium-232	Bq/L	0.045	0.17	BH – M5 (14-2126-02)
Radium-228	Bq/L	1.48	1.41	BH – M5 (14-2126-02)
Thorium-228	Bq/L	0.133	0.045	BH – M5 (14-2126-02)

Uranium radioisotopes				
Uranium-238	Bq/L	0.269	0.181	BH – M7 (14-2126-08)
Uranium-235	Bq/L	0.0091	0.0116	BH – M7 (14-2126-08)
Uranium-234	Bq/L	0.360	0.26	BH – M7 (14-2126-08)
Thorium radioisotopes				
Thorium-232	Bq/L	<0.0078	0.01*	BH – M7 (14-2126-08)
Thorium-230	Bq/L	0.0092	0.057*	BH – M7 (14-2126-08)
Thorium-228	Bq/L	0.039	0.072*	BH – M7 (14-2126-08)
Thorium-227	Bq/L	0.009	0.14*	BH – M7 (14-2126-08)
Polonium-210				
Polonium-210	Bq/L	<0.0016	0.0039	BH – M7 (14-2126-08)

*Max LOR or Max. Reported + Variation if LOR not > - equals the laboratory LOR value reported if exceeds “Max. Reported + Variation” value

At each location, a monitoring well has been installed into the underlying Loxton Parilla Sands aquifer system (construction depths up to 77m below ground level) and a shallower well into the overlying Shepparton Formation (construction depths up to 33m below ground level). Monitoring wells are identified as 50mm for the Loxton Parilla Sands aquifer and 32mm for the Shepparton Formation (equivalent to the diameter of the well casing).

Table 18: Overview of Radionuclide Data for the Loxton Parilla Sands Aquifer

PARAMETER	UNIT	PRE-MONITORING MAXIMUM REPORTED (JUNE 2014)	POST-MONITORING MAXIMUM REPORTED (MAY 2015)	SAMPLE (50MM WELL DIAMETER)
Total Metals				
Uranium	mg/L	0.004	0.002	BH – M1 (14-2126-14)
Thorium	mg/L	-	0.03	-
Gross Radioactivity Concentration				
Gross Alpha	Bq/L	1.06	1.06	BH – M2 (14-2126-16)
Gross Beta	Bq/L	0.624	0.597	BH – M2 (14-2126-16)
Uranium (U-238) Series				
Uranium-238	Bq/L	0.05	0.02	BH – M1 (14-2126-14)
Thorium-234	Bq/L	-	0.136	-

Radium-226	Bq/L	0.133	0.174	BH – M9 (14-2126-03)
Lead-210	Bq/L	-	0.104	-
Thorium (Th-232) Series				
Thorium-232	Bq/L	0.0008	0.12	BH – M7 (14-2126-07)
Radium-228	Bq/L	0.369	0.56	BH – M9 (14-2126-03)
Thorium-228	Bq/L	0.0256	0.03*	BH – M1 (14-2126-14)
Uranium radioisotopes				
Uranium-238	Bq/L	0.0301	0.014	BH – M9 (14-2126-03)
Uranium-235	Bq/L	0.0026	0.0017	BH – M7 (14-2126-07)
Uranium-234	Bq/L	0.0356	0.027	BH – M8 (14-2126-05)
Thorium radioisotopes				
Thorium-232	Bq/L	0.0019	0.0089*	BH – M7 (14-2126-01)
Thorium-230	Bq/L	0.0053	0.048*	BH – M7 (14-2126-07)
Thorium-228	Bq/L	0.0075	0.06*	BH – M7 (14-2126-01)
Thorium-227	Bq/L	0.0077	0.12*	BH – M7 (14-2126-01)
Polonium-210				
Polonium-210	Bq/L	0.011	0.0048	BH – M7 (14-2126-07)

*Max LOR or Max. Reported + Variation if LOR not > - equals the laboratory LOR value reported if exceeds "Max. Reported + Variation" value

The majority of samples collected from the Shepparton formation and a smaller number from the LPS aquifer reported an increase in concentrations of dissolved uranium.

The high saline groundwater (see Section 2.5.4) of the Shepparton and Loxton-Parilla Sands aquifer suggests the beneficial use of groundwater is limited to industrial water use and maintenance of ecosystems in a saline environment. At the lower end of the salinity range of the Loxton-Parilla Sands, groundwater is also marginally suitable (based on salinity alone) for stock-water use and primary contact (i.e. bathing/swimming). It is noted that in addition to the beneficial use being limited in the Shepparton Formation, it is also low yielding due to the discontinuous nature of the sand within the formation and therefore would preclude use for industrial purposes.

Groundwater levels and aquifer hydraulic properties

The following extract form the Balranald Project Modification 1 Groundwater Impact Assessment provides summary baseline information regarding groundwater levels and aquifer hydraulic properties. The full report can be accessed on the NSW government Major Projects Portal:

https://majorprojects.planningportal.nsw.gov.au/prweb/PRRestService/mp/01/getContent?AttachRef=SSD-5285-MOD-1%2120220509T071934.896 GMT

3.4 Groundwater levels and flow direction

3.4.1 Horizontal groundwater pressures

Regional groundwater level measurements taken during 2014 and part of previous detailed feasibility studies (prior to any large-scale site activities), have been used to develop plan-view unstressed potentiometric surfaces. These surfaces for the following main aquifers of interest as follows:

- Figure 3.3 - SFM unstressed (ie natural conditions) potentiometric surface shown on a 0.5 m interval.
- Figure 3.4 - LPS unstressed potentiometric surface shown on a 0.5 m interval.
- Figure 3.5 - Olney Formation unstressed potentiometric surface shown on a 1 m interval.

The contours have been developed using surveyed bore collars associated with previous Balranald field programs and the quarterly baseline data collection program. In summary, the potentiometric surfaces suggest:

- The potentiometric surfaces for the SFM and LPS are near identical under natural/unstressed conditions, with the SFM hosting the watertable across the West Balranald deposit (also refer to Figure 3.2). At Nepean, the watertable is hosted within the LPS.
- Local groundwater occurring at elevations greater than 52 mAHD prevail at the southern end of the West Balranald deposit. Groundwater levels between 48 and 49 mAHD dominate further north.
- The local groundwater flow direction is from the south-east to the north-west.
- Groundwater heads recorded within the Olney Formation range from 63 mAHD at the southern end of the West Balranald deposit, to 57 mAHD to the west. The prevailing groundwater flow direction in this unit is from east to west, and consistent with the historical groundwater maps produced by Kellet (1989, 1994).

On a regional scale, the Ivanhoe Block impedes westerly throughflow in the Riverine Plain as the regional aquifer either thins out over the rising basement block or is truncated by it. At the boundary of the Ivanhoe Block flow lines in the deeper aquifers are deflected north and south, and flow lines in the shallower aquifers on top of the ridge line are forced to converge. The Geera Clay also forms a hydraulic barrier to lateral flow in the middle Olney Formation, forcing westerly groundwater flow lines in the middle and upper Olney Formation to converge.

Iluka undertake groundwater monitoring events (GMEs) across the Balranald site on a six-monthly frequency. The Balranald bore network targeted for the GMEs is shown on Figure 3.6, and includes a selection of Iluka-installed bores, third party bores and government bores. A selection of hydrographs (measured during unstressed conditions (ie not during bulk sampling activities) across the site are shown in Figure 3.7. Time series for all hydrographs measured between 2016 and early 2021 are provided within the modelling report (Appendix A).

3.4.2 Vertical groundwater pressures

Kellett (1991 and 1994) indicates artesian conditions in the east of the study area and URS (2012) reports a measured head at West Balranald (WB3 P1 screening the Olney Formation), 3.1 m above the ground surface. Iluka have identified two artesian third party bores (HD1 and T02) that are screened within the Olney Formation (and suspect artesian conditions at T03), in the vicinity of the West Balranald deposit.

A strong vertical upwards gradient is pronounced at GW036866 (40 km north of Balranald) and GW036674 (68 km north of Balranald) where there is approximately 9 m and 5 m difference, respectively, in potentiometric head pressure between the Loxton-Parilla Sands, and the Geera Clay and Olney Formation. It is likely that the Geera Clay prevents artesian pressures in the Olney Formation from equilibrating with the shallower units. Upward vertical head gradients are consistent with the monitoring sites being at the discharge end of the Balranald trough and near where basement rises, causing upward groundwater flow.

Groundwater density differences associated with variable groundwater salinity may contribute to groundwater flow patterns. On the vertical scale, the potentiometric heads at depth may represent higher equivalent freshwater head, although due to the relative homogeneity in groundwater salinity within hydrostratigraphic units it is likely that density does not have a significant impact on horizontal groundwater flows (WRM, 2015).

Although heads in the Shepparton Formation and Loxton-Parilla Sands are similar, the results of pumping and injection trials during the 2014 site activities related to the previous EIS submission (EMM, 2015), indicate that the two units are poorly connected (Iluka 2015) and that significant head differences may be created when water is extracted from or injected into one or other of these units. This is likely to be associated with the clay lens observed throughout the Shepparton Formation, particularly near its base.

3.4.3 Groundwater hydrograph responses

A selection of long-term hydrographs are shown in Figure 3.7. The responses indicate consistent steady water levels across Balranald, with very little seasonal variation or trend in any direction. Water levels in the Shepparton Formation (SF series) and Loxton-Parilla Sands (LPS series) are similar, with all six bores showing groundwater levels between 50–55 mAHD. The groundwater pressures within the Olney Formation (OF series) are noticeably higher, ranging between 58–62 mAHD. The Olney Formation has artesian pressure at Balranald, with the Geera Clay acting as a thick confining layer between the Olney Formation and the shallower aquifers.

3.4.4 Hydraulic conductivity and properties

Hydraulic conductivity in the Shepparton Formation is highly variable, due to the heterogeneous nature of this Formation with sand and clay lenses throughout. Continual lateral flow through the units of this formation is not common. A range of bulk hydraulic conductivity is observed in the Loxton-Parilla Sands, and this is due to the differences in the hydraulic conductivities of the surf and offshore zones. The stratification in this unit is likely to cause considerable vertical anisotropy in hydraulic conductivity values (WRM, 2015).

