SOUTH AUSTRALIA

Government of South Australia
Department for Energy and Mining

Bird in Hand Gold Project

Assessment report

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Acknowledgement of Country

As guests here on Kaurna land, the Department for Energy and Mining (DEM) acknowledges everything this department does impacts on Aboriginal country, the sea, the sky, its people, and the spiritual and cultural connections which have existed since the first sunrise. Our responsibility is to share our collective knowledge, recognise a difficult history, respect the relationships made over time, and create a stronger future. We are ready to walk, learn and work together.

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Chapter 1

Introduction

Bird in Hand Gold project applications

Terramin Exploration Pty Ltd and Terramin Australia Limited (collectively referred to as Terramin in this report) have applied for a mining lease (ML) over mineral claim (MC) 4473 in Woodside and an associated miscellaneous purposes licence (MPL) at their existing Angas Zinc Mine near Strathalbyn. Both applications make up the Bird in Hand Gold Project.

Mining lease application

The proposed Bird in Hand Gold Project is located approximately 2 km east of Woodside within the Adelaide Hills. The MC total area is 194.78 hectares, which incorporates the footprint of both the proposed above ground operations and the underground operations. The proposed visible above-ground operations are located at 192 Pfeiffer Road, Woodside, with a total area of 36.6 ha. This parcel of land has been identified by Terramin as 'Goldwyn' within the MP. Figure 1 shows the entire MC as the white dotted area. Proposed surface infrastructure is located entirely on land owned by Terramin, indicated within the black line. Proposed underground operations extend under Bird in Hand Road into the central section of the MC.

Figure 1: Proposed mine location and associated infrastructure[1]

[1] Appendix C3 of the Mining Proposal – Note that ventilation shaft is now proposed in the location of the upper decline as per the applicant's response document.

Miscellaneous purposes licence application

The MPL application is over existing tenements, held by Terramin, EML 5325, and a portion of ML 6229, which make up the Angas Zinc Mine (AZM). AZM was placed into care and maintenance in October 2013 due to the lack of economic ore. The operation included an underground mine with portal/decline access and a mineral processing plant, which is in what was previously a limestone quarry and EPA licensed landfill.

Figure 2 shows that the proposed MPL extends to the south-east and south-west of ML 6229 increasing the overall footprint of AZM.

Figure 2: Proposed MPL boundary relative to existing ML 6229 and EML 5325[2]

Applicable legislation

Terramin submitted applications on 21 June 2019 in accordance with the *Mining Act 1971* (the Act) and *Mining Regulations 2011* for a ML and a MPL (referred to as the application).

As the application was submitted prior to amendments made to the Act on 1 January 2021 and the *Mining Regulations 2020* coming into effect, the various elements of the Application

[2] Figure 1-5 from the MPLA.

have been assessed against the appropriate version of each specific piece of relevant legislation based on the *Act's Interpretation Act 1915* and other relevant legal principles.

The South Australian government (referred to as government) considered the Application in the context of the requirements of other South Australian legislation, including but not limited to the *Environment Protection Act 1993, Landscape South Australia Act 2019, Planning, Development and Infrastructure Act 2016, Aboriginal Heritage Act 1988, Heritage Places Act 1993, Native Vegetation Act 1991 and* Commonwealth *Environment Protection and Biodiversity Conservation Act 1999*.

Specific Ministerial Determination

Government recognises the particular community and commercial interests arising from the location of the Bird in Hand Gold Project. In April 2017, on advice from technical specialists in the South Australian Department for Energy and Mining (DEM), Department for Environment and Water (DEW) and the Environment Protection Authority (EPA), a project-specific Ministerial Determination was published setting out the minimum requirements of a mining lease application for the Bird in Hand Gold Project. The Determination for a Mining Proposal for the Bird in Hand Gold Project (PDF 377 KB) sets out the information that must be provided by Terramin, including information to be obtained from in-depth studies on the interaction between the proposed mine, the environment (particularly groundwater), adjacent businesses, residents and the local community.

The miscellaneous purposes licence application for processing of gold ore at the AZM was prepared in accordance with the relevant Ministerial Determination[3] in place at the time of application.

Two-stage process

Mining applications go through a two-stage process before mining or ancillary operations can begin. The level of detail required in the initial application must be sufficient to enable assessment of potential impacts and to demonstrate that proposed design or control measures to manage those impacts will be effective.

If a lease and/or licence are granted they will include environmental outcomes based on the assessment of potential impacts that must be included in the PEPR. The tenement holder must develop a PEPR as per the relevant Terms of Reference that includes detailed design and control measures that will achieve required outcomes.

The level of detail required for designs or control measures in a PEPR must be sufficient to support construction, operation and closure of the mine. The PEPR must also include evidence of community engagement, which allows interested parties an opportunity to contribute to final designs prior to them being approved.

[3] Ministerial Determination 006 (2015): *Minimum information required to be provided in a mining proposal and/or management plan for a mineral lease (ML) and any associated miscellaneous purposes licence (MPL) applications for metallic and industrial minerals (excluding extractive coal and uranium).*

At the application stage the Act requires proposal of draft measurement criteria. During the PEPR stage the measurement criteria and any supporting leading indicator criteria must be finalised. Once approved, the tenement holder must demonstrate achievement of all outcomes through the measurement criteria in an annual compliance report that is publicly available.

Environmental outcomes

The Act requires that an outcome statement must be developed for each of the confirmed environmental impacts, covering all relevant stages of the proposed operation – construction, authorised operations, closure operations and completion.

Each proposed outcome statement must be:

- **Achievable** - The assessment must demonstrate that the proposed management and/or mitigation measure(s) will be effective in achieving the outcome. For post-completion impact events, this considers whether the proposed strategies would be self-sustaining in the long term.
- **Appropriate** - Each proposed outcome must refer to the confirmed environmental impact event(s) and the receptor that is potentially affected by the impact event. The expected level of impact on the receptor (residual impact subsequent to control strategies being implemented) must also be considered to be appropriate given the economic and social benefits.
- **Acceptable** - The outcomes must meet legislative requirements and regulatory standards.

Before granting approval for any new operation, the department reviews evidence provided in the application to assess whether the controls proposed by the applicant would be effective and achieve proposed or recommended outcomes.

The outcome must commit the tenement holder to an appropriate maximum level of impact, which is defined by the specific measurement criteria associated with each outcome. There may be many potential impact events that result in a single environmental outcome. Where this occurs there may be several measurement criteria specific to an outcome that must be developed in the Program for Environment Protection and Rehabilitation (PEPR). The Act requires proponents to set out draft measurement criteria at the lease/licence application stage, with final measurement criteria detailed in the PEPR.

If a tenement is granted, the tenement holder must demonstrate to all stakeholders that they are achieving the approved outcomes set in the conditions of their lease or licence and PEPR, through the measurement criteria approved in the PEPR.[4]

[4] Developing outcomes for quarrying and mining, Mineral Regulatory Guidelines MG30.

Assessment process

Government has assessed the application, response document and public submissions. The assessment process is shown below:

Terramin prepares applications for the Bird in Hand Gold Project, including for the proposed underground mine at Woodside, mineral processing at Strathalbyn, and groundwater management strategies at Woodside.

Terramin submits those applications in accordance with the requirements of the *Mining Act 1971*.

Government assesses those applications against requirements set out in the relevant Ministerial Determinations to ensure the applications are valid.

If the applications are valid, the applications are released for public and government agency comment.

Government review and compilation of all public submissions, as well as submissions prepared by technical experts across multiple government agencies. Government prepares a request requiring Terramin to provide a detailed response addressing all the concerns raised in submissions.

Public and government submissions are provided to Terramin with a formal request for a response. The submissions and request for response will be published on DEM's website.

Terramin reviews all submissions and responds to issues in a detailed Response Document.

Government undertakes a comprehensive assessment of the information provided in the Response Document. Issues not adequately addressed will be required to be addressed through the submission of a revised Response Document.

Government publishes the Response Document (once accepted by DEM) on DEM's website allowing the public to view how concerns raised in the submissions were responded to.

Government completes a comprehensive technical assessment of the applications taking into account public and government submissions, Terramin's Response Document and any other relevant information.

The government will then make decisions on the merits of the applications, taking into account whether the information provided demonstrates the ability to achieve all proposed environmental outcomes.

At this stage, the government may refuse or approve each of the applications. The outcome of these decisions will be published and communicated to all relevant landholders and people who made a submission.

If the applications are approved, the proponent must then meet all the conditions of those approvals. This would include the preparation of a PEPR developed in consultation with stakeholders which must be approved by government before any works can start. Government will not approve the PEPR until it has been comprehensively assessed by technical experts across government agencies to ensure all legislative requirements are met.

Assessment report

This assessment report addresses the environmental, social and economic impacts of the proposed activities as described in the application. While this assessment report is intended to be a stand-alone document, other supporting information includes:

- Terramin Mining Proposal (MP) and Management Plan (MPLA)
- Public submissions
- SA government requests for response
- Terramin Response Document

This assessment considered the following:

1. Whether Terramin provided adequate information about the existing receiving environment.
2. Whether Terramin identified all sensitive receptors and environmental values that may potentially be impacted by the proposed activities (additional sensitive receptors and environmental values may also be identified by DEM, other government agencies and/or the public).
3. Whether Terramin provided adequate information about the proposed activities within the application areas.
4. Whether Terramin provided adequate evidence of consultation with landowners and potentially affected persons, community and stakeholders in the development of the applications and environmental outcomes.
5. All relevant matters that were raised by members of the public during the government run consultation period.
6. Whether Terramin has identified and correctly assessed all potential impact events. Additional potential impact events may also be identified by DEM, other government agencies, and/or members of the public. The assessment considers the following matters:
    a. For any environmental aspects determined to be relevant as impact events, the source, pathway and receptor are confirmed to exist (or otherwise) for each phase of the proposed activities in the MP (construction, operation and post-completion). Impact events, outcomes and measurement criteria related to closure are incorporated into each environmental aspect.
    b. For all impact events where the source, pathway and receptor are confirmed to exist, whether the proposed outcome statement is appropriate. That is, whether the expected level of impact to the environment, subsequent to management and/or mitigation measures as described by Terramin, is appropriate. If the proposed outcome is not appropriate or requires amendment, government recommends a new appropriate outcome. If government assesses that it is not possible to state an appropriate outcome that can be achieved, government makes a recommendation to not grant the application (refuse).
    c. Whether the proposed or recommended outcome is achievable, which is based on an assessment of the likelihood that the proposed management and/or

mitigation measure(s) would be effective in achieving the outcome. For post-completion impact events, this considers whether the proposed strategies would be self-sustaining in the long-term. The assessment also considers any uncertainty or assumptions in relation to the impact event and control strategies proposed by Terramin.

If the recommended outcome is not achievable with the proposed control strategies but would be achievable with fit-for-purpose, leading practice industry control strategies, a recommendation to prescribe those strategies as a requirement of the lease or licence may be made. If the recommended outcome is not achievable with the proposed control strategies or fit-for-purpose, leading practice industry control strategies, a recommendation to limit or define the extent or scope of operations authorised under the proposed lease or licence may be made (if this will achieve the appropriate outcome) or a recommendation to not grant the application (refuse) may be made.

d. The recommended regulatory response in relation to the requirement for outcomes, strategies or conditions to be included in the lease and licence documents. All confirmed potential impact events require an outcome unless the consequence of the potential impact event has been demonstrated to be insignificant in nature. Recommended outcomes are based on the extent to which the proposed activities in the MP will limit an impact on the environment. Outcome statements are designed to be realistically achievable, appropriate and meet applicable legislative requirements.

e. Whether the draft measurement criteria are an appropriate measurement to demonstrate achievement of the proposed or recommended outcome and the requirement for criteria to be included in the lease/licence document. The assessment of draft measurement criteria considers whether relevant recognised industry, legislative or regulatory standards have been applied to the criteria. If appropriate standards have not been applied, government recommends their consideration. Recommendations for the modification or addition of new criteria are made where appropriate. Refinement of measurement criteria would occur in the PEPR, if a lease is granted.

f. The MP includes draft leading indicator criteria that are proposed where there is a high level of reliance on control strategies to ensure achievement of the proposed or recommended outcome. Refinement of leading indicator criteria will occur in the PEPR, if a lease is granted.

To avoid duplication, impact events, outcomes, strategies and measurement criteria may be assessed under a single environmental aspect – even though they may be related to more than one aspect.

The following is a summary of the processes to be undertaken after completion of the assessment.

1. The assessment is reviewed to ensure the correct statutory processes have been followed.
2. The assessment recommendation relating to the application is progressed to the Minister (or delegate).

3. The Minister (or delegate) is provided with all documents supporting the assessment and recommended terms, conditions and requirements to be imposed on the tenements should the tenements be granted.
4. The Minister (or delegate) then decides to either notify the applicant of the proposed terms, conditions and requirements of the tenement or refuse the application.
5. Should the Minister (or delegate) decide to refuse the application, the Minister (or delegate) notifies Terramin of the decision and the process ends.
6. If the Minister (or delegate) determines they are willing to notify Terramin of the proposed terms, conditions and requirements of the tenements, then they do so formally in writing.
7. Terramin must, within seven days (or such longer period as the Minister (or delegate) may allow) notify the Minister, in writing, whether Terramin is willing to accept the terms, conditions and requirements.
8. If Terramin accepts the terms, conditions and requirements, the Minister will grant the tenements.
9. If Terramin makes a submission to alter or remove a term, condition or requirement, DEM will assess the submission and decide whether to alter or proceed with the proposed terms, conditions and requirements.
10. The Minister will then move to publicly release the assessment report and details of the terms, conditions and requirements of grant or refusal.
11. The grant of the tenements would not give Terramin the right to commence mining operations (ML) or authorised operations (MPL) described in the Application. Should the tenements be granted, Terramin would be required to prepare a comprehensive and detailed PEPR for submission to DEM.
12. Authorised operations cannot commence until a PEPR is approved and a bond is registered in the Mining Register to cover the maximum rehabilitation liability.
13. Authorised operations cannot commence on exempt land until Terramin has obtained and registered waivers of exemption in accordance with section 9AA of the Act. These waivers would then need to be registered in the Mining Register.
14. Terramin will be required to obtain approvals under other legislation including an EPA licence and permitting under the *Landscape South Australia Act 2019.*

Chapter 2

Summary of proposed mining and processing operations

General overview

Terramin propose development of an underground gold mine and associated surface infrastructure at Woodside. Gold ore will be trucked from Woodside to the existing Angas Mine for mineral processing. The mine life including construction and closure is proposed to be 8 years. Figure 3 shows the main phases of mining and associated timeframes.

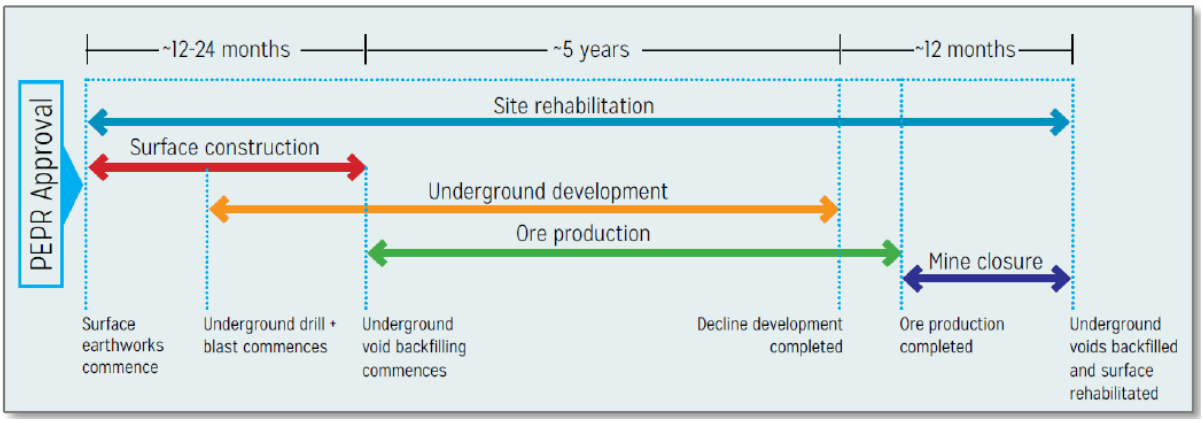


Figure 3: Proposed phases of mining and timeframes[5]

Construction

Mine

If a lease/licence is granted and subsequent PEPR approved the construction stage is estimated to take 12 to 24 months and would include upgrading the power supply to the site from the Woodside interconnector, access road construction, running of services for water, sewage and communications, formation of the redesigned landform (bunding etc.) and establishment of vegetation on site.[6]

Processing facility

No onsite processing of gold ore is proposed at the Woodside site. The processing of gold ore is almost identical to that used in the processing of lead/zinc ore. Terramin have selected the existing infrastructure at the AZM to process the material from the Woodside site to create gold concentrate.

The ore brought to the surface at the Woodside site will be trucked to the AZM processing facility. The facility consists of a multi-stage flotation plant using conventional processing

[5] Figure 3-2 from Chapter 3 of the Mining Proposal.
[6] Summarised from Chapter 3 of the Mining Proposal.

techniques for crushing, grinding, floatation and thickening, and a purpose-built tailings storage facility for tailings disposal.

The AZM is currently in care and maintenance. If a licence is granted and subsequent PEPR approved, the reinstatement of the processing facilities at the AZM is estimated to occur over 12 months.

Approximately 10,500 tonnes of ore from the Woodside site is expected to be transported to the AZM for processing each month. It is proposed that the processing of the ore will be campaigned for periods of 10-14 days per month, on a two-weeks-on, two-weeks-off, 24hr/day basis, or similar.[7]

Underground mine development and production

The underground mine development refers to establishment of the initial underground access, decline, stockpile/passing bays, underground magazine, underground substation, primary ventilation shaft, initial drives and secondary egress route prior to any ore being produced. Figure 4 shows the proposed mine surface layout.

The upper decline to the ore is approximately 1 km long and is estimated to take 16 months to construct. The rock mined during this process is not expected to contain any mineralisation and is collectively called mullock. Mullock mined during this stage will be stored on the surface for later use as backfilling, where it is used to replace the extracted gold ore as part of the cut and fill mining sequence and geotechnical support regime.

Once the ore zone is reached, 47 months of ore production has been planned. Production (mining of ore) consists of ore being brought to surface and mullock being returned as fill. Based on the current understanding of the ore body, mining has been planned to a depth of 450 metres.[8]

Closure

Terramin propose that once ore production is completed final backfilling of remaining open underground areas will occur, infrastructure will be removed and the decline and vent raises plugged, filled and sealed to provide stability and prevent access. The closure process is expected to take approximately 12 months. Final rehabilitation on the surface will be undertaken, with key infrastructure such as access roads, sheds and dams retained for future commercial/agricultural land use.[9]

[7] Summarised from Chapter 3 of the Miscellaneous Purposes Licence Application.
[8] Summarised from Chapter 3 of the Mining Proposal.
[9] Summarised from Chapter 3 of the Mining Proposal.

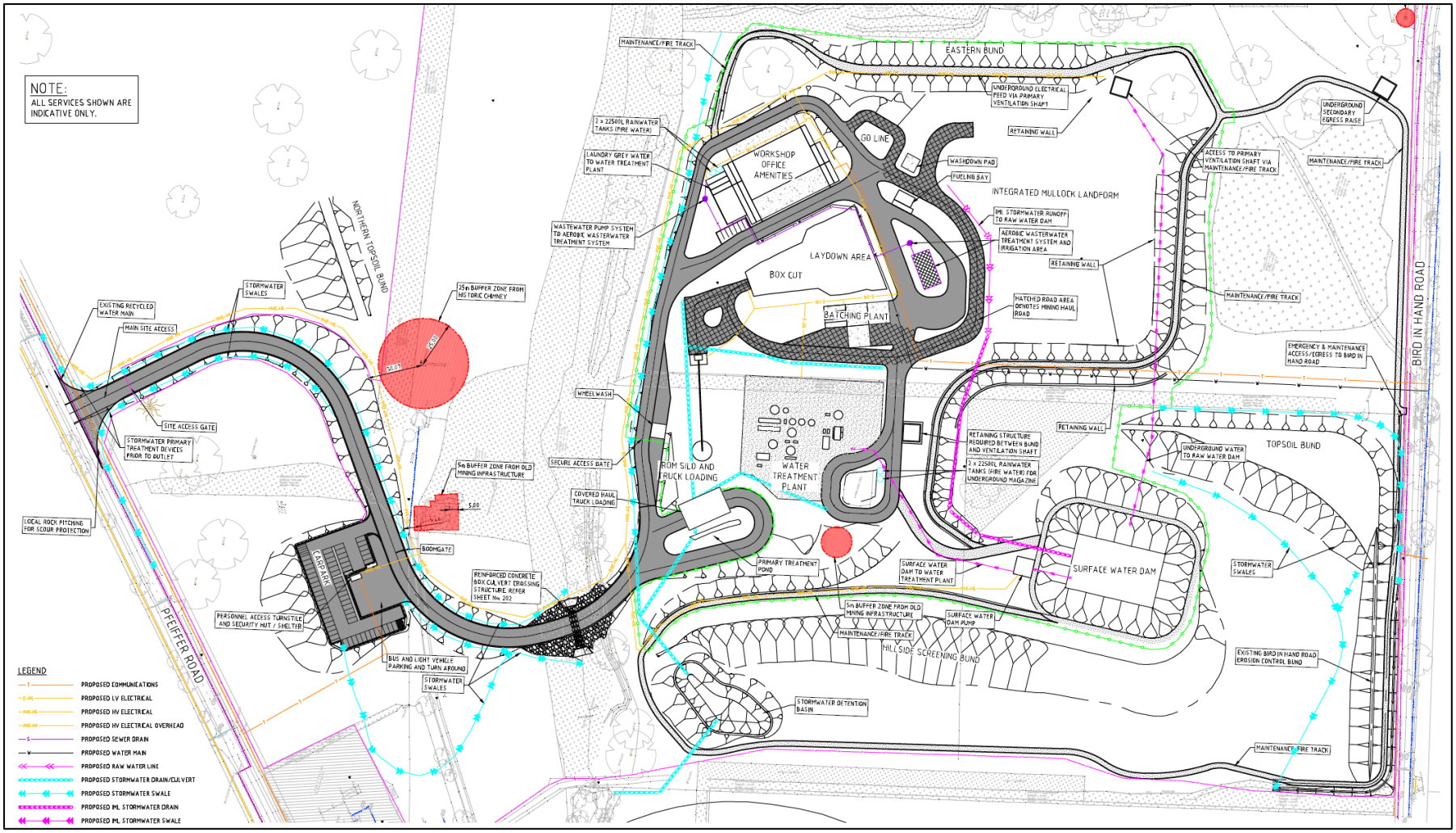


Figure 4: Proposed Site design – Appendix B1 of the Mining Proposal

Resource

The 2018 updated scoping study is based on the 2018 BIH Resource Estimate released by Terramin to the Australian Stock Exchange (ASX) on 30 October 2018.[10] The resource estimate was 650,000 tonnes at 12.6g/t gold for 265,000 ounces of gold at a 1.0g/t gold cut-off.

Table 1: 2018 BIH Mineral Resource Estimate[11]

Category	kt	Au (g/t)	Ag (g/t)	Au koz	Ag koz
Indicated Resource	432	14.4	7.56	200	105
Inferred Resource	220	9.2	2.4	65	17
Total Resource	650[1]	12.6	5.8	265	122

1- Numbers, totals and calculations included in this statement may be subject to rounding errors as a result of reporting to levels of precision
appropriate to the category of Mineral Resources.

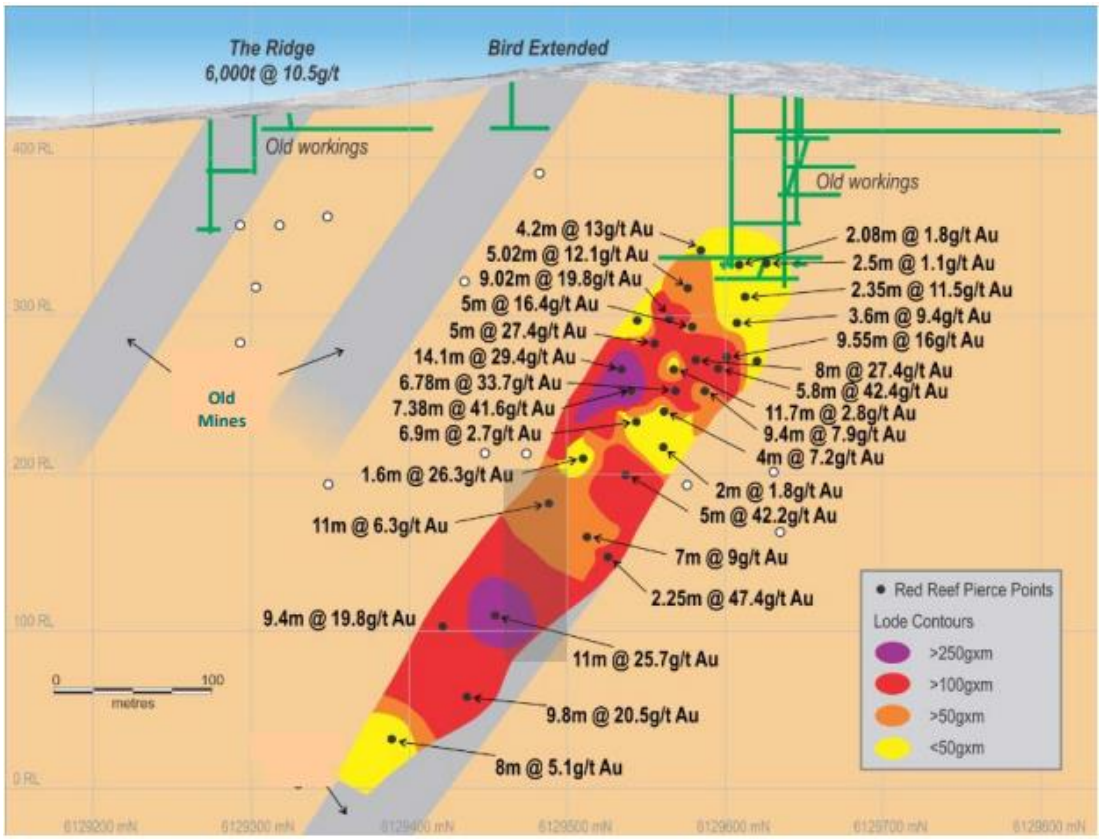


Figure 5: BIH Exploration cross section showing significant resource drilling intercepts[12]

[10] Note that Terramin released an updated feasibility study to the ASX on 23 June 2020. The resource estimate is the same as the 2018 estimate.
[11] Table 3-6, Chapter 3 of the Mining Proposal.
[12] Figure 3 from BIH Gold Project Feasibility Study (accessed online on 8 February 2022: https://www.terramin.com.au/bird-in-hand-gold)

The MP includes more detailed information about the resource and provides evidence that the resource estimate was undertaken by a Competent Person as defined in the 2012 Edition of the Australasian Code for Reporting of Exploration Results, Mineral Resources and Ore Reserves.

Figure 5 shows points where drilling intercepted gold across the deposit, noting some areas of very high grade, greater than 40g/t Au.

The department assesses that the inputs to the resource estimation are well documented and considered fair and reasonable. This includes considerations such as sampling protocols, analytical methodologies, quality assurance/quality control and density calculations. The processes undertaken to estimate the mineral resource are in line with accepted industry standards and conventions. The mineral resource for the Bird in Hand Gold deposit has been estimated on four occasions in recent times, the first three times based upon new drilling information with the last resource estimate based upon external review of existing data.

- No material changes have occurred during these iterations of resource estimations, which provides confidence in the overall resource inventory.
- Mineralisation is constrained by hard boundaries (ie vein-hosted), which reflects in the consistency across iterations of resource estimation.
- The proportion of indicated resources is around 75% with the balance in the inferred category. As per the previous two points this is not considered a material risk to the project viability.

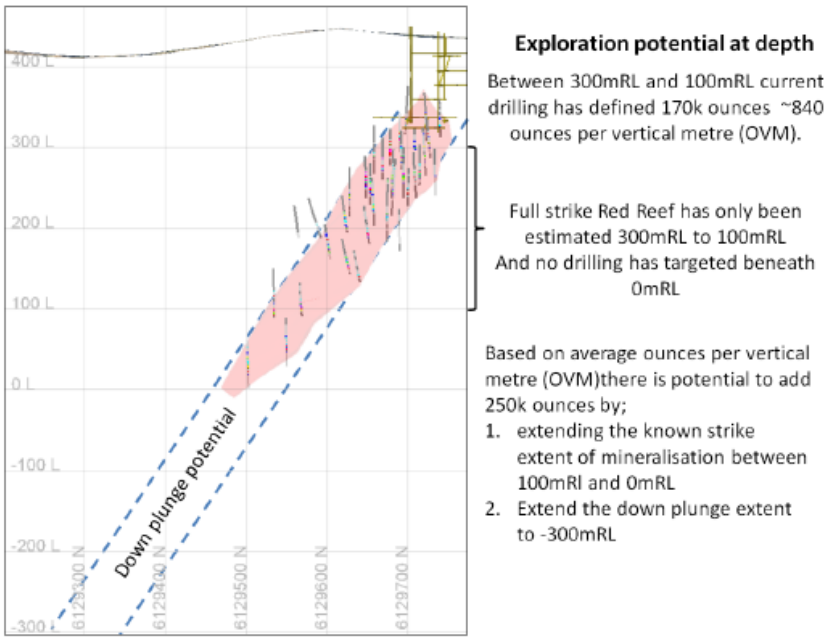


Figure 6: Bird in Hand Main Reef and drilling shown sectioned along the plane of mineralisation (20m window), viewed looking west[13]

[13] Figure 3-11, Chapter 3 of the Mining Proposal.

Additional resource potential

The MP notes the potential for the resource to continue as shown in Figure 6. The MP also notes exploration potential below the previous Ridge Mine and Bird in Hand Extended locations.[14]

Government noted the additional resource potential in its request for response, matter 78. Terramin responded that the results of exploration are uncertain and any timetable beyond the JORC resource would be speculative. As such, Terramin cannot provide any projections beyond the existing resource. If additional resource is discovered and Terramin propose extension mining past that proposed by this application, Terramin have acknowledged that new Mining Act regulatory applications and processes would be required.

Production rate and products

Production rate

Ore production is restricted by the mining rate associated with the cut and fill mining method used. Mine design and production scheduling has indicated that a maximum production rate for the project will be approximately 176,000 tonnes per annum. A summary of the expected production rate by year (with year 1 starting at the commencement of the decline development) is provided in Table 2.

Table 2: Summary of production rates over the life of the mine[15]

	Year 1	Year 2	Year 3	Year 4	Year 5	Total
Ore(t)	0	142,856	176,373	168,994	106,459	594,682
Waste(t)	194,686	196,415	146,201	105,100	47,777	690,179

Products

The commodities proposed to be generated by the project would include a gold concentrate and gold doré. It is proposed that both the gold concentrate and the gold doré would contain gold and silver.

Protection of worker safety underground

Worker safety is regulated under the *Work Health and Safety Act 2012* and administered by SafeWork SA.

The safety of workers in the underground mine is of utmost importance.

There is an interaction between strategies to ensure achievement of the proposed groundwater outcome and strategies to ensure the protection of workers in the underground

[14] Figure 3-11, Chapter 3 of the Mining Proposal.
[15] Table 3-6, Chapter 3 of the Mining Proposal.

mine. The main strategies to prevent water inflows to the underground mine are to avoid water-bearing structures and to apply grout and ground control strategies. The effectiveness of these strategies is also integral to the protection of workers in the underground mine.

In governments requests for information from the applicant, the following matters were highlighted as areas requiring further investigation by Terramin:

- The potential for the grouted rock mass, designed to control groundwater inflows, to relax.
- The effectiveness of the underground mine backfill strategy.

Terramin provided appropriate responses to both matters in their response document.

A model of the underground mine was used to predict the potential relaxation and deformation of the grouted rock mass. The model method is appropriate and was developed by suitably qualified experts. The model predicts that the proposed underground mine design would be effective to protect workers, based on the applied assumptions and strategies.

Terramin have proposed appropriate strategies to ensure protection of workers from rock mass relaxation. These include design and management strategies to ensure the implementation of grouting is effective and appropriate mitigation measures to identify and respond to a potential failure.

Government's geotechnical engineering experts have provided recommendations for Terramin to address as part of detailed operational designs, should a lease be granted. Refer to Appendix 5 for recommended conditions and PEPR requirements if a lease is granted. Given the importance of ensuring operational designs and management plans are effective in achieving outcomes, the conditions include provisions for independent expert reviews.

Terramin has considered two different methodologies of underground backfill. These are Cement Rock Fill (CRF) and Cement Aggregate Fill (CAF). Government requested additional information from the applicant to ensure the backfill strategy to be adopted would be effective to protect worker safety. Terramin provided a technical report in their response document that sets out the process and timing for undertaking site-specific analysis and studies to reduce uncertainty associated with the backfill strategy.[16] It is assessed that an effective backfill strategy can be designed, engineered, implemented and adopted.

It is recommended that a lease condition be applied to require further site-specific analysis and studies (committed to by Terramin) to inform the final backfill strategy to be provided in a PEPR, should a lease be granted.