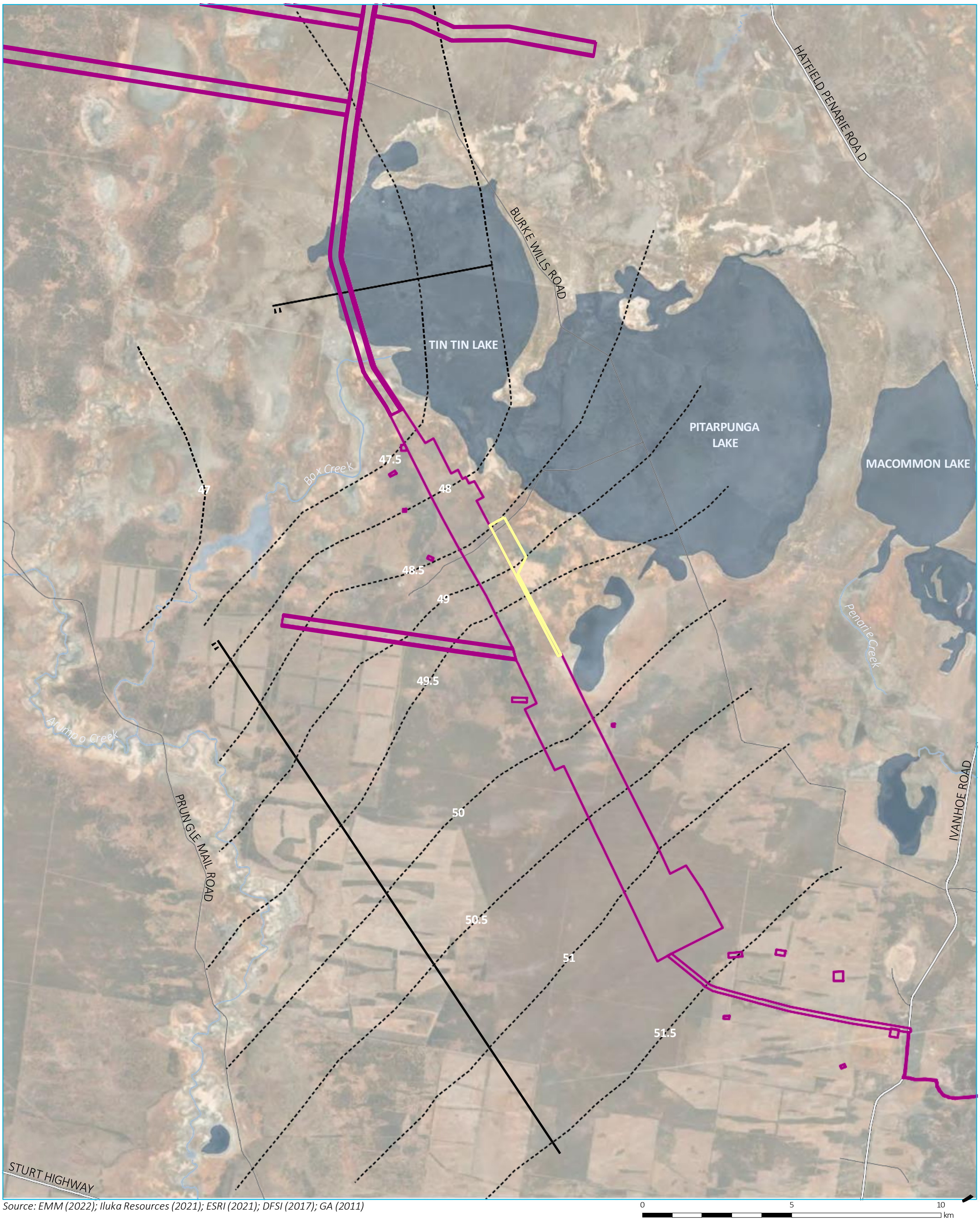
Horizontal hydraulic conductivity in the Olney Formation decreases proportionally with distance from the eastern to western Riverine Plain (Kellet 1994). Typically, the vertical hydraulic conductivity is at least an order of magnitude lower than horizontal hydraulic conductivity (Evans and Kellet 1989).

The hydraulic properties in the MOD1 numerical groundwater model (discussed further in Section 5.3) are presented in Table 3.2. The anisotropy in the Loxton-Parilla Sands is represented by five layers, from shallow to deep: LPS1 foreshore, LPS1 surf zone, LPS1 lower shore + LPS2 foreshore, LPS2 surf zone and LPS2 lower shore. The Shepparton Formation is modelled with two layers and of the same hydraulic properties. The calibrated modelled aquifer properties are consistent with the parameters derived from historic hydrogeological field assessments (Iluka 2015).

Table 3.2 MOD1 modelled aquifer hydraulic properties

Formation	Kh (m/d)[1]	Kv (m/d)[2]	Sy[3]	Ss (m^{-1})[4]
Shepparton Formation	1	0.001	0.15	3×10^{-5}
LPS1 foreshore	0.9	0.001	0.15	3×10^{-5}
LPS1 surf zone	16-24	0.1	0.15	3×10^{-5}
LPS1 lower shore/LPS2 foreshore	0.9	0.001	0.15	3×10^{-5}
LPS2 surf zone	10-40	0.1	0.15	3×10^{-5}
LPS2 lower shore	0.9	0.001-0.13	0.15	3×10^{-5}
Geera Clay	0.0001	0.00001	0.15	3×10^{-5}
Olney Formation	3	0.3	0.15	3×10^{-5}

Notes: 1. Horizontal hydraulic conductivity.
2. Vertical hydraulic conductivity.
3. Specific yield.
4. Specific storage.



Source: EMM (2022); Iluka Resources (2021); ESRI (2021); DFSI (2017); GA (2011)

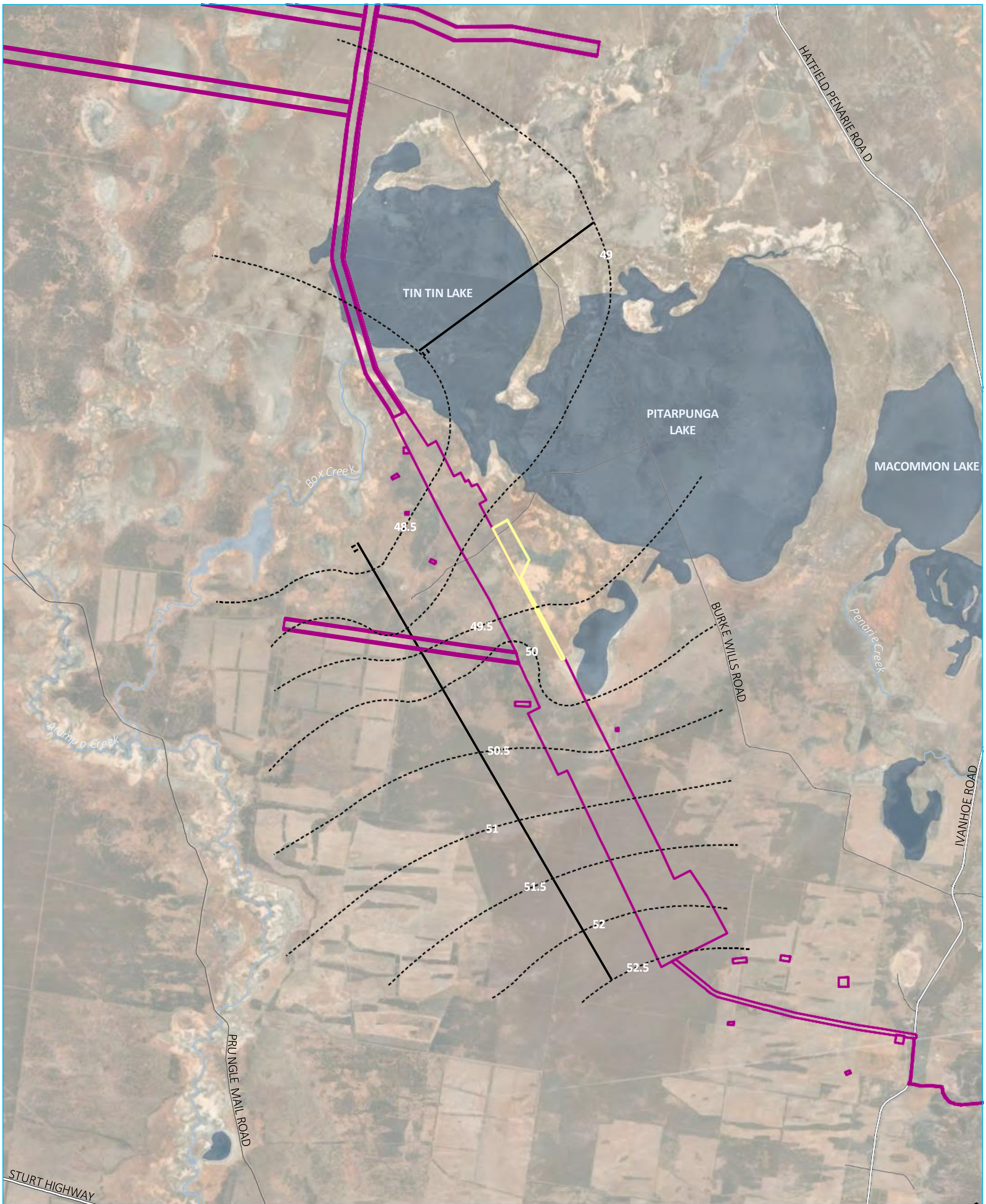
KEY

- EIS Approved Balranald Project Area (SSD-5285)
- Proposed modification extension to Balranald Project Area boundary
- Flow line
- Shepparton Formation (m AHD)
- Major road
- Minor road
- Named watercourse
- Ephemeral lake
- Perennial lake

Shepparton Formation (unstressed) potentiometic surface (m AHD)

Balranald Mineral Sands Project
Balranald groundwater comparative impact assessment
Figure 3.3

EMM creating opportunities



Source: EMM (2022); Iluka Resources (2021); ESRI (2021); DFSI (2017); GA (2011)

0 5 10 km
GDA 1994 MGA Zone 54

\\emmsvr1\EMM3\2020\S200529 - Balranald Modification of Development Consent Stage 2\GIS\02_Maps_GW_CIA\CIA005_LoxtonParillaSands_20220429_02.mxd 29/04/2022