Description of mine at completion

It is Terramin's intention that the Woodside site will be returned to a safe and stable landform that is suitable for use as lifestyle property or agribusiness in the same manner as those existing in the area. It is expected that the Goldwyn property would be made available for purchase by a third party once it has been rehabilitated to the satisfaction of government at the completion of mining. As part of the completion plan, a range of site infrastructure

[16] Mining One, 2020, Technical Memorandum – Bird in Hand Cemented Rock Fill Clarifications for the SA Government – Appendix E2 of the Response Document.

elements are proposed to be retained due to their values to potential future landowners ie sheds, roads and dams.

Terramin propose that post-mining land use options could include:

- Commercial – horticultural (vineyards, hydroponics etc), transport, maintenance, storage, function centre
- Private – club grounds, private residence
- Recreational – parks, open community space.

The reformed area would suit the construction of intense primary production or agricultural/viticulture processing facilities. Where suitable, these areas will be left as hard stands rather than being reformed and revegetated.

The remnant vegetation located to the south-east of the property, which would be further enhanced through construction and operations with additional native planting, would be protected in perpetuity as a native vegetation heritage agreement area, to complement and provide a valuable addition to the existing Native Vegetation Heritage Agreement Area located in the central land parcel of the proposed ML.[17]

Closure outcomes

Terramin proposed closure outcomes within Chapter 3 of the MP and in other relevant chapters. Government has assessed proposed closure outcomes relevant to specific environmental values in respective chapters of this report.

Table 3 provides the proposed outcome and government's assessment or reference to the relevant chapter of the assessment report.

Table 3: Proposed closure outcomes and government assessment

Terramin's proposed closure outcome	Government assessment or relevant chapter of this assessment report
Stabilise disturbed areas and prevent sediment from leaving the site	Chapter 13 – Surface water
No adverse impact to the supply or quality of water by the mining operations to existing users and water dependant ecosystems	Chapter 4 - Groundwater
No adverse impacts on soil quality within the mining lease that could compromise the post-mining land use	Chapter 14 – Other environmental values

[17] Summarised from Chapter 3 of the Mining Proposal.

Terramin's proposed closure outcome	Government assessment or relevant chapter of this assessment report
Ensure all underground voids are filled to the extent that subsidence cannot occur at any time after mine closure	Government assesses that this proposed outcome is a strategy to achieve the proposed third-party property outcome. It is recommended that this strategy is required in the PEPR, should a lease be granted.
Ensure that no damage occurs to third-party infrastructure and no injuries/ deaths result from collapse of the underground workings	Government confirms that the source(s), pathway(s) and receptor(s) would exist. The consequence of the potential impact is not insignificant; hence, an outcome is required. The outcome appropriately describes that there will be no damage to third-party property, injuries or deaths from collapse of the underground workings. The MP included a geotechnical assessment, which concluded that ground surface stability and subsidence will be managed through the proposed cut and fill mining approach, which limits the size of underground opening before being backfilled. Larger open void spaces like the vent shaft and decline will be monitored during operations and supported with ground support measures to prevent deterioration.[18] Government assesses that the proposed design and management strategies are likely to result in achievement of the proposed and recommended outcome. Refer to Appendix 5 for the recommended third-party property closure outcome should a lease be granted.
Ensure that, in constructing and operating the lease and after mine closure, there are no public injuries/deaths resulting from unauthorized entry to the mine site	Chapter 14 – Other environmental values
Ensure that upon mine closure, the site is left in a stable, non-polluting state indefinitely post closure	Government confirms that the source(s), pathway(s) and receptor(s) would exist. The consequence of the potential impact is not insignificant; hence, an outcome is required.

[18] Mining One, 2017, *Bird in Hand Gold Project Geotechnical Assessment* – Appendix M1 of the Mining Proposal.

Terramin's proposed closure outcome	Government assessment or relevant chapter of this assessment report
	The outcome appropriately states that the site must be left in a stable, non-polluting state indefinitely post closure. The outcome requires amendment to ensure it is appropriate for regulation. Government assesses that the proposed design and management strategies are likely to result in achievement of the proposed and recommended outcome. Refer to Appendix 5 for the recommended land and soil outcome should a lease be granted.
Ensure that upon mine closure, the decline under Bird in Hand Road is to be backfilled in a manner to ensure the long-term integrity of the public road structure.	Government assesses that this proposed outcome is a strategy to achieve the proposed third-party property outcome.
No permanent loss of abundance, condition or diversity of native vegetation (as defined by *Native Vegetation Act 1991*) on or off the lease during construction, operation and post mine completion through: • clearance • dust/contaminant deposition • fire • reduction in water supply, or • other damage unless prior approval under *Native Vegetation Act 1991* and Native Vegetation Regulations 2017 is obtained.	Chapter 14 – Other environmental values
The form, contrasting aspects and reflective aspects of mining structures are visually softened to blend in with the surrounding landscape.	Chapter 10 – Visual amenity
The lessee must ensure that upon mine closure, all plant and	Government considers this proposed outcome a strategy relevant to potential visual amenity

Terramin's proposed closure outcome	Government assessment or relevant chapter of this assessment report
equipment (unless otherwise agreed with the Chief Inspector of Mines) is removed from the site	impacts at closure. Government will require a bond upon approval of the PEPR, should a lease be granted. It is appropriate for all plant and equipment associated with mining to be removed from the site upon closure. Refer to Appendix 5 for the recommended visual amenity closure strategy should a lease be granted.

Chapter 3

Land ownership and access to land

Land ownership and notices of entry

A full list of landowners, current at the time of this assessment, is provided in Chapter 21 of the MP.

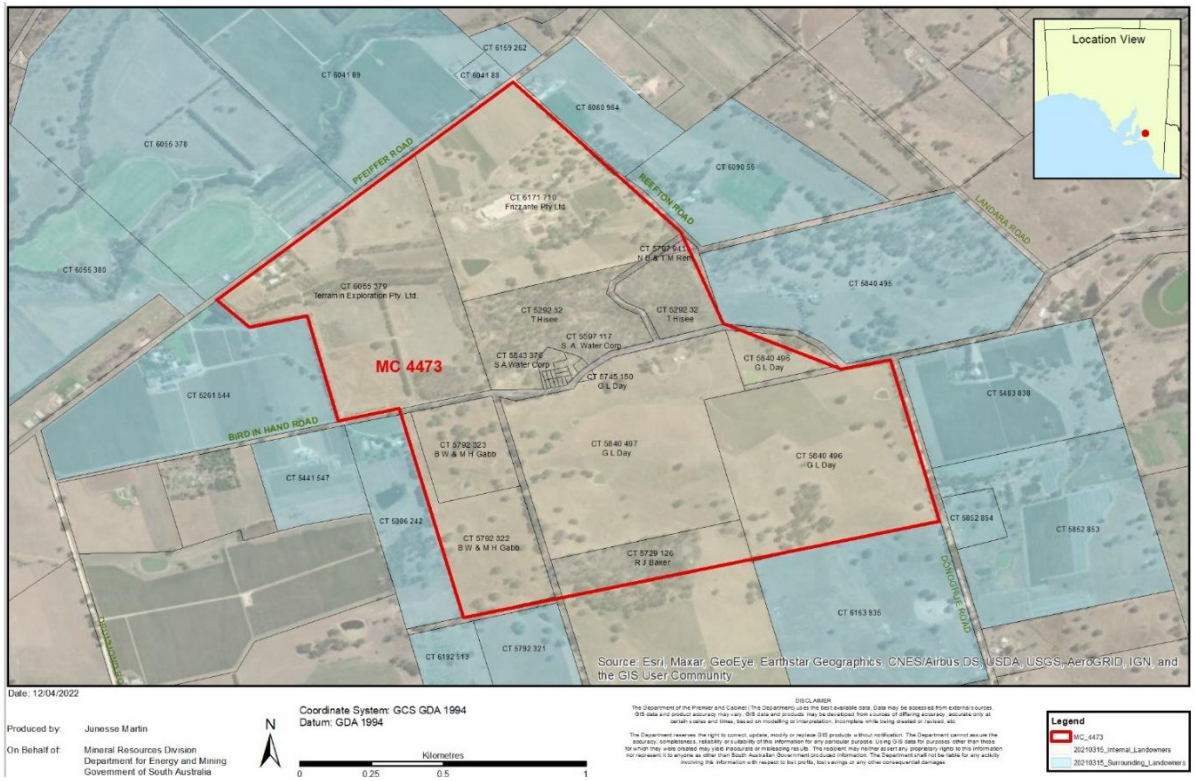


Figure 7: Map showing landowners within and adjacent to MC 4473

Terramin served the correct Notice of Entry Forms on landowners within MC 4473 and over the proposed MPL area at Strathalbyn. Required council consents for road reserves were also provided.

For more detail in relation to notices of entry refer to Appendix 1 of this report.

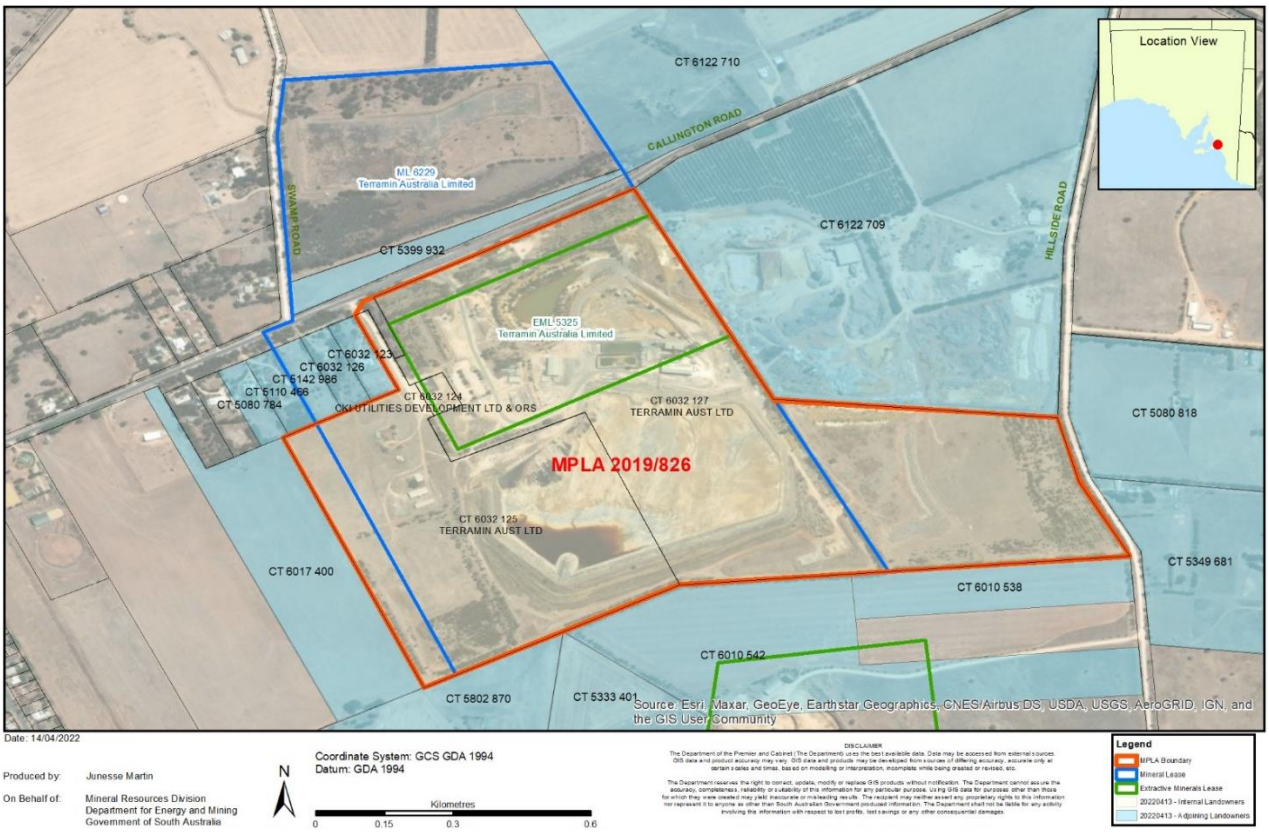


Figure 8: Map showing landowners within and adjacent to MPLA

Exempt land

The Mining Act provides that some land is 'exempt' from mining, exploration and ancillary operations. Should a lease or licence be granted, a miner cannot conduct any authorised operations on exempt land unless the landowner agrees to waive the exemption.

Section 9 of the Mining Act sets out the definitions of exempt land. The following are relevant to private landowners:

- Land that is lawfully and genuinely used as a yard or garden, plantation, orchard, vineyard, airfield or cultivated field, which is any field that is cultivated on a regular basis or is in the process of being re-established as cultivated.
- Land that is situated within 400 metres of a building or structure used as a place of residence.[19]
- Land that is situated within 150 metres of a building or structure with a value of $200 or more used for an industrial or commercial purpose, or a spring, well, reservoir or dam. A water bore falls within the definition of a well, according to a Warden's Court ruling.

[19] Historic Act s.9(1)(d)(i) applies as this was the legislation at the time of application as per the transitional provisions outlined in Schedule 5, s.2 of the *Mining Regulations 2020*.

A person is regarded as having the benefit of an exemption if:

- they are the owner of exempt land, or
- if they own a building, structure, spring, well or dam on land that is next to the area to be explored or mined.

Exempt land provisions also apply to ancillary operations that are authorised under a miscellaneous purposes licence granted under the Mining Act, for example, building and operating roads, pipelines, power lines and mineral processing plants.

Exempt land on the mineral claim and within the proposed ML

The MP proposes the majority of surface mining infrastructure on CT 6055/379, which is owned by Terramin Exploration Pty Ltd. Table 4 provides all beneficiaries of exempt land on CT 6055/379, type of exempt land and the proposed mining operations.

Table 4: Proposed mining operations and beneficiaries of exempt land on CT 6055/379

Landowner and Title Ref	Category of exempt land	Proposed mining operations
Frizzante Pty Ltd CT6171/710	Dam x2, wells x3, tank x8, shed x3 and cellar door, vineyards X2 and winery	MAR Well 6 and pipes Eastern bund Workshop office
Adelaide Polo Club Inc. CT6055/378	Residence, shed x 3, tank and horse yard x2	Access road Carpark Covered truck loading area Primary treatment pond Screening bund
Chatenois Pty Ltd & ORS CT6041/88	Residence, shed x4 and well	Access and portion of road Possibly topsoil stockpile
J A*Kelly CT5441/547	Residence, tank, shed and cellar door	Turkeys nest dam and pump Screening bund MAR well 3 and pipes
K H*Davis & ANR CT5306/242	Residence, tank, shed, well and dam x2	IML Turkeys nest dam and pump Topsoil and screening bunds MAR wells 3 and 4 MAR pipes
T*Hisee CT5292/32	Residence, shed x5, dam x4 and well	Underground operations and surface infrastructure
Terramin Exploration Pty Ltd. CT6055/379	Residence, garage, shed x4 dam x2 and well x3	Surface infrastructure

Proposed underground mining operations are located on exempt land underneath the following titles for which the listed landowners have the benefit of an exemption:

- CT5292/32 (T*Hisee)
- CT5843/376 (SA Water)

- CT5597/117 (SA Water)
- CT5840/497 (G*Day)

The MP states that other elements of the project have been designed to avoid mining operations on exempt land, however in some cases the location of mitigation measures (eg bunding, waste landforms, water storage dam) to avoid potential impacts are located on exempt land.

The conceptual MAR well locations were informed by numerical groundwater modelling to target specific geological formations and mitigate impacts to specific receptors. Six of the eight proposed MAR wells are within exempt land.

Exempt land on miscellaneous purposes licence application (MPLA) area

Terramin identified 23 parcels of land that may have exempt land in the MPLA. The following eight titles within the proposed MPL contain exempt land on which ancillary operations are proposed:

- CT5080/784 (T A*Hull)
- CT5110/466 (K A*Webb)
- CT6032/123 (Terramin Australia Ltd – C Spooner as Lessee)
- CT6032/124 (CKI Utilities Development Ltd & ORS)
- CT6032/125 (Terramin Australia Ltd – A Stefanowicz as Lessee)
- CT6032/126 (Terramin Australia Ltd – D Mobbs as Lessee)
- CT6122/709 (Adelaide Hills Property Pty Ltd)
- CT5079/330 (R W & G K Glover)

Waivers of exemption

ML application

Based on the location of proposed mining operations, including conceptual managed aquifer recharge wells, Terramin will require waivers from 14 landowners including one company owned by Terramin. Terramin have obtained waivers of exemption from some landowners already. The MP states that Terramin intends to negotiate waivers for all required exempt land with each of the landowners individually before the commencement of mining operations.

MPL application

Terramin has obtained the majority of waivers required for proposed ancillary operations. The MPLA states that any remaining waiver negotiations will be completed as part of the PEPR process, should a lease be granted, prior to MPL activities commencing.

Government considers that there are three avenues by which Terramin could undertake operations on exempt land:

- Waiver by agreement
- Land purchase and then the registration of a waiver of exemption; or
- ERD Court order that waives the benefit of exemption.

Terramin appropriately proposes a negotiation process with individual landowners to obtain waivers for exempt land where authorised operations are proposed. Terramin has already entered into agreements for exempt land waivers over significant parts of the proposed mining operations at Woodside and ancillary operations at Strathalbyn.

Based on the evidence provided and available avenues, government assesses that there is a reasonable prospect that Terramin can obtain access to the land required to ensure efficient and effective mining of the mineral resource and undertake the proposed ancillary operations.

Chapter 4

Groundwater

Introduction

In the location of the proposed mine, the water resources, groundwater, surface water and watercourses are prescribed under the *Landscape South Australia Act 2019*. Water use is managed and regulated through the Western Mount Lofty Ranges Water Allocation Plan (WMLR WAP).

Terramin began groundwater investigations in 2013, five years before the applications were lodged, to understand the existing groundwater environment and use. Following discussions with community and Terramin about their plans, government recognised that the MP would require a greater level of detail on groundwater than other proposals to enable a rigorous assessment of potential impacts to groundwater quantity and quality. Specific requirements were set out by the Ministerial Determination for the Bird in Hand Gold Project, published in April 2017.

In public submissions received by DEM during the consultation period, groundwater was the most raised matter of concern. Government requested that Terramin respond to all public submissions and matters raised by government.

Terramin chose to assess potential impacts from mining using numerical groundwater modelling. Each numerical groundwater model (model) is used as a predictive tool to quantify the project's potential groundwater impacts. The general building blocks of a model are data acquisition, conceptual hydrogeological understanding and a mathematical translation of the concepts, which includes appropriate boundary conditions and hydraulic parameters. History matching, also called calibration, is generally used to fit the model to observations. Once a model is calibrated, predictive scenarios are built and analysed.

There may be many ways to adequately calibrate a model and it is the role of hydrogeologists to choose those that are realistic and reliably recreate existing data and information. Sensitivity and uncertainty analysis are used to determine the range of groundwater model predictions that are consistent with hydrogeological knowledge.

For all model predictions, representative percentiles of probability were estimated based on the results of the Monte Carlo analysis. These include the 5th, 20th, 33rd, 50th, 67th, 80th and 95th percentiles[20] (referred to as P5 etc. onward).

Evaluative tools (criteria) in the Groundwater Modelling Guideline[21] are often used to judge whether groundwater models are fit for purpose.

[20] Appendix B7A of response document.
[21] Barnett et al, 2012, *Australian groundwater modelling guidelines*, Waterlines report, National Water Commission, Canberra.

To operate within the bounds of the WMLR WAP, Terramin have proposed combined control measures of grouting and managed aquifer recharge (MAR) that are unique to mining in South Australia.

This chapter will provide government's assessment of all relevant groundwater information presented by Terramin in the MP and response document.

Before finalising the chapter, government engaged CSIRO to conduct an independent peer review of this chapter. The scope of the review was for CSIRO to examine if:

1. The Government assessment and recommendations are consistent with the groundwater outcome and the documentation provided
2. The model predictions the Government assessment and recommendations rely on are conservative, ie that they overestimate negative impacts
3. Any issue identified during the review is material, ie that addressing the issue has the potential to change the predictions to the extent that a revision of the assessment or recommendation would be warranted.[22]

The report found that the government assessment and recommendations are consistent with the groundwater outcome.

The final CSIRO independent peer review report is included as Appendix 7.

Bird in Hand Project groundwater investigations overview

Australian Groundwater Technologies (AGT) performed a groundwater assessment to investigate the groundwater system on behalf of Terramin. On a local scale they used a drilling and aquifer testing program, and on a catchment scale, regional groundwater monitoring and a census of private wells. The results were used to develop a conceptual understanding of the hydrogeology and a base case numerical groundwater model to:

- assess the proposed mining operation's effects on groundwater inflow to the mine, drawdown to existing users, the depletion of baseflow in the Inverbrackie Creek and inflow of higher salinity groundwater from the Eastern Mount Lofty Ranges (EMLR)
- assess water management options including grouting for groundwater control and reinjecting mine water back into the same aquifer to prevent drawdown[23].

In 2018-2019 Terramin's groundwater study was extended to include additional drilling and aquifer re-injection tests. Golder reported on the drilling and testing of injection and monitoring wells to inform the proposed MAR[24]. The results were also used to validate aspects of the existing conceptual hydrogeology and recalibrate the base case numerical groundwater model[25]. In 2020, Terramin commissioned Golder Associates to undertake an uncertainty analysis of the groundwater model. The results determined plausible ranges of

[22] Peeters LJM and Marshall S, 2022, *Review of groundwater chapter of SA DEM assessment of the Terramin Bird in Hand MLA*, CSIRO, Australia.
[23] Summarised from Chapter 10 of the Mining Proposal
[24] Golder Associates Pty Ltd, 2019, *Managed Aquifer Recharge Investigation - Stage 1 drilling and pumping tests - Bird-in-Hand Gold Project* - Appendix H8 of the Mining Proposal.
[25] Golder Associates Pty Ltd, 2019, *Bird-in-Hand Gold Project - Investigation into Managed Aquifer Recharge Stage 2 Injection tests and Stage 3 Groundwater model validation* - Appendix H9 of the Mining Proposal.

groundwater model predictions for mine inflow, drawdown and the depletion of baseflow in the Inverbrackie Creek, without MAR. The results led to revisions of the MAR impact assessments and estimates of the possible inflow of higher salinity groundwater from the Eastern Mount Lofty Ranges.

Groundwater outcome

Terramin have proposed the following environmental outcome:

> **"No adverse impact to the quantity or quality of water caused by the mining activities to existing and future licenced users and water dependant ecosystems".**

The outcome identifies two relevant receptors:

- Existing and future users
- Water dependent ecosystems

Since groundwater in the project area is fresh and suitable for drinking, government considers that the groundwater's ambient quality should also be a receptor. This aligns with requirements of the Water Allocation Plan[26].

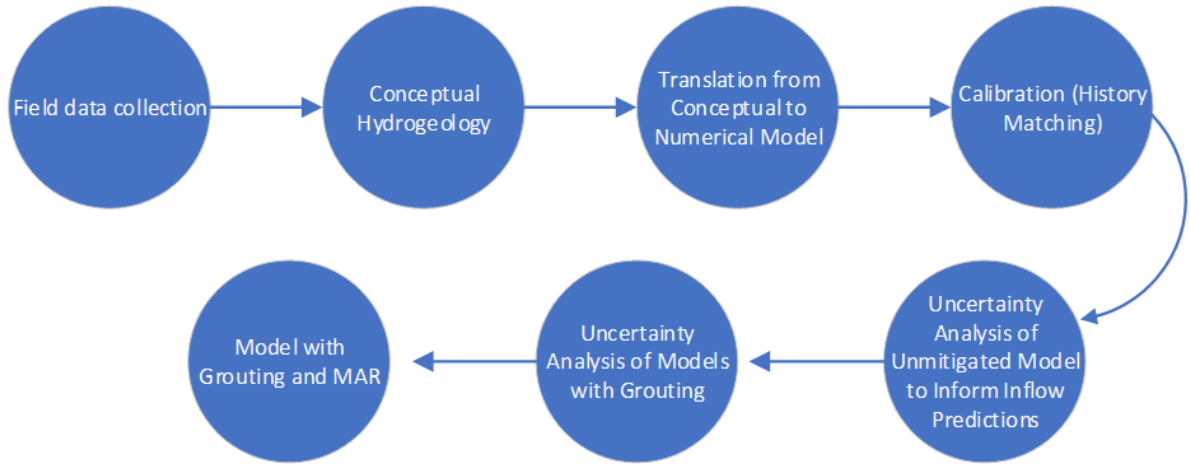
The outcome appropriately states that mining operations should cause no adverse impact to receptors.

The outcome identifies that both groundwater quantity and quality must be considered. Government's assessment addresses each of these values below. Government recommends that the outcome include all relevant phases of mining.

Refer to Appendix 5 for the recommended groundwater outcome, should a lease be granted.

Groundwater quantity– Potential impact assessment

In late 2013 the groundwater investigations began to characterise the groundwater system of the Inverbrackie Creek Sub-Catchment and assess potential groundwater impacts. The



[26] WMLR WAP, 2013.

following section summarises the work that was done and provides government's assessment of the description of the existing groundwater environment and the potential impacts before the implementation of mitigation measures. The model and predictions were developed using the linear sequence shown below. The following sections of this chapter provide a summary of each of these stages and government's assessment, with a recommended regulatory response where required.

Field data acquisition

AGT provided a description of hydrogeology and an assessment of the mining proposal's potential impacts, based on the following works completed from 2013 to 2017:

- Exploration drilling
- Investigation drilling
- Pumping tests and interpretation to hydraulic parameters
- Baseline groundwater monitoring
- Surface water monitoring
- Groundwater and well census
- Geophysics
- The development of a numerical groundwater flow model and impact assessment[27].

The groundwater investigation began with a review of existing information and a groundwater census to identify receptors such as private wells and springs surrounding the project area. This survey covered the Inverbrackie Creek sub-catchment (within the EMLR) and parts of the neighbouring Dawsley Creek sub-catchment (within the EMLR). The census documented the location, status, condition and use of over 58 private wells across 35 properties and groundwater-dependent ecosystems such as the Inverbrackie Creek and associated springs.[28]

In 2014, a drilling program installed five investigation wells and pumping tests to assess hydraulic characteristics of the fractured rock aquifer around the proposed mine workings. It used information from the investigation wells, such as lithology, downhole geophysics, fracture characteristics, aquifer yield and permeability to update the conceptual hydrogeology that identified the main water -bearing zones.

Depth to groundwater and groundwater quality monitoring of approximately 30 private wells, site monitoring wells and springs in the Inverbrackie Creek began in 2013 and is ongoing. This information was used to develop the conceptual hydrogeology and the numerical groundwater flow model.

A second drilling program in 2018 installed a further six investigation wells, including two injection wells, around the periphery of the proposed mine area. It involved extensive injection testing to assess the fractured rock aquifer's ability to receive mine water through MAR and offset potential groundwater-related impacts.

Terramin collected limited data on Inverbrackie Creek's streamflow. Groundwater outflow (baseflow) to the lower Inverbrackie Creek is a significant portion of the modelled

[27] AGT, 2017, *Bird-in-Hand Gold Project Groundwater Assessment* - Appendix H1 of the Mining Proposal
[28] Summarised from Chapter 10 of the Mining Proposal

groundwater outflow and the uncertainty in baseflow may have resulted in uncertainties in the proposed mine's modelled impacts. This issue was resolved by a comprehensive uncertainty analysis provided in 2021.

Government has assessed that Terramin collected adequate field data and presented it in the MP to inform development of conceptual hydrogeology and provide a baseline to assess potential impacts on groundwater quantity receptors.

Conceptual hydrogeology

Conceptual hydrogeology is a summary of the important aspects of hydrogeology – including but not limited to geology, hydrostratigraphy, aquifers and aquitards, recharge and discharge, depth to groundwater, groundwater heads, horizontal and vertical groundwater flow, groundwater-surface water interaction, hydraulic parameters, Groundwater Dependent Ecosystems (GDEs) and the unique features of local hydrogeology that are considered important for impact assessment. For this assessment, the conceptual hydrogeology must appropriately represent key groundwater processes and properties to ensure that its translation to a numerical groundwater model will credibly address the potential impacts.

Groundwater monitoring information, investigation well drilling, pump and injection tests all contributed to development of a conceptual hydrogeology for the proposed mine, summarised in a cross-sectional view in Figure 9.

Figure 9 identifies the major features and complexity of the site hydrogeology:

- A catchment divide between the Western and EMLR
- Steeply dipping fractured rock units
- The water table is hosted in various units forming the Fractured Rock Aquifer (FRA)
- A fault zone with associated fracturing

The MP describes geology, hydrostratigraphy and aquifers/aquitards[29]. Hydraulic parameters from pumping test analysis on both Terramin and private wells provide an understanding of the hydraulics of the major units – Tapley Hill Formation, Tarcowie Siltstone and Kanmantoo Formation[30].

The MP[31] presents mapped regional groundwater elevations for the spring of 2014 and summer 2015 in sufficient detail. A chloride mass balance method by AGT estimated rainfall recharge rates. Government has assessed that Terramin developed an appropriate conceptual hydrogeological understanding that served as the basis for the numerical groundwater flow model to assess potential impacts of mining on receptors.

[29] Appendix H1 of the Mining Proposal
[30] Appendix H9 of the Mining Proposal
[31] Figure 37 of Appendix H1 of the Mining Proposal

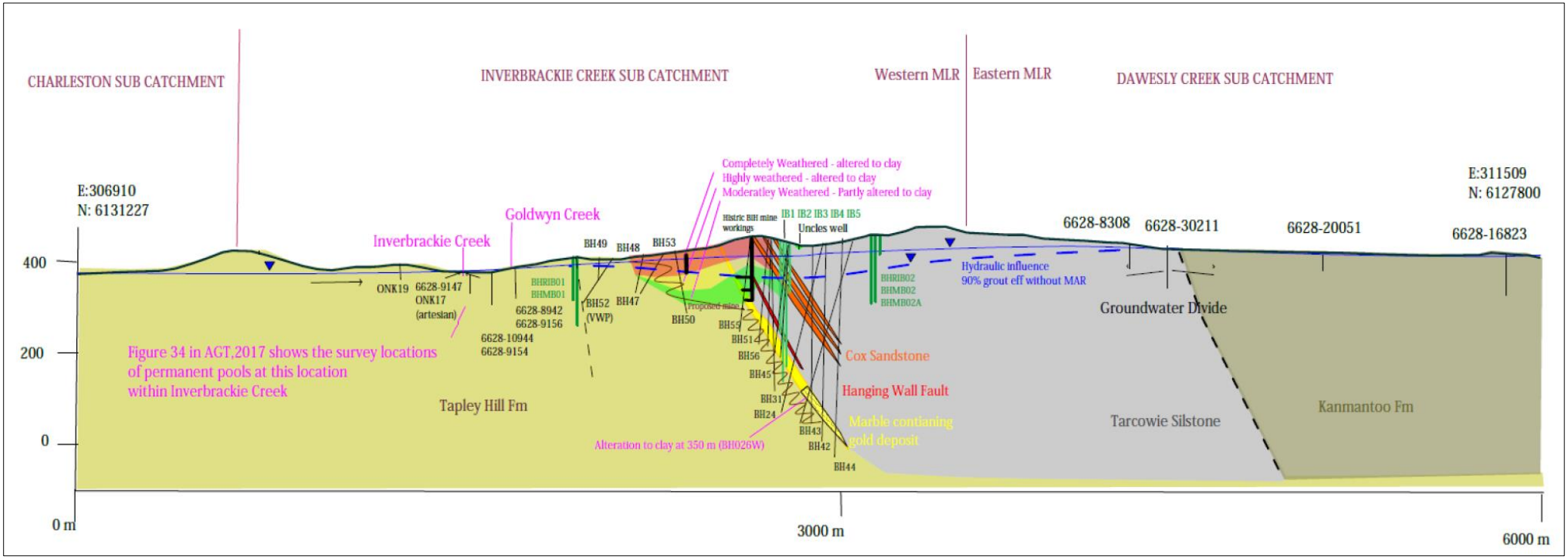


Figure 9: Hydrogeological cross-section showing conceptual hydrogeology[32]

[32] Appendix B1 of the Response Document

Translation from conceptual to numerical model

The aim of the numerical model is to assess the mine's impacts and its proposed mitigation strategies on:

- groundwater inflow to the mine
- depth to groundwater in nearby wells used by others
- baseflow to Inverbrackie Creek
- changes in regional groundwater salinity.

To do this, the model must incorporate key field data and conceptual hydrogeology, while allowing for the inherent uncertainty in groundwater data collection and interpretation. The model must appropriately represent key groundwater processes and properties that influence modelled impacts.

Best practice for impact assessments should follow the *Australian groundwater modelling guidelines* and recent guidance on uncertainty analysis[33]. Terramin developed a series of related numerical groundwater flow models. The models can be summarised as:

1. A "base case" groundwater flow model simulating historical conditions, which was tested and refined during a multiple-step calibration (history-matching) process.
2. An ensemble of "unmitigated" groundwater flow models simulating mining without grouting and without MAR, which were used to estimate potential groundwater inflow rates to the mine, adopting a Monte Carlo type of uncertainty analysis. Models with poor history-matching were rejected.
3. An ensemble of groundwater flow models with good history-matching, which assessed mining impacts with grouting and without MAR.
4. A groundwater flow model for simulating MAR, which was developed from the base case model, where mining inflows and MAR injection rates are based on the outcome of the impact assessment ensemble, and on assumptions about the efficacy of grouting. MAR pumping is included.
5. A solute transport model, assuming the highest mine inflow of the unmitigated models, which estimates the mine's impact on regional groundwater salinity.

These numerical models have appropriate choices of model domain, spatial and temporal discretisation, aquifer parameters, boundary conditions and initial conditions. The main uncertainty identified is that the numerical model simulates fractured rock as equivalent porous media. This is a common and necessary assumption for a model domain of the required size. However, it means that model outputs are representative over medium and large scales but will be inaccurate over small scales.

Government accepts that it is impractical to gather enough data to fully characterise small-scale heterogeneities and features across the model domain, so there are always some assumptions about aquifer parameters, leading to non-uniqueness. This means multiple parameters sets can provide a model with a good match to observations. This is addressed via the Monte Carlo ensemble of models – ie the uncertainty analysis.

[33] Middlemis H and Peeters L. (2018). *Uncertainty analysis - Guidance for groundwater modelling within a risk management framework.* Prepared for the Independent Expert Scientific Committee on Coal Seam Gas and Large Coal Mining Development.

Rainfall recharge

Government notes that a single method (chloride mass balance) was used to calculate recharge from rainfall. Government questioned the use of a single method as use of additional methods would have provided a more detailed approach.

Rainfall recharge is important because it provides a significant proportion of water input to the conceptual and numerical groundwater flow models. The rainfall recharge used in the base case model is approximately one-third of that used for the resource estimate for the Inverbrackie Creek Adelaidean underground water management zone of WMLR WAP. Using a potentially underestimated rainfall recharge in the model may result in uncertainty in the predicted mine inflows. This was addressed in the uncertainty analysis where recharge rates were varied.

Equivalent porous media modelling

The BIH numerical groundwater flow predictions are based on a porous media isotropic model whilst the aquifer is fractured rock with anisotropy. Porous media contains the solid matrix and pores (voids) and groundwater flow is through these pores. In fractured rock aquifers, groundwater flow is through fractures, joints, bedding planes and cavities. Pores are generally frequent, small and can be horizontally isotropic, while fractures are in comparison infrequent, large and tend to follow structural orientations (anisotropy).

In the *equivalent porous media* approach, the system's hydraulic properties are modelled using equivalent coefficients such as hydraulic conductivity and porosity to represent the volume-averaged behaviour of many fractures within a fractured rock body[34]. An equivalent porous media approach assumes that a *representative elementary volume* (REV), characterised by equivalent hydraulic parameters, can be defined and modelling results are only valid at scales larger than the REV, such as scales of hundreds of metres or more relevant to basin or sub-basin studies[35].

Government considers modelling fractured groundwater flow with the equivalent porous media approach acceptable at a scale larger than REV. The consequence of a REV at several hundred meters (approximately 700 m based on hydrogeological experience) is that predictions on smaller scales may be uncertain or incorrect.

If a lease is granted, as a requirement for the PEPR it is recommended that the model is revised to incorporate tested hydraulic properties for the purpose of informing operational groundwater management plans over small scales. A comprehensive groundwater compliance monitoring framework is also recommended. Refer to Appendix 5 for recommended conditions and PEPR requirements if a lease is granted.

The model predictions are strongly influenced by the underground mine dewatering represented by model drain cells at the location of the underground mine stopes. Importantly, the nearest adjacent landowner groundwater bores for which the model predicts drawdown are all greater than 700m away from the mine stopes, a distance larger than the REV when measured from the mine stopes.

[34] Peter G. Cook, 2003. *A Guide to Regional Groundwater Flow in Fractured Rock Aquifers* CSIRO Land and Water, Glen Osmond, SA, Australia.
[35] Middlemis and Peeters, 2018.

MAR wells are designed to mitigate groundwater impacts to adjacent landowner groundwater bores and regional groundwater quality and quantity. By design, Terramin has proposed to locate MAR wells in locations to achieve these outcomes, including in proximity to adjacent landowner groundwater bores. Some MAR wells are located within 700m from the nearest adjacent landowner groundwater bores (a distance less than the REV when measured from the receptors). This is assessed to be appropriate for the purpose of modelling to support a mining lease application. As discussed subsequently in this report, MAR has been assessed as an effective strategy to mitigate impacts to adjacent landowner groundwater bores and regional groundwater, and for this to be the case the MAR wells must be located in appropriate locations to achieve these outcomes.

The MAR approach as proposed by Terramin is appropriate to support a mining lease application. Detailed operational designs are undertaken as a requirement of the PEPR process (should a lease be granted). This must include investigations based on initial operational testing of MAR wells to define the hydraulic properties of the system on a scale smaller than REV and adjust appropriately for operation. The model must also be reviewed and revised to incorporate this information. Refer to Appendix 5 (Recommended conditions 5-7 within the Second Schedule) for recommended conditions and PEPR requirements if a lease is granted.

The CSIRO review considered the REV assessment and recommendation and ranked the matter as a low priority. A low priority matter is defined by CSIRO as a matter that "does not affect the degree of conservatism: potential to lead to minor or no change in key predictions or their range, such that predictions are not expected to change."

CSIRO go on to say, "While the groundwater model is suited to simulate median predictions of mine water inflow, drawdown and potential for reinjection at the regional scale, it is less suited to predict local impacts. Should local impact estimation be necessary, such as in the development of a groundwater management plan, it is recommended to revise the model, with particular attention to the model structure and numerical stability of the model".[36]

For clarity in relation to terminology used in this section, local impacts are defined as being on a scale smaller than the REV (700m).

Calibration (history matching)

Four calibration processes were applied to the model[37], including:

1. A pre-mining steady-state calibration process
2. A transient calibration process based on the pumping test of the underground mine area
3. A regional transient calibration process based on seasonal abstraction for irrigation and the regional groundwater level response
4. A transient calibration process based on two pumping and injection tests on wells surrounding the proposed mine

[36] Peeters LJM and Marshall S, 2022.
[37] Appendix H1 of the Mining Proposal

A subsequent model validation phase included:

- comparison with catchment modelling-based estimates of baseflow to Inverbrackie Creek
- a scenario simulation for comparison with historical anecdotal observations of drawdown during historic mining operations.

Summary and assessment of proposed mitigation measures to maintain groundwater availability

Terramin used the numerical models as tools to assess the proposed mine design's groundwater-related impacts before and after applying the key mitigation measures of grouting and managed aquifer recharge (MAR).

Grouting effectiveness was assumed based on expert advice (MultiGrout), while MAR was tested and shown to be effective. The following section summarises all measures proposed to mitigate potential groundwater impacts related to the groundwater quantity available and provides government's assessment on whether these measures would be effective in achieving the groundwater outcome.

Grouting to manage mine inflow

Groundwater control in mining typically involves depressurising and/or dewatering aquifers to reduce inflows to a mine and allow access. The aim of groundwater management at BIH is to reduce groundwater inflow to manageable rates, removing the need to dewater the aquifer. The key control strategy proposed by Terramin to achieve this is to inject cementitious grout into rock exposed by mining, to seal fractures and increase the strength of the ground around the decline, ore drives and cut and fill stoping areas resulting in reduced water inflows.

MultiGrout, on behalf of Terramin, undertook a desktop groutability assessment of the project, including the hanging wall and adjacent fractures within the Tarcowie Siltstone Formation. Their analysis indicates that grouting of the decline and drives ahead of development will reduce inflows into the underground workings by between 70% and 90%[38]. This was represented in numerical groundwater modelling by reducing the conductance of the drain cells to simulate a 70% and 90% reduction of the unmitigated mine inflows. An external review of the proposed MultiGrout grouting program was undertaken by a grouting specialist and geotechnical engineer within Golder Associates. The review concludes that it is reasonable to expect a 90% or greater inflow reduction using cementitious grouts, assuming good practice and adequate resources[39].

Responses to matters raised by government on the practical application of grouting in a cut and fill stope form of mining were provided by Sovereign Hydroseal,[40] a specialty grouting

[38] MultiGrout, 2017, *Bird-In-Hand Gold Project – Grouting for Groundwater Control* - Appendix H4 of the Mining Proposal
[39] Golder Associates, 2017, *Bird in Hand Gold Project – External Review of Proposed Grouting Programme, Technical Memorandum* - Appendix H5 of the Mining Proposal
[40] Sovereign Hydroseal, *Technical Support of Grouting Clarifications for Departmental Approvals* - Appendix I1 of Terramin Response Document

company that provides grouting expertise internationally for mining, tunnelling and civil projects. Sovereign Hydroseal endorse the proposed approach of probe drilling and pre-excavation grouting to manage mine inflows and note that:

> "The efficiency of grouting is driven, or affected, by many key factors such as (but not limited to):
>
> - Resources/equipment allocated to the grouting program
> - Time constraints or time allotted to the grouting program
> - The effectiveness of the grout technology selected
> - Accuracy of the investigative work
>
> The 90% is not an unrealistic target and is quite achievable when applying the above factors. It is commonplace for the tunnelling and civil construction sectors specifying and achieving near 100% dry zones."

Government's geotechnical expert considers that 70% is a readily achievable minimum grouting efficiency in this circumstance, and therefore an appropriate planning efficiency level or 'reference level' to use for the groundwater impact assessment. While greater than 90% may be ultimately achievable, it is expected that initial trials and grouting programs may not achieve this value without adjustments and changes based on adaptive management, as is common practice with grouting. Peer reviewers of the grouting program highlighted key factors that would contribute to the effectiveness of grouting. All these factors are dependent on quality assurance and quality control procedures being in place as well as an overarching policy to allocate adequate resources to ensure the success of grouting and continuous improvement. In response to matter 97[41] raised by government, Terramin provided a draft Grouting Governance Policy[42]. The policy acknowledges the importance of grouting to success of the project and commits to establishment of a Grouting Management System and governance framework that will be published by the Terramin Board and be the responsibility of the CEO.

As the key strategy to reduce inflows into the mine, measuring the effectiveness of the grouting program to reduce groundwater inflows is critical. The two main methods to measure and demonstrate the effectiveness of rock mass grouting are:

- Groundwater instrumentation (Piezometric monitoring)
  - If all pre-grouting is completed and no water enters the excavations, this is the only method available to confirm the water and pressures remain at the pre-mining levels, other than no water observed in the mine.
- Demonstrating actual field evidence of groundwater flow reductions in an underground excavation
  - If water is discovered in the probe holes, grouting effectiveness can be and should be directly measured through the reduced volume of water ingress before and after grouting.

[41] DEM request for a response letter dated 20 February 2020
[42] Terramin, 2020, *Terramin Draft Grouting Management and Governance Policy* - Appendix J1 of the Response Document

The information provided by Terramin and expert peer reviews demonstrate that grouting is accepted as a proven strategy to limit mine inflows. While 90% effectiveness is likely achievable, it is appropriate that allowance is made for predicted inflows associated with a 70% grouting effectiveness to allow sufficient design contingency.

Terramin presented a new "hybrid" grout effectiveness scenario in the response document, where drain cell conductance values were adjusted in the model to achieve a 90% reduction for the decline and 70% reduction in the mine stopes[43]. Based on expert advice, the use of grout to control inflow in a tunnel is well understood[44]. Grouting in a stope environment is likely to be more dynamic and require an adaptive approach. It is also closer to the water-bearing structures of the footwall and hanging wall faults. In comparison, the decline is located within the Tapley Hill Formation, which generally appears to have low fracture permeability and typically may not require grouting[45]. Decline rock walls would also be more accessible than the stoping area, allowing for easier identification of groundwater inflows and remedial grouting if required.

Based on this, government considers the hybrid scenario to be a more realistic conservative scenario than the 70% or 90% effectiveness scenarios that apply to a broad grouting effectiveness over the whole mine.

Grouting analogues

Terramin provided case studies in the MP and response document of mines that have used grouting to control groundwater inflow. The case studies provided include elements that are analogous to tunnel development, pre-excavation and post-excavation grouting proposed in the MP. The case studies provided all included some form of depressurisation, either before or during grouting, but do demonstrate that grouting can be effective in managing groundwater inflows at rates higher than that expected by the conservative 70% grouting effectiveness scenario.

Post-stoping grouting

Government's geotechnical expert advised that failure of the hanging wall is unlikely once stopes have been backfilled, but relaxation could occur that may result in damage to the grout curtain. Therefore the likelihood of a failure causing inflow from the grouted hanging wall and the need for post-stope grouting is low but possible. A flow in this scenario may be difficult to locate. Based on this advice, government requested further information on the feasibility/ability to conduct post-stoping grouting over the life of the mine should inflow occur in a previously mined stope that was already successfully grouted and backfilled.

Terramin proposed in the response document that hydraulic lines could be installed while mining and used to "pressure test" the hanging wall to check for movement. Terramin noted that:

> "The use of hydraulic hose lines is a common practice in many mines for post-grouting pressure bulkhead walls or dams to ensure that there is no tracking of water

[43] Golder, 2021, *Technical Memorandum – Bird in Hand Groundwater Modelling – Nonlinear uncertainty analysis* - Appendix B7A of the response document
[44] Appendix H4 of the Mining Proposal
[45] Appendix H1 of the Mining Proposal

along the contact of the wall and the bulkhead. Drilling through rock fill is also a proven method of post-grouting if required. In this case, a drill rig drills as far as it can in the rock fill until returns are lost. The hole is then pressure-grouted to consolidate the surrounding broken rock. The drill rig then repeats the process in the same hole to drill further until the drill gets to the hanging wall and into solid rock. Pressure grouting can then occur in the hanging wall if required"[46].

Government's geotechnical expert reviewed the response and advised that the methods described are achievable but would become challenging in the event where high flows occur.

The scenario described above, if not managed appropriately, could potentially result in enaction of the "controlled inundation" strategy proposed by Terramin, which is addressed below in further detail.

The effectiveness of grouting determines the rate of inflow and hence the design of subsequent water treatment and MAR systems. Government considers it appropriate that the requirement for a Grouting Governance Policy and leading indicator criteria to measure inflow are required to regulate this key strategy.

Refer to Appendix 5 for recommended conditions and requirements for the PEPR should a lease be granted.

MAR

Groundwater that enters the underground mine is planned to be pumped to surface, treated, and reinjected back into the aquifer. This is designed to offset any groundwater drawdown and thereby maintain supplies to licenced users, maintain the groundwater divide between the EMLR and WMLR and prevent intrusion of higher saline groundwater from the EMLR.

MAR is an accepted and proven method of injecting water into an aquifer, for storage or to offset drawdown. Managed aquifer recharge is widely used in metropolitan Adelaide by local councils to inject and later harvest stormwater[47]. Terramin provided several examples where injection of water has been used in a mining context to re-inject treated mine water for positive environmental and community outcomes.

Terramin undertook pumping and injection tests on the Tapley Hill Formation and Tarcowie Siltstone within the MC. The combined injection rate was up to 20 L/s, which is greater than the median (P50) value of 18 L/s in year 5 for the hybrid grouting effectiveness, which government considers to be the most realistic scenario.

[46] Table 4 of the response document, response to matter 99.
[47] *Managed Aquifer Recharge Schemes in the Adelaide Metropolitan Area, DEWNR Technical report*.

Table 6: Monte Carlo Risk Analysis - Injection Rates/Mine inflow (L/s) Under Hybrid Scenario[48]

	P5	P20	P33	P50	P67	P80	P95
Year 1	2.1	2.8	3.1	3.5	3.8	4.1	4.8
Year 2	3.7	5.6	6.5	7.6	8.6	9.5	11
Year 3	4.5	7.3	8.8	10	12	13	16
Year 4	5.6	9.4	11	14	16	18	21
Year 5	7.8	13	15	18	21	23	28

Table 6 shows that estimated inflows are within the capacity of the two injection wells until mine year 4 (21 L/s) of the most conservative estimate (P95). Terramin propose that the two injection wells established for the test will be supplemented by six additional wells commissioned prior to commencement of mining to allow for contingency to deal with unforeseen events such as higher than expected inflow to the mine or clogging of MAR wells.

Government considers the contingency provided by eight injection wells to be an effective approach in managing the unlikely P95 peak flow in year 5 of 28 L/s. In the event that additional wells are required to manage operational issues the applicant can apply for additional permits under the WAP process. Figure 10 shows the current and proposed MAR wells located around the mine to target specific geological units.

Table 7: Monte Carlo Risk Analysis - Injection Rates/Mine Inflow (L/s) Under 70% Grouting Effectiveness Scenario[49]

	Calibrated model (AGT, 2017)	P5	P20	P33	P50	P67	P80	P95
Year 1	**6.7**	3.1	4.2	4.8	5.4	6.0	6.6	7.7
Year 2	**10.4**	5.6	8.4	9.8	11	13	14	17
Year 3	**13.1**	6.3	10	12	15	17	19	23
Year 4	**15.3**	7.7	13	15	18	21	24	29
Year 5	**13.6**	11	18	21	25	29	32	39

To allow for sufficient contingency Terramin have proposed that the MAR system will be designed to accommodate the conservative 70% grouting effectiveness scenario with higher inflow, pumping and injection rates. Table 7 shows the results of the uncertainty analysis under this scenario as compared with the base model prediction. A grouting effectiveness of 70% was assumed in the uncertainty analysis to estimate inflows. The Response Document included an independent peer review of MAR in response to matter 92 of the DEM request for information letter. The peer review found that the design capacity of the MAR scheme

[48] Golder, 2021, *Risk Assessment for the Bird-In-Hand Managed Aquifer Recharge System*, Table 16 - Appendix B5A of the Response Document
[49] Table 15 of Appendix B5A from the Response Document.

and water treatment plant has been conservatively planned based on 70% grouting effectiveness, with provisions for up to 50 L/s for short-term mine ingress (max. 3.8 days based on storage dam capacity). [50] The additional capacity in design also allows for scheduled maintenance, management of potential clogging or redevelopment of MAR wells where required.

Under this the 70% scenario, predicted injection rates at the median (P50) value are estimated at 5.4 L/s in year 1 and 25 L/s in year 5, which is within capacity of the proposed eight injection wells. The conservative P95 value peaks at 39 L/s in year 5 of mining, which is predicted to result in a higher water level in receptor bores. The CSIRO analysis indicates that the P95 inflow at mining year 5 for the hybrid scenario, shown in Table 6 as 28 L/s, may be closer to the P95 inflow rate for the conservative 70% grouting effectiveness scenario, shown in Table 7 as 39 L/s.[51]

The conceptual location and depth were informed by the numerical model and pump testing. Data collected during the pump tests was used to refine the numerical model. Groundwater modelling predicted that groundwater level impacts to surrounding groundwater receptors, including the Inverbrackie Creek, would be reduced by a combination of grouting to control mine inflow and injection.

The injection of water back into the aquifer has been trialled and demonstrated to be achievable. As discussed in the section above on equivalent porous media, model review will be required to confirm assumptions at a smaller scale than REV. MAR will also mitigate the potential for saline intrusion from the EMLR Kanmantoo Formation into the WMLR higher quality aquifer.

[50] IGS, 2020, *MAR Independent Peer Review for Bird-in-Hand Gold Project* - Appendix H3 of the Response Document.
[51] Peeters LJM and Marshall S, 2022.

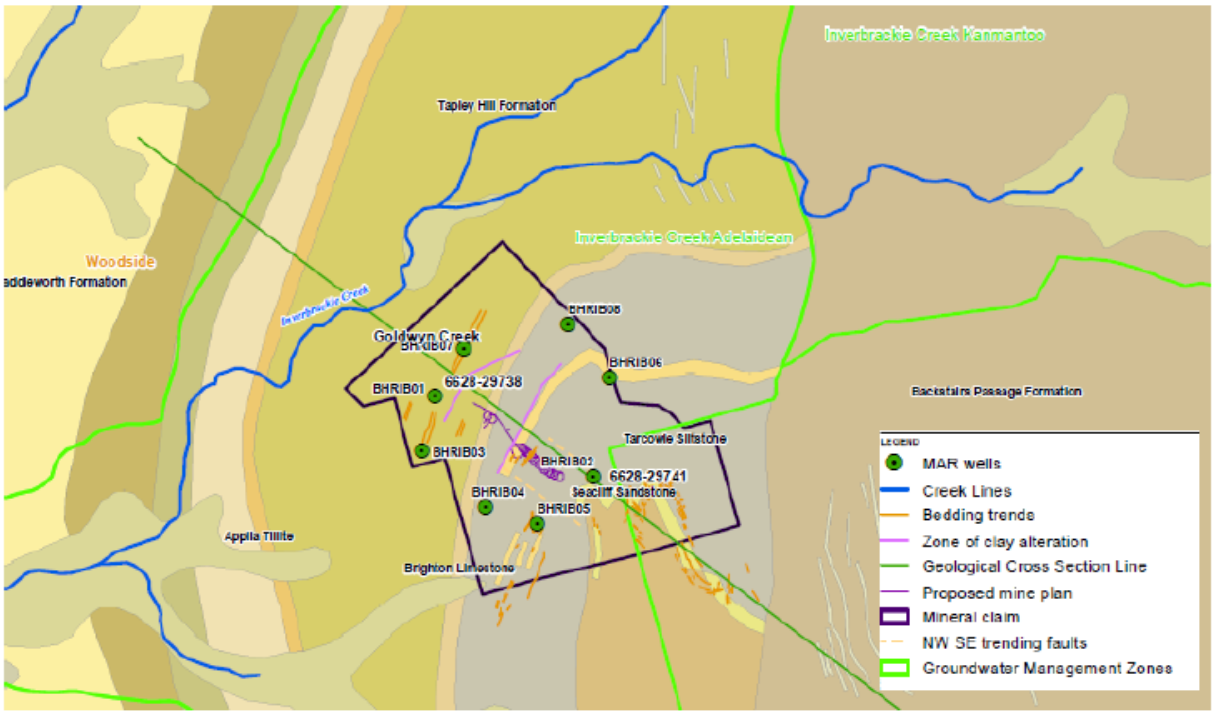


Figure 10: Conceptual MAR System Layout[52]

Principle 145 of the WAP states that water may be drained or discharged into a well for the purpose of a managed aquifer recharge operation where a hydrogeological risk assessment undertaken by the applicant in accordance with principles 146 to 152 (inclusive) shows that:

a. the source water:
   i. will not contravene the water quality criteria in Schedule 2 of the Environment Protection (Water Quality) Policy 2003 or any subsequent or related policy; or
   ii. is of equal or better quality than the *ambient underground water*; and

b. a lowering of salinity levels in the ambient underground water will not have the potential to adversely impact on *water-dependent ecosystems*[53].

Terramin provided a hydrogeological risk assessment for the proposed MAR system that used predictions from the modelling to demonstrate that the proposed MAR system will meet the relevant principles of the WAP.[54]

Public submissions raised the risk of MAR wells clogging. The MP acknowledges the potential for clogging and proposes a monitoring and trigger action response plan to manage and respond to any clogging issues. Government consider that eight operational injection wells allow sufficient contingency using the proactive approach proposed.

[52] Appendix B7A of the response document
[53] Appendix H8 of the Mining Proposal
[54] Appendix B5A from the response document

Government considers MAR as a key strategy to manage potential drawdown impacts on receptors. As discussed above in the grouting section, government considers the application of a 70% grouting effectiveness across the entire mine to be conservative, with 90% effectiveness readily achievable in the decline area, however it is useful to use the 70% value to inform contingency in the injection well design. The CSIRO review has expressed confidence in the P50 inflow values as discussed in the uncertainty analysis section of this chapter below.

Government assesses that the level of testing presented in the MP is appropriate for a mining lease application. If a lease is granted it is recommended that the aquifer re-injection system is designed with sufficient injection capacity to provide appropriate contingency for higher-than-expected groundwater inflow rates, and that the PEPR include an updated Trigger Action and Response Plan for the MAR system.

Avoidance of high-water areas

The mine plan has been designed to avoid water-bearing fractures to reduce groundwater inflows. Ore drives have been designed to access the middle of the ore body then drive out towards the north and south extremities of the gold reef. These extremities are intercepted by faults and higher permeable rock types and relocating the ore access drives away from the fracture zone reduces the risk of high groundwater inflows. The decline has been designed to avoid locations of the underground fractures where possible. Vent raises have also been designed to avoid the high fracture, high water-bearing zones.

In the response document, Mining One[55], acting on behalf of Terramin, propose that a buffer will be maintained for worker safety. Probe drilling is proposed as part of the mining cycle to verify and maintain the standoff. Government considers this would also reduce the risk of intercepting the hanging wall fracture and experiencing high inflows to the stope.

Controlled inundation

Controlled inundation was proposed in the response document[56] as a strategy that could be enacted if water flow is greater than expected or the water allocation is insufficient. A draft Inundation Safety Management Plan[57] was also included in the response document. In addition to this, Terramin provided further information specifically on controlled inundation in response[58] to a subsequent request from Government.

Terramin outlined the following scenarios which would result in a transition from normal operations to controlled inundation:

- Scenario A, which is an increase in the volume of inflows into the mine leading to an accumulation of groundwater in the underground mine.

[55] Mining One, 2020, *Bird in Hand Gold Project Addressing the Matters Raised By the SA Government* - Appendix E1 from the response document.
[56] Table 4 – Response to matter 54
[57] Appendix E3 of the response document.
[58] Terramin response to request for additional information received 1 December 2021.

- Scenario B, where the water extracted to surface is limited, leading to an accumulation of groundwater in the underground mine.
- Scenario C, which is a combination of scenarios A and B, where water extracted to surface is limited combined with an increase in inflows.[59]

As described earlier in this report, MAR is essential to ensure that the proposed groundwater outcome can be achieved. Key elements of the MAR system design and capacity are the surface storage capacity, maximum flow rate of the water treatment plant and injection capacity of individual wells.

If downtime is needed to manage any of the above elements, Terramin propose that controlled inundation could be enacted in the short term to allow for a reduction of untreated water held in surface storage, reduced flowrate through the water treatment plant or to manage any issue with MAR wells. Government notes that Terramin has provided evidence to demonstrate sufficient contingency to deal with inflow associated with the conservative 70% grouting effectiveness scenario. As detailed earlier in this chapter, government considers the hybrid scenario and associated inflow to be realistic at early stages of mining. Grouting experts noted that grouting effectiveness would likely increase with experience and that it is possible that 90% effectiveness could be achieved.

Golder[60] modelled a worst-case scenario as the greatest potential inflows caused by the hanging wall fracture (HWF) interception due to maximum mining depth, hydraulic pressure, and the longest recovery time due to the decline being fully developed. Government considers that this scenario could also occur if damage to the grout curtain occurred. Mine inflow in this scenario may be difficult to locate as described above under post-stoping grouting. Terramin note in the response that remedial grouting may require access from a different direction with uncertain timeframes. The model report attached to Terramin's response does not provide specific detail on why certain parameters were altered to simulate a breach of the HWF at maximum depth and void space. Government consider that the report provides appropriate information to assess potential consequences of a controlled inundation on receptors and assess whether enaction of controlled inundation, as described would achieve the groundwater outcome. The CSIRO review supports this position, and their conclusion is discussed subsequently in this section.

The maximum modelled inflow rate under this HWF interception scenario is 150L/s with 70% grouting effectiveness and 140L/s with 90% grouting effectiveness[61]. The simulation is discontinued shortly after HWF interception, as this event is the trigger for temporary cessation of mining and the onset of controlled inundation. The simulation was used to predict drawdown effects on the same wells where a change in water level was identified in the uncertainty analysis. The simulation used drain cells to remove groundwater from the mine with sustained hydraulic potential. The model is conservative as it does not reflect what Terramin propose in terms of concentrated pumping to remove as much water as possible given the systems design capacity. Terramin propose that in the event of a controlled

[59] Terramin response to request for additional information received 1 December 2021.
[60] Terramin response to request for additional information received 1 December 2021.
[61] Golder, 2021, *Technical Memorandum – Bird in Hand Project: Controlled Inundation Model Scenario* – Attachment 1 of Terramin response to request for additional information received 1 December 2021.

inundation, pumping would increase. Faster removal of water from the void would allow for faster equilibrium of groundwater levels and a decrease in hydraulic potential[62].

The model results shown in Figure 11 for 70% grouting effectiveness predict the greatest temporary drawdown from steady state groundwater levels to be 5 metres at well 6628-23182 and 2 metres at 6628-9153. Modelling shows that wells further from the mine are predicted to have a slight water level rise. Government considers it unlikely that by year 4 of mining the grouting effectiveness would be 70% across the entire mine. As discussed in the grouting section of this chapter, a consistent 70% grouting effectiveness is considered conservative (with 90% being more likely) and was proposed by Terramin to ensure sufficient contingency in the groundwater management system.

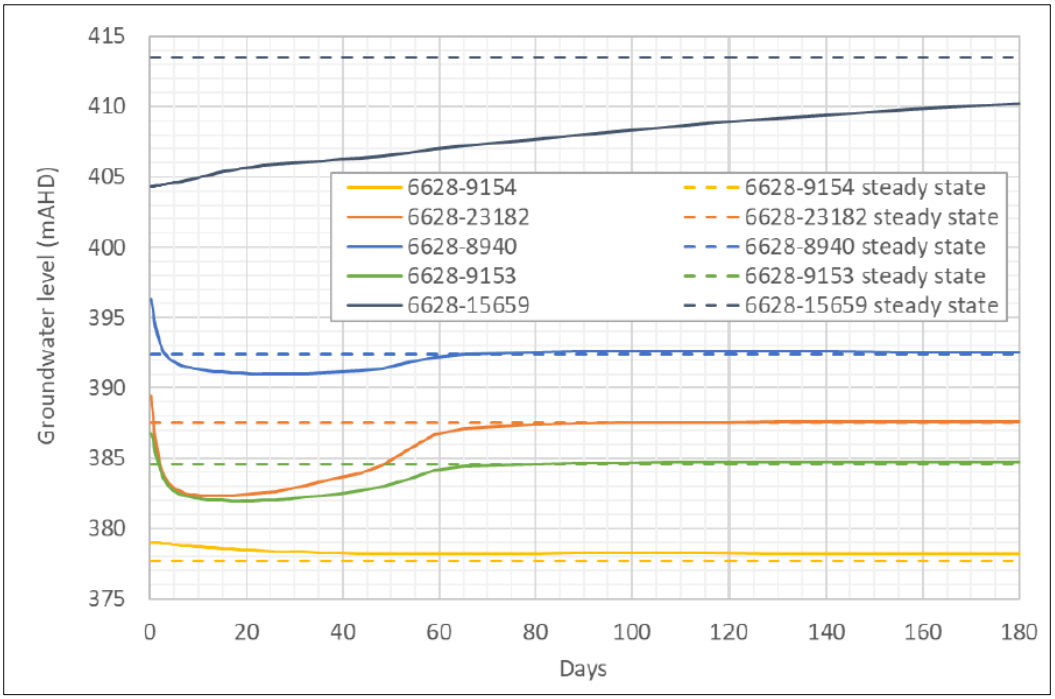


Figure 11: Groundwater recovery over 6 months simulated for closer private wells after interception of the HWF and prior grouting effectiveness of 70%[63]

Figure 12 shows the results for a prior 90% grouting effectiveness. Drawdown at the most affected well for the 90% prior grouting effectiveness scenario are predicted to be less than 1.5 metres with a recovery time of 10 days. As discussed above this assumes that pumping and MAR cease entirely, which is not proposed by Terramin.

[62] Attachment 1 of Terramin response to request for additional information received 1 December 2021.
[63] Figure 2 from Attachment 1 of Terramin response to request for additional information received 1 December 2021.

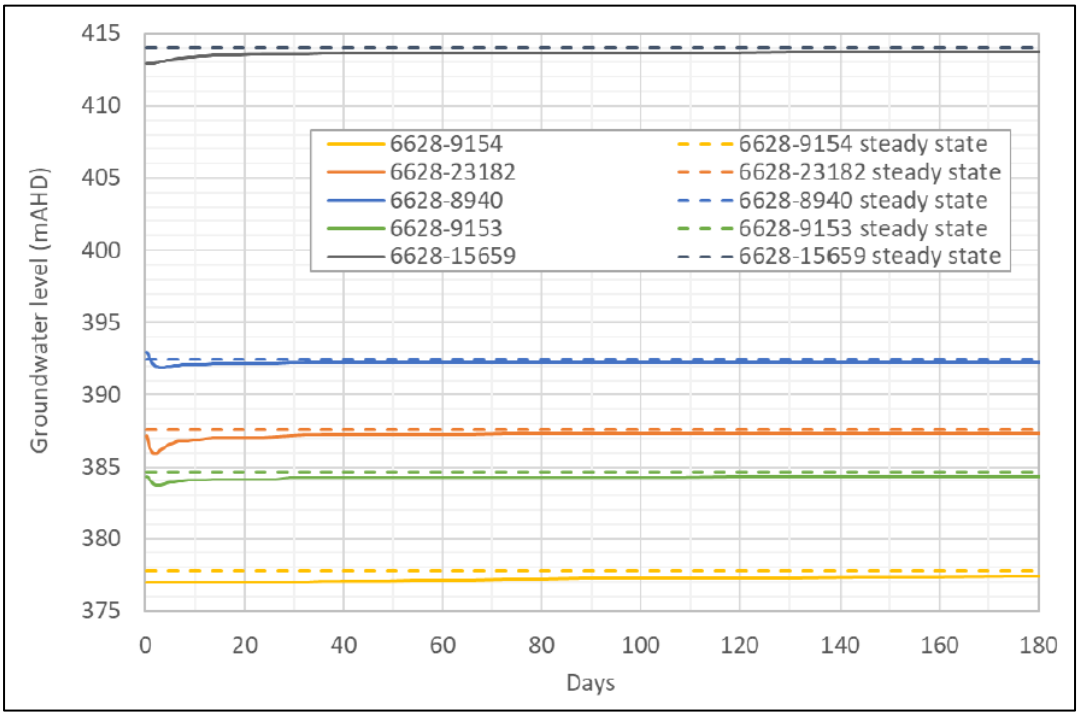


Figure 12: Groundwater recovery simulated for near private wells after interception of the HWF and prior grouting effectiveness of 90%[64].