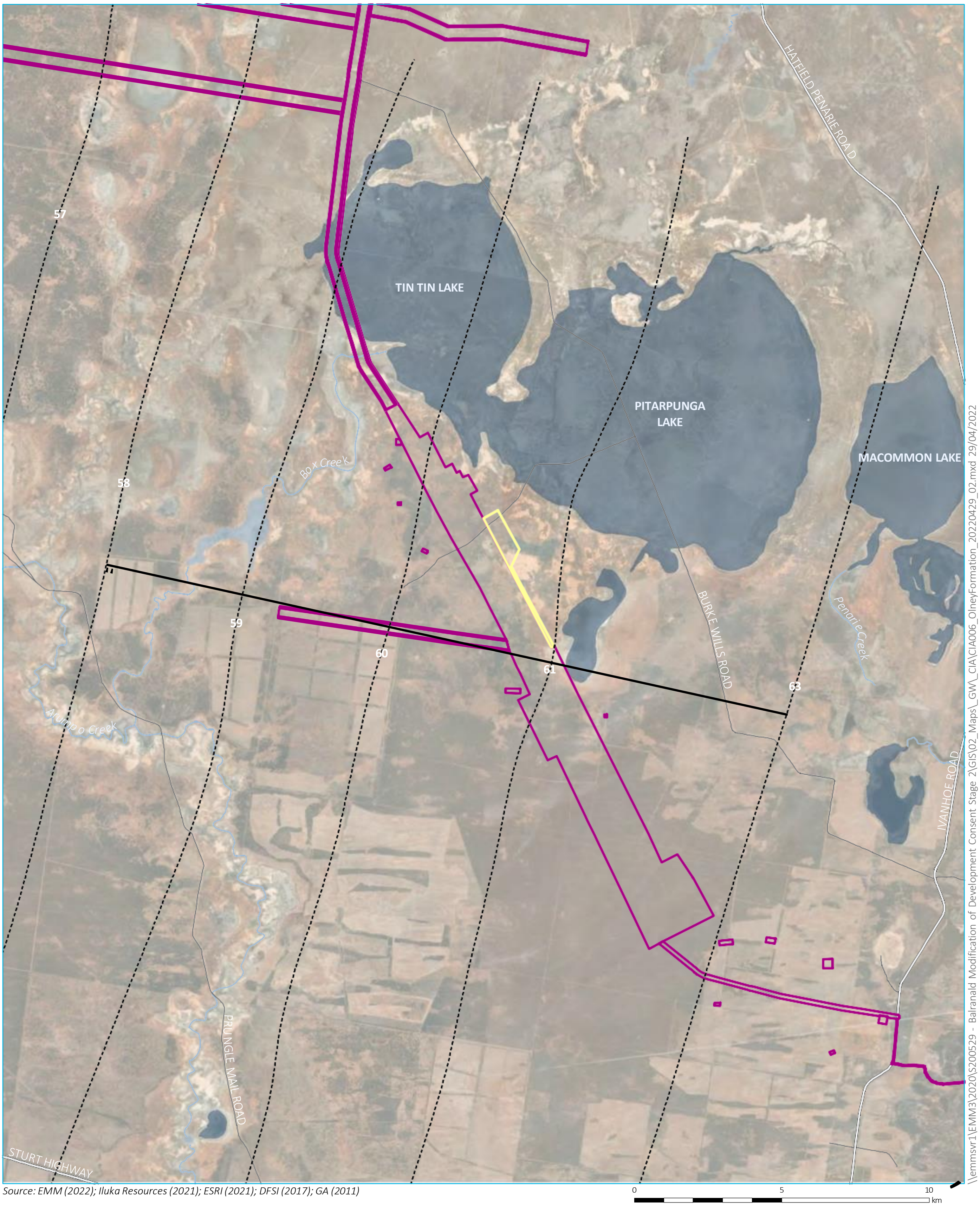
KEY

- EIS Approved Balranald Project Area (SSD-5285)
- Proposed modification extension to Balranald Project Area boundary
- Flow line
- Loxton Parilla Sands (m AHD)
- Major road
- Minor road
- Named watercourse
- Ephemeral lake
- Perennial lake

Loxton Parilla Sands Formation (unstressed) potentiometric surface (m AHD)

Balranald Mineral Sands Project
Balranald groundwater comparative impact assessment
Figure 3.4

EMM
creating opportunities



Source: EMM (2022); Iluka Resources (2021); ESRI (2021); DFSI (2017); GA (2011)

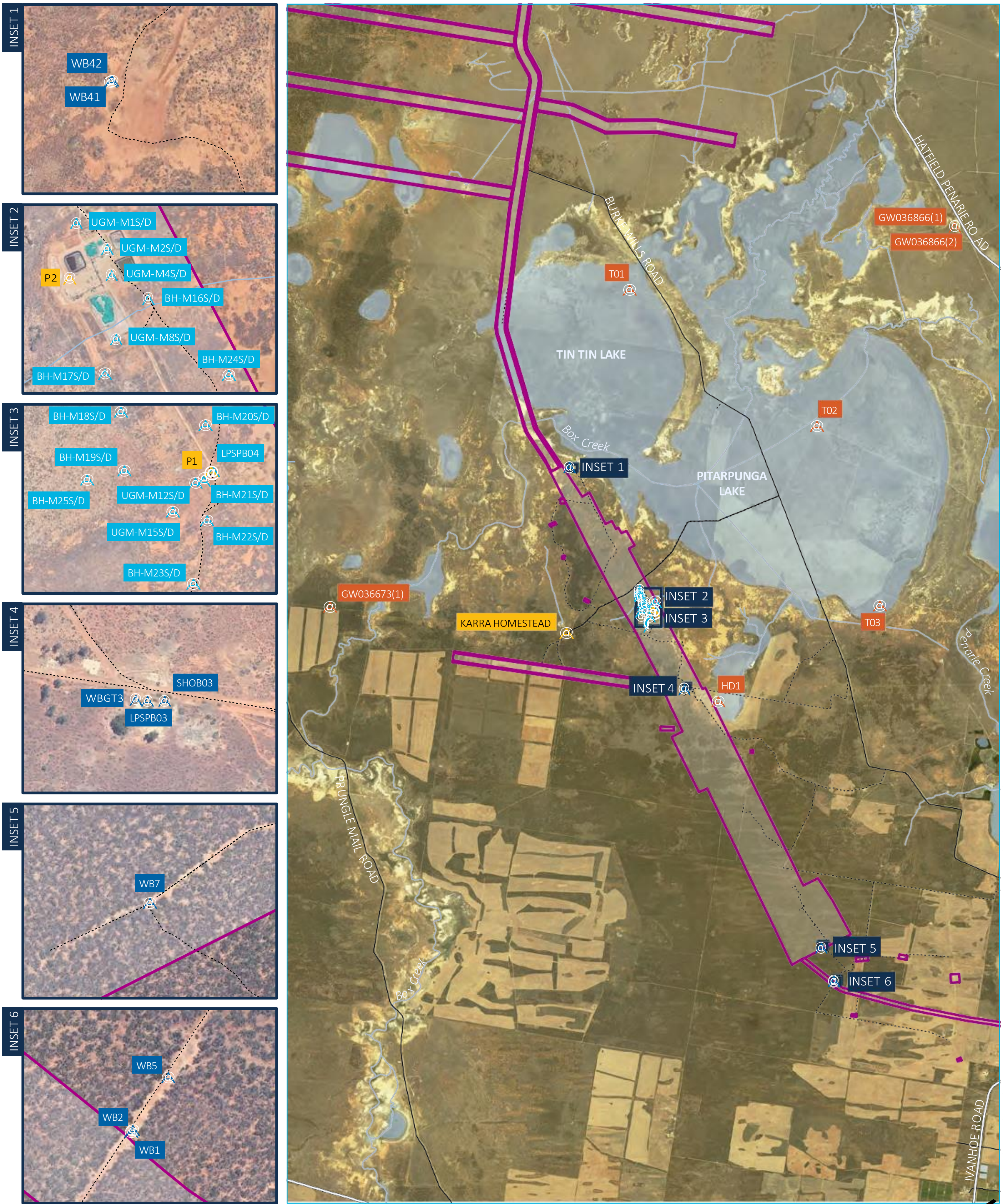
KEY

- EIS Approved Balranald Project Area (SSD-5285)
- Proposed modification extension to Balranald Project Area boundary
- Flow line
- Potentiometric surface (m AHD)
- Major road
- Minor road
- Named watercourse
- Ephemeral lake
- Perennial lake

Olney Formation (unstressed) potentimetric surface (m AHD)

Balranald Mineral Sands Project
Balranald groundwater comparative impact assessment
Figure 3.5

EMM creating opportunities



Source: EMM (2022); Iluka Resources (2021); DFSI (2017)

0 5 10 km

GDA 1994 MGA Zone 54

\\emmsvr1\EMM3\2021\S210560 - Balranald Bridging Phase MOD1 Activities\GIS\02_Maps\W001_RegionalGWN_20211201_01.mxd 17/03/2022

KEY

- EIS Approved Balranald Project Area (SSD-5285)
- Major road
- Minor road
- Vehicular track
- Watercourse/drainage line
- Waterbody

Groundwater bore

- Monitoring bore
- Regional monitoring bore
- Production bore
- Third-party bore

Balranald monitoring network (GME and T3 network)

Balranald Mineral Sands Project
Balranald groundwater comparative impact assessment
Figure 3.6

EMM creating opportunities

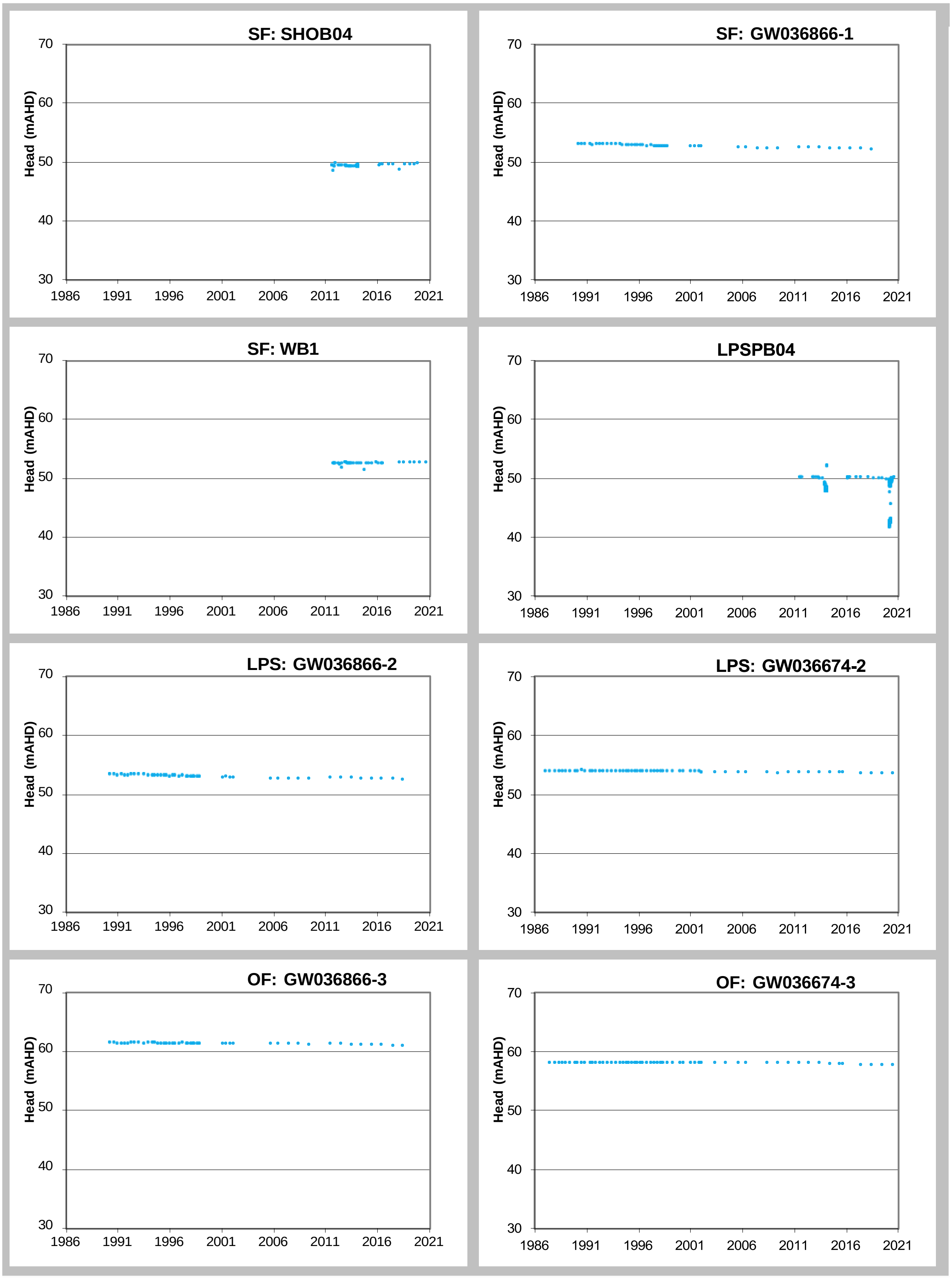


Figure 3.7 Selected long term hydrographs

Appendix E- Standard Operating Procedures (EMM, 2019)

SOP001_Groundwater Sampling_ Micro-purge Pump

Ground floor, 188 Normanby Road
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2 September 2019

Subject: Standard Operating Procedure (SOP001) Sampling Groundwater using Micro-purge pump

1 Purpose and Scope

To instruct field staff on how to collect representative site-specific groundwater samples from the aquifer formation, with minimal disturbance to the water column.