Terramin proposed that potential drawdown at wells could also be mitigated by strategic extraction of water from a bore or series of bores located close to the mine. This will enable the water treatment and injection to continue operation if required, as well as having the effect of potentially removing some of the volume and pressure of the water entering the mine through the inundation[65].

If the mine was completely flooded and Terramin did not attempt to recover the mine at all, modelling results shows that in a worst-case 70% grouting effectiveness scenario, existing users would still be able to access groundwater, and after 80 days groundwater would return to steady state levels. Under the 90% grouting effectiveness scenario, existing users would once again not be impacted, and groundwater recovery would take place within approximately 10 days. Well 6628-15659 is located above the ore body and will be dewatered as a result of mining operations. Terramin have negotiated alternative water supply arrangement with the user, which is acceptable to government. By extrapolating from the range of drawdown predictions presented in the uncertainty analysis, CSIRO expect that the predicted range of drawdown and recovery under controlled inundation is relatively symmetric around the median (P50). Based on this, CSIRO concurred with government that groundwater users would still be able to access groundwater under controlled inundation, for both scenarios.[66] Figure 13 below provides a summary of the applicant's controlled inundation modelling results for adjacent landowner groundwater bores.

[64] Figure 4 from Attachment 1 of Terramin response to request for additional information received 1 December 2021.
[65] Terramin response to request for additional information received 1 December 2021.
[66] Peeters LJM and Marshall S, 2022.

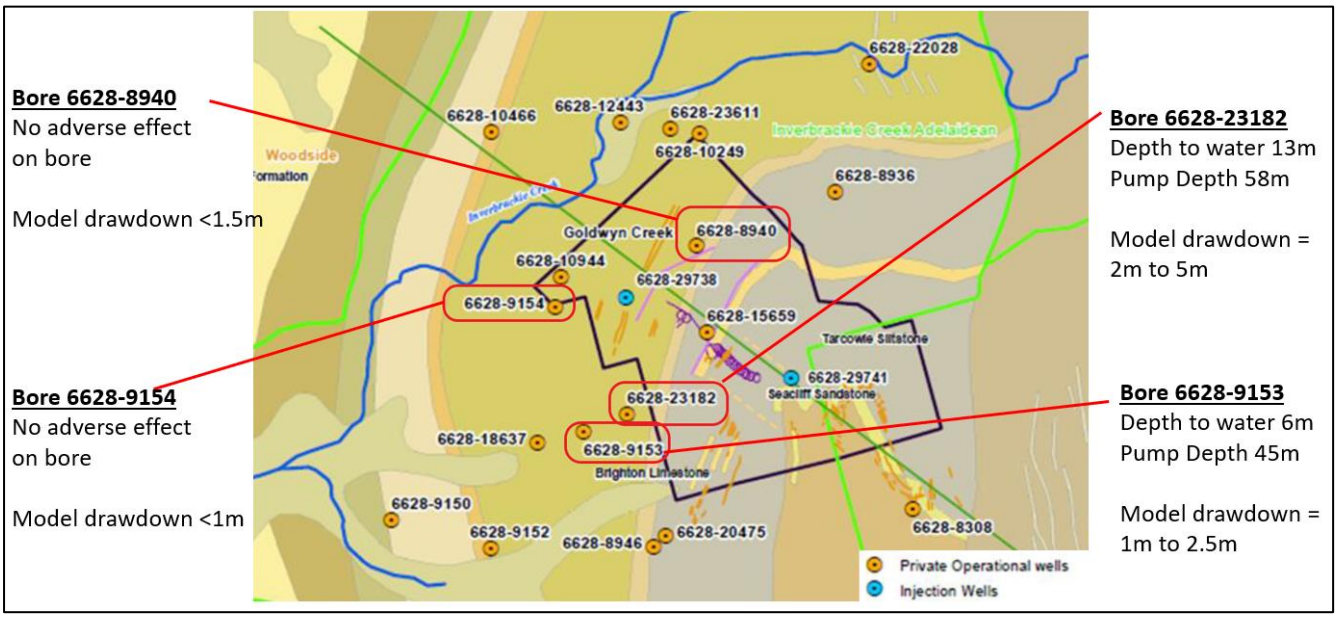


Figure 13: Results of the applicants modelling of controlled inundation on adjacent landowner groundwater bores.

Model and impact predictions

The purpose of the numerical modelling is to predict impacts on groundwater without and with proposed control measures.

Potential impact on existing wells

Groundwater inflows into the proposed mine will cause a zone of dewatering and depressurisation as water flows to voids created by mining, which if not managed would result in drawdown of water levels in surrounding bores and, depending on the pump height within the bore, may result in existing users being unable to access groundwater at some private wells. Well 6628-15659 is located above the ore body and will be dewatered as a result of mining operations. Terramin have negotiated alternative water supply arrangement with the user, which is acceptable to government.

Table 8 below shows the predicted drawdown at operational wells under each modelled scenario. Negative drawdown values in the table represent a groundwater level rise, while positive values represent a groundwater level decline.

The model results show no drawdown of any third-party operational wells and an increase in water available to eight receptor wells in the 70% grouting effectiveness and MAR scenario in the final year of mining. In the 90% grouting effectiveness and MAR scenario, one well would experience a drawdown of 0.5 m, which would not affect the ability to access allocated water, and two wells would experience an increase.

The conservative P95 70% grouting effectiveness scenario shows an increase in water available at all wells.

Groundwater modelling showed that drawdown at private wells can be reduced by pre-excavation grouting and eliminated by MAR of treated mine water to offset groundwater drawdown around the mine.

Impact on Inverbrackie Creek

The results of the uncertainty analysis for the median (P50), excluding MAR showed that by the last year of proposed mining, baseflows to the Inverbrackie Creek would:

- reduce by 2.5% for the 90% grouting effectiveness scenario
- reduce by 5% for the hybrid scenario
- reduce by 12% for the 70% grouting effectiveness scenario[67].

The model predicts MAR will mitigate any reduction in baseflow to the creek.

[67] Appendix B7A of the Response Document.

Table 8: Predicted groundwater level change at private wells at mine year 5[68]

Well	Hydro-stratigraphic unit	Baseline DTW (m)	Well Depth (m)	Well Construction	Pump Depth (m)	Groundwater Level Change (m) from Steady State Negative Values = rise		
						70% Grouting + MAR at 15 L/s (m)	90% Grouting + MAR at 5 L/s (m)	MCUA P95 70% Grouting + MAR at 39 L/s (m)
6628-8936	TS		50.9	No details	27.4	-1.5	-1	-1.5
6628-8940	TH		Unknown	No details		-2	-1	-3.5
6628-10944 (Terramin owned)	TH	11.69	76	Casing 0-16.2 m OH 16.2 – 76 m	60	-1.5	0	-3
6628-9154	TH	22.2	51.5	Casing 0-11 Open hole 11 – 51.5	30.5	-2	0	-2.8
6628-23182	TH	13.2	64	PVC screen 30 – 48 m	58	-1	0.5	-3.5
6628-9153	TH	3.1 – 6.71	134	No details	45.7	-2	0	-2.8
6628-8946	TS	16.57 – 24.0	UKN	No details		0	0	-1.9
6628-20475	TS	20 – 25.08	70	SC 64 – 70m	60	0	0	-2.5
6628-8950	TS	8.1 – 10.90		STL to 22.9 m (no details)	26	0	0	-1
6628-8952	TS	24.10 – 30.14	45.7 (water connect = 74.5)	Possible production zone 51 to 74 m	50	0	0	-1.1
6628-18637	TH	11.87 – 23.4	70	Open hole 18 to 70 m	45.7	-1.5	0	-2
6628-9152	TH	11.00	91	Open hole 64 to 91 m		0	0	-1
6628-10249	TH	12.07 – 21.31	98.8	Open hole 58 to 98.8 m		0	0	-1.8
6628-8301	K	9.14	100.58	Unknown production Zone 39.6 to100.58	80	0	0	-2.8
6628-8308	TS	9.1 – 13.8	92.3	203 mm diam casing from 0 to 41.5 m Production zone 41.45 to 92.35 m		0	0	-2.8
6628-23611	TS	8.6 - 15	56	-		-2	0	-2

[68] Table 18 from Appendix B5A of the response document.

Potential cumulative drawdown impacts

Government notes that the cumulative impact of existing users and the mine are not explicitly simulated and explained in the MP and response document. Rather, the approach taken by Terramin is to predict them separately and then add the impacts to get a cumulative effect. While such superposition of drawdown is valid for confined aquifers, it may be inaccurate for unconfined aquifers if the drawdown is a significant fraction of the total saturated thickness of the aquifer. Hence, this approach is suitable for the simulations with grouting and MAR, where the mine-induced drawdown is negligible.

Representation of mitigation measures in the model

Grouting was represented in the model by reducing the conductance of drain cells representing the decline and drives through trial-and-error until mine inflows reduced by 70% and 90%, based on advice from MultiGrout, of unmitigated inflows[69].

Groundwater flow into the mine, reduced by grouting, is next reinjected to the model domain. The total MAR rate is equal (for each stress period) to the total modelled mine inflows, distributed across eight MAR bores[70].

The then-conceptual MAR bores were placed at strategic locations around the mine to offset groundwater drawdowns and to minimise the risk of shifting the groundwater divide between the eastern and western Mount Lofty Ranges prescribed areas and any potential associated salinity changes. In 2018, two of the injection wells were drilled and tested and the results were incorporated to the BIH numerical groundwater flow model. The two injection wells were included in the model, leaving six others conceptual.

Government considers that the mitigation measures were modelled adequately to predict effectiveness in reducing impacts on receptors. Government notes that the implementation of mitigation measures in the BIH numerical groundwater flow model are based on the following:

1. An assumption that the grouting will be effective in reducing 70% (or 90%, or a hybrid) of the unmitigated mine inflow depending on the model scenario.
2. An assumption that the grouting-mitigated mine inflow is reinjected to the groundwater system.

The model does not factor in or present identified practical operational management details that contribute to the effectiveness of the mitigation measures, such as confirmation of operational designs in relation to how many MAR wells can operate and management of clogging.

Post-mining predictions

Once mining is completed Terramin propose that the following will occur:

- All shafts will be filled, plugged and sealed
- The mine portal will be plugged and sealed

[69] Appendix H1 of the Mining Proposal.
[70] Appendix B5A of the response document.

- Ore drives and underground excavations, including the decline, will be backfilled.

Terramin propose that the MAR system will be decommissioned and water treatment plant infrastructure removed following mine closure[71].

Figure 14 below shows that under the conservative 70% grouting effectiveness with MAR used during mining scenario, the model predicts that groundwater elevations would reduce by half a metre at one receptor well[72]. Government notes that the model flow rates have been slightly modified since 2017 when this figure was generated, meaning the half a metre drawdown may actually be less if the slightly higher flow rate from the median 70% scenario were to be used.

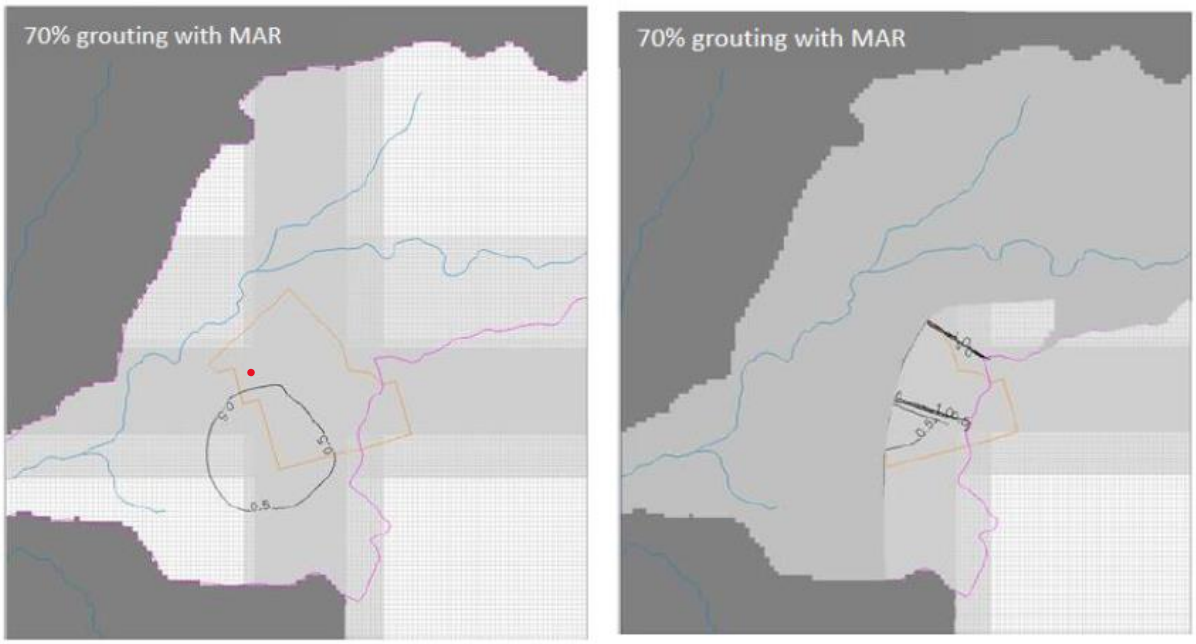


Figure 14: Residual Drawdowns 5 Years Post Closure (approximate well 6628-23182 location shown as the red dot) in the Tapley Hill Formation (Left) and Tarcowie Siltstone (Right)[73].

Uncertainty analysis

In July 2020, Terramin commissioned Golder Associates to undertake a non-linear uncertainty analysis of the groundwater model in response to a request for information from government.

For an impact assessment model, the purpose of uncertainty analysis is to determine the range of groundwater model predictions that are consistent with hydrogeological knowledge of the area. A solution provided by a groundwater model may not be the only possible solution as the model must be based on inputs that cannot be fully measured in the field and must be approximated to replicate the natural system. Many solutions to a particular problem may exist and it is the role of hydrogeologist to choose those that are realistic and recreate

[71] Chapter 3 of the Mining Proposal.
[72] Appendix H1 of the Mining Proposal.
[73] Figure 3-219 from the Mining Proposal

existing data and information reliably. The results of the uncertainty analysis provide a range of possible model outcomes in terms of mine inflow, drawdown and baseflow depletion.

Implementation

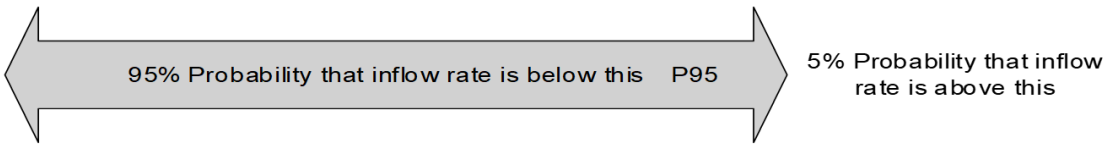
The uncertainty analysis used Monte Carlo techniques, which involves generating randomised parameter combinations from realistic ranges of input parameters. The parameter combinations served as inputs to the groundwater model. The groundwater model was run and only combinations that led to reasonable matches with historical data were retained, in that the results were constrained by calibration criteria. Outputs (mine inflow, drawdown and baseflow depletion at the Inverbrackie Creek) were collated together with the input parameters. Standard statistical methods were next employed to predict the probabilities of outcomes for selected input variables.

The calibration-constrained Monte Carlo analysis was used starting with 10,000 parameter combinations. Constraints, agreed by Terramin and government hydrogeology experts, on water balance and model calibration errors, reduced those 10,000 to 301. These 301 parameter combinations[74] were used to predict the outcomes, which have been plotted as distribution curves. This method of displaying results allows the range and likelihood of scenarios to be easily visualised.

Results

The response document[75] provides estimates of inflow, drawdown and depletion of baseflow across the unmitigated, conservative 70% grouting effectiveness scenario, a “hybrid" scenario (90% effectiveness for the decline and 70% for stopes) and the 90% grouting effectiveness scenario. MAR was excluded from the mitigation scenarios so that drawdown risk could be evaluated.

For all model predictions, representative percentiles of probability were estimated based on the results of the Monte Carlo analysis. These include the 5th, 20th, 33rd, 50th, 67th, 80th and 95th percentiles[76] (referred to as P5 etc onward). Percentiles indicate the percentage of results that fall below a particular value. It is also useful to consider the percentage of results above. This is useful when considering the probability of the result occurring. For example, when considering mine inflow results at each end of the probability spectrum, for P5 there is a 5% probability that the inflow rate will be less and 95% probability it will be higher. P95 is the opposite as shown below.



[74] The final Monte Carlo predictive ensemble sizes were: 218 for the unmitigated scenario, 146 for the 70% grouting effectiveness scenario, 125 for the 90% grouting effectiveness scenario, and 101 for the hybrid grouting effectiveness scenario (Appendix B7A of the response document).
[75] Appendix B7A of the response document.
[76] Appendix B7A of response document.

For P50 the mine inflow rate has a 50% probability of being less or higher making this the median.

As discussed in the grouting section of this chapter, government considers the "hybrid" grouting effectiveness scenario realistic. Table 9 below shows the median (P50) peak inflow rate during mining to occur during year 5 at 18 L/s. The CSIRO report found that the P50 mine inflow rates calculated with the numerical groundwater model converged rapidly and were almost identical to the analytical solution used by CSIRO to evaluate results of the uncertainty analysis. CSIRO concluded that:

> "The estimated 5th and 50th percentiles of predicted mine inflows across the various scenarios are adequate. The rejection sampling approach chosen to simulate the range of predictions results in a robust estimate of the 5th and 50th percentile."[77]

CSIRO considered that the P95 inflow results could be underestimated in the uncertainty analysis because:

1. The sample size after constraining the Monte Carlo ensemble is not sufficient to reliably estimate P95 and,
2. The sampled distribution of effective hydraulic parameters (ie those averaged across a flow path) cover a smaller range than the range of each individual zone's distribution.

Government considers the higher but less probable values associated with P95 useful for assessing proposed designs and planning for contingency in the system.

Table 9: Percentiles of probability for average mine inflows by mining year – hybrid grout effectiveness scenario[78]

Mining year	P5 (L/s)	P20 (L/s)	P33 (L/s)	P50 (L/s)	P67 (L/s)	P80 (L/s)	P95 (L/s)
Year 1	2.1	2.8	3.1	3.5	3.8	4.1	4.8
Year 2	3.7	5.6	6.5	7.6	8.6	9.5	11
Year 3	4.5	7.3	8.8	10	12	13	16
Year 4	5.6	9.4	11	14	16	18	21
Year 5	7.8	13	15	18	21	23	28

Figure 15 below shows predicted inflows for the conservative 70% grouting effectiveness scenario. As discussed in the preceding MAR section of this chapter DEM consider it appropriate for the MAR system and water treatment plant to have appropriate redundancy to handle higher than expected inflow associated with this scenario. Figure 4 shows the median (P50) peak inflow rate during mining at 25 L/s in year 5. The conservative (P95) shows an inflow rate of 39 L/s in year 5.

[77] Peeters LJM and Marshall S, 2022.
[78] Table 4 from Appendix B7A of response document.

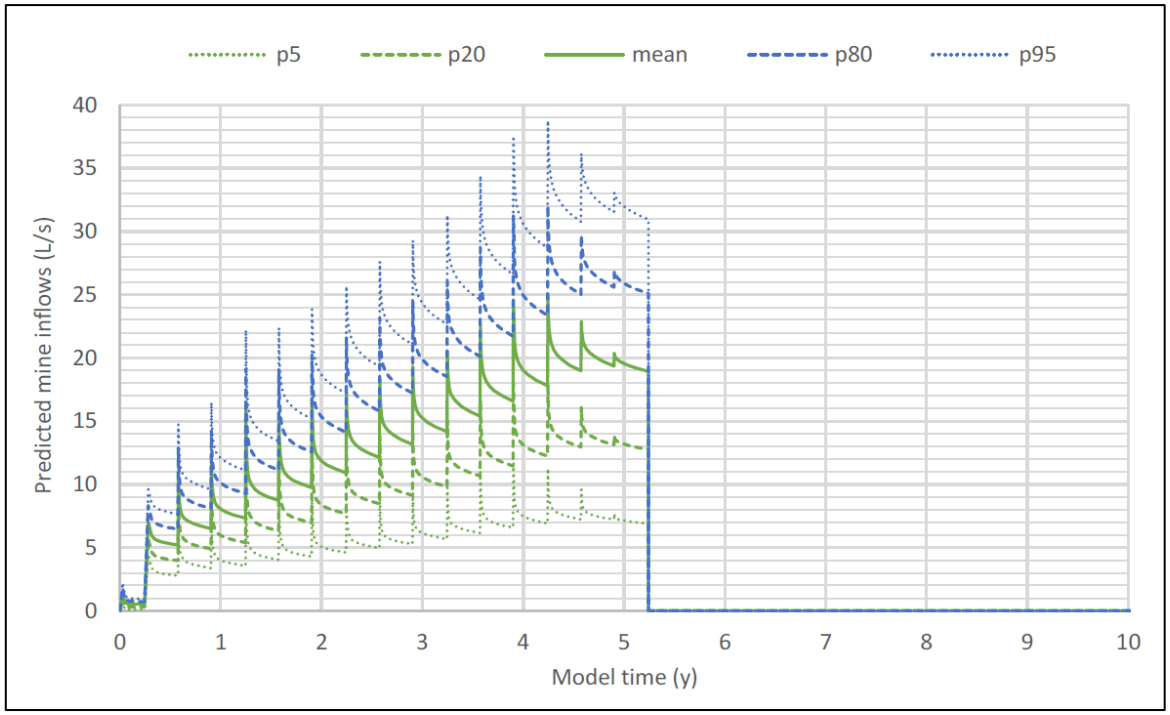


Figure 15: Predicted mine inflows at 70% grouting efficiency[79]

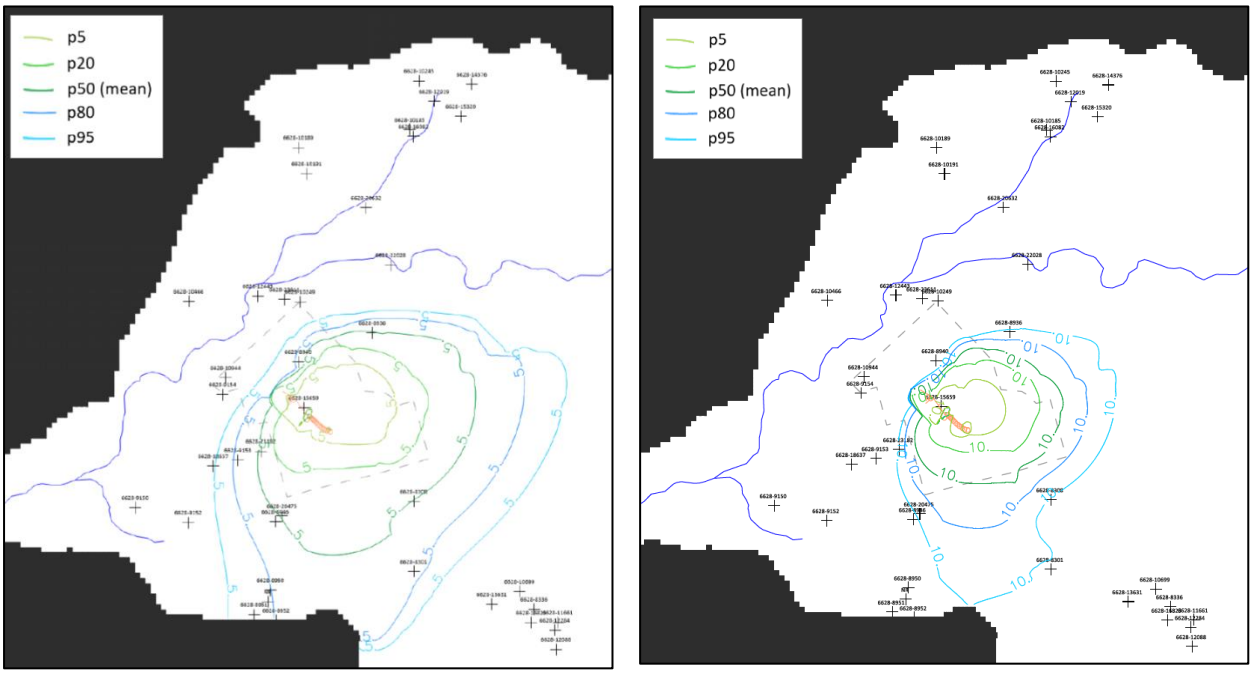


Figure 16: (Left) Percentiles of probability for predicted maximum (end-of-mining) extent of 5 m drawdown contour for the hybrid grout effectiveness scenario[80] *(Right) Percentiles of probability for predicted maximum end-of-mining) extent of 10 m drawdown contour for the hybrid grout effectiveness scenario*[81]*. MAR is not included.*

[79] Figure 57 from Appendix B7A of the response document.
[80] Figure 9 from Appendix B7A of the response document.
[81] Figure 10 from Appendix B7A of the response document.

Figure 16 shows that the predicted maximum extent of 5 m drawdown for the “hybrid” scenario without MAR will affect 4 receptor wells, for the median (P50) value, noting a fifth well directly over the mine is owned by Terramin. The conservative P95 contour includes 12 receptor wells. In comparison the P50 contour showing predicted maximum extent of 10 m drawdown for the “hybrid” scenario does not impact on any receptor wells. The P95 contour includes 4 receptor wells.

Government has assessed that Terramin evaluated model uncertainty adequately to present plausible ranges for the median (P50) to allow for the prediction of potential impacts. The uncertainty analysis used a non-linear method which is the most comprehensive for a mine to date in SA.

Modelling expert peer reviews

The model and groundwater assessment were peer reviewed by Innovative Groundwater Solutions (IGS) and found to be fit for purpose against the Australian Groundwater Modelling Guideline[82]. The uncertainty analysis provided by Terramin in the response document was peer reviewed by Hugh Middlemis from HydroGeoLogic in accordance with best practice principles and procedures outlined in Chapter 7 (uncertainty section) of the Australian Groundwater Modelling Guideline and recent guidance on uncertainty analysis of which he was a co-author. The review concluded that the uncertainty analysis utilises the groundwater model, was designed and executed consistent with best practice guidelines and that the results are suitable to support the decision and risk management process[83].

Potential impact events - No outcome proposed

Government has assessed all potential impact events identified in the MP[84] where an outcome was not proposed and confirms that the source, pathway and receptor do not exist, hence, an outcome is not required for those impact events.

Water licencing

At the time of application, water resources were managed through the *Natural Resources Management Act 2004* (NRM Act) and associated water allocation plans. From 19 December 2019 the *Landscape South Australia Act 2019* (LSA Act) replaced the NRM Act as the key framework for managing the state's land, water, pest plants and animals, and biodiversity across the state.

The proposed mine is located within the WMLR Prescribed Water Resources Area. All water use in this area is regulated through the WMLR WAP. The objectives of the WAP are to:

a. Allocate and use water resources sustainably.

[82] Harrington, 2017, *Groundwater Assessment Peer Review* – Appendix H3 of the Mining Proposal.
[83] Middlemis, 2021, *Independent peer review of Bird in Hand groundwater modelling uncertainty analysis* - Appendix B8 of the Response Document
[84] Table 10-6 of the Mining Proposal

b. Maintain water-dependent ecosystems.
c. Minimise the impact of the taking and use of water on prescribed water resources, other water resources, other water users and the environment.[85]

The LSA Act requires that all water taken from a prescribed water resource is taken as part of a water allocation that relates to the relevant water resource (through the licensing process) or through an authorisation granted under section 105 of the Act.

Injection of water is authorised either through a drainage and discharge permit by the Department for Environment and Water (DEW) or an environmental authorisation granted pursuant to the *Environment Protection Act 1993*.

The WAP allows for water allocations to be transferred subject to the principles of the WAP. Terramin has assessed the project against the WAP objectives and demonstrated that all objectives could be met under the proposed allocation transfer approach[86]. Transfer of allocations are assessed by DEW against the transfer criteria of the WAP to ensure that the transfer will not cause a significant adverse effect on an aquifer, including (but not limited to), changes in local water levels and salinity.[87]

Principle 23 of the WAP states: Water that has been drained or discharged into a well in a recharge period in accordance with a permit granted pursuant to section 135 of the NRM Act (now LSA Act) or an environmental authorisation granted pursuant to the *Environment Protection Act 1993* may be allocated to be taken in the recovery period (and is referred to in this plan as a 'recharge allocation'), subject to the following conditions:

a. the volume of water allocated must not exceed 80% of the volume of water that was drained or discharged into a well, as recorded by a water meter, in the recharge period; and
b. the water must be taken from the same allotment and from the same aquifer that the water was drained or discharged into.

Terramin has negotiated with other licence holders and applied for transfer of a licenced groundwater allocation. Combined with Terramin's existing allocation, the proposed licence transfer would result in a base annual allocation of 122ML. Terramin proposes a strategy of extraction and injection of water to accumulate recharge allocations before the commencement of year 1. If the lease and transfer applications are approved, Terramin could begin injecting water through the existing permitted injection wells subject to approval within a PEPR.

For example, if a total of 100ML is injected prior to year 1 (assuming 20ML is used onsite) this would result in a recharge credit of 80ML. In the following year Terramin would then theoretically have an allocation of 202ML. Based on approximate timeframes for PEPR development, assessment and the surface construction phase of 1 year shown in Figure 3, Terramin's allocation would exceed the operational estimate shown in Table 10 of 110ML.

As discussed in the grouting section of this chapter government considers the hybrid grouting scenario to be a more realistic scenario. The CSIRO review expressed confidence in the estimated P50 inflow rates based on rapid convergence as discussed in the above

[85] *Water Allocation Plan for the Western Mount Lofty Ranges Prescribed Water Resources Area*, 2013, Adelaide and Mount Lofty Ranges Natural Resources Management Board, Government of SA.
[86] Appendix B8 of the Mining Proposal.
[87] Principle 98 of the WAP.

assessment of the uncertainty analysis. In the response document, Terramin note that the inflow values for any scenario assume that the previous 4 years have operated under the same conditions therefore making the results overly conservative. As discussed in the grouting section of this chapter grouting experts consider that grouting processes would improve over time with appropriate resources, quality assurance and quality control procedures in place.

To inform the water licencing requirements, Government considers it appropriate for Terramin to secure annual allocation for years 1 and 2, for rates estimated under the hybrid scenario, shown in Table 10. This grouting effectiveness estimate is considered conservative given year 1 only proposes development of the decline[88] but allows sufficient redundancy for the first operational year of grouting and refinement of processes prior to development of the ore drives (stoping area) in year 2. As discussed in the grouting section of this chapter, the use of grout to control inflow in a decline tunnel is well understood. The decline comparison is also located within the Tapley Hill Formation which generally appears to have low fracture permeability and typically may not require grouting.

Government assesses that by year 3 a 90% grouting effectiveness scenario is more realistic, based on the decline representing a larger void space and operational learnings of the previous years. Table 10 reflects this in the operational estimate column.

Table 10: Annual predicted median inflow for the 90% grouting effectiveness scenario and hybrid grouting effectiveness scenario based on results of the uncertainty analysis[89]

Year of mining	P50 Annual inflow (ML) for hybrid scenario[90]	P50 Annual inflow (ML) for 90% grouting effectiveness scenario	Operational estimate
Year 1	110	57	110
Year 2	240	120	240
Year 3	315	155	155
Year 4	442	192	192
Year 5	568	262	262

Terramin have calculated that the base allocation would be sufficient to support their proposed operations.[91] If additional allocation is required Terramin also have the option of negotiating additional transfers or managing operations to ensure the allocation is not exceeded subject to meeting all legislative requirements. Terramin will be required to closely monitor its water use to ensure it has sufficient allocation on an annual basis to remain within its licensed allocations and adhere to all the conditions endorsed on its water licence.

[88] Figure 3-68 from Chapter 3 of the Mining Proposal.
[89] ML values converted from L/s values in Table 9 of this report.

[91] Section 5.2.2 of the Response Document.

Groundwater quantity conclusion

In relation to groundwater quantity, the assessment uses the correct legal standard, which is set out in the WMLR WAP.

The outcome is technically achievable as Terramin's groundwater model has been appropriately developed in accordance with the requirements of the Australian Groundwater Modelling Guidelines and provides credible groundwater quantity impact predictions. Uncertainty in the model was extensively and correctly evaluated. Extensive expert peer reviews of the model, impact predictions and uncertainty analysis have confirmed their credibility.