This Field Instruction (FI) describes the methodology for the collection of groundwater samples using a bladder pump (low flow technique). This procedure should be read in conjunction with the following Australian/New Zealand Standards:

- AS NZS 5667.1.1998 – Water Quality Sampling – Part 1 Guidance on the design of sampling programs, sampling techniques and the preservation and handling of samples; and
- AS NZS 5667.11,1998 – Water quality - Sampling guidance on sampling of groundwaters.

2 Responsibilities

Role	Responsibility
Fieldwork Staff	To apply the methods detailed in this FI. To ensure equipment is in good working order prior to use, is maintained according to supplier's advice and is appropriately calibrated or verified, have a basic understanding of common faults and field-based repairs. Any faults shall be reported to the Project Manager (PM) or the equipment supplier as soon as they are identified. To ensure Quality Assurance/Quality Control and Health and Safety Compliance.
Project Manager	Define the objectives and appropriate methodology to field staff prior to mobilisation into the field. The Project Manager should check (or designate another to check) the gauging data recorded by the fieldwork staff for anomalies such as measurements inconsistent with historical groundwater level fluctuations or well construction records. To ensure Quality Assurance/Quality Control and Health and Safety Compliance.
Office HSE Advisor	The Office Health, Safety and Environment (HSE) Advisor is an assigned person in each office and is responsible for reviewing and approving Health, Safety and Environment (HSE) Plans, monitoring the implementation of HSE Plans, interface with PMs in matters of health and safety, investigating reports of incidents or accidents.

3 Equipment and Materials

3.1 Equipment

Equipment required to complete this task includes:

- Low Flow (Bladder) Pump Casing;
- wire hanger;
- control box;
- compressor (air or CO_2 gas cylinder, regulator and hose);
- water quality meter and flow-through-cell; and
- oil-water interface meter or electronic dip meter drawdown meter.

Optional or supplemental equipment:

- Lower Explosive Limit (LEL) Detector; and
- Photo Ionisation Detector (PID).

For remote sites consideration should be given to providing a backup set of equipment, if the cost of remobilisation is high, and there is no access to technical repair facilities.

3.1.1 Water Level Meter

A water level meter, also called electric dip meter, is used to measure the depth to standing water. Where non-aqueous phase liquid (NAPL) is expected or suspected to be present in groundwater wells an oil/water interface meter should be used. A beeping sound is made when the electronic dip meter intersects the standing water level.

3.1.2 Drawdown Meter

A drawdown meter works differently to a water level meter: it makes a beeping sound when exposed to air and is silent in water. The probe should be locked in place in the water column above the pump inlet approximately 10 cm below the pre-pumping water level. As the water level drops during pumping the probe will beep when it is exposed to air. The probe can then be lowered until the beeping stops and the process repeated. The water levels will be recorded against time during the pumping on the field sheets.

3.1.3 Oil/Water Interface Meter

The oil/water interface probe should be used where light non-aqueous phase liquid (LNAPL) or dense non-aqueous phase liquid (DNAPL) are expected or suspected to be present in the wells. The probe emits two different sounds for distinguishing the depth to NAPL (continuous tone) and the standing water level (short beeping). Because LNAPL floats on top of water, the continuous tone will occur typically before the beeping tone; with DNAPL, the continuous tone would occur towards the base of the well, after the beeping tone of the water column. As the water level drops during pumping the probe will stop beeping when it is exposed to air. The probe can then be lowered until the beeping starts to gauge water level and the process repeated. The water levels will be recorded against time during the pumping on the field sheets.

3.1.4 Water Quality Meter

A water quality meter will typically comprise instrument probes to measure electrical conductivity (EC), pH, temperature, oxidation reduction potential (ORP) and dissolved oxygen (DO). Common water quality meters include YSI and TPS FLMV. When renting a water quality meter, the rental company should supply a calibration certificate indicating that the equipment has been cleaned, calibrated and is ready for use. Ensure that a flow-through cell is included with the water quality meter.

3.1.5 Low Flow Pump Casing/Wire Hanger

Casing which is lowered down the well to pump groundwater. Holds the bladder that is used to pump water, one bladder is used per well and replaced during decontamination. The pump is connected to both the discharge line and airline. Both these lines must be securely in place with a tight seal for the pump to work properly. The pump contains o-rings that must be checked each time before the pump is used, for if one is missing or worn the pump will not operate properly.

A wire cable/hanger is connected to the pump from the surface, to hold the pump in place as a safe guard to stop it falling down the well. The D-bolt on the hanger should be checked between each well during the decontamination process to prevent it from loosening and dropping the pump down the well.

3.1.6 Low Flow Control Box

Used to control the rate at which water is pumped (Cycle per Minute) and the pressure that the water is pumped out of the well. The control box (shown in Figure 1) may contain a compressor or is connected to the gas cylinder through the hose and regulator, and also the pump through the air line. Low flow controller may be connected via 12v cables to a battery.

Figure 1 **Low Flow Control Box**

3.1.7 Compressor, Gas Cylinder, Regulator & Hose (if required)

CO_2 gas cylinder can be used to pump groundwater. This is connected to a regulator and regulator is connected to the hose.

Note the pressure on the gas bottle. A full gas bottle should read 5,000 kpa (1,900 psi) and will allow you to sample approximately 20 wells (varying with well depth). If the bottle reads 500 kpa or less it should be marked empty and replaced.

Compressors can be either battery powered or powered using a combustion engine, make sure the pressures are appropriately controlled and that a clear knowledge of operation and the HSEP reflects compressor use prior to mobilization.

3.1.8 Photo Ionisation Detector (PID)

Refer to Operating a Photo-Ionisation Detector (PID), for applicability, operation and calibration of a PID.

3.1.9 Lower Explosive Limit (LEL) Detector

Refer to Operating a Lower Explosive Limit (LEL), for applicability, operation and calibration of a LEL.

3.2 Materials

Materials and consumables that may be required to complete this task include:

- Tubing – air and discharge line (enough metres for all wells including spares)
- Appropriate buckets (based on COPC)
- Potable water
- Deionised water
- Scrubbing brush
- Paper towel
- Steel brush
- Permanent Marker Pens (thick and thin)
- Scissors / tube cutters
- Funnel
- Ice / ice blocks
- Alcohol wipes
- Adjustable spanner
- Stericup filters or in-line filters (if required for COPCs)
- Tools for opening well gatic (eg hammer, screwdriver)
- Hex keys
- Spare O-rings and hex bolts
- Phosphate free detergent (eg Decon 90)
- Wastewater container (ie jerry can)
- Laboratory supplied sampling containers
- Laboratory supplied rinsate water
- Low-flow bladders (1 per well with spares)
- Garbage bags
- Field book
- Esky
- Nitrile gloves
- Duct tape
- Hand pump (if Stericup filters are used)

4 Background

The objective of groundwater sampling is to obtain water samples that best represent natural undisturbed hydrogeological conditions. Low flow sampling is one of the techniques used to achieve this. It works by lowering the pump to a specified depth in the bore screen, thus pumping water coming into the bore from the aquifer, to achieve representative samples of the aquifer with minimal disturbance to the standing water in the well.

Before commencing low flow sampling, some important factors should be considered including, the method used historically on the site for sample collection. The groundwater characteristics may take some time to stabilise after installation and development of new wells. Refer to SOP002 and SOPXXX for further information regarding the monitoring well installation and development.

Pumping should be done in a manner that minimises stress (drawdown) to the system to the extent practical.

6 Fieldwork Instruction

(PRINT THIS SECTION FOR USE IN THE FIELD)

Any variations to this Fieldwork Instruction required to meet project specific objectives should be identified by the Project Manager prior to fieldworks and an amended uncontrolled instruction provided to fieldwork staff.

Variations made in the field by fieldwork staff should be documented in the site notes and communicated to the Project Manager.

6.1 Decontamination

The equipment (low flow pump/interface probe) shall be decontaminated prior to use and between sampling each surface sample location by the following procedure.

1. Wipe the probe and measuring tape (the length that comes into contact with groundwater) using disposable alcohol wipes. Dispose of the alcohol wipes into a contaminated waste bag.

2. Empty pump bladder and leftover groundwater in waste water container using a funnel.

3. Wash the low flow pump, suspension wire, probe and associated tape using a scrubbing brush in a bucket with a solution of potable water and detergent (phosphate free and biodegradable, e.g. Decon 90).

4. Rinse the low flow pump, probe, wire and tape with potable water in another bucket.

5. Final rinse of all apparatus using deionised water in a spray bottle/bucket or directly from the deionized water container.

6. The wash solution needs to be renewed when the decontamination process becomes ineffective, e.g. product on the probe after rinsing or sheen in the wash solution buckets.

6.2 Low Flow Groundwater Sampling

- YSI model WQMs should be turned on 30 minutes before sampling to allow sensors to stabilise. Ensure protective covers are removed from probe;

- Check the pressure on the gas cylinder – a full cylinder should read initially on the regulator 5000 kpa; and

- Check for leakage of CO_2 or air in the system, if identified immediately turn off CO_2/compressor and undertake repair/change equipment with apparatus isolated and de-energized.

1. The wells on the site least likely to be contaminated should be targeted first so as to reduce the risk of potential cross contamination between sample locations.

2. (If using CO_2) Connect gas cylinder/compressor to regulator, the regulator to hose and the hose to the control box.

3. Turn on the gas/start compressor, control box and Water Quality Meter (WQM).

4. Ensure pump casing and hanger cable have been decontaminated. Install new disposable bladder in pump, check o-rings are all in place correctly and undamaged. Connect hanger cable to pump casing, ensuring d-bolt is tightly secured.

5. Connect the tubing line to the pump casing, discharge line (larger diameter) and air line (thinner diameter). If using twin tubing (joined tubing), ensure the excess glue has been removed from tubing line using scissors or tube cutters before connecting to pump and controller to prevent damage to inlets and o-rings. Once connected pull on the tubing to test they aresecure.

6. Open the monitoring well cover by (a) unlocking the flush mount well gatic with a hex key or (b) lifting the hinge lid on the monument/stick up well cover or (c) removing the lid on any other well cover as required (e.g. quarter turn well covers).

Monitoring well covers can cut/injure hands. Use cut resistant gloves to open well covers. Be careful for wells with positive pressure (such as landfill leachate bores that could pop off the loosened well cap. Keep body parts clear of well when opening).

Biological hazards (eg spiders, ants) may be present within gatic covers, exercise caution when opening wells. Wear gloves and remove cobwebs before placing hands into the well.

7. Remove the well cap (e.g. J-plug), PVC end cap, torque cap.

High concentrations of vapours can build up in the well and be released into the breathing zone when the well cap is removed. Implement appropriate work space monitoring (eg LEL, PID, colorimetric gas detection tubes) and HSE procedures (eg maintain appropriate fire extinguishers in work area) prior to removal of well cap.

8. Measure the SWL in the well with the interface probe. This depth will be taken as the original SWL on your purging sheet.

9. Wells should be gauged prior to the commencement of any sampling, where possible.

10. Lower pump into well slowly to avoid water column disturbance (pump should not be lowered to the bottom of well as this could cause resuspension of solids which will have collected at the bottom of the well). Lower tubing and wire carefully together to prevent tangling which can lead to the pump becoming lodged in the well. Review each well completion log to select the depth to which the pump inlet will be set. The pump should be positioned dependent on the contaminant of concern or to target high permeability zones. Where this is not known, the pump inlet should be located approximately in the middle of the screened interval so as not to disturb the bottom of the well and allow for sufficient water above the pump. Ensure the hanger cable is tight and that the cable reel has been locked in place. The depth of the pump inlet can be measured by using the interface probe/water meter to measure the depth to the top of the pump. Record depth to pump on purging sheet.