The groundwater model has been appropriately developed because it is built upon appropriate field data and conceptual hydrogeology. The translation of the conceptual hydrogeology to numerical flow predictions was appropriate and the model was satisfactorily calibrated, and history matched. The CSIRO review found that the approach chosen to simulate the range of predictions for the uncertainty analysis results in a robust median estimate (P50) providing confidence in the inflow rates and drawdowns calculated for the most likely case within the numerical groundwater model.

The outcome is practically achievable as Terramin has adopted effective strategies to prevent drawdown of existing users wells and maintain flow to the environment. Expert peer review reports confirm that strategies could achieve the proposed outcome. Grouting to manage water inflow to the mine is an accepted and proven strategy. The prediction results show no drawdown of any operational wells under the conservative 70% grouting effectiveness and MAR scenario.

MAR is widely used, and the water treatment plant has been designed with enough flexibility to handle higher than expected inflows. The Monte Carlo results for the most realistic "hybrid" grouting effectiveness scenario predict a median (P50) mine inflow rate of 18 L/s in Year 5 that is within the capacity of the existing two injection wells that reinjected 20 L/s during testing. Six more MAR wells are proposed to accommodate more conservative estimates and to provide redundancy in the MAR system. The mine plan has been designed to avoid water-bearing fractures to reduce groundwater inflows. The predictive scenarios prepared to simulate the unmitigated and mitigated mining operations (eg grouting and MAR) provide credible results. Appropriate contingencies have been proposed to account for higher-than-expected inflow to the mine. If the quantity of mine inflow exceeds the capacity of the water treatment and MAR system-controlled inundation of the mine would allow for continued achievement of the groundwater outcome. If controlled inundation is implemented, modelling predicts that there will be no drawdown of adjacent landowner groundwater bores. The conclusions in relation to controlled inundation predictions are supported by the CSIRO review.

Should a lease be granted, government recommends that the lease includes an extensive set of groundwater quantity conditions and requirements (see Appendix 5), including a requirement that Terramin monitor groundwater quality and quantity on a continuous basis (where practicable) and report that data to a publicly accessible website.

Groundwater quality – Assessment of potential impacts

Baseline understanding

Field data acquisition

Groundwater sampling was undertaken at site wells and private wells to understand the existing groundwater quality ('baseline') and the capacity of groundwater to support a range of environmental and human uses. The results showed groundwater quality for the fractured rock aquifer within Inverbrackie Creek sub-catchment to be fresh, typically less than 100 mg/L of total dissolved solids (TDS) with the potential to support a large range of environmental and human uses, including drinking water for human consumption. Groundwater of the Kanmantoo Group was identified as having higher groundwater salinities, with TDS up to 4,000 mg/L.

Establishment of baseline

The baseline groundwater quality is important, as it informs the water treatment plant design and MAR discharge targets, and provides a means to efficiently identify and manage any impacts to groundwater quality as a result of the proposed operations. A significant amount of field data has been collected from site wells and private wells to date. However, additional baseline groundwater quality data is required to support detailed design of mitigation strategies and compliance criteria. The information provided in the MP and the response document[92] demonstrates that there are likely to be a sufficient number of appropriately located wells (targeting each hydrostratigraphic unit) to enable the establishment of baseline groundwater quality. This will require additional sampling, to ensure a sufficient density of contemporary data to establish confidence in the natural variability of groundwater quality in the vicinity of the site.

Groundwater water quality impact assessment

In response to matters raised by government on water quality, Golder undertook hydrogeochemical modelling to assess geochemical impacts on mine water, influences of geochemistry in the void, develop qualitative understanding of the feed water for the treatment system, and determine whether the MAR of treated mine water will induce mineralogical effects or significantly impact the ambient groundwater quality[93].

Terramin considered the following influences most likely to affect water quality:

- Saline drainage into the mining void
- Blasting residue interacting with underground water and at the integrated mullock landform (IML)
- Mineralogical and geochemical impacts underground and at IML
- Metal and semi-metal leachate mobilised from road runoff

[92] Appendix B1 and B4 of the Response Document
[93] Golder, 2021, *Water Quality Impact Assessment* - Appendix B4 of the Response Document.

The conceptual model mineralogical interactions are based on exposure to oxygen. Any water encountering oxidised material has the potential to transport contaminant products of the reaction process to water collection areas.

Terramin have proposed that all water from underground and the IML will report to a turkey's nest dam before undergoing treatment to remove contaminants.[94]

Once an appropriate baseline has been established, additional assessment of the geochemical impacts of treated water to the aquifer will be required to identify and manage risks to groundwater quality. Government acknowledges that this assessment would require an accurate understanding of the existing groundwater quality at the proposed injection sites. Government assesses that it is appropriate for this additional detailed work to be done at the PEPR stage (should a lease be granted).

Solute transport

Groundwater modelling was used to assess the potential water quality impacts due to drawdown drawing more saline water from the Kanmantoo Group into the fresh WMLR area. Groundwater salinities were broadly assigned to the numerical model in accordance with salinities obtained from baseline well sampling. Representative initial salinity values of 2,400 mg/L and 1,000 mg/L were applied to the EMLR and WMLR areas respectively.[95] The simulated salinity at the end of mining (5.5 years) without grouting or MAR showed a small increase of 100 mg/L relative to baseline.

As discussed earlier in this chapter, use of the equivalent porous media approach at smaller scales than REV may not be accurate. This same principle applies to modelling of solute transport. While a calibrated flow model may adequately simulate observed hydraulic behaviour, significant errors are likely to occur in subsequent use of the flow model to predict solute transport.

Further, the peer review of MAR (Appendix B6) stated:

"…contaminant travel times and plume directions cannot be predicted with a high degree of confidence in these systems using an equivalent porous media (EPM) approach such as that required for the current MODFLOW model. This has, in part, been addressed through the assignment of different solute transport parameters (effective porosity and dispersivity) for the fault zone and surrounding aquifer, however smaller-scale heterogeneity (beyond the fault zone) cannot be ruled out. Accordingly, the predictions of percentage of recharge water to reach the wells of existing users and environmental receptors should be interpreted with caution."

The solute transport simulation presented in the MP[96] was repeated based on the Monte Carlo analysis[97]. The solute transport simulation was run using a conservative approach for the unmitigated scenario for the (accepted) Monte Carlo realization, giving the highest mine inflows. Salinity changes were minor even under these conditions.

[94] Figure 1 - Appendix B4 of the Response Document.
[95] Appendix H1 of the Mining Proposal.
[96] Appendix H1 of the Mining Proposal.
[97] Appendix B7A of the Response Document.

Government acknowledges that the results are using a highly conservative approach, and that grouting and MAR are considered to be effective in ensuring achievement of the quality component of the groundwater outcome. Nevertheless, it is important that baseline groundwater quality is understood at wells within the zone of potential saline intrusion so monitoring during and post mining can be used to demonstrate achievement of outcomes.

If a lease is granted, it is recommended that additional data is collected to establish an appropriate baseline to inform design and compliance criteria. Refer to Appendix 5 for recommended conditions and PEPR requirements should a lease be granted.

Government assesses that the groundwater model used to inform the water quality impact assessment[98] has used appropriate inputs and provides qualitative results that could be reviewed further with baseline data.

Acid and metalliferous drainage

Terramin included an acid and metalliferous drainage (AMD) assessment conducted by Tonkin in the MP. The objective of this assessment was to classify the rock samples tested based on their AMD characteristics, as either Potential Acid Forming (PAF) or Non-acid Forming (NAF), to enable the identification of an AMD field within the geological block model[99]. Where iron sulphides such as pyrite are present in mined rocks, AMD may occur if these sulphides are exposed to aerated conditions following the lowering of groundwater tables or if brought to the surface for storage in the IML. The risk of AMD is considered low as the proposed mine design avoids the supergene zone, which has been identified as highest risk of encountering PAF material. The assessment found waste rock from the primary vent rise was likely to contain PAF where it intersected the supergene pyrite zone. However, the response document proposed that the vent rise would run up the centre of the decline, which avoids the supergene zone.

The decline and ore drives are within the Tapley Hill and Brighton Limestone respectively and considered NAF and acid consuming material (ACM) due to the presence of carbonate minerals. Terramin propose that all PAF material will either be encapsulated with this NAF and ACM in the IML or managed at their tailings storage facility at Strathalbyn, which is designed for this purpose. All drainage from the IML reports to the treatment plant, which has been conceptually designed to treat salts and metals that may be mobilised.

Tonkin recommend that:

- future drilling should be sampled for AMD
- as mine planning is progressed, the geological model should be updated with AMD results to enable waste rock types and volumes to be refined
- the AMD block model should be used to inform production schedules of PAF and NAF and to form the basis for AMD management planning; including the design of the IML, groundwater management and prepare rehabilitation and post-closure plans

[98] Appendix B4 of the Response Document.
[99] Tonkin Consulting, 2017, *Acid and Metalliferous Drainage Assessment* - Appendix M2 of the Mining Proposal.

- groundwater and environmental monitoring programs should include assessment of AMD and NMD indicators, metals and metalloids typically associated with country rock units at BiH[100].

Government considers that appropriate strategies have been proposed to manage the risk of AMD and support the above recommendations made by Tonkin, and recommends that if a lease is granted, they inform requirements of the PEPR. It is also recommended that the PEPR include a leading indicator criterion as a contingency measure in relation to AMD to ensure proactive identification of water quality trends.

Groundwater quality – Assessment of mitigation

The following section summarises the key measures proposed to mitigate potential groundwater impacts related to quality and provides government's assessment as to whether these measures would achieve the groundwater outcome.

Water treatment

GPA Engineering (GPA) on behalf of Terramin initially developed a concept water treatment plant design to treat mine water and the mine-affected runoff water to remove contaminants so that resulting clean water meets or improves the quality of the surrounding aquifers as required by the Water Quality Policy and the Landscapes South Australia Act.[101]

Further hydrogeochemical modelling was undertaken by Golder as described in the previous section of this chapter. The water treatment plant concept was assessed against the modelling results with reverse osmosis added to provide sufficient flexibility and redundancy to enable a wider quality range of water to be treated.[102] In the response document GPA also noted potential upgrades that would enable treatment of mine inflow at 39 litres per second, which correlates with the P95 the conservative 70% grouting effectiveness scenario.[103]

Government considers that the proposed method of water treatment is well understood and the conceptual design is appropriate to manage identified contaminants.

Should a lease be granted, a detailed water treatment plant design must be included in the PEPR that is based on the groundwater quality baseline and aquifer re-injection targets.

[100] Appendix M2 of the Mining Proposal.
[101] GPA Engineering, 2017, *Water Treatment Options Study Report* - Appendix J1 of the Mining Proposal.
[102] GPA Engineering, 2020, *Technical Memorandum - Review of Water Treatment Plant Concept for BIH* - Appendix B9 of the Response Document.
[103] GPA Engineering, 2021, *Technical Memorandum - Response to Item #46 of MLA and MPL for the Bird in Hand Gold Project* – Appendix B10 of the Response Document.

Groundwater quality conclusion

For groundwater quality, the outcome is achievable as the model uses the Water Quality Policy[104] as the correct legal standard for assessment of potential impacts.

Terramin's groundwater models have been appropriately developed and provide credible predictions of mine inflow and water quality to inform the water treatment design and MAR. Terramin's uncertainty analyses has shown that the limited potential migration of saline groundwater from the EMLR to WMLR will be mitigated by grouting and MAR.

Water treatment technology is well understood and the proposed treatment plant has been conceptually designed to treat identified contaminants with additional redundancy. The use of MAR to re-inject water of an appropriate quality back into the fractured rock aquifer has been trialled and demonstrated.

If a lease was granted, it is recommended the lease include a condition requiring Terramin to establish a more detailed groundwater quality baseline to allow for development of water quality targets. Terramin have demonstrated that there are enough appropriately located bores to do this.

Chapter 5

Community and engagement

Introduction

The process of applying for a tenement allows for both formal and informal stakeholder engagement. The specific Ministerial Determination for the Bird in Hand Gold Project required that Terramin develop a Community Engagement Plan (CEP) to be included in the MP that sets out the purpose, objectives and parameters of engagement with the community.

Government expects that all proponents engage relevant stakeholders throughout the preparation of any application, to enable the identification of stakeholder concerns. Determinations for the ML and MPL[105] required that the results of consultation be provided, detailing any concerns raised and the response from Terramin to address concerns.

Evidence that the community has been engaged on the development of environmental outcomes proposed in the MP was also a requirement of both determinations. Government considers engagement on proposed outcomes to be an important part of the pre-application engagement process as it allows stakeholders to raise potential impacts that may have not been considered, which can influence the project design and strategies that will be proposed in the application.

Statutory consultation processes are established under the Historic Act[106], which required that the Application be publicly circulated to provide the opportunity for the public to make written submissions. The applicant is provided with an opportunity to respond to issues raised. DGovernment then considers all relevant matters in the submissions and applicant response when undertaking its assessment of the Application.

This chapter will summarise engagement undertaken by Terramin to inform development of the Application for the mining lease and Woodside and MPL at Strathalbyn.

Terramin's stakeholder engagement prior to application

Terramin used the IAP2[107] spectrum, which is considered best practice, to guide their engagement approach and provided evidence of extensive engagement with the community through a variety of methods prior to the application being made.

Methods of engagement used by Terramin since 2014 include:

- Public meetings and community information sessions

[105] Ministerial Determination 006 set out the requirements for the MPL application.
[106] Section 35A of the Historic Mining Act 1971.
[107] International association for public participation: https://iap2.org.au/

- Community open days and drop-in sessions[108]
- Focus groups
- Technical workshops
- Posters[109]
- One on one meetings
- Surveys[110]
- Community perceptions survey (undertaken independently by the CSIRO)
- Community Consultative Committees.

Table 5-7 of the MP provides a full summary of Terramin's community engagement activities since 2014. Figure 16 shows how Terramin used results of engagement to develop the Application.

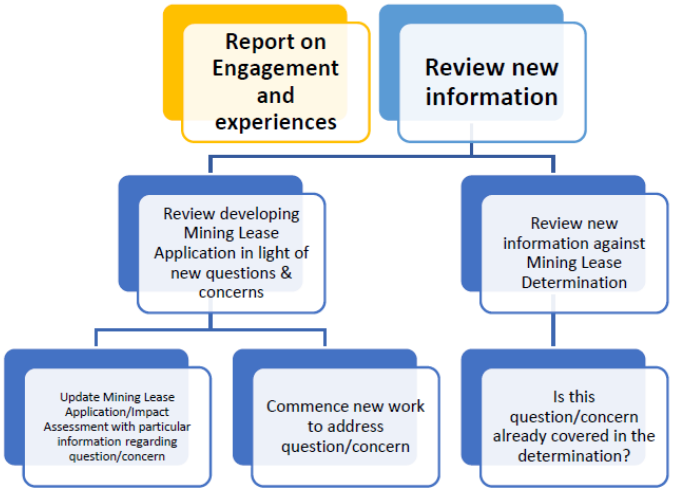


Figure 16: Stakeholder engagement approach prior to lodgement[111]

Community perceptions survey

CSIRO, Terramin and The Innovations Connections Scheme jointly funded a survey of the local community perceptions of Terramin's proposed underground gold mine project.[112] The purpose of the project was to understand community attitudes in 2016-2017, in the context of concerns and potential benefits to create a structured engagement process.[113]

[108] Community Drop in Days Report - Appendix C9 of the Mining Proposal.
[109] Community information posters – Appendix C3 of the Mining Proposal.
[110] Community Awareness Survey – Appendix C8 of the Mining Proposal.
[111] Figure 5-3 from the Mining Proposal.
[112] Chapter 5 of the Mining Proposal.
[113] Carr-Cornish S, Moffat, K., & Boughen, N.,2017, *Local community perceptions of Terramin's proposed underground gold mine: Initial results from the community survey*. CSIRO, Australia – Appendix C7 of the Mining Proposal.

Woodside Community Consultative Committee (WCCC)

Community consultative committees are used across Australia to allow for structured engagement on mining projects and usually continue for the life of the mine. The aim of the WCCC is to promote the best possible outcomes for the local community, through community participation in the consideration of matters that may positively or negatively impact on them in relation to Terramin's Bird in Hand Gold Project[114].

Between the 11 October 2017 and the 17 April 2019 there were 16 WCCC meetings that were attended by WCCC members, Terramin, government representatives and technical experts where required. The WCCC was independently chaired and allowed for open communication between the community and Terramin. Through WCCC meetings the community raised issues that resulted in changes to the project design and informed the assessment of potential impacts. Full detail of matters raised by the WCCC and Terramin's response to how issues were addressed is included in Appendix C5 of the MP.

Strathalbyn Community Consultative Committee (SCCC)

The SCCC was formed to engage with the community on the Angas Zinc Mine which is now in care and maintenance. The SCCC is independently chaired and currently meets quarterly. The committee was engaged during the preparation of the most recent Angas Zinc Mine PEPR which includes detailed closure designs for the mine. In 2013 Terramin introduced the Bird in Hand Gold Project scope to the SCCC and it has been a regular agenda item since then[115]. The MPL application notes that the SCCC raised concern regarding:

- potential noise impacts associated with restarting the processing facility
- the management of tailings
- the management of water in the Tailings Storage Facility (TSF)
- potential for the project to affect the mine closure plan.

All of these matters have been addressed in the Application. For further information on Government's assessment of the MPL application please refer to Chapter 15.

Government assesses that Terramin has met the consultation requirements for the Application as set out in the Mining Act, Regulations and respective Ministerial Determinations. For further information on the specific requirements and legislative references refer to Appendices 1 to 4.

Government public consultation

Government statutory public consultation was undertaken in accordance with the Act.[116] The Act requires the Minister to invite written representation on all mining production tenement applications. Notice of the consultation period was published in:

- the South Australian Government Gazette
- The Advertiser

[114] WCCC Terms of Reference, 2017.
[115] Summarised from Chapter 5 of the MPLA.
[116] Section 35A(1) of the Historic Mining Act 1971

- The Courier (Mount Barker)
- The Adelaide Hills Weekender Herald
- Southern Argus (Strathalbyn)
- The Times (Victor Harbor)

and on the DEM website, inviting members of the public to make submissions on the Application from 11 July 2019 until 20 September 2019.

During the consultation period the application was also referred to technical experts within the following government departments:

- South Australian Environment Protection Authority
- Department for Environment and Water
- Department for Infrastructure and Transport
- Department of Primary Industries and Regions

Government received 254 public submissions. Comments from government departments were collated into a list of government matters.

Government reviewed all public submissions received. Public submissions that included supporting technical expert reports were referred to technical experts across government for consideration.

On 7 February 2020 DEM formally requested that Terramin review and respond to all relevant matters raised in public submissions and all Government matters in a response document.

Terramin's analysis of matters raised in public submissions

Terramin analysed public submissions and sorted the matters raised into common themes, which align with chapters of the MP and MPLA. Appendix A1 of the response document provides Terramin's analysis of individual public submissions. Terramin chose to group public submissions into the following categories:

- Supportive submissions (22)
- Submissions raising issues or seeking clarity on details of the applications (41)
- Submissions resulting from campaigns 1-5 (189).[117]

Government reviewed the initial response document received on 21 April 2020 and assessed that Terramin did not sufficiently address all relevant matters raised in public submissions or government matters.

Government requested that Terramin respond to a list of relevant matters identified within public submissions in a revised response document. Table 11 of the response document provides Terramin's response to these additional matters. Government also required that Terramin respond to government matters that were not addressed or where further clarification was required.

[117] Summarised from the Response Document.

Terramin submitted a second version of the response document on the 5 March 2021. Government assessed the response and identified six matters requiring further clarification and requested this information be provided in a final response document.

The final response document was submitted on 23 July 2021 and accepted by Government on 23 August 2021.

Figure 17 provides a summary of matters raised in public submissions and shows groundwater, traffic, agricultural impacts, economic, tourism, air quality and noise as the key matters raised by the public.

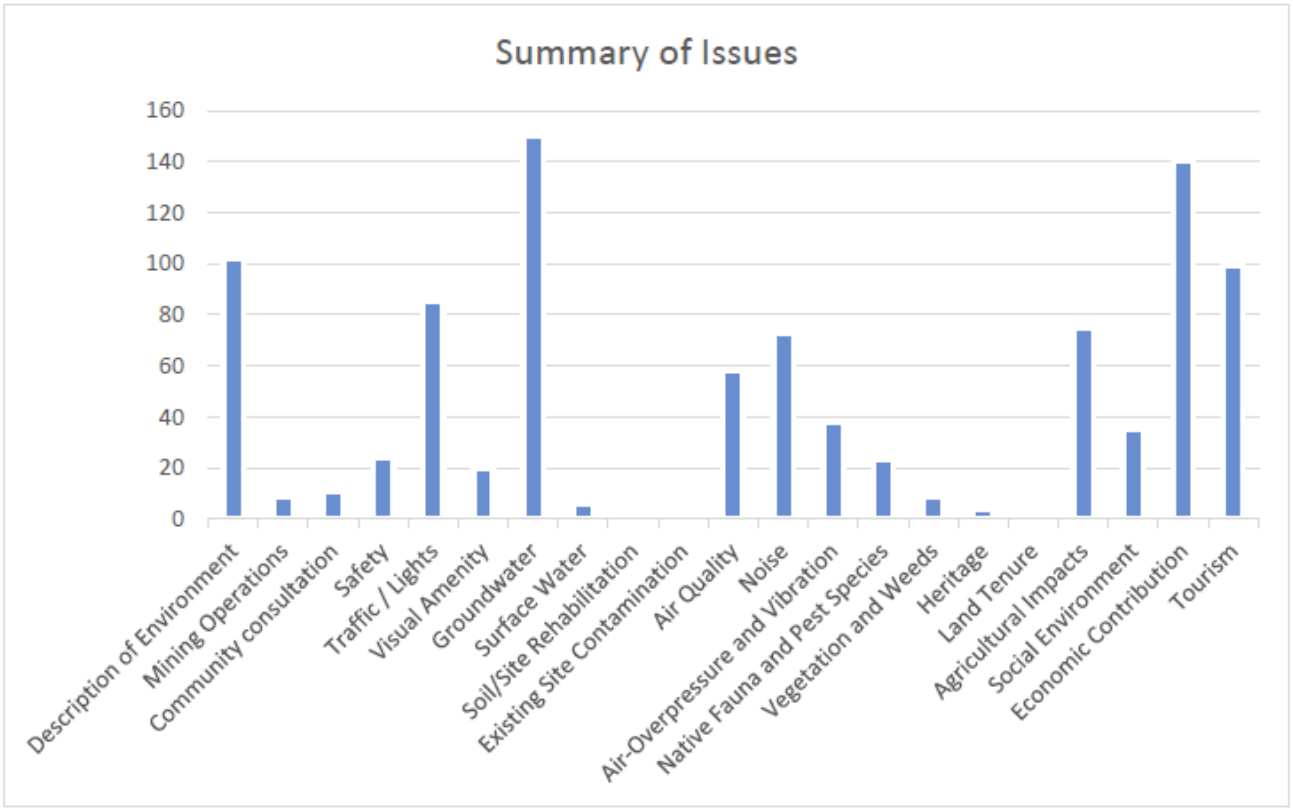


Figure 17: Number of matters raised in public submissions against each chapter of the MP and MPLA[118]

Government assesses that Terramin have reviewed all public submissions and provided a response to relevant matters raised in the response document.

Government assessment of public submissions and response

Government reviewed every submission and compiled a list of grouped matters that were consistently raised. Specific grouped matters raised are discussed in further detail below under relevant headings. Government has specifically addressed matters that received the most community interest as chapters within this assessment report.

[118] Figure 1 of the Response Document

Groundwater

The following matters were raised in public submissions related to groundwater:

- Mining will impact on groundwater quantity available to existing users
- Mining will impact on groundwater quality
- Remediation following interception of the hanging wall fault has not been described
- Water licencing for the mine has not been obtained
- Injection will impact on groundwater quality
- Groundwater modelling is not adequate to give certainty that there will be no impacts.

Public submissions also included the following supporting reports from technical experts relevant to groundwater:

1. Cook PG, Simmons CT and Wallis I (2019) *Bird-in-Hand gold mine - Review of groundwater characterisation and modelling*, NCGRT Report to Piper Alderman and Accolade wines.
2. Martin R, (2019), *Inverbrackie Creek Catchment Group Bird in Hand Proposed Mine Managed Aquifer Recharge Review*, WGA, Report.
3. Saydam, S, (2019), *Accolade Wines Australia Limited Bird in Hand Gold Mine,* University of NSW, Report.

Government considered matters raised in public submissions and expert reports when compiling government's request for further information. Terramin specifically addressed matters raised in these reports in the response document (Table 10).

For further information on groundwater including a summary of work completed by Terramin, government's assessment and the recommended regulatory response (including conditions) refer to Chapter 4.

Noise

The following matters were raised in public submissions related to noise:

- Noise from trucks will impact on the local community
- Noise will be constant all day every day
- Noise will impact on the enjoyment of local events
- Noise from mining will impact on the local community
- Audible noise from mining will impact on surrounding businesses

Government notes that all the matters above were raised by the community with Terramin and through the WCCC[119] prior to the application being lodged, and were addressed in the assessment of potential impacts as specific impact events. All noise impact events were confirmed for the application with an outcome proposed by Terramin. Potential noise impacts were also assessed for the MPL with an outcome proposed.

Public submissions also included the following supporting report:

1. Sonus, (2019), *Bird in Hand Gold Mine Project Environmental Noise Assessment Review*, Report.

[119] WCCC Issues Papers – Appendix C5 of the Mining Proposal.

Matters raised in the Sonus report were addressed in the response document.

For further information on noise including a summary of work completed by Terramin, government's assessment and recommended regulatory response refer to Chapter 9.

Traffic

The following matters were raised in public submissions related to traffic:

- More traffic will create delays for other road users
- Trucks will reduce safety on local roads
- Roads are not suitable for large trucks
- More heavy vehicles will damage roads

Government notes that all the matters above were raised by the community through the WCCC[120] prior to the applications being lodged and were addressed in the assessment of potential impacts as specific impact events

A public submission also included the following supporting letter with technical comments on traffic aspects of the applications:

1. Mellen M, (2019) *Letter RE: Bird in Hand Gold Mine*, MFY Pty Ltd.

Matters raised in the above letter were addressed in Table 11 of the response document.

For further information on traffic, including a summary of work completed by Terramin, government's assessment and recommended regulatory response, refer to Chapter 7.

Economic

The following matters were raised in public submissions regarding economic related impacts:

- Mine will impact on the clean green reputation of the Adelaide Hills
- Local business impacted on by noise, dust, blasting, traffic
- The mine will reduce business at surrounding wineries
- Property values will decrease because of the mine
- The mine will put at risk food, wine and agricultural enterprises that make a higher contribution to the state's economy than a short term mine
- The mine will decrease tourism in the region
- Loss of water for irrigation could make winery operations non-viable
- The mine may result in a loss of employment due to impacts.

Public submissions also included the following supporting reports:

1. BDO Econsearch, (2019), *Economic Contribution of the Petaluma Winery*, Report to Accolade Wines.

[120] Appendix C5 of the Mining Proposal.

2. EconSearch, *Economic Contribution of Agriculture and Related Activity in the Inverbrackie District, Adelaide Hills*, Report.
3. BDO EconSearch, (2019), Economic Impact of the Bird in Hand Gold Mine on South Australia and Regions: Peer Review, Report.
4. Hamilton R, (2019), *Report for Accolade Wines Australia Limited RE: Bird in hand Gold Mine*, Hamilton Viticulture.

Terramin specifically addressed the matters raised above in reports provided in their response document.

For further information about economics and land use including a summary of work completed by Terramin, government's assessment, which includes the matters raised, and recommended regulatory response, refer to Chapter 12.

Air quality

The following matters were raised in public submissions related to air quality:

- Dust from the mine will impact on health of the local community
- Dust from the mine will impact on amenity of the area
- Dust will decrease productivity of crops
- Dust will impact on vegetation

Government notes that all the matters above were raised by the community through the WCCC[121] prior to the application being lodged and were addressed in the assessment of potential impacts as specific impact events. Terramin proposed outcomes specific to public health, amenity and productivity. Potential impacts on native vegetation were assessed and evidence provided to demonstrate that estimated dust deposition rates would not impact on the health of native vegetation.

For further information on air quality including a summary of work completed by Terramin, government's assessment, which includes the matters raised, and recommended regulatory response, refer to Chapter 8.

Visual amenity

The following matters were raised in public submissions related to visual amenity:

- The mine will reduce visual amenity of the area
- A mine has no place in the current pristine landscape
- Lighting from the mine will impact on the local community
- The mullock pile will cause a visual impact
- The silo structure will reduce the visual amenity of the area.

[121] Appendix C5 of the Mining Proposal.

Government notes that all the matters above were raised by the community through the WCCC[122] prior to the application being lodged and were addressed in the assessment of potential impacts as specific impact events.

For further information on visual amenity including a summary of work completed by Terramin, government's assessment, which includes the matters raised, and recommended regulatory response, refer to Chapter 10.

Blasting

The following matters were raised in public submissions related to blasting:

- Vibration from blasting will impact on the local community
- Blasting will damage the aquifer and result in groundwater contamination
- Noise from blasting will impact on the local community
- Blasting will cause structural damage

Government notes that all the matters above were raised by the community through the WCCC[123] prior to the Application being lodged and were addressed in the assessment of potential impacts as specific impact events.

For further information on blasting including a summary of work completed by Terramin, government's assessment, which includes the matters raised, and recommended regulatory response, refer to Chapter 11.

Social

The following matters were raised in public submissions related to impacts on the social environment:

- Incompatible land uses
- The mine will impact on the existing social environment
- The mine will impact on health of the community
- Location is not suitable for a mine.

Government has assessed the potential for mining to impact on existing land uses. For the assessment of potential impacts on existing land use refer to Chapter 6.

Terramin provided a description of the existing social environment including health of the community. For further information on social impacts including a summary of work completed by Terramin, government's assessment, which includes the matters raised, and recommended regulatory response, refer to Chapter 6.

Other matters raised

The following other matters were raised consistently in public submissions:

- The mine will impact on fauna

[122] Appendix C5 of the Mining Proposal.
[123] Appendix C5 of the Mining Proposal.

- The proposal has not considered climate change
- Terramin financial position
- Community consultation
- Bushfire risk from an increase in native vegetation
- How will community be compensated if there is an incident
- Financial assurance

Terramin addressed fauna, consultation and bushfire risk in the MP. Potential impacts to fauna and bushfire risk were assessed with appropriate outcomes proposed. Refer to fauna and public safety sections of Chapter 14.

Government's assessment of Terramin's consultation is provided earlier in this chapter.

Terramin provided an estimate of greenhouse gas emissions of the proposed mine and assessed carbon sequestration from revegetation of the site.[124]

Terramin responded to matters raised about the company's financial position in its response document.

Regarding compensation and financial assurance, if a lease is granted the Mining Act requires that Terramin provide an estimate of the maximum rehabilitation liability at any time over the life of the mine, based on third-party contractor rates. The estimate will include all costs associated with mine closure planning, decommissioning and removal of infrastructure, earthworks, project management, government costs, forward inflation and normal project variation contingencies. Government will then review this detailed estimate to inform the required bond amount. The bond will be held by the department and used for rehabilitation should the company become insolvent and unable to meet their rehabilitation obligations. Terramin will also be required to provide evidence of public liability insurance at an appropriate coverage for proposed operations. This will be assessed as part of the PEPR, should a lease be granted.

Government also received the following expert reports after the final response document was made available on the DEM website:

1. WGA, (2021), *Memorandum/Technical Note – Terramin Response*.
2. National Centre for Groundwater Research and Training, (2022), *Bird in Hand Gold Mine Evaluation of risks to the local groundwater resource and its current users*.
3. Sonus, (2022), *Bird in Hand Gold Mine Project Review of Environmental Noise Assessment*.

All of the relevant matters raised in these documents were considered as part of government's assessment.

[124] Table 3-63 and Figure 3-223 from Chapter 3 of the Mining Proposal.

Community engagement plan (CEP)

Terramin provided a CEP for proposed operations at Woodside and Strathalbyn.[125] The CEP was developed using industry guidelines and government's better together principles of engagement.

Government recognised that the CEP was appropriate at the time of submission but requested[126] that Terramin include detail specifying how the community would be engaged in preparation of the response document. Terramin provided an updated CEP with the response document.[127]

As described earlier in this chapter, Terramin has undertaken extensive engagement on this project since 2014. Government considers that the CEP should be a continually evolving document that is regularly updated to suit relevant stages of the assessment process and if a lease is granted, subsequent stages of mine life including closure and post mine land use planning. Terramin acknowledge this in the CEP:

> *"Terramin recognises engagement with the community is an ongoing and continuous process and consequently the document regarded as the CEP - Community Engagement Plan, is reviewed, revised and added to as community feedback is gleaned".*[128]

Figure 18 shows the process Terramin has and intends to follow to continually evolve the CEP as a living document.

Figure 18: Process of CEP evolution[129]

[125] Appendix C1 of the Mining Proposal and Management Plan.
[126] DEM request for response letter dated 7 February 2020.
[127] Appendix A2 of the response document.
[128] s4.3.2 of the CEP
[129] Figure 3 from CEP.

The CEP states that:

“Terramin is committed to working with communities where we operate to maximise the benefits and minimise the impacts resulting from our activities.”

If a lease is granted, ongoing engagement during development of the PEPR, construction, operation and closure of the mine is essential to maximise benefits and respond to any issues and concerns that arise.

It is essential that Terramin plan for and engage with community when developing detailed designs in the PEPR. To ensure this happens, government recommends that if a lease/licence is granted, Terramin be required to submit an updated and revised CEP for assessment and approval by government within 3 months of grant.

Government also recommends that the CEP includes specific requirements set out in the Second Schedule of Appendix 5 of this report.

Chapter 6

Social

Introduction

The Ministerial Determinations for the ML and MPL required that Terramin provide information on local demographics, economy, services and employment. A description of the existing environment currently experienced by the local community was also required.

The determination also required an assessment of anticipated social benefits including potential opportunities that could be delivered during operations and post mine completion.

A social impact assessment was not specifically required. Terramin approached the assessment of potential social impacts using the source, pathway, receptor framework set out by the Ministerial Determinations.

Existing social environment

The profile of the existing social environment was prepared through a desktop study using information available from various local, state and federal government data. This included:

- Analysis of quantitative data from the Australian Bureau of Statistics (ABS) and government departments of the study area.
- Review of community reports, agency plans and planning documents focussed on the socio-cultural environment of the study area.
- Review of various external reports on the social environment in the study area, including the CSIRO reports mentioned in the previous chapter, Regional Development Australia (RDA) and any other social research undertaken in the study area.[130]

Social impact assessment and outcomes

Terramin assessed potential impacts on the existing social environment and confirmed potential impact events for the following environmental values:

- Noise
- Air Quality
- Vibration
- Visual Amenity
- Traffic
- Groundwater

[130] Summarised from Chapter 23 of the Mining Proposal.

- Surface Water
- Economic
- Closure.[131]

Terramin have proposed environmental outcomes for all the above and government's assessment of these aspects is provided in respective chapters of this report. Terramin proposed the following specific outcome in the Social chapters of the MP and MPLA:

"Terramin is committed to working with communities to maximise the benefits and minimise the impacts resulting from our activities."

Government supports the intent of working with community to maximise benefits, however, this statement does not meet the definition of an outcome as set out in DEM's Minerals Regulatory Guideline MG30 – Developing outcomes for quarrying and mining.

Social performance is defined by a company's interactions, activities, and outcomes with respect to local communities. Performance is supported by systems, data and capability that align with international standards and locally negotiated commitments, with the objective of avoiding harm to people and ensuring a stable operating environment in which communities and companies can prosper.[132]

Several submissions from the public note the requirement for Terramin to gain a "social licence" to operate which refers to acceptance of a mining development by local communities. Studies on the topic conclude that trust built through meaningful engagement, regulatory transparency and a clear line of sight to shared benefits of the proposal are likely to increase social performance.[133]

Terramin have provided evidence of engagement with the community that has resulted in changes to designs, implementation of additional strategies and the assessment of potential impacts specific to the local area. Should a lease be granted, continued engagement with the community will be essential to ensure Terramin:

- undertakes proactive community engagement that periodically informs the community with up to date and appropriate information
- demonstrates responsiveness to community concerns during construction, operations, closure and post completion
- has a continual focus on mine closure and post mine land use planning undertaken in conjunction with community members who will reside in the area long after the mine has closed.

Further information on engagement and government's recommendations regarding the Community Engagement Plan are provided in Chapter 5.

To ensure community have a clear line of sight to shared social and economic benefits proposed by Terramin, government recommends that should a lease be granted, the

[131] Summarised from Chapter 23 of the Mining Proposal.
[132] Kemp, D. and J.R. Owen, 2018, *Social performance gaps in the global mining industry: A position paper for executives*, CSRM, Sustainable Minerals Institute, University of Queensland: Brisbane.
[133] Moffat, K. and Zhang, A, 2013, *The paths to social licence to operate: An integrative model explaining community acceptance of mining*, Resources Policy 39 (2014) pages 61–70.

requirement to develop, implement and maintain a Social Management Plan (SMP) be a condition of the lease. A SMP is required due to the:

- introduction of a modern gold mine in an area, which is now predominantly viticulture and agriculture, hence requiring the effective management of multiple land uses within that area
- ongoing interest and a high level of concern from members of the community that continued after the government statutory public consultation process closed
- proximity to existing long-term businesses that will operate after the mine closes and have a legitimate and definable interest in post closure planning.

The CEP and SMP would need to outline Terramin's engagement and social management commitments to the local community and other stakeholders, and provide a description of the framework that Terramin will use to fulfil the objectives of these plans. The objectives and key elements of an SMP will be to:

- identify potential social issues that may arise from mining operations and how Terramin will respond to, as far as practicable, those issues
- set out strategies, initiatives and commitments to be adopted
- integrate with the CEP process for identifying, analysing and responding to project related social issues identified through engagement with community
- explain how Terramin will maximise and measure the potential socio-economic benefits of the mine within its area of influence, in particular as it relates to:
    - community preparedness and opportunities for collaboration during both mine development, operations, closure and planning for the post mining land use
    - supporting regional business development, local and regional employment with proportionate metrics and targets
    - aligning with local socio-economic development, particularly in relation to closure and post mining land use planning
    - integration with closure planning and opportunities for post mining land use appropriate to the socio-economic environment where the Mineral Tenement is granted.

The SMP must focus on the mine's area of influence, described above, acknowledging that the degree of benefit-sharing and issue management should be proportionate to the degree to which the mine affects them. The SMP will need to demonstrate such prioritisation. The SMP needs to focus on the potential and perceived impacts[134] facing communities in the mine's area of influence in five key focus areas, as identified in the MP:

1. Communication relating to being a good neighbour as a mining operation in a predominantly agricultural area[135]
2. Local employment and local business
3. Community relations

[134] Perceived impacts are acknowledged as a legitimate social impact according to both the World Health Organisation and the International Association of Impact Assessment.
[135] Good neighbour in this regard will relate to demonstrating how the company is adhering to the principles of leading practice engagement outlined in an acknowledged sustainable mining business approach such as the ICMM Mining Principles on Engagement and Community, the MCA Enduring Values, or with community engagement, the IAP2 Engagement Principles.

4. Achievement of environmental outcomes
5. Closure management plan.

Should a lease and licence be granted, Terramin must prepare a SMP in consultation with the community within 12 months of the date of the grant of the tenements. The SMP will also need, via the preparation and implementation of a standalone CEP, to include a specific separate focus on Strathalbyn for the proposed MPL.

Upon completion, the SMP must be implemented soon after its preparation and must be made publicly available. The SMP must be reviewed and audited at least annually with the results being made publicly available. Hence, reporting against the SMP is required to be transparent, relevant and credible.[136] Government consider that the tenement holder could use the SMP and its review and audit requirements to report on benefits.

The SMP and CEP should be living documents that evolve every year as the mine progresses through different stages to allow for changing social issues and community needs.

Should a lease be granted, recommended lease conditions relating to the SMP are set out in Appendix 5.

[136] Munday, J, 2020, *Guide to Social Impact Assessment*, Darwin, Australia.

Chapter 7

Traffic

Introduction

Movement of heavy vehicles on roads is regulated against the Heavy Vehicle National Law (HVNL) by the National Heavy Vehicle Regulator (NHVR). The Mining Act does not regulate traffic movements on the public road network.

Public roads are assets under the care and control of either the Department for Infrastructure and Transport (DIT) or local Councils. This includes the management and coordination of road infrastructure and the ongoing care and maintenance of public roads for all road users.

Traffic outcomes

In relation to potential impacts to roads. Terramin have proposed an environmental outcome of:

“No impact to third-party infrastructure caused by mining activities”.

The outcome identifies relevant receptors as third-party infrastructure. The impact assessment defines the receptor as road asphalts. The outcome appropriately states that no impact to third-party infrastructure is to be caused by mine-related traffic.

DIT and local councils are the responsible authorities for public roads including the ongoing inspection of road condition, routine road maintenance activities and the management of hazards in order to provide safe road conditions for all road users. Terramin identified deterioration of roads and increased road maintenance requirements as a potential impact during operation and closure but not for construction.

The intent of the outcome proposed is appropriate, however, it requires alteration to ensure that the outcome is appropriate for regulation. Government considers closure to be operations in this context and assesses that while unlikely, road damage could also occur during the construction stage.

The government-recommended outcome specifically refers to unauthorised damage to public and private property. It is not government’s intent that normal road wear and maintenance requirements are regulated, however it is appropriate that Terramin is liable for reparation costs in the event that damage exceeds normal use and is considered unauthorised damage by the relevant authority.

Refer to Appendix 5 for the recommended Traffic outcomes, should a lease be granted.

In relation to potential impacts to the public from mining vehicles, Terramin have proposed an environmental outcome of:

“No traffic accidents occur involving the public and mine traffic that could have been reasonably prevented”.

Government considers that the proposed outcome is achievable but requires changes to make it appropriate for regulation.

The outcome identifies relevant receptors as the public, which includes road users and pedestrians. The outcome appropriately states that no traffic accidents are to be caused by mine-related traffic, however, it requires alteration to ensure that the outcome is appropriate for regulation. Potential for drag-out to reduce road safety was also considered by Terramin for this outcome.

Refer to Appendix 5 for the recommended Traffic outcomes, should a lease be granted.

Existing environment

Government confirms that the existing environment has been appropriately assessed addressing the requirements of the Mining Act and the Ministerial Determination for a Mining proposal for the Bird-in-Hand Gold Project.

The Transport Assessment[137] includes details from four traffic surveys undertaken on Pfeiffer Road, during April 2014, November 2014, February 2015 and November/December 2017.

Existing Traffic Volumes	April (2014)	November (2014)	February (2015)	November/ December (2017)
24 Hours	1,036	953	955	944
Cars	867	762	857	879
Heavy Vehicles	170 (16.4%)	190 (19.9%)	99 (10.4%)	74 (8.4%)
AM Peak	86	72	68	98
PM Peak	92	90	79	101

Table 10: Traffic survey data on Pfeiffer Road[138]

The above survey results show a consistent number of car movements with heavy vehicle movements variable. The Tonkin assessment of heavy vehicle daily traffic on arterial roads varied from 3.5% of total traffic on Old Princess Highway to 16.5% on the South Eastern Freeway.

Variability in traffic movements is stated to be attributed to the activities in the region, including wine production, hay, grape harvest (vintage), polo and cellar door events, business' establishment and expansions, through traffic avoiding Onkaparinga Valley Road, and cattle movements.

An assessment of crash data identified specific points of interest; of which Terramin have identified the Pfeiffer Road/Nairne Road intersection 'not fit' for the purposes of General Access Vehicles (GAV) use and requiring an upgrade despite current use by GAV.

[137] Tonkin Consulting, 2018, *Bird in Hand Gold Mine Transport Assessment* – Appendix F1 of the Mining Proposal.
[138] Table 2.7 from Appendix F1 of the Mining Proposal

Local public transport and school bus routes are present on the proposed transport route from the Woodside mine to the Strathalbyn processing plant. Of note is the school bus route, identified as a sensitive receptor, and present along Bird in Hand Road and Nairne Road on weekdays between 7.30am and 8.30am, and between 3.45pm and 4.30pm.

Proposed transport route and potential impact assessment

Terramin expect the mine to generate approximately 100,000 tonnes of material per annum, increasing to 140,000 tonnes of yield at peak operation. Assuming a 7-day/week and the payload information (34.19 tonnes) for a 19m rigid truck and dog, the following truck transport movements are estimated:

- Haulage vehicles – 24 trips per day
- Other trucks (eg supply trucks) – 4 trips per day
- Company light vehicles – 10 trips per day
- Employee vehicles – 30 trips per day
- Visitors – 6 trips per day.

The proposed heavy vehicle trips are not considered to be a material increase on the results of traffic survey data collected.

In total, the mine site is expected to generate approximately 74 trips per day on Pfeiffer Road and surrounding road network. [139]

The overall increase of 74 trips per day may speed up wear of the road pavement, specifically Pfeiffer Road, over the life of the mine resulting in additional maintenance, therefore an outcome is required.

Potential impacts assessed by Terramin as a result of mine-related traffic include:

- Delays to school bus routes as a result in increased heavy vehicle traffic.
- Drag out from mine traffic results in a safety hazard for local traffic.
- Public safety impacts at the access point.
- Mine traffic increases road safety risk for local residents and other road users.
- Spillage of material from haulage trucks causing road accident to other road users.

All above mentioned potential impact events were confirmed with an appropriate outcome proposed.

The Transport Assessment considered 3 different routes for haulage of ore from the proposed mine at Woodside to the processing facility at AZM in Strathalbyn. The transport route has been assessed by Tonkin for overall efficiency of ore haulage and relative impact on the surrounding environment. This included looking at the suitability of the truck type selected, and the safety and suitability of the proposed access point at Woodside in relation to sight distances and the then proposed, now developed, polo facility.

[139] Appendix F1 of the Mining Proposal.

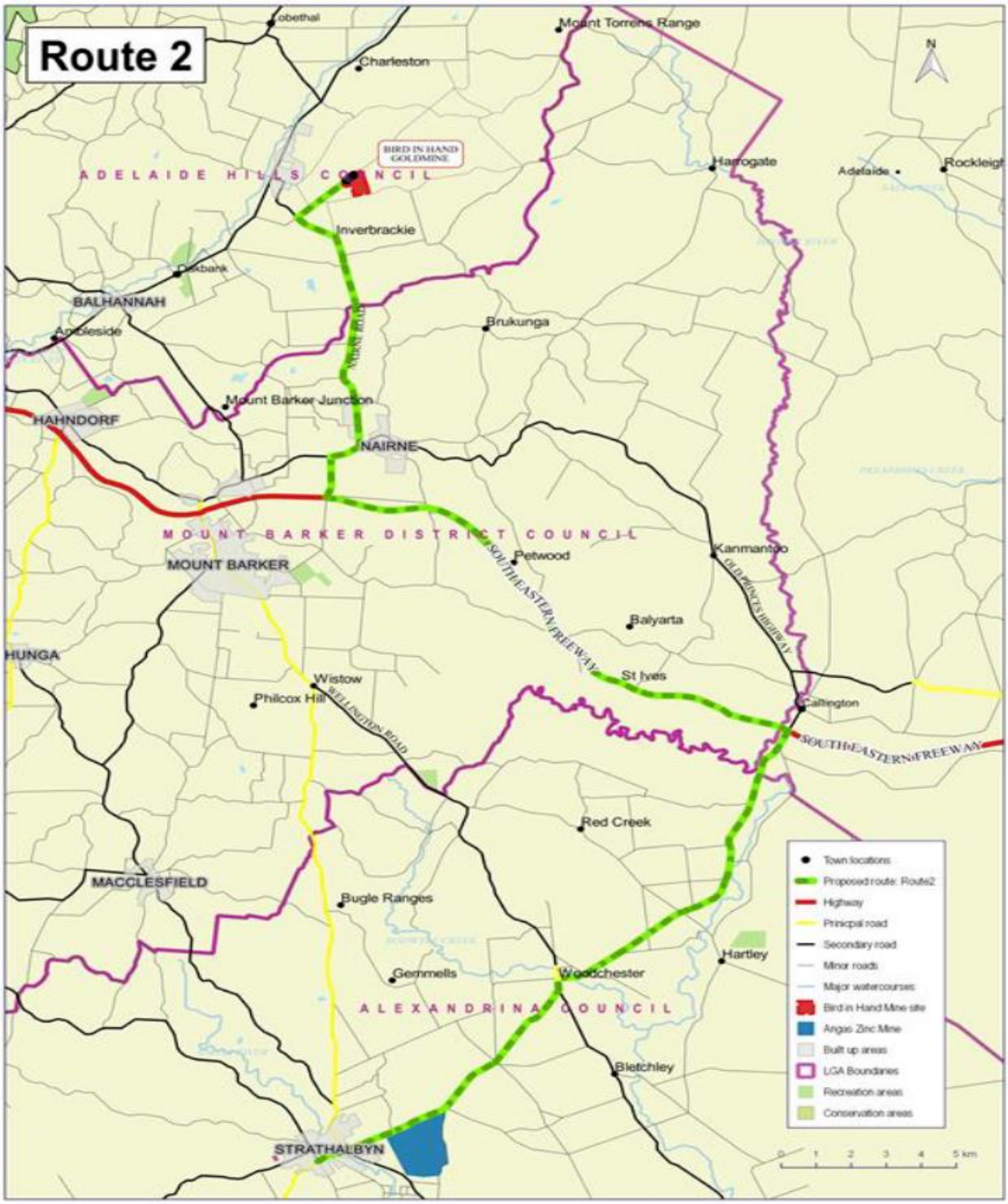


Figure 19: Proposed haul route from Woodside to processing facility at Strathalbyn[140]

The MP states that route 2 is the preferred haulage route as shown in Figure 19. This route involves haulage vehicles utilising the South Eastern Freeway from the Bald Hills Road Interchange, then Callington Road to Strathalbyn. This route was chosen as it has minimal

[140] Figure 8-6 from the Mining Proposal

impact on existing townships. The roads are currently approved for B-Double and 23m Rigid Truck and Dog access.[141]

The Transport Assessment recommends several upgrades along route 2, including:

- Upgrade of the Nairne Road / Pfeiffer Road intersection
- Upgrade of Nairne Road between North Road and Old Princes Highway
- Widening of the rail crossing north of Old Princes Highway.

While road upgrades and maintenance are the responsibility of local council and DIT, Terramin stated in the response document that co-funding arrangements would be considered and subject to further engagement if a lease/licence is granted.[142]

The application and response document were referred to the Transport branch of DIT who advised that DIT would engage with Terramin regarding co-funding of any road upgrades if a lease is granted. It is also noted that DIT are currently upgrading the intersection of Woodside Road and Old Princess Hwy at Nairne. Major works for the project commenced in late July 2021, and are expected to be completed in 2022, weather permitting.[143]

The Adelaide Hills Council were also open to negotiating a funding agreement with Terramin for road upgrades and maintenance should the lease/licence be granted.[144]

Government notes that the roads in their current form are approved for use by GAV proposed by Terramin, but consider the recommended upgrades important to ensure that other road users are not put at risk by haulage vehicles.

It is recommended that consultation between Terramin, DIT and local council regarding recommended road upgrades occurs prior to the commencement of mining operations, if a lease/licence is granted.

Refer to Appendix 5, Second Schedule for the recommended road infrastructure condition.

Assessment of proposed design and management strategies

The analysis of existing road conditions and safety risks associated with high and low points on Pfeiffer Road was used to locate the site access. Figure 20 below shows the proposed road upgrade to allow for trucks to enter and exit the site safely.

[141] Appendix F1 of the Mining Proposal.
[142] Table 4 - response to matter 107 of the response document.
[143] DIT webpage accessed online on 19 January 2022 [https://dit.sa.gov.au/infrastructure/road_projects/nairne_intersection_upgrade]
[144] Adelaide Hills Council submission.

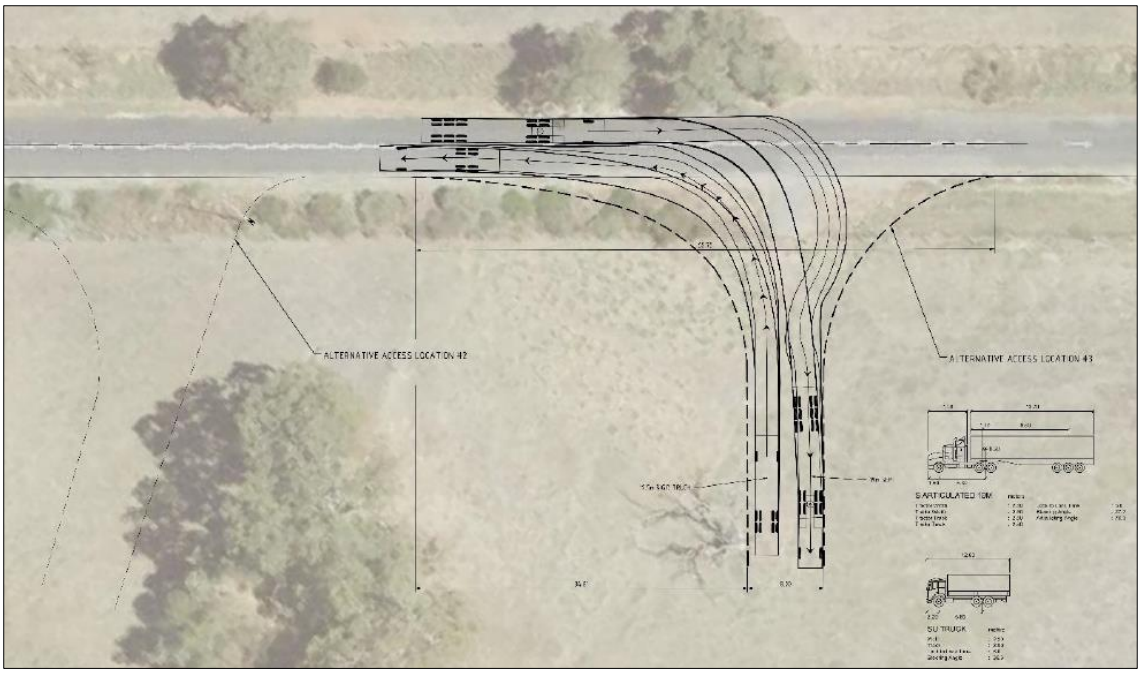


Figure 20: Basic right (BAR) turn treatment on a two-lane rural road proposed for the site access[145]

Terramin propose the use of GAV vehicles that comply with mass and dimension requirements and do not require a notice or permit to operate on the road network. These vehicles have general access to the road network unless the road is sign-posted otherwise.

There are no restrictions on the use of these vehicles on the proposed route from the proposed mine site to the AZM at Strathalbyn, which already has an appropriate access point for heavy vehicles.

The proposed haulage route, shown in Figure 20, considered safety and sightlines for chosen GAV. It has also considered the use of arterial roads to the maximum extent practicable to minimise disturbance to sensitive receptors.

Government considers the proposed haulage route viable and appropriate to minimise potential impacts on receptors.

Additional design strategies also include a designated wheel wash and vehicle washdown area, sealed roads onsite and defined pedestrian crossing at the site access.

Mitigation strategies proposed include:

- Road signs displayed along Pfeiffer Road and at the site access/egress point
- Driver safety and awareness induction training
- Tarping/covering loads
- A self-imposed curfew on haulage activities, to avoid peak traffic times limiting haulage operating hours outside of school pick up/drop off times, night-time period and community events.[146]

[145] Figure 8-5 from the Mining Proposal
[146] Table 8-8 from the Mining Proposal

These mitigation strategies are considered industry standard practice and are appropriate to achieve the outcome.

Conclusion

The road use baseline information was measured over an appropriate period to enable the assessment of potential impacts on traffic flow and public safety. The proposed movement of heavy vehicles a day is not considered a material increase in heavy vehicle traffic along the proposed haulage route.

The outcomes recommended by Government are practically achievable as Terramin have proposed industry standard design and control strategies.

The site access design was completed by a suitably qualified person and is supported by Adelaide Hills Council, which is the relevant authority for Pfeiffer Road.

The transport route proposed meets the vehicle requirements of the NHVR, which is the relevant authority. The proposed route considered potential impacts to public safety and avoids higher risk roads and peak traffic times. Recommended road upgrades, which may be co-funded by Terramin if a lease is granted, will result in a benefit to the local community and other road users.

Chapter 8

Air quality

Introduction

In South Australia air quality is regulated against maximum ground level concentrations outlined in the *Environment Protection (Air Quality) Policy 2016* (Air Policy). This policy provides the framework to ensure that air quality impacts associated with authorized activities are reduced or controlled across the state to prevent health and nuisance impacts on people and the environment.

Particulate matter

Dust can cause a range of impacts to public health, amenity through nuisance, third-party property, and other aspects of the environment. Dust is also termed particulate matter (PM), and PM refers to all solid and liquid particles suspended in the atmosphere – eg dust, pollen, water vapour, smoke etc – and for the purposes of regulation categorised into sub-groups based on their physical properties. The impacts from PM vary depending on a range of factors, such as:

- concentrations of dust at the sensitive receptor location or ground level concentration (GLC)
- offensiveness of the dust
- sensitivity of the receptor or receiving environment
- frequency and duration of exposure
- background dust levels.

A proportion of PM produced from resource industry operations is PM_{10}[147] and therefore fine enough to enter the upper airways and lungs. PM from resource industry operations is usually generated by physical processes such as drilling, blasting, processing, truck movements on haul roads, or from wind erosion of disturbed areas.

Based on the evidence of the relationships between PM_{10} and public health impacts, government considers PM_{10} as the appropriate primary environmental indicator to be measured for public health impacts from particulates and dust generated by mining operations, with $PM_{2.5}$ also included as required.

Total suspended particulates (TSP)

TSP is the term used to describe the total concentration of airborne PM, and is comprised of $PM_{2.5}$, $PM_{10\text{-}2.5}$ and all particles larger than PM_{10} that are light enough to be suspended in the atmosphere. A significant proportion of the dust generated by the resource industry is larger

[147] Particles with a diameter of 10 microns or less are referred to as PM_{10}. Particles that are 2.5 microns or less in diameter are referred to as $PM_{2.5}$.

than PM_{10} and, in terms of public health, these larger particles tend to be captured within the nasal and throat passages and subsequently exhaled and are not generally associated with health impacts. Rather, TSP is generally associated with nuisance impacts, such as a loss of visibility on roads, aesthetically displeasing visible dust plumes, and/or the anticipation of consequent depositional impacts.

Deposited dust

Particulate matter that settles out of suspension onto a surface is known as deposited dust. Excessive levels of deposited dust can cause economic impacts to primary production by, for example, soiling produce like stone fruits or causing reduced crop growth due to covering plants and obstructing photosynthesis. Deposited dust can also cause ecological impacts where excessive deposition occurs over native vegetation or in a sensitive environment.

Deposited dust along with TSP is also generally associated with nuisance impacts.

As dust deposition can cause a range of issues, sampling and analysis using the methods discussed in Australian Standard 3580.10.1:2003 are widely used and accepted approaches to providing a quantitative measure of dust deposition levels for compliance purposes.

AECOM Australia Pty Ltd (AECOM) conducted air quality baseline monitoring and modelling (dust dispersion and deposition) on behalf of Terramin to:

- assess the potential impacts from mining on the existing environment
- assess effectiveness of control measures in preventing air quality impacts
- demonstrate that proposed outcomes can be achieved.

Terramin also commissioned Food and Beverage Australia Limited (FABAL) to conduct an Agricultural Impact Assessment (AIA) to inform the assessment of potential impacts of dust on agricultural activities.

This chapter will provide government's assessment of Terramin's proposed air quality outcomes, description of environment, potential impact assessment, and proposed control measures.

Air quality outcomes

Terramin have proposed the following environmental outcome for confirmed potential air quality impact events related to public health:

"No public health impacts to the public from dust generated by construction, mining or closure activities."

The outcome appropriately states that there will be no impact on public health, identifies the relevant receptor and includes the relevant phases of mining. Government considers closure activities within the operation phase of mining.

Refer to Appendix 5 for the recommended Air Quality outcomes, should a lease be granted.

Terramin have proposed the following environmental outcome for confirmed potential air quality impact events related to nuisance dust:

“No public nuisance impacts to local residents from dust generated by construction, mining or closure activities.”

The outcome appropriately states that there will be no public nuisance impacts, identifies the relevant receptor and includes the relevant phases of mining. Government considers closure activities within the operation phase of mining.

Refer to Appendix 5 for the recommended Air Quality outcomes, should a lease be granted.

Terramin have proposed the following environmental outcome for confirmed potential air quality impacts on adjacent vineyards and agricultural operations:

“No loss of productivity on properties surrounding the mining lease from dust generated by construction, mining or closure activities.”

The outcome appropriately states no impact on productivity and identifies surrounding properties as receptors. Government notes that there are also vineyards located within the proposed lease area. Government considers closure activities within the operation phase of mining.

Refer to Appendix 5 for the recommended Air Quality outcomes, should a lease be granted.

Existing environment – Air quality baseline monitoring

AECOM collected baseline air quality data at six monitoring locations ie Sites 1–6[148].

TSP and heavy metals monitoring

TSP baseline was monitored by high volume air sampler (HVAS) at Site 1 between June 2014 and July 2015, and Site 6 between April 2016 and January 2017. The dust collected by the HVAS was analysed for traces of heavy metals to establish a baseline concentration, which is considered representative of the existing environment before the commencement of mining operations. TSP samples were recorded once every six days over a 24-hour period. The TSP and heavy metals analyses were performed by ALS Environmental, which have a NATA Accredited Laboratory (Accreditation No. 825). Table 11 shows the summary of the TSP results.

The average 24-hour TSP concentration measured over the monitoring period was 22.8µg/m^3. The maximum 24-hour average TSP measured at Site 1 was 64.0µg/m^3.

Of the total samples that were collected during the monitoring period, eight (8) were invalidated because the filters were not changed between the sampling runs. These 8 were not included in the average calculation.

[148] AECOM, 2017, *Air Quality Baseline Assessment* – Appendix N2 from the Mining Proposal.

Table 11: Summary of TSP results

Monitoring Year	Site	Number of Valid Samples*	TSP Concentration (µg/m3)	
			Average	Maximum
2014	Site 1	23	27.8	48.1
2015	Site 1	27	18.6	64
2016	Site 6	27	28.9	111
2017	Site 6	3	33.2	43.2
Guideline			90	-

** Not including samples where the same filter was used for two non-consecutive 24-hour periods.*

The metals monitoring results[149] showed no detections of arsenic, cadmium, chromium or nickel during the monitoring period. However, low concentrations of copper, zinc and lead were detected on at least one occasion during the monitoring period[150].

The maximum 24-hour concentrations measured at Site 1 for arsenic, cadmium, chromium, copper, nickel and zinc were at least an order of magnitude below the 1-hour NSW criteria[151]. Nickel and zinc were generally an order of magnitude or more below the 1-hour NSW guideline. The annual average lead concentration was well below the adopted guideline.

Government notes that the Air Policy[152] includes ground level concentration criteria for metals with a 3-minute averaging time. Use of the NSW guideline, which uses a 1-hour averaging time, is considered more appropriate for the purpose of analysing baseline data.

Particulate matter monitoring

PM_{10} baseline was monitored in real-time at Site 1 by a continuous Beta Attenuation Monitor (BAM) between April 2014 and May 2015. The siting of the BAM and subsequent monitoring of PM_{10} was done, respectively, in accordance with the relevant Australian Standard. [153]

PM_{10} was also monitored at Site 6 between February 2017 and October 2017, in accordance with the relevant HVAS standard.[154] PM_{10} samples were recorded once every six days over a 24-hour period. Results of the continuous PM_{10} monitoring by BAM at Site 1 showed no exceedances of the Air Policy criteria of 50 µg/m³. The corrected data capture rate over the full monitoring period was 97%. Average PM_{10} concentrations were lowest during winter 2014 and highest during spring 2014.[155]

[149] Table 15-8 from the Mining Proposal
[150] Chapter 15 of the Mining Proposal
[151] New South Wales' Approved Methods for the Modelling and Assessment of Air Pollutants in New South Wales guidelines. These guidelines outline the methods for modelling and assessing emissions of air pollutants from stationary sources (in New South Wales). This document was adopted to complement the regulatory coverage of the South Australian Environment Protection (Air Quality) Policy (EPP Air) 2016 to model dust dispersion and deposition associated with the construction and operation of the Bird in Hand Mine.
[152] Schedule 2 of the Environment Protection (Air Quality) Policy 2016
[153] *AS/NZS 3580.1.1:2007 Methods for sampling and analysis of ambient air – Guide to siting air monitoring equipment*; and *AS/NZS 3580.9.11:2008 – Determination of suspended particulate matter – PM10 beta attenuation monitors*.
[154] AS/*NZS 3580.9.6:2015 – Method 9.6 Determination of suspended particulate matter – PM10 high volume sampler with size selective inlet – Gravimetric method*.
[155] Tables 15-4 and 15-5 from Chapter 15 of the Mining Proposal

$PM_{2.5}$ baseline data was obtained from the South Australian EPA monitoring station at Elizabeth with the assumption that the Bird in Hand Mine site is likely to have $PM_{2.5}$ concentrations similar to or lower than those measured at Elizabeth. $PM_{2.5}$ data recorded at Elizabeth in 2017 (slightly higher than 2015 and 2016) was adopted as the background for the project: With a 24-hour average of 9.8 µg/m³ and annual average of 7.3 µg/m³. Similar to PM_{10}, a 90th percentile was chosen as a conservative estimate of the 24-hour $PM_{2.5}$ background concentration.

Dust deposition

Baseline dust deposition rates were measured at sites 1-4 and 6 between July 2014 and October 2017 in accordance with the relevant Australian standard[156]. Dust deposition analysis was performed by ALS Environmental.