11. Attach the tubing airline to the control box (see Figure 1). Attach discharge line (larger diameter) to the flow cell in the bottom outlet to allow flow cell to fill with water before discharge. Place flow cell into a bucket to ensure overflow from discharge is contained.

12. Remeasure the SWL in the well or use the drawdown meter to monitor any drawdown during pumping.

13. The difference in depth between the SWL recorded before the pump was lowered into the well and after will give a rough estimate of how quick the well will recharge if no historical data is available (the larger the difference in depths the slower the recharge as a general rule).

14. Measure depth to top of pump and record as purging depth on purge sheet. If this is not possible, ie in wells with a diameter greater than 50 mm, an estimate can be made.

15. For CO_2 setup - Set the air pressure on the gas cylinder regulator and control box throttle to required pressure. Using the formula Purging Depth (1 metre = 1 psi) + 10 psi = Air Pressure e.g. 15m depth = (15x1) +10 = 25. The pressure should be slightly greater on the gas cylinder regulator compared to the control throttle. Watch the rate at which water is discharged and adjust pressure as necessary.

16. Review previous sampling sheets to obtain an idea of the appropriate pumping rate. Set the controller to the estimated flow rate or if unknown start on 100 ml/min (CPM 1). One cycle yields approximately 100 ml of water. Groundwater flow should be between 0.1-0.4 L/ min.

17. For O2 setup – set the fill and discharge times. Discharge times are the time it takes to squeeze the bladder and fill time is the time allowed for the bladder to refill. Fill and discharge rates depend on hydrostatic pressure (i.e. water above the pump). The airline pressure gauge should not exceed the equivalent depth to water 1 PSI = 0.7 m of water.

18. Review previous sampling sheets to obtain an idea of the appropriate flow rate. If discharge falls off before the discharge cycle is complete, the discharge time can be lowered. If drawdown is significant, fill time can be increased.

19. Start the pump. Allow purged water to overflow (into a container) the flow-through cell before starting to take water quality parameter readings and standing water level readings, once this occurs take readings every three minutes (where sampling rate is 100ml/minute or more) or five minutes (if flow rate is less than 100 ml/minute).

20. Fill in data on CPM or fill/discharge rate, SWL readings and water quality parameters on the field purging sheet.

21. The drawdown should not exceed 10 cm difference from the original SWL at any time. However, it is more important that the groundwater quality parameters stabilise before sampling. If the drawdown is dropping continuously lower the flow rate to see if the SWL will stabilise. Once the SWL stabilises wait for three successive stable parameter readings before sampling (at 3 to 5 minute interval between each successive reading).

Caution	**If you are still getting drawdown with the very low pump rates, contact PM for advice.**

22. Once field parameters have stabilised samples can be collected (a minimum of 1 L of groundwater should be removed prior to sampling). The water quality parameters are considered stable when for three successive readings the parameters are within the following: ±10% Dissolved Oxygen; ±3% Electrical Conductivity; ±0.05 pH; ±10 mV Redox Potential; and ±0.2°C Temperature. Pay attention to water quality parameters and check that readings are as expected based on site knowledge and chemistry. Issues often occur with WQMs. Parameters can also be easily recorded incorrectly if the wrong units or parameter is referenced. Taking time to set-up WQM display screen with the required parameters and units may help as parameters that are not recorded (e.g. salinity) are not displayed. Contact PM and/or equipment supplier if unsure of readings or experiencing issues with WQM.

23. If water quality parameters have changed significantly since last GME call the PM.

24. Maintain the same pumping rate for sampling. Disconnect the pump's tubing from the flow-through-cell so that the samples are collected from the pump's discharge tubing. Air pressure on the gas cylinder can be turned down so samples can be filled with minimal turbulence (if applicable).

25. Fill samples over a bucket/basin to minimise spillage.

26. Store samples in esky with sufficient ice or ice bricks. Ice should form a bed beneath samples and cover samples. Glass vials and bottles should be stored in bubble wrap and eskies should not be over-filled.

27. Turn the controller off. Remove the pump from the monitoring well. Decontaminate the pump and probe following steps decontamination steps in section **6.1** and dispose of the tubing, bladder and other waste. The flow-through cell doesn't need to be rinsed between wells (unless a sheen, strong hydrocarbon odour or sediment is noticed to keep it in good working condition). Water quality sensors should be rinsed with tap water.

- If SWL varied during purging, measure the SWL after sampling to ensure that levels did not exceed 10 cm difference from the original SWL.

- If this is the last well for the day, or before a break, the gas line should be turned off and de- pressurised before leaving by turning the gas off at the cylinder and running the controller through one or two cycles. All caps should be replaced on the WQM.

28. Replace cap on well, lock gatic. Check area for anything left behind before leaving.

7 Troubleshooting

7.1 Water isn't discharging from the pump:

- Check gas bottle is not empty/compressor is operating.
- Check air pressure gauges on the gas bottle and controller are at appropriate levels (if applicable).
- Re-connect air hose to compressor to ensure there isn't a leak.
- Remove pump from well.
- Check water and air lines connecting pump to ensure there isn't a leak.
- Check o-rings are in place in pump; replace any worn o-rings.
- Check bladder hasn't broken and is in good condition.
- Decon or clean pump and inlet to remove sediment.

7.2 There are air bubbles (observed audibly from the well head) in the water discharge tube:

- O-rings are missing or worn, check and replace if needed.
- Air line connecting to pump is leaking causing water bubble in discharge line, re-connect both air and water tubes connecting to pump.
- Bladder is missing or not sealed.

7.3 The water level keeps fluctuating up and down rapidly:

- O-rings are missing or worn, check and replace if needed.
- Air line connecting to pump is leaking causing water to bubble in well, re-connect both air and water tubes connecting to pump.
- Bladder is missing or not sealed.

8 References

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EMM 2019, Groundwater Monitoring Well Installation SOP002

SOP006_Groundwater Sampling_ HydraSleeve

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18 September 2019

Subject: Standard Operating Procedure (SOP006) Sampling Groundwater using a HydraSleeve

1 Introduction

The HydraSleeve is classified as a no-purge (passive) grab sampling device, meaning that it is used to collect groundwater samples directly from the screened interval of a well without having to purge the well prior to sample collection. When it is used as described in this Standard Operating Procedure (SOP), the HydraSleeve causes no drawdown in the well (until the sample is withdrawn from the water column) and only minimal disturbance of the water column, because it has a very thin cross section and it displaces very little water (<100 ml) during deployment in the well. The HydraSleeve collects a sample from within the screen only. It excludes water from any other part of the water column in the well through the use of a self- sealing check valve at the top of the sampler. It is a single-use (disposable) sampler that is not intended for reuse, so there are no decontamination requirements for the sampler itself.

The use of no-purge sampling as a means of collecting representative groundwater samples depends on the natural movement of groundwater (under ambient hydraulic head) from the formation adjacent to the well screen through the screen. Robin and Gillham (1987) demonstrated the existence of a dynamic equilibrium between the water in a formation and the water in a well screen installed in that formation, which results in formation-quality water being available in the well screen for sampling at all times. No-purge sampling devices like the HydraSleeve collect this formation-quality water as the sample, under undisturbed (non- pumping) natural flow conditions. Samples collected in this manner generally provide more conservative (i.e., higher concentration) values than samples collected using well-volume purging, and values equivalent to samples collected using low-flow purging and sampling (Parsons, 2005).

2 Applications of the HydraSleeve

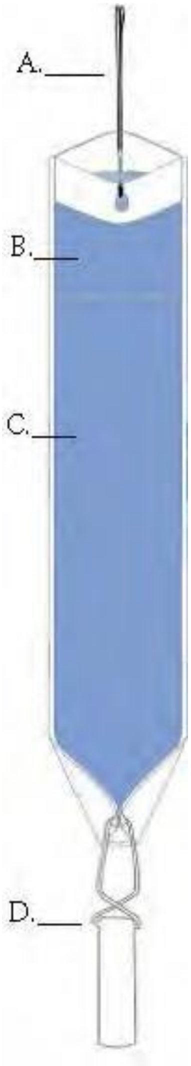
The HydraSleeve can be used to collect representative samples of groundwater for all analytes (volatile organic compounds (VOCs), semi-volatile organic compounds (SVOCs), common metals, trace metals, major cations and anions, dissolved gases, total dissolved solids, radionuclides, pesticides, PCBs, explosive compounds, and all other analytical parameters).

Designs are available to collect samples from wells from 1" inside diameter and larger. The HydraSleeve can collect samples from wells of any yield, but it is especially well-suited to collecting samples from low-yield wells, where other sampling methods can't be used reliably because their use results in dewatering of the well screen and alteration of sample chemistry (McAlary and Barker, 1987).

The HydraSleeve can collect samples from wells of any depth, and it can be used for single- event sampling or long-term groundwater monitoring programs. Because of its thin cross section and flexible construction, it can be used in narrow, constricted or damaged wells where rigid sampling devices may not fit. Using multiple

HydraSleeves deployed in series along a single suspension line or tether, it is also possible to conduct in-well vertical profiling in wells in which contaminant concentrations are thought to be stratified.

As with all groundwater sampling devices, HydraSleeves should not be used to collect groundwater samples from wells in which separate (non-aqueous) phase hydrocarbons (ie gasoline, diesel fuel or jet fuel) are present because of the possibility of incorporating some of the separate-phase hydrocarbon into the sample.



3 Description of the HydraSleeve

The basic HydraSleeve (Figure 1) consists of the following components*:

- A suspension line or tether (A), attached to the spring clip or directly to the top of the sleeve to deploy the device into and recover the device from the well. Tethers with depth indicators marked in 1-foot intervals are available from the manufacturer.

- A long, flexible, 4-mil thick lay-flat polyethylene sample sleeve (C) sealed at the bottom (this is the sample chamber), which comes in different sizes, as discussed below with a self-sealing reed-type flexible polyethylene check valve built into the top of the sleeve (B) to prevent water from entering or exiting the sampler except during sample acquisition.

- A reusable stainless-steel weight with clip (D), which is attached to the bottom of the sleeve to carry it down the well to its intended depth in the water column. Bottom weights available from the manufacturer are 0.75" OD and are available in a variety of sizes. An optional top weight may be attached to the top of the HydraSleeve to carry it to depth and to compress it at the bottom of the well (not shown in Figure 1).

- A discharge tube that is used to puncture the HydraSleeve after it is recovered from the well so the sample can be decanted into sample bottles (not shown).

- Just above the self-sealing check valve at the top of the sleeve are two holes which provide attachment points for the spring clip and/or suspension line or tether. At the bottom of the sample sleeve are two holes which provide attachment points for the weight clip and weight.

* Other configurations such as top weighted assemblies, Super/SkinnySleeves, Speedbags, and W3Hybrids are available.

Note: The sample sleeve and the discharge tube are designed for one-time use and are disposable. The spring clip, weight and weight clip may be reused after thorough cleaning. Suspension cord is generally disposed after one use although, if it is dedicated to the well, it may be reused at the discretion of the sampling personnel.

4 Selecting the HydraSleeve size to meet the site-specific sampling objectives

It is important to understand that each HydraSleeve is able to collect a finite volume of sample because, after the HydraSleeve is deployed, you only get one chance to collect an undisturbed sample. Thus, the volume of sample required to meet your site-specific sampling and analytical requirements will dictate the size of HydraSleeve you need to meet these requirements.

Table 1 Dimensions and volumes of HydraSleeve models

Diameter	Volume	Length	Lay-Flat Width	Filled Diameter
2-inch HydraSleeves				
Standard 600 ml HydraSleeve	~600 ml	30”	2.5”	1.4”
Standard 1 L Hydrasleeve	~ 1 L	38”	3”	1.9”
Super/SkinnySleeve 1 L	~1 L	38”	2.5”	1.5”*
Super/SkinnySleeve 1.5 L	~1.5 L	52”	2.5”	1.5”*
Super/SkinnySleeve 2 L	~2 L	66”	2.5”	1.5”*
4-Inch HydraSleeve				
Standard 2.5 L	~2 L	38”	4”	2.7”

* outside diameter on the Heavy Duty Universal Super/SkinnySleeve is 1.5” however when using with schedule 40 hardware the OD of the assembly will be 1.9”

It's also recommended that you size the diameter of the HydraSleeve according to the diameter of the well (ie use 2-inch HydraSleeves in 2-inch wells). Using smaller sleeves in larger diameter wells (ie 2-inch HydraSleeves in 4-inch wells) will result in a longer fill rate and will require special retrieval instructions (explained later).

The volume of sample collected by the HydraSleeve varies with the diameter and length of the HydraSleeve. Dimensions and volumes of available HydraSleeve models are detailed in Table 1.

HydraSleeves can be custom-fabricated by GeoInsight in varying diameters and lengths to meet specific volume requirements. HydraSleeves can also be deployed in series (i.e., multiple HydraSleeves attached to one tether) to collect additional sample to meet specific volume requirements, as described below.

If you have questions regarding the availability of sufficient volume of sample to satisfy laboratory requirements for analysis, it is recommended that you contact the laboratory to discuss the minimum volumes needed for each suite of analytes. Laboratories often require only 10% to 25% of the volume they specify to complete analysis for specific suites of analytes, so they can often work with much smaller sample volumes that can easily be supplied using a HydraSleeve.

5 HydraSleeve deployment

5.1 Information Required Before Deploying a HydraSleeve

Before installing a HydraSleeve in any well, you will need to know the following:

- the inside diameter of the well;
- the length of the well screen;
- the water level in the well;
- the position of the well screen in the well; and
- the total depth of the well.

The inside diameter of the well is used to determine the appropriate HydraSleeve diameter for use in the well. The other information is used to determine the proper placement of the HydraSleeve in the well to collect a representative sample from the screen (see HydraSleeve Placement, below), and to determine the appropriate length of tether to attach to the HydraSleeve to deploy it at the appropriate position in the well.

Most of this information (with the exception of the water level) should be available from the well log; if not, it will have to be collected by some other means. The inside diameter of the well can be measured at the top of the well casing, and the total depth of the well can be measured by sounding the bottom of the well with a weighted tape. The position and length of the well screen may have to be determined using a down-hole camera if a well log is not available. The water level in the well can be measured using any commonly available water-level gauge.

5.2 HydraSleeve Placement

The HydraSleeve is designed to collect a sample directly from the well screen. It fills by pulling it up through the screen a distance equivalent to the length of the sampler when correctly sized to the well diameter. This upward motion causes the top check valve to open, which allows the device to fill. To optimise sample recovery, it is recommended that the HydraSleeve be placed in the well so that the bottom weight rests on the bottom of the well and the top of the HydraSleeve is as close to the bottom of the well screen as possible. This should allow the sampler to fill before the top of the device reaches the top of the screen as it is pulled up through the water column and ensure that only water from the screen is collected as the sample. In short-screen wells, or wells with a short water column, it may be necessary to use a top-weight on the HydraSleeve to compress it in the bottom of the well so that, when it is recovered, it has room to fill before it reaches the top of the screen.

Example

2” ID PVC well, 50’ total depth, 10’ screen at the bottom of the well, with water level above the screen (the entire screen contains water).

Correct Placement (figure 2): Using a standard HydraSleeve for a 2” well (2.5” flat width/1.5” filled OD x 30” long, 600 ml volume), deploy the sampler so the weight (a 5 oz., 2.5” long weight with a 2” long clip) rests at the bottom of the well. The top of the sleeve is thus set at ~34” above the bottom of the well. When the sampler is recovered, it will be pulled upward approximately 30” before it is filled; therefore, it is full (and the top check valve closes) at approximately 64” (5.3 feet) above the bottom of the well, which is well before the sampler reaches the top of the screen. In this example, only water from the screen is collected as a sample.

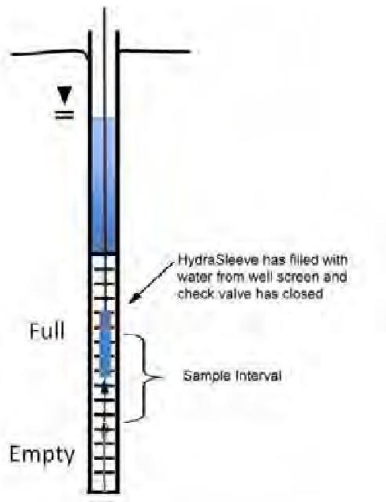


Figure 2 Correct placement of HydraSleeve

Incorrect Placement (figure 3): If the well screen in this example was only 5’ long, and the HydraSleeve was placed as above, it would not fill before the top of the device reached the top of the well screen, so the sample would include water from above the screen, which may not have the same chemistry.

The solution? Deploy the HydraSleeve with a top weight, so that it is collapsed to within 6” of the bottom of the well.

When the HydraSleeve is recovered, it will fill within 36” (3 feet) from the bottom of the well, or 2-feet before the sampler reaches the top of the screen, so it collects only water from the screen as the sample.

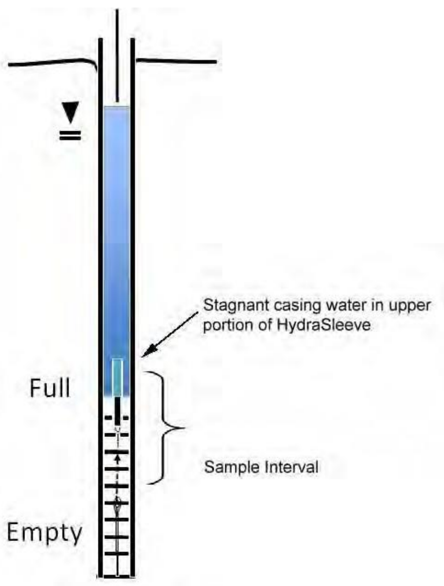


Figure 3 Incorrect placement of HydraSleeve

This example illustrates one of many types of HydraSleeve placements. More complex placements are discussed in a later section.

Note: Using smaller diameter HydraSleeves (2-inch) in larger diameter wells (4-inch) causes a slower fill rate. Special retrieval methods are necessary if this is your set up (shown later in this document).

6 Procedures for sampling with the HydraSleeve

Collecting a groundwater sample with a HydraSleeve is usually a simple one-person operation.

Note: Before deploying the HydraSleeve in the well, collect the depth-to-water measurement that you will use to determine the preferred position of the HydraSleeve in the well. This measurement may also be used with measurements from other wells to create a groundwater contour map. If necessary, also measure the depth to the bottom of the well to verify actual well depth to confirm your decision on placement of the HydraSleeve in the water column.

Measure the correct amount of tether needed to suspend the HydraSleeve in the well so that the weight will rest on the bottom of the well (or at your preferred position in the well).

Make sure to account for the need to leave a few feet of tether at the top of the well to allow recovery of the sleeve.

Note: Always wear sterile gloves when handling and discharging the HydraSleeve.

6.1 Assembling the Basic HydraSleeve*

1. Remove the HydraSleeve from its packaging, unfold it, and hold it by its top.

2. Crimp the top of the HydraSleeve by folding the hard polyethylene reinforcing strips at the holes.

3. Attach the spring clip to the holes to ensure that the top will remain open until the sampler is retrieved.

4. Attach the tether to the spring clip by tying a knot in the tether.

Note: Alternatively, if spring clips are not being utilized, attach the tether to one (NOT both) of the holes at the top of the Hydrasleeve by tying a knot in the tether.

1. Fold the flaps with the two holes at the bottom of the HydraSleeve together to align the holes and slide the weight clip through the holes.

2. Attach a weight to the bottom of the weight clip to ensure that the HydraSleeve will descend to the bottom of the well.

*See Super/SkinnySleeve assembly manual and HydraSleeve Field Manual for other assembly instructions.

6.2 Deploying the HydraSleeve

1. Using the tether, carefully lower the HydraSleeve to the bottom of the well, or to your preferred depth in the water column

2. During installation, hydrostatic pressure in the water column will keep the self-sealing check valve at the top of the HydraSleeve closed, and ensure that it retains its flat, empty profile for an indefinite period prior to recovery.

Note: Make sure that it is not pulled upward at any time during its descent. If the HydraSleeve is pulled upward at a rate greater than 0.5'/second at any time prior to recovery, the top check valve will open and water will enter the HydraSleeve prematurely.

1. Secure the tether at the top of the well by placing the well cap on the top of the well casing and over the tether.

Note: Alternatively, you can tie the tether to a hook on the bottom of the well cap (you will need to leave a few inches of slack in the line to avoid pulling the sampler up as the cap is removed at the next sampling event).

6.3 Equilibrating the well

The equilibration time is the time it takes for conditions in the water column (primarily flow dynamics and contaminant distribution) to restabilise after vertical mixing occurs (caused by installation of a sampling device in the well).

- Situation: The HydraSleeve is deployed for the first time or for only one time in a well.

  The basic HydraSleeve is very thin in cross section and displaces very little water (<100 ml) during deployment so, unlike most other sampling devices, it does not disturb the water column to the point at which long equilibration times are necessary to ensure recovery of a representative sample.

  In some cases, like when using the Speed Bags, the HydraSleeve can be recovered immediately (with no equilibration time) or within a few hours. In regulatory jurisdictions that impose specific requirements for equilibration times prior to recovery of no-purge sampling devices, these requirements should be followed.

  NOTE: If using top weights additional equilibration time is needed to allow the top weight time to compress the HydraSleeve into the bottom of the well.

- Situation: The HydraSleeve is being deployed for recovery during a future sampling event.

  In periodic (i.e., quarterly, semi-annual, or annual) sampling programs, the sampler for the current sampling event can be recovered and a new sampler (for the next sampling event) deployed immediately thereafter, so the new sampler remains in the well until the next sampling event.

  Thus, a long equilibration time is ensured and, at the next sampling event, the sampler can be recovered immediately. This means that separate mobilizations, to deploy and then to recover the sampler, are not required. HydraSleeves can be left in a well for an indefinite period of time without concern.

6.4 HydraSleeve recovery and sample collection

1. Hold on to the tether while removing the well cap.
2. Secure the tether at the top of the well while maintaining tension on the tether (but without pulling the tether upwards)
3. Measure the water level in the well.
4. Use one of the following 3 retrieval methods. In all 3 scenarios, when the HydraSleeve is full, the top check valve will close. You should begin to feel the weight of the HydraSleeve on the tether and it will begin to displace water. The closed check valve prevents loss of sample and entry of water from zones above the well screen as the HydraSleeve is recovered.