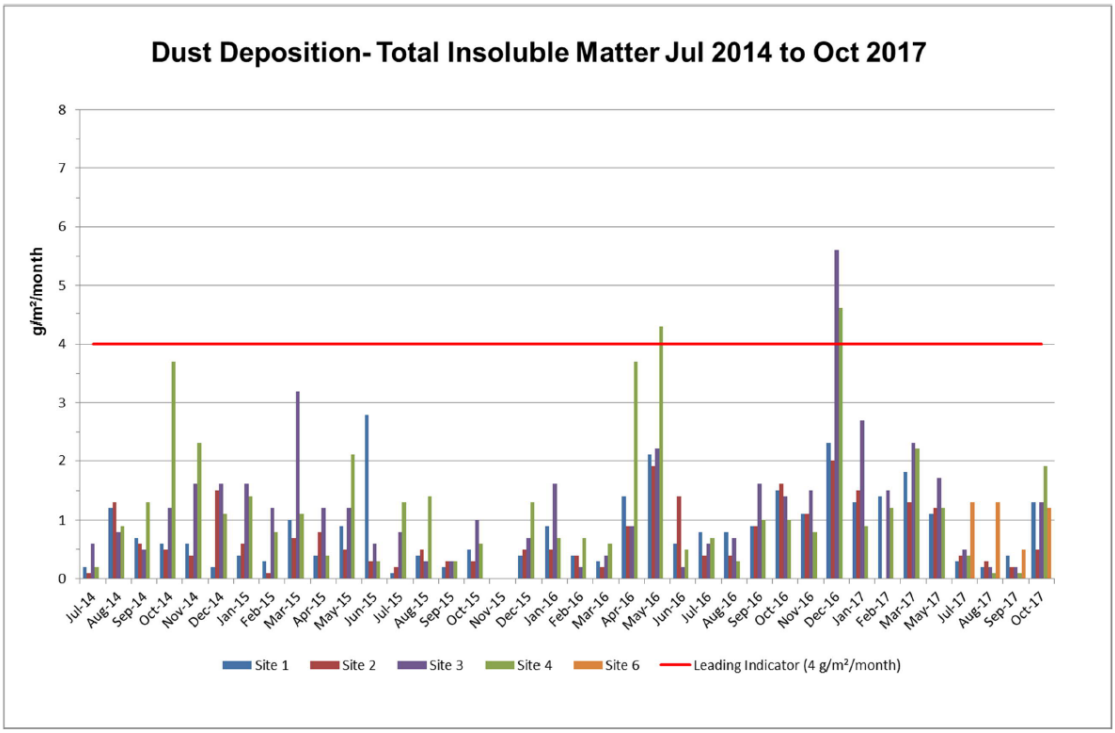


Figure 21: Summary of dust deposition results[157]

Figure 21 shows that dust deposition rates were relatively low over the monitoring period. The adopted guideline of 4g/m^2/month was exceeded 3 times as follows: Site 4 on May 2016 and December 2016; Site 3 on December 2016.

[156] *AS/NZS 3580.10.1:2003 – Determination of particulate matter – Deposited matter – Gravimetric method*.
[157] Figure 10 from Appendix N2 of the Mining Proposal.

Meteorological baseline data

Baseline meteorological data was obtained from monitoring stations set up at Site 1 (recorded as 10-minute averages) and Sites 5 and 6 (recorded as 15-minute averages) over a 16-month period between April 2014 and October 2016. The meteorological parameters collected include temperature, humidity and rainfall. This data was compared with long-term climatic data of up to 155 years from a BoM station in Mt Barker, about 13 km south-southwest of the mine site, to provide a better characterisation of the regional climate of the Adelaide Hills area and the long-term climate trends at the mine site.

Data collected from the meteorological stations showed that temperatures were generally cooler than the long-term averages at Mt Barker. Humidity and rainfall patterns were as expected, with the most rainfall occurring in winter, and the least during the summer months. Wind data collected on site over the monitoring period was discontinuous due to equipment malfunctions and sensor issues. The data was therefore not used in the modelling.

The baseline monitoring program was undertaken to determine existing conditions (ie sensitive receptors, climate, meteorology, terrain and baseline air pollutant levels) to compare any future monitoring conducted after commencement of operations and to support the air quality model. Table 12 below provides a summary of TSP, PM and dust deposition baseline results. Government considers that the baseline provided was measured in accordance with the Air Policy and relevant EPA guidelines, and by a suitably qualified person over a sufficient period to provide a representation of the existing air quality environment.

Table 12: Summary of baseline air quality results[158]

Indicator	Period	Project Background	Units	Averaging Period	Project Objective
TSP	Jun 2014 to Jan 2017	24.8	µg/m³	Annual	90 µg/m³*
PM_{10}	Apr 2014 to May 2015	14.6	µg/m³	24-hour	50 µg/m³
$PM_{2.5}$	Jan 2016 to Dec 2016	9.8 7.3	µg/m³	24-hour Annual	25 µg/m³ 8 µg/m³
Dust deposition	Jul 2014 to Jan 2017	1.3	g/m²/month	Monthly	4 g/m²/month*

**Not legislative, recommended project goal in relation to the nuisance outcome*

Sensitive receptors

The MP identified 22 sensitive receptors, made up of residences, wineries, the air strip, heritage listed native vegetation and polo facilities, shown in Figure 22. Government requested that Terramin provide further information to justify exclusion of local orchards and strawberry growing operations as sensitive receptors[159]. Terramin responded that there are

[158] AECOM, 2018, *Bird in Hand Gold Mine Air Quality Impact Assessment* – Appendix N3 from the Mining Proposal.
[159] Matter 117 of DEM request for response letter dated 7 February 2020.

no strawberry farms or apple orchards within the realistic zone of influence for a potential dust impact[160].

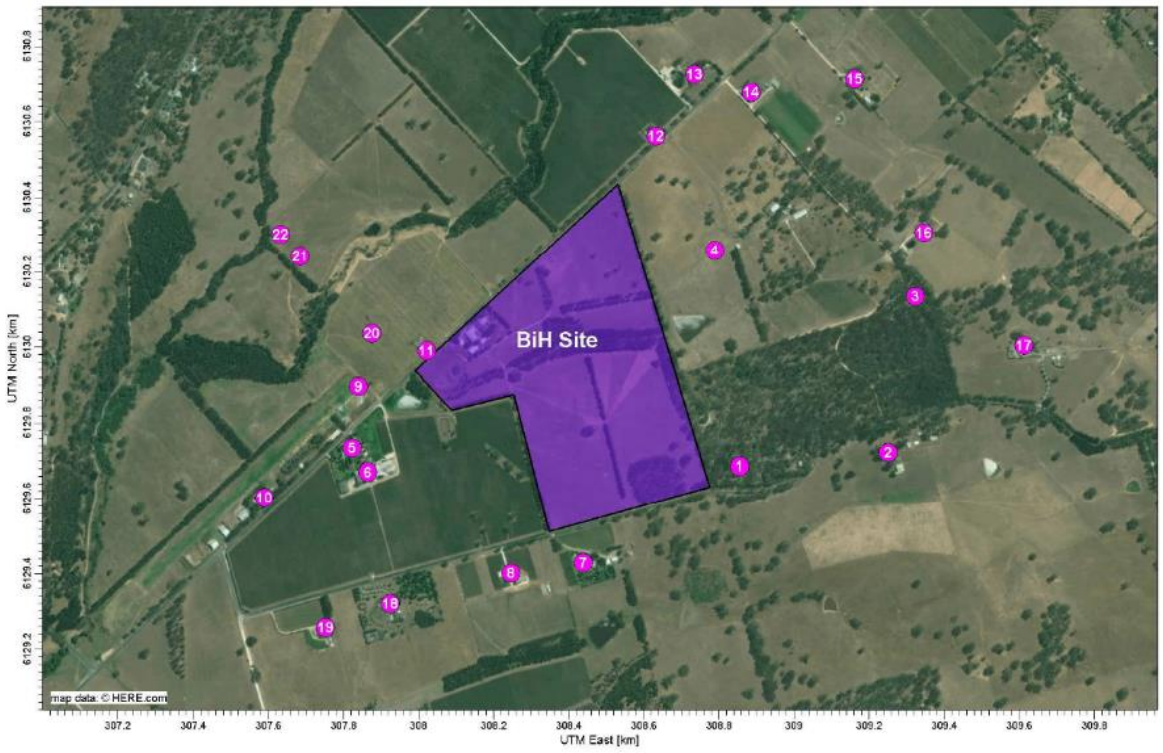


Figure 22: Location of nearby sensitive receptor[161]

Project air quality criteria

The dust dispersion and deposition models used in the air quality impact assessments met the requirements of the South Australian *Environment Protection Act 1993*, Air Policy and the NSW modelling guidelines[162]. The PM project objectives align with the criteria within the Air Policy.

The Air Policy provides maximum GLCs for a range of air pollutants but does not prescribe impact assessment criteria for total suspended particulates (TSP) and dust deposition. The NSW Department of Environment and Conservation released guidelines in 2015 that include assessment criteria for TSP and dust deposition.

The proposed limits set for dust deposition on vineyards and nuisance are a maximum total of 4 g/m^2/month and/or a maximum increase of 2 g/m^2/month over background levels. Table 13 below shows the criteria that were used by Terramin to assess potential impacts from mining.

[160] Response to matter 117 in response document.
[161] Figure 3 from Appendix N3 of the Mining Proposal.
[162] NSW Department of Environment and Conservation (DEC) (2005). *Approved Methods for the Modelling and Assessment of Air Pollutants in New South Wales*, New South Wales Department of Environment and Conservation (DEC) 2005 (Approved Methods).

Table 13: Proposed air quality criteria[163]

Indicator	Project Objective	Average Period	Environmental Value
TSP	90 µg/m³	24-hour	Amenity*
PM_{10}	50 µg/m³	24-hour	Toxicity
$PM_{2.5}$	25 µg/m³	24-hour	Toxicity
	8 µg/m³	Annual	
Dust deposition	4 g/m²/month (maximum total deposited dust level)	Annual*	Nuisance/Ecological
	2 g/m²/month (maximum increase in deposited dust level)		

**Not legislative; recommended project goal in relation to the nuisance outcome*

Air quality modelling and potential impact assessment

Terramin commissioned AECOM to conduct air quality (dispersion and deposition) modelling to identify and understand the potential air quality impacts associated with the proposed Bird in Hand Gold Project at the proposed mine location and processing facility at Strathalbyn.

Refer to Chapter 15 for government's assessment of the proposed air quality outcome for the MPLA.

The modelling considered sensitive receptors in the area surrounding the proposed site – residential and commercial structures, as well as nearby vineyards and heritage-listed remnant vegetation with ecological sensitivity.

Prior to the air quality modelling, baseline monitoring found that the main sources of air pollution in the Woodside area included agriculture, bushfires, domestic wood smoke and windblown dust. Baseline data was used in the model to assess the proposed mine contribution in the air quality modelling.

The modelling – ie dust dispersion and deposition – was conducted using the TAPM Meteorological Model, CALPUFF Air Dispersion Model Suite and CALMET. A single scenario was considered for both the construction and operational phases of the mine, and quantified scenario-specific emission rates for relevant dust-generating activities.

Emission rates for each modelling scenario are generally calculated based on the total volume and mass of material that is being displaced. Key material volumes that were used in the modelling for each scenario are presented in Table 15-3 of the MP. A site-specific emissions inventory for each pollutant of interest and each operational scenario was developed based on published emission factors[164].

All predicted 24-hour average PM_{10} concentrations, and 24-hour and annual average $PM_{2.5}$ concentrations were below the project objectives for both construction and operation. See Table 14 and Table 15.

[163] Table 15-1 from Chapter 15 of the Mining Proposal
[164] *National Pollutant Inventory Emission Estimation Manual for Mining (NPI 2012)* and the *USEPA AP-42*.

Total predicted dust deposition rates (mine contribution plus background) were below the project objective of 4g/m2/month at all nearby sensitive receptors and in the surrounding vineyards. All predicted mine contribution dust deposition rates during construction and operation are below the project objective of 2 g/m^2/month, including in the adjacent native vegetation area.

Government notes that all dust-generating activities were modelled simultaneously to show a worst-case scenario. While this is possible, it is also unlikely meaning that the dust deposition rates are likely to be lower than those predicted.

Government assessed that the dispersion modelling methodology was appropriate:

- The choice of models was appropriate – *TAPM Meteorological Model* for predicting meteorological parameters and *CALPUFF Air Dispersion Model Suite* for predicting ground level particulate concentrations and dust deposition rates.
- The model was set up against the relevant standards and considered the worst-case scenarios for both construction and operation of the mine.

Table 14: Predicted TSP, PM_{10}, $PM_{2.5}$ concentrations and dust deposition at sensitive receptors during construction[165]

Receptor	Predicted Annual Average TSP Concentration (µg/m³)		Maximum Predicted 24-hour PM_{10} Concentration (µg/m³)		Maximum Predicted 24-hour $PM_{2.5}$ Concentration (µg/m³)		Predicted Annual Average $PM_{2.5}$ Concentration (µg/m³)		Maximum Predicted Monthly Dust Deposition Rate (g/m²/month)	
	Project Contribution	Cumulative	Project Contribution	Cumulative	Project Contribution	Cumulative	Project Contribution	Cumulative	Project Contribution	Cumulative
	Background – **24.8** µg/m³		Background – **14.6** µg/m³		Background – **9.8** µg/m³		Background – **7.3** µg/m³		Background – **1.3** g/m²/month	
1	2.3	27.1	9.7	24.3	1.0	10.8	0.1	7.4	0.9	2.2
2	0.4	25.2	3.3	17.9	0.4	10.2	0.04	7.3	0.1	1.4
3	0.2	25.0	3.5	18.1	0.4	10.2	0.02	7.3	0.1	1.4
4	0.4	25.2	5.6	20.2	0.7	10.5	0.04	7.3	0.1	1.4
5	0.1	24.9	2.0	16.6	0.2	10.0	0.01	7.3	0.02	1.3
6	0.1	24.9	1.6	16.2	0.2	10.0	0.01	7.3	0.02	1.3
7	1.1	25.9	10.1	24.7	1.2	11.0	0.1	7.4	0.3	1.6
8	0.5	25.3	7.8	22.4	0.7	10.5	0.1	7.4	0.2	1.5
9	0.1	24.9	1.7	16.3	0.2	10.0	0.01	7.3	0.03	1.3
10	0.03	24.8	1.0	15.6	0.1	9.9	0.00	7.3	0.01	1.3
11	0.3	25.1	2.6	17.2	0.3	10.1	0.02	7.3	0.1	1.4
12	0.1	24.9	7.2	21.8	0.4	10.2	0.02	7.3	0.04	1.3
13	0.1	24.9	5.0	19.6	0.4	10.2	0.01	7.3	0.02	1.3
14	0.1	24.9	2.9	17.5	0.3	10.1	0.01	7.3	0.02	1.3
15	0.05	24.8	1.6	16.2	0.2	10.0	0.01	7.3	0.02	1.3
16	0.1	24.9	1.8	16.4	0.2	10.0	0.01	7.3	0.04	1.3
17	0.1	24.9	1.6	16.2	0.2	10.0	0.01	7.3	0.04	1.3
18	0.1	24.9	2.6	17.2	0.2	10.0	0.01	7.3	0.02	1.3
19	0.04	24.8	1.7	16.3	0.2	10.0	0.01	7.3	0.01	1.3
20	0.1	24.9	1.9	16.5	0.2	10.0	0.01	7.3	0.1	1.4
21	0.1	24.9	3.0	17.6	0.3	10.1	0.01	7.3	0.1	1.4
22	0.1	24.9	2.5	17.1	0.3	10.1	0.01	7.3	0.1	1.4
Project Objective	**90**		**50**		**25.0**		**8.0**		**2**	**4**

[165] Appendix N3 of the Mining Proposal.

Table 15: Predicted TSP, PM_{10} and $PM_{2.5}$ concentrations at sensitive receptors during operation[166]

Receptor	Predicted Annual Average TSP Concentration (µg/m³)		Maximum Predicted 24-hour PM_{10} Concentration (µg/m³)		Maximum Predicted 24-hour $PM_{2.5}$ Concentration (µg/m³)		Predicted Annual Average $PM_{2.5}$ Concentration (µg/m³)		Maximum Predicted Monthly Dust Deposition Rate (g/m²/month)	
	Project Contribution	Cumulative	Project Contribution	Cumulative	Project Contribution	Cumulative	Project Contribution	Cumulative	Project Contribution	Cumulative
	Background – **24.8** µg/m³		Background – **14.6** µg/m³		Background – **9.8** µg/m³		Background – **7.3** µg/m³		Background – **1.3** g/m²/month	
1	4.0	28.8	18.2	32.8	3.4	13.2	0.3	7.6	1.5	2.8
2	0.6	25.4	4.4	19.0	1.0	10.8	0.10	7.4	0.2	1.5
3	0.3	25.1	4.4	19.0	0.9	10.7	0.05	7.4	0.1	1.4
4	0.5	25.3	11.1	25.7	1.7	11.5	0.08	7.4	0.1	1.4
5	0.1	24.9	1.7	16.3	0.2	10.0	0.01	7.3	0.02	1.3
6	0.1	24.9	1.6	16.2	0.2	10.0	0.01	7.3	0.02	1.3
7	1.0	25.8	7.2	21.8	1.2	11.0	0.1	7.4	0.4	1.7
8	0.4	25.2	4.9	19.5	1.4	11.2	0.1	7.4	0.2	1.5
9	0.1	24.9	1.3	15.9	0.2	10.0	0.01	7.3	0.03	1.3
10	0.03	24.8	0.9	15.5	0.2	10.0	0.01	7.3	0.01	1.3
11	0.2	25.0	2.0	16.6	0.3	10.1	0.02	7.3	0.1	1.4
12	0.2	25.0	3.9	18.5	0.5	10.3	0.03	7.3	0.1	1.4
13	0.1	24.9	2.2	16.8	0.4	10.2	0.03	7.3	0.03	1.3
14	0.1	24.9	3.7	18.3	0.6	10.4	0.03	7.3	0.03	1.3
15	0.1	24.9	2.1	16.7	0.4	10.2	0.02	7.3	0.02	1.3
16	0.2	25.0	3.0	17.6	0.4	10.2	0.04	7.3	0.1	1.4
17	0.2	25.0	2.3	16.9	0.5	10.3	0.04	7.3	0.1	1.4
18	0.1	24.9	1.5	16.1	0.3	10.1	0.01	7.3	0.02	1.3
19	0.03	24.8	1.1	15.7	0.1	9.9	0.01	7.3	0.01	1.3
20	0.2	25.0	1.5	16.1	0.3	10.1	0.01	7.3	0.1	1.4
21	0.1	24.9	3.1	17.7	0.4	10.2	0.02	7.3	0.02	1.3
22	0.03	24.8	2.8	17.4	0.4	10.2	0.02	7.3	0.01	1.3
Project Objective	**90**		**50**		**25.0**		**8.0**		**2**	**4**

[166] Appendix N3 of the Mining Proposal.

Potential impacts on agricultural activities

FABAL also conducted an Agricultural Impact Assessment (AIA) and assessed the potential for deposited dust to inhibit photosynthesis by blocking sunlight onto grapevine leaves. Based on the modelling results, which show dust deposition rates to be consistent with the background average, FABAL concluded that it is difficult to conceive any impact above and beyond the normal background intrinsic activities (spraying, slashing etc) already underway in the adjacent vineyards[167].

Based on this advice Terramin did not confirm a source-pathway-receptor relationship for total insoluble dust to impact on vineyards. Government requested further information to justify this. The response document referenced a study[168] that found that deposition of mining, quarry and road dust on vegetation canopies has been observed to inhibit plant growth when dust burdens exceed 7 g/m^2, which is 3 g/m^2 higher than the project objective. Nevertheless, Terramin responded that it is assumed that there is a confirmed impact and therefore an outcome is required.

Government has assessed all other potential impact events identified in the MP[169] where an outcome was not proposed and confirms that the source, pathway and receptor do not exist, hence, an outcome is not required for those impact events.

Assessment of proposed design and management strategies

Terramin proposed design measures[170] and management strategies[171] to prevent air quality impacts and manage dust-generating activities. Design measures proposed in the MP include:

- Enclosed Run of Mine (ROM) silo system rather than a ROM pad
- Established vegetation wind breaks and successful revegetation strategies (ground cover) – planted through construction and established through operation and closure
- Sealed roads – asphalt on roads for external vehicles, including ROM silo turn around, excluding fire access tracks
- Batching plant covered and enclosed delivery system.

For a full list of the proposed design measures refer to Chapter 15 (Table 15-12) of the MP.

Terramin state that the highest risk period for potential impacts occurs through the construction period, where the most land is disturbed and covering has not been established – either asphalting of the roads or vegetation establishment. As part of the management strategies proposed by Terramin, water trucks and sprinkler systems will be used in the drier months during the construction phase.

[167] Keegan, A, 2017, *Bird in Hand Gold Project – Agricultural Impact Assessment*, FABAL Operations Pty Ltd – Appendix U1 of the Mining Proposal.
[168] Doley, David and Rossato, Laurence (2010). *Mineral particulates and vegetation: Modelled effects of dust on photosynthesis in plant canopies. Air Quality and Climate Change 44* (2) 22-27.
[169] Chapter 15 of the Mining Proposal.
[170] Table 15-12 from Chapter 15 of the Mining Proposal
[171] Table 15-14 from Chapter 15 of the Mining Proposal

Newly constructed landscape/amenity bunding will be spray seeded as soon as practicable following earthworks, while asphalting of roads will be a priority as roads are constructed. The water truck will continue to spray unsealed roads and landforms until asphalting and spray seeding has occurred.

Terramin has also proposed a permanent sprinkler system for the IML to reduce dust impacts associated with movement of mullock material. Additional management strategies proposed include:

- Blast management plan – product selection, timings, design of blast
- Mine air quality monitoring – occurs underground, includes re-entry procedure, diesel particulate monitoring etc
- Rehabilitate and revegetate (perennial native grass & shrub covering) areas of bunds and other areas of bare earth as soon as practical – progressive rehabilitation.
- Hydromulching (includes spray seeding) of newly constructed landforms – bunding, IML etc.

Terramin included a draft Trigger Action Response Plan[172] (TARP) in the MP. The TARP outlines the actions and responses Terramin would take in response to certain impact events – such as high wind days. The TARP will set certain responses to the live reporting of dust and weather conditions, to allow operations to be modified proactively to ensure achievement of the air quality outcomes. Proposed responses range from modification of operations all the way to a complete shutdown onsite.[173]

Government notes that the dust deposition rates discussed in the previous section were modelled without implementation of a TARP and consider that the predicted rates could easily be managed through TARP implementation.

Government considers development of an appropriate TARP supported by real-time monitoring to be best practice and recommend that the requirement for a TARP and real-time air quality monitoring are conditioned on the lease and required in the PEPR if a lease is granted.

Conclusion

The air quality model and assessment of potential impacts has used the Air Policy as the correct legal standard to assess potential public health impacts. Use of the NSW guideline for TSP and dust deposition to inform project objectives for nuisance and amenity is appropriate. The outcomes are technically achievable as the air quality model was developed against the relevant standards and considered the worst-case scenarios for both construction and operation of the mine.

The baseline data provided was measured in accordance with the relevant standards and guidelines and undertaken by a suitably qualified person over a sufficient period to provide a representation of the existing air quality environment. Relevant receptors were identified,

[172] Appendix N5 of the Mining Proposal
[173] Chapter 15 of the Mining Proposal.

and appropriate particulate and dust sources included in the model based on the proposed mining operations.

The outcomes are practically achievable as Terramin have proposed proven effective industry design and control strategies to prevent impacts on receptors. The use of a TARP supported by real time monitoring are effective strategies to ensure achievement of all proposed outcomes.

Chapter 9

Noise

Introduction

In South Australia, legal noise limits are set by the *Environment Protection (Noise) Policy 2007* (Noise Policy). The intent of the Noise Policy is to strike a balance between the interests of those whose legitimate activities cause noise, and the interests of those who are exposed and affected by the noise. It also seeks to provide clarity and consistency in environmental noise regulation[174].

The noise goals proposed in the application, required by Part 4 of the Noise Policy, are 57 dB(A) between 7am and 10pm; and 50 dB(A) between 10pm and 7am, when measured and adjusted in accordance with the Noise Policy.

Noise associated with blasting is excluded from the Noise Policy and regulated directly through the Mining Act. Further information on blasting and government's assessment is provided in Chapter 11.

Noise outcome

Terramin have proposed an environmental outcome of:

"No public nuisance impacts from mining activities from noise caused by mining activities".

The outcome identifies relevant receptors as the public, which includes residences and adjacent businesses. The outcome appropriately states that no nuisance impact is to be caused by mining activities.

Refer to Appendix 5 for the recommended noise outcome, should a lease be granted.

Existing environment – Baseline monitoring

AECOM on behalf of Terramin conducted baseline noise monitoring to understand the existing noise environment for two week-long campaigns during each of the following periods in September-October 2014, February-April 2015, March 2016 and April 2018[175]. The timing of the monitoring was selected to correspond with periods that fell both outside of and during the vintage season of the local viticulture industry.

Table 16 and 17 below summarise the baseline noise monitoring at the various monitoring locations. Location numbers are identified in Figure 16-2 of the MP.

[174] EPA, 2009, *Guidelines for use of the Environment Protection (Noise) Policy 2007*, South Australia.
[175] Summarised from Chapter 16 of the Mining Proposal

Table 16: Summary of the baseline noise monitoring results, daytime in dB(A)[176]

Location	$L_{Aeq,15hr}$	Highest $L_{Aeq,15min}$	Lowest $L_{Aeq,15min}$	Median $L_{Aeq,15min}$	Daytime ABL
April 2018					
Location 4	50	57	34	48	29
Location 5	47	57	32	44	30
February-March 2016					
Location 1	46	55	35	44	30
Location 2	47	54	35	46	27
Location 3	48	56	31	46	27
Location 4	47	55	36	46	29
February-April 2015					
Location 1	52	59	39	51	31
Location 2	49	57	34	46	28
Location 3	48	59	33	44	28
Location 4	47	57	32	46	30
September-October 2014					
Location 1	46	52	34	43	31
Location 2	48	57	35	46	30
Location 3	48	58	29	43	29
Location 4	47	53	30	46	27

Table 17: Summary of the baseline noise monitoring results, nighttime in dB(A)[177]

Location	$L_{Aeq,9hr}$	Highest $L_{Aeq,15min}$	Lowest $L_{Aeq,15min}$	Median $L_{Aeq,15min}$	L_{Amax}	Night time ABL
April 2018						
Location 4	39	50	26	31	73	23
Location 5	36	47	26	31	73	23
February-March 2016						
Location 1	38	47	30	35	69	27
Location 2	41	46	30	40	68	25
Location 3	41	51	27	33	78	24
Location 4	41	50	29	37	70	26
February-April 2015						
Location 1	44	53	28	38	73	26
Location 2	38	45	28	35	68	23
Location 3	40	49	28	35	75	25
Location 4	40	49	27	31	69	25
September-October 2014						
Location 1	43	52	29	36	70	28
Location 2	45	56	28	36	76	25
Location 3	39	48	26	33	74	26
Location 4	44	53	24	33	77	22

[176] Table 16-6 from the Mining Proposal
[177] Table 16-7 from the Mining Proposal

The baseline monitoring results indicate several exceedances of the day and night criteria for the highest measured readings over all monitoring periods and at the majority of locations. The median baseline noise levels are all below the Noise Policy criteria of 57dB(A) for day activities and 50dB(A) for night activities.

Government considers that the baseline provided was measured in accordance with the Noise Policy by a suitably qualified person over appropriate periods to provide a representation of the existing noise environment.

Sensitive receptors

The proposed mine is located near a range of different sensitive receptors as shown by Figure 23. The Noise Policy[178] requires noise assessments to be undertaken at noise-affected premises, which are defined as premises where the noise is audible and the premises:

- are in separate occupation from the noise source and used for residential or business purposes; or
- constitute a quiet ambient environment set aside as a park or reserve or for public recreation or enjoyment.

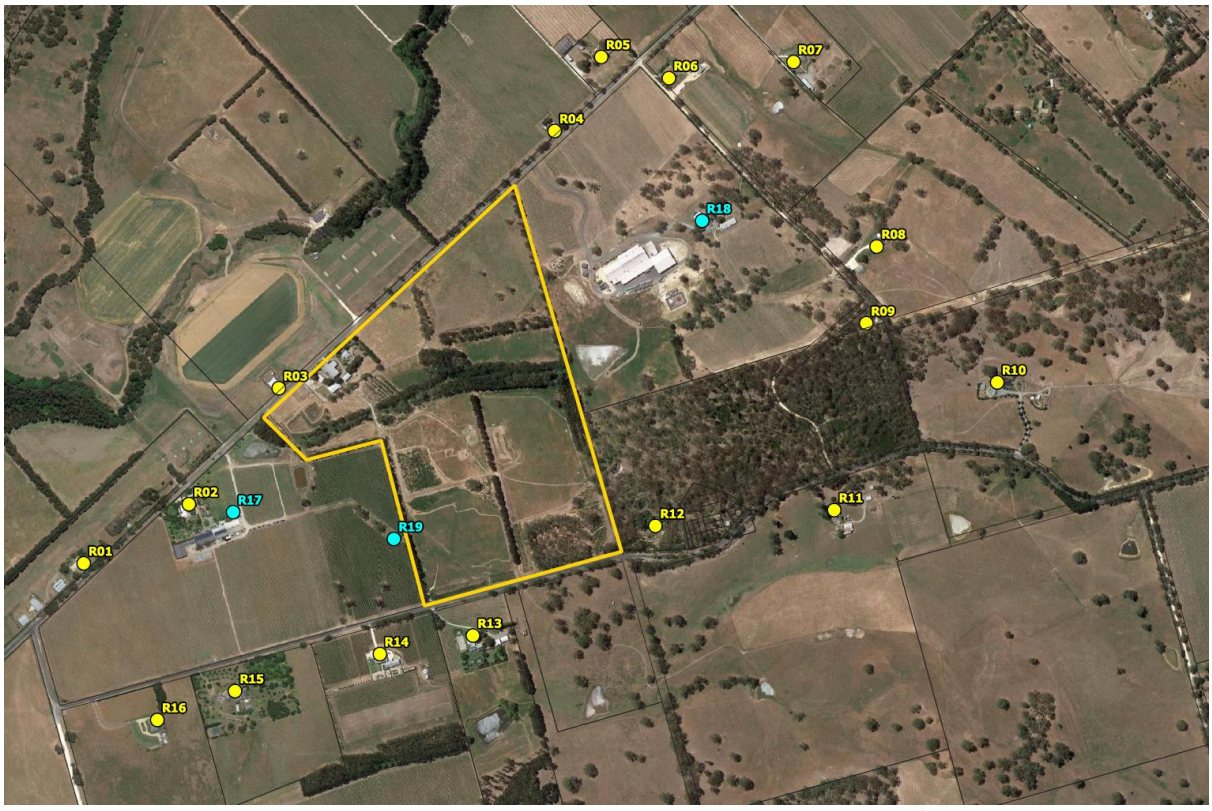


Figure 23: Sensitive receptors, yellow shows residential and blue shows commercial[179]

[178] Clause 12 of the Noise Policy
[179] Figure 2.1 from Appendix D1 of the Response Document.

Receptors around the proposed mine include 16 residential properties, 3 wineries with cellar doors, polo facility and a native vegetation heritage agreement area, which may provide habitat for native fauna. Receptor 19 (R19) shown in Figure 23 was added as a receptor following the government's request for response to ensure that weddings at Bird in Hand Winery are appropriately considered in Terramin's assessment.

Assessment of proposed design and management strategies

Terramin proposed design measures and management strategies to prevent noise and manage noise generating activities. Design measures proposed by Terramin in the MP[180] include:

- Landscape bunding and shielding around the proposed operation area to limit noise propagation
- Insulation within infrastructure to limit propagation of noise from sources within – eg pump stations
- Underground ventilation fans designed to have two silencers installed around them to reduce any continuous hum from the ventilation system
- Rubber lining of the ore silo to reduce noise associated with dropping of ore into the metal silo
- Inclusion of an enclosure around the truck unloading point and surge bin on the ROM bin and conveyor, and an open-ended enclosure around the haul truck loading area.

Management strategies include limiting activities with the highest noise impacts to daytime hours and management of noise producing activities – eg management plans for the ROM silo and IML to ensure frontend loaders are not operating continuously. For a full list of management strategies proposed refer to Chapter 16 of the MP.

In the response document Terramin proposed that acoustic enclosures would be installed at ore loading points to treat impulsive characteristics. This is explained in greater detail in the section below.

Terramin propose that noise will be managed through implementation of a TARP, which sets out trigger levels that will instigate an escalation of proactive actions to prevent potential noise impacts on receptors. The TARP would be supported by real-time noise monitoring that will give early warning of a trigger level being exceeded and initiate a corresponding action.

If a lease is granted, it is recommended that the proposed TARP and establishment of a real-time noise monitoring network that is accessible to the public be specifically required in the PEPR.

Project noise criteria

The Noise Policy sets noise goals that are based on land uses promoted by the relevant planning zone. At the time of application, the proposed mining lease area was located within

[180] Chapter 16 of the mining proposal

the Primary Production zone within the Onkaparinga Valley Policy Area, as defined under the Adelaide Hills Council Development Plan. The Primary Production zone referred to both Rural Industry and Rural Living land uses but the Onkaparinga Valley Policy Area specifically excluded rural living. Therefore the land use principally promoted by the development plan was Rural Industry.

All Council Development Plans were revoked and replaced by the Planning and Design Code on 19 March 2021. The zone for the project and all adjacent land is now the Productive Rural Landscape Zone[181]. The Desired Outcome and Performance Outcome of the Productive Rural Landscape Zone primarily promotes primary production and horticulture activities, and therefore is assigned the Rural Industry land use category in accordance with the Noise Policy. Government considers the indicative noise criteria to be 57dB(A) for day[182] activities and 50dB(A) for night activities within the Productive Rural Landscape Zone.