- In one smooth motion, pull the tether up 30”-60" (the length of the sampler) at a rate of about 1foot per second (or faster). The motion will open the top check valve and allow the HydraSleeve to fill (it should fill in about 1:1 ratio or the length of the HydraSleeve if the sleeve is sized to fit the well). This is analogous to coring the water column in the well from the bottom up.

- There are times it is recommended that the HydraSleeve be oscillated in the screen zone to ensure it is full before leaving the screen area. Pull up 1-3 feet, let the sleeve assembly drop back down and repeat 3-5 times before pulling the sleeve to the surface. The collection zone will be the oscillation zone. ***When in doubt use this retrieval method.***

- SpeedBags require check valve activation and oscillation during recovery: When retrieving the SpeedBag, pull up hard 1-2 feet to open the check valve; let the assembly drop back down to the starting point; REPEAT THIS PROCESS 4 TIMES; and then quickly recover the SpeedBag through the well screen to the surface.

5. Continue pulling the tether upward until the HydraSleeve is at the top of the well.

6. Discard the small volume of water trapped in the Hydrasleeve above the check valve by pinching it off at the top under the stiffeners (above the check valve).

6.5 Sample discharge

Note: Sample collection should be done immediately after the HydraSleeve has been brought to the surface to preserve sample integrity.

Be sure you have discarded the water sitting above the check valve – see step #6 above.

1. Remove the discharge tube from its sleeve.

2. Hold the HydraSleeve at the check valve

3. Puncture the HydraSleeve at least 3-4 inches below the reinforcement strips with the pointed end of the discharge tube. NOTE: For some contaminants (VOC's/sinkers) the best location for discharge is the middle to bottom of the sampler. This would be representative of the deeper portion of the well screen.

4. Discharge water from the HydraSleeve into your sample containers. Control the discharge from the HydraSleeve by either raising the bottom of the sleeve, by squeezing it like a tube of toothpaste, or both.

5. Continue filling sample containers until all are full.

6.5.1 Measurement of field indicator parameters

Field indicator parameter measurement is generally done during well purging and sampling to confirm when parameters are stable and sampling can begin. Because no-purge sampling does not require purging, field indicator parameter measurement is not necessary for the purpose of confirming when purging is complete.

If field indicator parameter measurement is required to meet a specific non-purging regulatory requirement, it can be done by taking measurements from water within a HydraSleeve that is not used for collecting a sample to submit for laboratory analysis (ie a second HydraSleeve installed in conjunction with the primary sample collection HydraSleeve [see Multiple Sampler Deployment below]).

6.5.2 Alternate deployment strategies

Deployment in Wells with Limited Water Columns

For wells in which only a limited water column needs to be sampled, the HydraSleeve can be deployed with an optional top weight in addition to a bottom weight. The top weight will collapse the HydraSleeve to a very short (approximately 6” to 24”) length, depending on the length and volume of the sampler. This allows the HydraSleeve to fill in a water column only 3’ to 10’ in height (again) depending on the sampler size. Note the SuperSleeves accomplish the same thing but provide greater sample volume at a lower per sample cost.

Multiple Sampler Deployment

Multiple sampler deployment in a single well screen can accomplish two purposes:

1. It can collect additional sample volume to satisfy site or laboratory-specific sample volume requirements.

2. It can be used to collect samples from multiple intervals in the screen to allow identification of possible contaminant stratification.

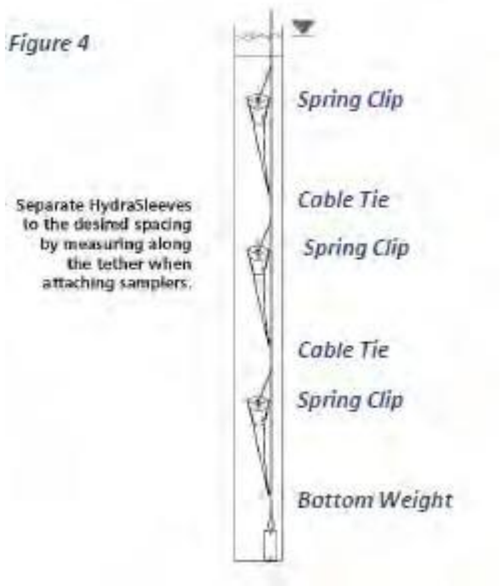


Figure 4 Multiple HydraSleeve deployment

If there is a need for only two samplers, they can be installed as follows. The first sampler can be attached to the tether as described above, a second attached to the bottom of the first using your desired length of tether between the two and the weight attached to the bottom of the second sampler (figure 6). This method can only be used with two samplers; three or more HydraSleeves in tandem need to be attached as described above.

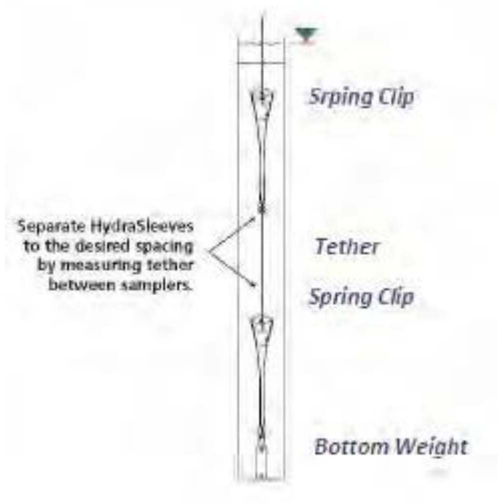


Figure 6 Alternative method for deploying multiple HydraSleeves

In either case, when attaching multiple HydraSleeves in series, more weight will be required to hold the samplers in place in the well than would be required with a single sampler. Recovery of multiple samplers and collection of samples is done in the same manner as for single sampler deployments.

7 Post-sampling activities

The recovered HydraSleeve and the sample discharge tubing should be disposed as per the solid waste management plan for the site. To prepare for the next sampling event, a new HydraSleeve can be deployed in the well (as described previously) and left in the well until the next sampling event, at which time it can be recovered.

The weight and weight clip can be reused on this sampler after they have been thoroughly cleaned as per the site equipment decontamination plan. The tether may be dedicated to the well and reused or discarded at the discretion of sampling personnel.

8 References

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SOP007 Bore/well development

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12 September 2019

To: EMM staff
From: Kate Holder
Subject: Bore / well development SOP No.7

Dear team,

1 Introduction

The purpose of bore/ well development is to:

- Rectify drilling damage to the formation by:
  - removing mud filter cake on borehole wall (where mud rotary drilling methods are used); and
  - removing smeared clay/formation material on borehole wall.
- Remove fine grained sediment and drilling fluid from the area immediately surrounding the screen to:
  - increase hydraulic connection to the formation near the borehole to aid water flow towards the bore/ well;
  - eliminate turbidity in future samples; and
  - obtain groundwater samples representative of the formation.

Bores / wells must be developed following installation and prior to groundwater monitoring, aquifer testing or operation. Most development methods reverse flow through the screen to loosen fine-grained materials, draw them out of the area surrounding the screen and rearrange the filter pack and the formation material for greater pumping efficiency. The flow reversals can be induced by surge blocks, bailers, pumps, airlifting with compressed air or by water jetting. Jetting and airlifting are the most effective development methods, especially in larger diameter bores/ wells. To be effective, bore / well development must reach past the screen and the filter /gravel pack to the borehole wall to rectify drilling damage to the formation and to remove any drilling fluids. Development should not be applied to bores/ wells with free product (hydrocarbons), as it may result in the formation of an oil/water emulsion, which can alter the chemistry at the bore/ well for months.

Where possible, bore/ well development should be conducted by the drilling contractor as soon practicable following bore construction. However, this is not always possible.

The following sources were used to prepare the following Standard Operating Procedure:

Sterrett, R. 2007, Groundwater and Wells, 3rd edn, Johnson Screens, United States of America, pp 501-550.

2 Project planning

2.1 Field equipment and supplies

Field equipment for bore development may include the following:

- water level tape /meter or interface probe;
- field water quality meter (YSI 556 Multi Parameter meter or similar);
- calibration solutions (buffer pH 4, 7, 10 solutions; ORP calibration solution; electrical conductivity standard solutions);
- 20 L bucket;
- disposable nitrile gloves;
- tag line;
- clipboard or folder;
- permanent marker and pencils / pens;
- paper towel;
- personal protective equipment.

3 Bore / well development

Bore / well development is performed after the annular seal materials have set/ cured. Development before the annular seal has set may result in the formation of gaps between the filter pack /gravel pack and the annular seal as the filter /gravel pack materials settle and compact. It is useful to collect a sample of the annular seal during installation to be used as a reference for assessing the setting/curing time.

During bore development the following should be recorded:

- initial and final groundwater level measurements;
- airlift yield;
- volume purged; and,
- field water quality parameters, such as temperature, pH and electrical conductivity at regular intervals during the bore / well development process.

The bore screen should be developed in sections, starting at the top of the screen, working down as the sections clear up and the amount of sediment decreases.

The bore is commonly developed until the discharge water is clear or until no further improvement is observed.

Although field parameters are measured during development, they do not indicate development completion; there is no relationship between the stabilisation of field parameters and the objectives of bore development, other than indicating that the drilling water has been removed and formation water is being pumped. However, this is still an important observation.

In addition to recording the initial and final groundwater level, the field hydrogeologist should measure and record the depth to groundwater at the beginning of each shift before recommencing bore development (if the bore development duration extends beyond one shift).

The sections below list some commonly used development techniques in monitoring and production bores.

3.1 Airlift technique (monitoring bores)

Airlifting pumping technique involves the use of an air compressor to alternate lifting the water column to surface for a specified time (typically 10 minutes) and then shutting the compressor off to allow the water column to fall and flow back through the screen (typically 5 minutes). It is advisable to open both valves on the air compressor to relieve back pressure. Airlifting should continue until the pumped water is free of sediment (or as approved by the Project Manager or technical advisor).

Care should be taken to minimise the potential for introducing air or airborne contaminants into the formation. For this reason, the intake of the air compressor must be located upwind of any sources of air contaminants, such as exhaust fumes, and a particulate filter should be utilised. Airlifting should be done through an air–injection pipe (typically 25 mm PVC hose) and a discharge connector, which is secured to the top of the PVC. The air-injector pipe is run down the bore / well to no more than 3 metres above the screen. This prevents oxygenation and introduction of air compressor oils into the formation, which may result in chemical alteration of the sampling zone (Strickland et al, 2009).

Airlift pumping can also be performed with a drilling rig. However, the drilling contractor must conduct the airlifting with care to avoid damaging the bore casing and screens (e.g. damage by lowering to the bottom of the bore and puncturing the bore, or the tool is lowered into the bore at an angle and punctures the casing).

Instantaneous pressure differentials developed during the initial airlift may cause the screen to collapse.

“The casing or screen experiences 1 psi of force for every 2.31 feet of head differential between the inside and outside water level, so a water column differential of 231 feet would exert a pressure of 100 psi at the base of a casing assembly” (Johnson Screens, 2005).

ADVANTAGES

- Well-suited to all types of bore construction.
- The surge action is very effective in rearranging the filter / gravel pack and clearing fines from the bore column due to large amounts of energy available.

DISADVANTAGES

- May alter water chemistry by the introduction of foreign particles from the compressor and oxygen.
- Requires heavy bulky equipment (air compressor or drilling rig).

3.2 Air/ water jetting with jetting tool (production bores)

This method aims to maximise the yield and is typically used in production bores. The drilling contractor should be equipped with a jetting tool, which projects air or water through nozzles. As in Section 3.1, the casing collapse pressure and collapse strength need to be considered when using this methodology, especially if the bore was constructed with PVC.

The procedure for development with a jetting tool is as follows:

1. Review the bore design information.
2. Measure the static groundwater level and total depth of the bore.

3. The jetting tool should be positioned halfway between the static water level and the top of the screen. Airlift to evacuate the water column above the tool. This reduces the differential pressure created between the inside of the screen and the formation, and prevents potential screen collapse. Continue lowering the jetting tool in sections until flow is established with the jetting tool above the top of the screen.

4. Once flow is established, the jetting tool is moved to the top of the screen and lowered at a rate of 0.3 m/min to 0.5 m above the bottom of the screen.

5. The jetting tool is then raised at 1.5 m/min to the starting depth.

6. The jetting tool is then lowered back to 0.5 m above the bottom of the screen.

7. The bore / well is then airlift surged five times at that depth.

8. The jetting tool remains at 0.5 m above the bottom of the bore / well and the entire bore / well is airlifted for at least 30 minutes.
   Sediment testing occur during development. If the amount of sediment in a 20 L bucket is less than the size of a 20 cent piece, the development is complete. Confirmation with the Project Manager or technical advisor should be sought.
   Flow measurements (either using a V-notch weir or conducting a bucket test) and field water quality parameters (temperature, pH, electrical conductivity, dissolved oxygen and oxygen reducing potential) shall be recorded during development and at completion.

9. If development criteria is not met, the process (step 4 to 7) will be repeated. If the amount of sediment in subsequent cycles does not decrease and the water quality parameters are stable, development may be discontinued after consultation with the Project Manager and/ technical advisor.

10. At completion of development, measure and record the final airlift yield and field water quality parameters. Measure the final groundwater level and total depth. A decrease in total depth indicates required additional development time or screen damage.

If possible, pressure transducer data loggers (PTDLs) should be installed in surrounding bore / wells during development. The recorded groundwater elevation data can be used to assess the hydraulic connection and hydraulic parameters.

Once a bore / well is developed by this method, it can be valuable to conduct an airlift recovery test. This involves airlifting at a relatively constant air pressure for a period of time (usually 30 min). Airlift yield (discharge) measurements are recorded at regular intervals while the bore / well is being airlifted. After the airlift period, the air is turned off and the groundwater level recovery is recorded. The simplest way to record the groundwater level recovery is to install a PTDL within the bore / well prior to conducting the airlift recovery test.

3.3 Low yielding bores / monitoring bores

For low-yielding bores, the bore may go dry prior to development completion. If the bore goes dry and does not recover promptly, it is recommended to inject potable water down the bore and commence surging followed by pumping to remove injected water and fines. If a source of potable water is not available, use Waterra tubing with the foot valve deactivated by sealing the foot valve ingress and surge with a surge block followed by pumping to remove fines and formation water.

3.4 Mechanical surging technique

Mechanical surging involves the agitation of the water column in the bore/ well with the up-and-down motion of a plunger-like device, such as a surge block, followed by the removal of sediment brought into the bore by this action through pumping. To effectively surge a bore, apply an up-and-down motion, repeatedly raising and dropping the plunger by about 1 metre. The up-and-down plunging action causes water and fine sediment to flow into and out of the bore / well, agitating and mobilising particles around the screen.

3.4.1 Inertial lift (monitoring bores)

A surge block is a tight-fitting, solid block that is affixed to the end of Waterra tubing and acts as a plunger beneath the groundwater level. The Waterra tubing is equipped with a one-way foot valve, which closes on the "up" cycle, pushing water up to ground surface. Surging should initially be gentle and at a slow rate so that the surge block does not potentially damage the screen through friction. Surging should start at the top of the bore screen to avoid the possibility of “sand-locking” the surge block. The up and down motion can be achieved by hand pumping or by using a Waterra Pump. The use of surge blocks is most effective in 50 mm diameter monitoring bores and is not recommended for larger diameter bores.

Waterra tubing, foot valves and pumps recommended for use at different depth ranges in 50 mm diameter monitoring bores are summarised in Table 1.

Table 1 Recommended tubing, foot valves and pumps

	50 mm diameter Bores with Total Depth < 50 m	50 mm diameter Bores with Total Depth 50 – 90 m
Tubing	5/8” OD x ½” ID High Density Polyethylene Waterra Tubing	1” OD x ½” ID High Density Polyethylene Waterra Tubing
Foot Valve	D-25 Waterra Foot Valve	D-32 Waterra Foot Valve
Pump	Waterra Power Pack (backpac pump)	Waterra Power Pump (large pump)

Note: OD: Outer Diameter; ID: Inner Diameter

ADVANTAGES

- Uses simple, highly portable equipment
- Does not require introduction of foreign fluids
- Effective and relatively inexpensive

DISADVANTAGES

- Not recommended for bores with total depths greater than 90 m
- Not well suited to bores with non-flush casing joints or for bores with an inner diameter greater than 50 mm

3.4.2 Bailer (monitoring bores)

The diameter of a bailer is slightly smaller than the diameter of a 50 mm monitoring bore. The bailer can be used to agitate the water in the bore in a similar manner to a surge block, but less effectively. The bailer is submerged to the top of the screen and pulled up quickly to agitate that portion of the screen. The distance of the pull should be approximately that of the bailer length, usually 1 m. The surging should start at the top of the screen and continue in bailer length intervals towards the bottom. It is recommended to surge the bore using a bailer for 10-20 minutes prior to bailing out the column of water.

ADVANTAGES

- Uses simple, highly portable equipment
- Does not introduce foreign fluids
- Relatively inexpensive

DISADVANTAGES

- Less effective development method compared to using a surge block with Waterra equipment
- Time consuming
- Not recommended for deep bores and bores with deep water columns.
- Not well suited to bores with non-flush casing joints or for bores with inner diameter greater than 50 mm

3.5 Development assisted with chemicals

The use of chemicals in developing a bore / well that will be used to monitor groundwater quality should be avoided if possible; however polyphosphates (a dispersing agent), acids or disinfectants can be used in general bore / well development. Sodium or calcium hypochlorite can be used to break down polymer muds used in drilling. Either of these reagents are usually mixed at a concentration of 1,000 parts per million (ppm) and are injected at a flow rate sufficient to ensure ample mixing of the solution with the drilling mud in the bore. The hypochlorite solution is usually jetted into the bore / well and allowed to react with the drilling fluid for several hours; then the bore / well is developed.

4 Development record

The following should be recorded during bore / well development (see Attachment 1):

- Prior to development:
  - bore ID
  - date
  - total depth
  - screened interval
  - depth to groundwater
- airlift yield
- field water quality parameters
- water clarity should be described in detail and photographed, as that is the main indicator of development completion.
- After to development:
  - final airlift yield
  - field water quality
  - total depth
  - depth to groundwater

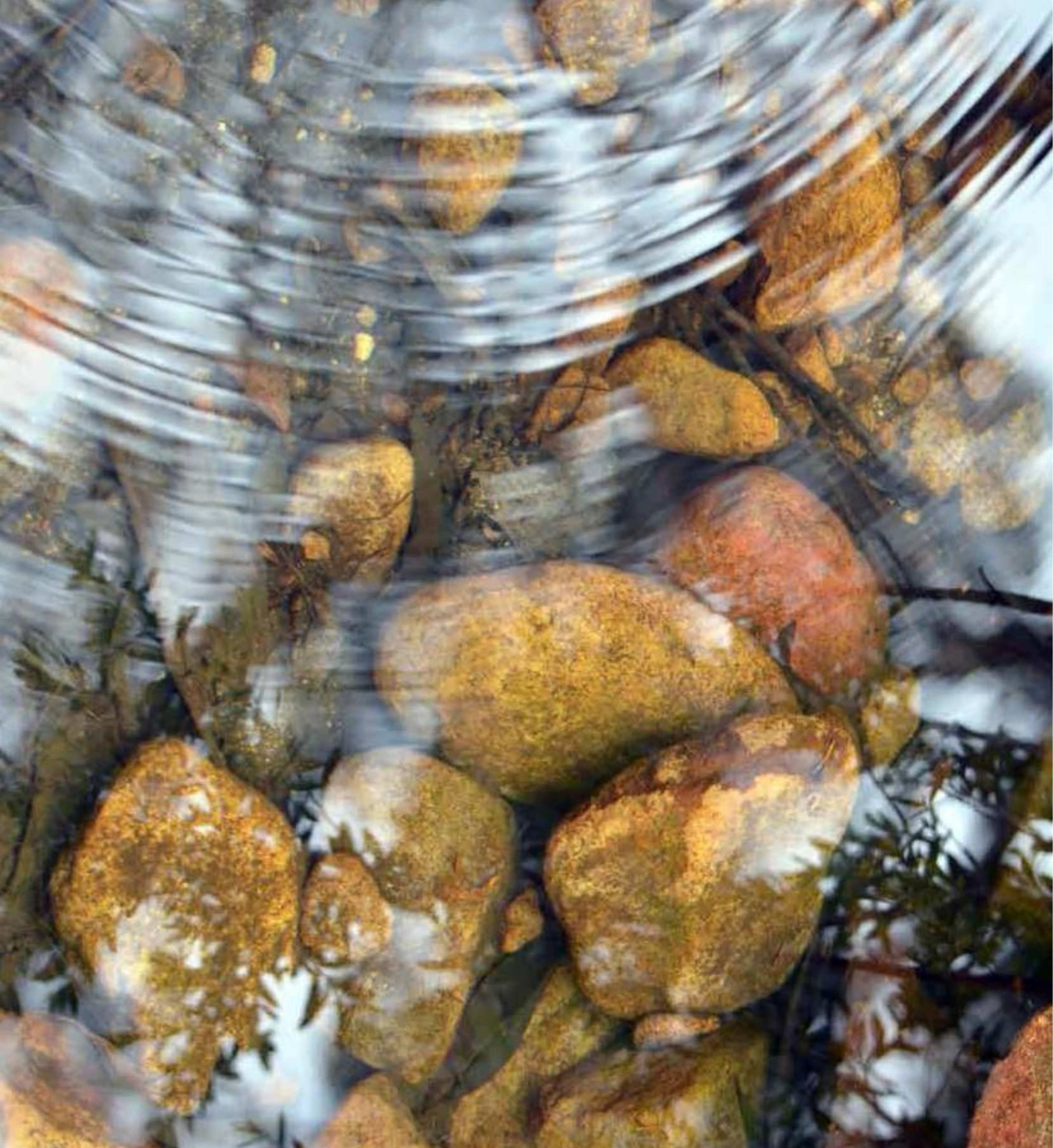
The Project Manager / technical advisor may request that a groundwater sample be collected for laboratory analysis following well development.

Project / Borehole						Name				
Date	Depth (m)	Airlift (L/s)	Development volume/time	EC (µS/cm)	TDS (mg/L)	pH	TEMP (°C)	DO (%)	DO (mg/L)	ORP (mV)

Attachment 1: Development Record

Project / Borehole						Name				
Date	Depth (m)	Airlift (L/s)	Development volume/time	EC (µS/cm)	TDS (mg/L)	pH	TEMP (°C)	DO (%)	DO (mg/L)	ORP (mV)

Attachment 1: Development Record



Water Management Plan_V5 (Operations)

Final Audit Report 2025-05-09

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