Indicative noise levels are intended by the Noise Policy to be used to trigger investigation for further action to reduce noise from the noise source should they be exceeded[183]. The indicative noise levels are underpinned by the recommendations in the World Health Organization (WHO) guidelines[184].

The WHO recommended noise levels are considered by the EPA to be stringent and conservative benchmarks. The indicative noise levels in the Noise Policy have been graded according to the acoustic amenity of the different land use categories[185].

In the case of operational mines, government uses the indicative noise criteria as compliance criteria to demonstrate achievement of relevant noise outcomes. For the Woodside component of the Bird in Hand Project, the legal limit for all stages of mining is 57dB(A) for day activities and 50dB(A) for night activities as described above.

Table 18: Project Noise Criteria[186]

SCENARIO	APPLICABLE TIME PERIOD	NOISE CRITERIA $L_{EQ,15MIN}$
Surface construction (Year 0-1)	Day period	57 dBA
Underground development (Year 1-2)	Day period	57 dBA
	Night period	50 dBA
Ore production (Year 2-7)	Day period	52 dBA
	Night period	45 dBA

[181] Planning and Design Code Zones - Woodside Inverbrackie Map
[182] The Noise Policy defines day time as between 7.00 am and 10.00 pm on the same day and night time as between 10.00 pm on one day and 7.00 am on the following day.
[183] EPA, 2009 – Noise Policy Guideline.
[184] Berglund B, Lindvall T and Schwela DH (1999), *World Health Organization Guidelines for Community Noise*.
[185] EPA, 2009 – Noise Policy Guideline.
[186] Table 3.1 from Appendix D1 of the Response Document.

Table 18 above shows the noise criteria chosen by Terramin for stages of the proposed project. For the ore production stage of the project (year 2 to 7), Terramin have voluntarily applied a criterion that is 5 dB(A) less than the indicative Noise Policy limit and demonstrated through modelling that this lower limit could be achieved at all receptor locations.

Government notes that several residences are located within 1km of the proposed mine and sources of noise. The presence of residences within this zone does not alter the Noise Policy limits even through the residences are essentially rural living as they were established in the rural industry zone. Nevertheless, government considers the existence of residences within 1km to warrant a more stringent compliance criteria than required by the Noise Policy.

In this case, government considers the limit proposed by Terramin of 52dB(A) for day activities and 45dB(A) for night activities for the ore production stage (year 2 to 7) to be more appropriate than the legal limit, given the mix of Rural Industry and Rural Living located in close proximity to the site.

If a lease is granted, government recommends that the noise criteria of 52dB(A) for day activities and 45dB(A) for night activities proposed by Terramin for the ore production stage be used as the compliance criteria during this stage of mining to demonstrate achievement of the noise outcome in the PEPR.

Leading indicator criteria

The baseline noise monitoring results showed a median daytime range of between 43 and 51 dB(A) and median night time range of 31 and 40 dB(A), which generally aligns with the Rural Living indicative noise levels of 47dB(A) for daytime and 40dB(A) for night time.

Terramin acknowledged this in the MP and proposed a leading indicator criterion (LIC) for the ore production stage of mining that aligns with the Rural Living limits stated above. AECOM modelled the ore production stage (day and night) to inform additional measures that may be required to achieve the LIC. Modelling predicted that noise levels would be higher than the LIC at R3 and R12. In response to the modelling, the proponent proposed and modelled additional control measures that were subsequently shown to be effective in achieving the LIC[187].

Government requested additional information on the proposed mitigation treatments (noise wall and/or berm, shed over IML) to determine whether these conceptual measures are to be adopted and if so, whether potential impacts associated with construction of a large shed had been considered. Terramin confirmed in the response document that they are not part of the design for the project[188]. As assessed above, modelling indicates that noise levels will be 5dBA less than the Noise Policy criteria, however it is reasonable for the proponent to finalise additional control measures in relation to LIC and the TARP through further detailed design in a PEPR (should a lease be granted).

[187] AECOM, 2017, *Leading Indicator Assessment* – Appendix O5 of the mining proposal.
[188] Table 4 of the response document, response to matter 62.

If a lease is granted, appropriate leading indicator criteria must be developed for stages 1-3 and stages 4-5 of proposed mining to inform proactive measures to be undertaken through the proposed TARP and prevent exceedance of the relevant PEPR compliance criteria.

Noise modelling and potential impact assessment

AECOM on behalf of Terramin developed a noise model to assess the effect of construction and operational noise from the proposed mine on receptors. The MP presents scenarios for surface construction (daytime only), underground development (day and night), and ore production (day and night)[189].

In accordance with the Noise Policy, noise from the source is assessed over a continuous 15-minute period unless otherwise specified. Where a noise source is not expected to operate continuously over a 15-minute period, adjustments are applied to account for duration to calculate an effective noise level over the time period. The continuous 15-minute period used for the model assumes all activities are being undertaken simultaneously onsite at their highest noise level to simulate an unrealistic, but possible, worst-case scenario in terms of noise impacts[190].

Terramin used the model to support the potential impact assessment and confirmed that all potential impact events require an outcome. The model predicted the following:

- No exceedances of the daytime noise criteria during the surface construction stage.
- During the underground development stage an exceedance was predicted at R12.
- During ore production exceedances of both the day and night-time limits were predicted at R3 and R12.

The strategies were then implemented in the model and shown to be effective in reducing noise at R3 and R12 to below the Terramin proposed limit.[191]

As part of the request for response, Government required that the model be updated to allow for overlapping scenarios[192] as this is considered possible. The updated prediction scenarios were provided in the response document.[193] Five modelling scenarios were presented based on different stages of mining with overlapping noise sources.

[189] Appendix O3 of the mining proposal
[190] Summarised from Chapter 16 of the mining proposal
[191] Appendix O3 of the mining proposal
[192] Matter 63 of DEM Request for Response Letter - dated 7 February 2020
[193] Appendix D1 of the Response Document

Table 19: Noise modelling results for all stages with noise mitigation[194]

RECEIVER	S1 SURFACE CONSTRUCTION	S2 SURFACE CONSTRUCTION (PORTAL START)	S3 SURFACE CONSTRUCTION & UNDERGROUND DEV.			S4 UNDERGROUND DEVELOPMENT AND ORE PRODUCTION			S5 ORE PRODUCTION	
	DAY(1)	DAY(1)	DAY [RAISE BORER VENT SHAFT]	DAY [RAISE BORER ESCAPE SHAFT]	NIGHT(1)	DAY [RAISE BORER VENT SHAFT]	DAY [RAISE BORER ESCAPE SHAFT]	NIGHT	DAY	NIGHT
(Criteria)	57	57	57	57	50	52	52	45	52	45
R01	49	47	44	44	34	41	42	33	43	35
R02	52	50	47	48	38	44	45	37	46	38
R03	56	55	52	52	42	48	49	41	51	41
R04	50	49	44	43	33	41	40	32	46	36
R05	48	47	43	43	34	40	39	33	42	35
R06	45	45	38	38	26	35	34	25	41	28
R07	43	43	37	37	24	32	32	23	37	27
R08	48	48	45	44	37	42	41	36	42	37
R09	49	48	45	45	37	42	41	37	42	38
R10	41	41	37	37	27	35	34	26	36	27
R11	47	47	47	47	27	46	46	26	47	31
R12	56	55	55	54	44	53	52	43	53	43
R13	56	54	52	53	32	52	53	31	52	35
R14	55	51	49	50	33	47	48	32	49	36
R15	51	48	45	45	32	42	43	31	44	34
R16	48	46	42	43	30	40	41	29	42	32
R17(2)	53	51	48	48	N/A	45	46	N/A	47	N/A
R18(2)	52	51	48	48	N/A	45	45	N/A	46	N/A
R19(2)	58	53	50	51	N/A	48	48	N/A	50	N/A

The updated modelling shows that noise levels will be higher than the initial modelling results for stages S1 and S2 (surface construction), shown in Table 19, which is an expected result as the operational noise sources were added. The updated model predicts one exceedance at receiver R19 by 1dB(A).

During stages S3-S5, noise levels are below the Terramin proposed limits, apart from 3 instances at receivers R12 and R13, which are 1dB(A) above the Terramin proposed limits, but 4dB(a) under the Noise Policy limits.

When interpreting these results, it is important to note that the model is conservative and simulates a worst-case scenario. Government considers it unlikely that noise levels would reach the predictions presented in Table 19, including those for R12, R13 and R19, as the assumptions made in the model assumes all mining noise sources simultaneously and for overlapping stages.

The Noise Policy also requires that the measured source noise level must be adjusted by the following amounts if the noise source contains modulation, tonal, impulsive or low-frequency characteristics:

- 1 characteristic: +5 dB(A)

[194] Appendix D1 of the Response Document.

- 2-3 characteristics: +8 dB(A)
- 4 characteristics: +10 dB(A)

Modulating characteristic

A noise source that attracts a modulating characteristic will often be described as something with a varying, fluctuating, pulsating or changing noise characteristic that is clearly audible above everything else[195]. An impulsive characteristic would not be applied to a noise that simply varies in level. The modulating characteristic is established to deal with such a noise. A short burst or impact, or series of impacts, need to be present to apply the impulsive characteristic. AECOM assessed that modulation would not be an annoying characteristic of the proposed mine site based on the distance to the nearest receptor (200m).

During the assessment process government received a submission from Accolade Wines, which included a report from Sonus, a consultancy company that specialise in noise. In the submission, Sonus states that the noise assessment should have considered modulating characteristics of mobile plant and equipment that will operate at the mine. This could add up to 5 dB(A) to all predicted noise levels during operation. Terramin provided further justification for not applying a penalty in the response document.[196]

Government noise specialists assessed the MP and response document and concluded that operations on site would not require the modulation noise characteristic as noise from truck movements within the site would likely be indistinguishable from truck noise on adjacent public roads. Due to this similarity in noise characters, the modulation characteristics would not be considered dominant as provided in the Terramin's response.

Tonal characteristic

A noise source that attracts a tonal characteristic will often be described as something with a pitch or sharply defined note that is clearly audible above everything else[197]. Tonal vehicle reversing alarms are a common annoyance issue for the community. Terramin propose to use broadband vehicle reversing alarms for all mobile plants that are regularly used on site to prevent this annoying characteristic.

Impulsive characteristic

A noise source that attracts an impulsive characteristic will often be described as something with a thumping, banging or impact noise that is clearly audible above everything else. It is distinguished by a sharp rise in noise level. An impulsive characteristic would not be applied to a noise that simply varies in level. The modulating characteristic is established to deal with such a noise. A short burst or impact, or series of impacts, need to be present to apply the impulsive characteristic[198].

[195] EPA, 2009, *Guidelines for the use of the Environment Protection (Noise) Policy 2007*, EPA, South Australia.
[196] Table 10, aspect 63 of response document.
[197] EPA, 2009 – Noise Policy Guideline.
[198] EPA, 2009 – Noise Policy Guideline.

For the ore production stage, a +5 dB(A) character adjustment was added to the model-predicted noise level at all receivers for impulsive noise characteristics specifically associated with ore loading into the surge bin during day and night time, and loading of ore into haul trucks during the day-time periods. Noise levels during ore production are predicted to meet the Noise Policy criteria of 57/50dB(A) without further mitigation but exceed the project noise limits proposed by Terramin during both the daytime and night time scenario of 52/45 due to this impulsive noise character penalty.

To address this, Terramin subsequently proposed acoustic enclosures around the ore loading point and ore haul truck loading point to treat the impulsive noise characteristic. Acoustic enclosures were added to the model scenario and the resulting simulation found that with the enclosure, the highest noise contribution associated with impulsive character from ore loading into the surge bin and haul truck is more than 10 dB(A) lower than the overall predicted noise level ie it is not the controlling noise source at the site, and is also lower than the median night time ambient noise levels[199]. Based on this, the impulsive noise penalty was removed from predicted noise levels at receptors. Government assesses that based on the justification provided, it is reasonable to remove this character adjustment.

Potential noise impacts on fauna

Baseline studies have shown bird species to be present in the application and surrounding areas[200]. Terramin have assessed that noise generated by mining operations will not impact on birds in the area. This is supported by academic papers cited in the MP[201] that show that birds tend to adapt to steady state noise up to 70 dB(A), which is much higher than the predicted levels.

Conclusion

Terramin has demonstrated through fit-for-purpose noise modelling and the application of appropriate control measures that noise caused by proposed mining activities will be lower than the limits prescribed by the Noise Policy.

The baseline data provided was measured in accordance with the Noise Policy by a suitably qualified person over a sufficient period to provide a representation of the existing noise environment. Relevant receptors were identified and appropriate noise sources input into the model based on proposed mining operations.

The model appropriately simulated all activities occurring simultaneously at their highest noise level to simulate an unrealistic worst-case scenario. The model indicates that predicted noise levels would comply with the Noise Policy goals for all stages and are predicted to be 5 dB(A) below the limit for the ore production stage.

Real-time noise monitoring will allow for proactive management of noise through the proposed TARP. Making real-time noise monitoring data available to the public is recommended, should a lease be granted.

[199] Table 10, response to matter 62 in the response document.
[200] Chapter 18 of the MP.
[201] Chapter 16 of the MP.

Chapter 10

Visual amenity

Introduction

The proposed Bird in Hand Gold Project is located approximately 2 km east of Woodside in the Adelaide Hills. The MC total area is 194.78 hectares, which incorporates the footprint of both the proposed above ground operations and the underground operations. The proposed visible above ground operations are located at 192 Pfeiffer Road Woodside, with a total area of 36.6 ha. This parcel of land has been identified by Terramin as 'Goldwyn' within the MP.

Visual amenity outcomes

Terramin proposed the following visual amenity outcomes:

1. **No impact to visual amenity cause by use of colour and/or materials of built structures related to mining activities.**
2. **No public nuisance or loss of amenity caused by external lighting from mining activities.**
3. **The form, contrasting aspects and reflective aspects of mining structures are visually softened to blend in with the surrounding landscape.**
4. **Designated rehabilitation sites are established self-sustaining systems.**
5. **No impact to visual amenity caused by the clearance of boundary vegetation within CT6055/379.**

Government assesses that proposed outcome (1) is a statement of design measures to prevent impact associated with achievement of outcome (3). Outcome (3) appropriately states sources of potential impact. Government considers that the form refers to landform, contrasting and reflecting aspects refers to colour and materials used for infrastructure. The outcome should apply to all stages of mining.

Government assesses that proposed outcome (2) appropriately states the public as the receptor, with external lighting the source.

Government assesses that proposed outcome (4) is a control strategy relevant to closure, not visual amenity. Proposed outcome (5) does not meet the requirements for an outcome statement.

Refer to the Fourth Schedule of Appendix 5 for recommended visual amenity outcomes and requirements, if a lease is granted.

Existing environment

The area is predominantly cleared agricultural land of either pasture or intensive horticulture with limited remnant vegetation. The cleared paddocks are covered in pastoral grasses and scattered paddock Eucalypt trees. The area within and surrounding the MC is undulating, with topography ranging from the highs of up to 470 m AHD, to the valley which includes small ephemeral drainage lines that join the Inverbrackie Creek at approximately 380 m AHD.

The proposed above-ground area of disturbance is contained within the Goldwyn property, which has been cleared extensively over the preceding century and has been used for mining, potato farming, dairy operations and, in the last 20 years, as a cattle grazing property.[202] Four houses were located within the MC at the time of application. Since the time of application two houses were damaged in the 2019 bushfire and are yet to be rebuilt.

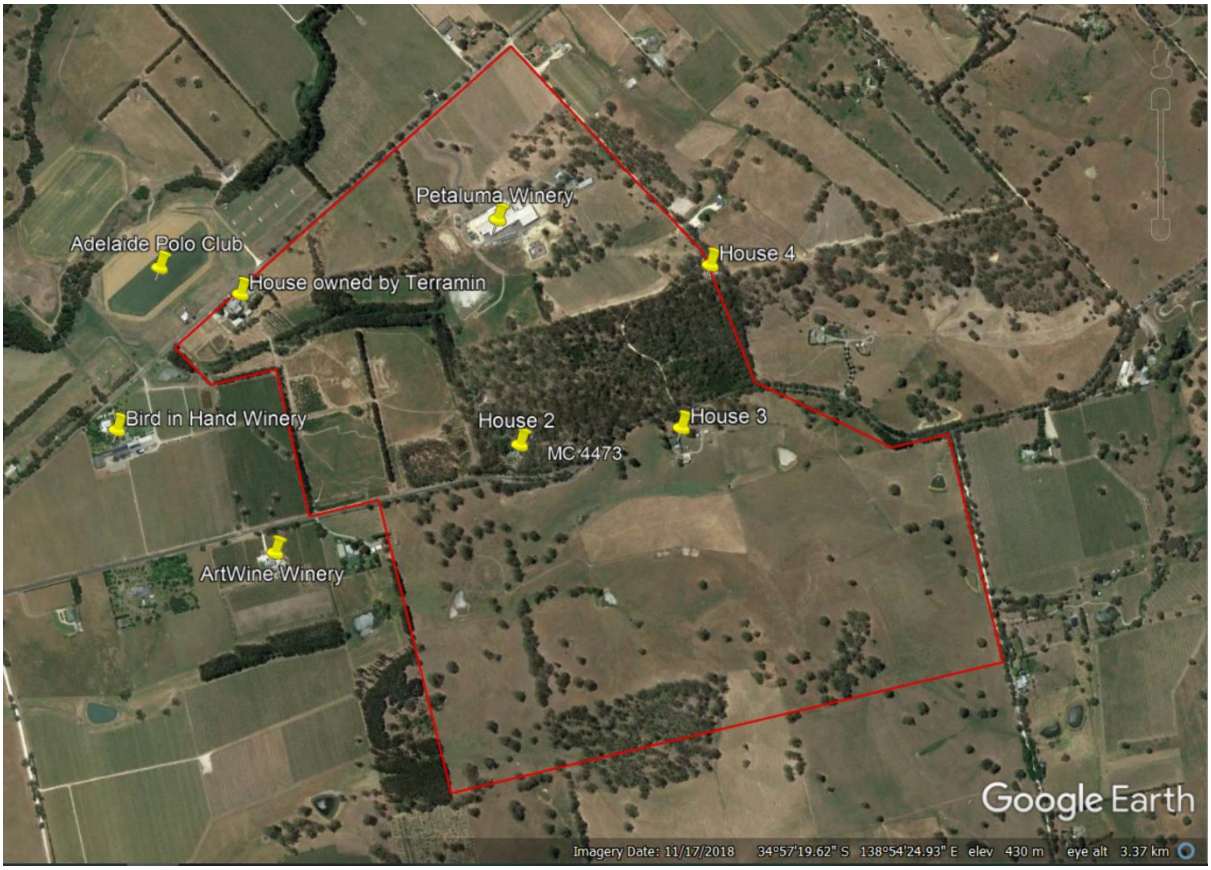


Figure 24: MC 4473 showing houses within and nearby businesses[203]

As shown in Figure 24 above, Petaluma Winery and cellar door is also within the MC. The Bird in Hand Winery, vineyard and cellar door adjoin the western boundary of the MC. Artwine Winery and cellar door are to the southwest. The Adelaide Polo Club fields and

[202] Summarised from Chapter 9 of the Mining Proposal.
[203] Produced by DEM.

facilities are located to the north along Pfeiffer Road, along with a privately owned air strip used for both fixed and rotary winged aircraft (west of the area shown in Figure 24).

The landscape character of the surrounding area is rural with viticultural and agricultural land use within the undulating topography of the Onkaparinga Valley. Sparsely clustered trees within open paddocks and boundary tree rows provide definition of allotments. A predominately native tree cover follows the alignment of existing roads, creek lines and property boundary windbreaks throughout the region.

Figure 25: Existing settlement patterns and built form[204]

Assessment of potential impacts

The MP included a Strategic Visual Amenity Plan (SVAP) prepared by Oxigen Landscape Architects (Oxigen). The SVAP:

- examined the existing landscape character
- identified objectives for enhancing the visual amenity of 'Goldwyn'

[204] Oxigen, 2019, *Strategic Visual Amenity Plan* – Appendix G1 of the Mining Proposal.

- identified techniques to strategically address potential visual amenity impacts of proposed mine infrastructure and operations
- illustrated the visual effects of earthworks and associated landscape remediation techniques from key viewpoints. [205]

To understand current sight lines to the proposed mine site, Oxigen undertook a photographic survey in March 2017 at key viewpoints from public roadways, businesses and residential dwellings.

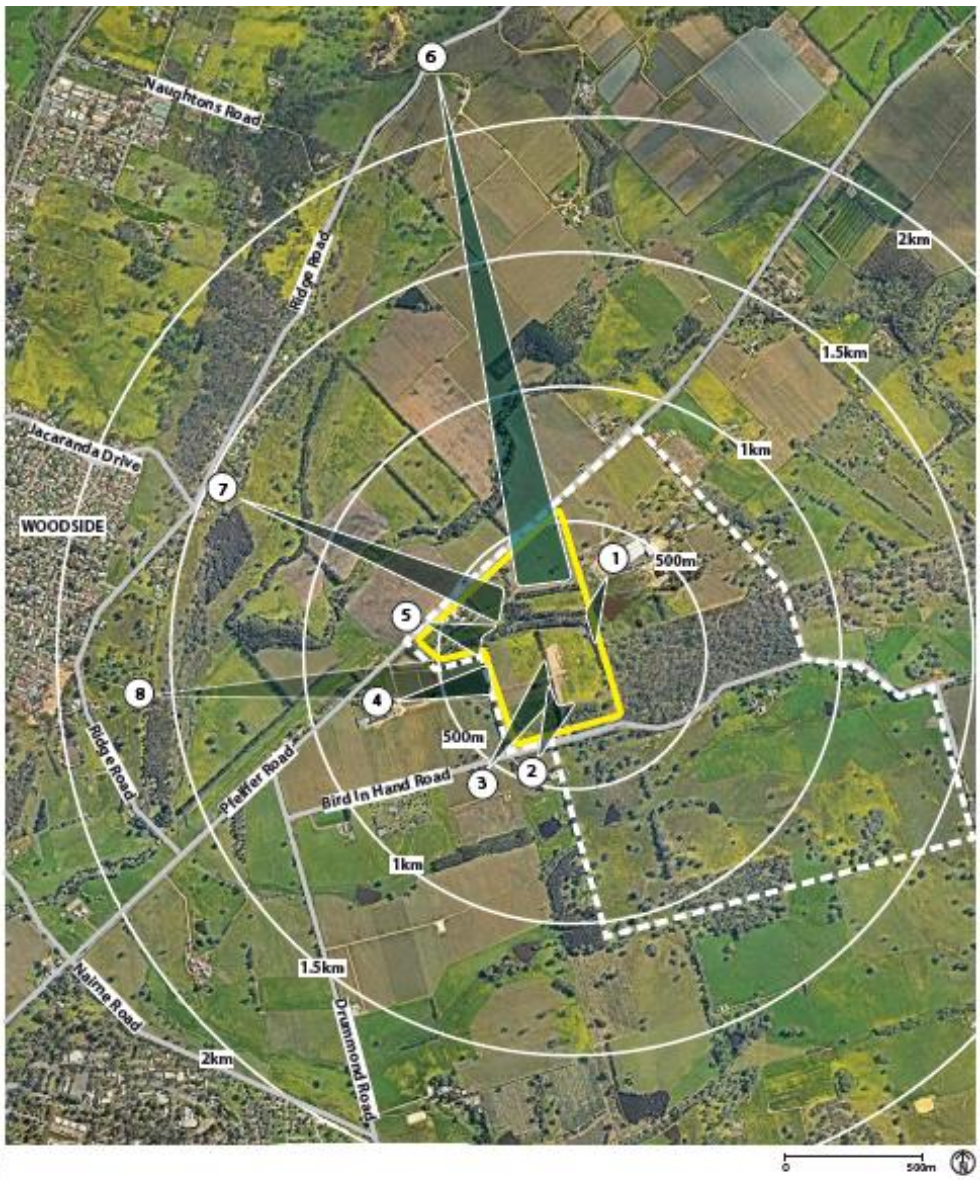


Figure 26: Viewshed and distance from Goldwyn property[206]

[205] Appendix G1 of the Mining Proposal.
[206] Figure 4 – Appendix G1 of Mining Proposal.

The surrounding hills and valley topography limit external views of the project site. The assessment concluded that there are no locations where a view of the entire site is possible. As shown in Figure 26 views are scattered and partially obscured by existing vegetation and/or topography.

Figure 26 shows that residence (2) overlooks the proposed operational area. The Bird in Hand Winery cellar door and Artwine cellar door both have partial views of the western side of the proposed mine area. The Bird in Hand Winery cellar door exit pathway faces the project site with existing vines in the foreground and a row of existing boundary trees providing mid-level screening, while existing trees within the Artwine carpark perimeter and Bird in Hand Road verge provide partial northeastern screening towards the project site. Both cellar doors predominantly face north.[207]

Government assess that the key viewpoints identified in the SVAP are sufficient to represent the broader viewpoints in the region and are appropriate to be used as a baseline measurement. It is recommended that if a lease is granted these points should be used as reference points to measure the effectiveness of design and control measures for visual amenity impacts over the life of the mine.

Design and control measures

Oxigen concluded that the following external factors affect the extent that proposed mining operations would create a visual impact on the landscape and receptors:

- Landform and proportion
- Colours and materials
- Vegetation type and density
- Built structures

The MP shows how the site layout has been designed so that the placement of infrastructure avoids sightlines where possible. [208] Where this is not possible bunds, vegetation and landform shaping is proposed to mitigate visual impacts.

Landform and proportion

Figure 27 shows the location of landscape bunds (2,12 &16) and the integrated mullock landform (IML) (10), which have been designed to reflect the undulating profile and contours of the surrounding valley. At closure material from the IML will be used to backfill the mine void reducing its height to that of the adjacent vegetation bund so it blends into the regional landform.

Colour, material and lighting

Colours have been selected to match the surrounding landscape of natural tones of browns, greens, and greys. Materials for building cladding are proposed to be selected for non-

[207] Summarised from Chapter 9 of the Mining Proposal.
[208] Site Layout Plans, Sheet 204 – Appendix B1 of the Mining Proposal.

reflective surfaces that align with materials used at adjacent wineries. Terramin propose that all required lighting will be established in accordance with the relevant Australian Standard.[209]

Figure 27: Proposed site master plan showing visual design mitigations[210]

Vegetation type and density

The MP proposes new planting of upper, middle and lower story native vegetation to expand existing tree cover within the site, perimeter and adjacent water courses. In late 2019 the boundary vegetation was burnt by the locally occurring bushfire. Government conducted a site inspection on 28 January 2020 and noted that the vegetation on the western aspect of the property that screens views of the site from multiple directions and elevations was damaged by the fire. Government requested further information[211] to demonstrate that an effective screen could still be established.

[209] AS4282, 1997, *Control of the obtrusive effects of outdoor lighting*.
[210] Appendix G1 of the Mining Proposal.
[211] Matter 111 of DEM request for response letter dated 7 February 2020.

Terramin responded that the upper and lower story vegetation has recovered, or will recover, and continue to serve as an effective screen, however some middle story vegetation will need to be replaced. Terramin committed to undertaking this work in the winter of 2020.

Government conducted a subsequent site inspection on 30 November 2021 that confirmed that upper story vegetation appeared to have recovered with evidence of regrowth. However, replanting had not occurred as per the Terramin response.

If a lease is granted, it is recommended that Terramin plant a variety of mid-storey, local native plant species within the existing fenced areas along the western boundary of the MC adjacent to Bird in Hand Winery immediately to allow sufficient time for establishment before any construction occurs.

Built structures

Terramin propose screening of prominent built structures using bunding and vegetation where possible. The ROM silo and loading structure, shown on Figure 27 as item 22, are too tall to be screened. The SVAP provides conceptual views from 6 photo points that show that the ROM silo would be visible from Petaluma Winery, Bird in Hand Winery, 5A Ridge Road (although from a distance) and 86 Bird in Hand Road. Terramin propose that the silo will be constructed to look like the silos at Bird in Hand Winery shown in Figure 28. The MP notes that the colour of the silo will be the subject of discussion with community if a lease is granted.

At closure Terramin propose that some buildings and structures will be retained for potential reuse by the future landowners, for example the administrative office, staff amenities and workshop could be utilised for agriculture enterprises - eg viticulture. The ROM Silo will be decommissioned and removed from site. The landform will be rehabilitated with topsoil and replanted with vegetation.[212]

Government considers that construction of the site against the design presented in the SVAP is critical to ensure that proposed operations blend in with the surrounding landscape. If a lease is granted it is recommended that an audit is undertaken during and periodically after construction to confirm that the site has been constructed as per the SVAP design.

Modelled views

Oxigen created images of the land as it looks now, with impressions of what it would look like at the end of construction - considered to be the highest impact, operations - with controls applied, and closure from selected viewpoints that were previously assessed to have views of the site.[213] The modelled views show the ROM silo as the most visible feature. The construction stage shows a low level of short-term temporary visual impact that would not be inconsistent with development of the Petaluma bottling facility and the establishment of the polo fields that occurred within the application period.

[212] Summarised from Chapter 9 of the Mining Proposal.
[213] Appendix G1 of the Mining Proposal.

Bird in Hand Winery development

In September 2019, a development application to redevelop Bird in Hand Winery was approved under the *Planning, Development and Infrastructure Act 2016*. Conceptual design images of the development show addition of a second story to the cellar door area with open views towards the proposed mine site. As this development application was approved prior to a decision on the lease, it must be considered in the assessment of potential impacts.[214] Government requested that Terramin assess whether the proposed design and control measures to mitigate visual amenity impacts would still be able to achieve the proposed outcomes.

Oxigen, on behalf of Terramin, prepared additional figures with impressions depicting the view of the proposed mine site for someone standing on the proposed roof deck above the Gallery restaurant as per the development application.[215]

Figure 28: Left image shows current view from proposed roof deck and right image shows photomontage of proposed mining operations.[216]

As shown in Figure 28 the ROM silo is clearly visible, as are the vegetated mullock landform and bunding. The photomontage shows that landforms blend in with the surrounding landscape and, if constructed to design, would achieve the recommended visual amenity outcome.

Conclusion

Government considers that appropriate vantage points have been used to inform the assessment of potential impacts on receptors. All outcomes recommended by government are practically achievable based on the proposed design to screen views from receptors or blend in with the surrounding landscape. Aspects of the proposed site that would be visible have been designed using similar colours, landforms, vegetation and built structures. Photomontages show short-term visual impacts at some receptors that can be managed through temporary control measures and the early establishment of screening vegetation, if a lease is granted.

[214] Government notes that at the time of writing this report construction on the approved Bird in Hand Winery development has not commenced.
[215] Appendix L2 of the Response Document.
[216] Figures 5 and 6 from Appendix L2 of the Response Document.

Chapter 11

Blasting

Introduction

Use of explosives to fracture rock for mining can potentially impact on community through ground vibrations, air blast overpressure, flyrock, generation of blasting fumes and dust. Explosives are commonly used in mining, quarrying and civic projects throughout Australia. The effects from blasting can be predicted and efficiently controlled through blast planning and execution.

In South Australia, blasting and blast-related activities, including purchase, transport, storage and use of explosives/blasting, are regulated by the *Mining Act 1971, Mines and Works Inspection Act 1920, Explosives Act 1936, Work Health and Safety Act 2012*.

Blasting Outcomes

Terramin proposed the following environmental outcomes related to blasting:

"No adverse impact on public health or amenity from air overpressure, flyrock and vibration caused by blasting."

"No adverse impact to heritage buildings from air overpressure, flyrock and vibration caused by blasting."

The first proposed outcome identifies the relevant general receptors as public health and amenity. The second outcome identifies heritage buildings, which includes Lone Hand Chimney, a State heritage place, and Ridge Mine Chimney, an existing stone chimney from Ridge Mine during 1880s, recognised onsite under the *Heritage Places Act 1993* (SA) as relevant receptors.

The outcomes appropriately state that no adverse impact is to be caused by blasting. Government assess that all receptors should be referred to in one outcome along with the relevant phases of mining.

Refer to Appendix 5 for the recommended blasting outcome, should a lease be granted.

Compliance criteria

Potential effects of blasting, including noise/air overpressure, blasting vibrations and flyrock, are guided by *Australian Standard 2187.2 – 2006, Explosives-Storage, transport and use Part 2: Use of explosives* (Explosives Standard). This standard is used as guide for human comfort-based criteria. Blasting compliance limits in the Explosives Standard are among the most stringent in the world.

Table 20: Summary of ground vibration and air overpressure limits to minimise human discomfort from long-term blasting activities at a sensitive site[217]

Category	Type of Blasting Operations	Parameter	Peaks Level
Sensitive Site*	Operations lasting longer than 12 months or more than 20 blasts	Ground Vibration	5mm/s for 95% blasts per year, 10mm/s maximum unless agreement is reached with the occupier that a higher limit may apply
Sensitive Site*	Operations lasting longer than 12 months or more than 20 blasts	Air Overpressure	115dBL for 95% blasts per year, 120dBL maximum unless agreement is reached with the occupier that a higher limit may apply
**A sensitive site includes houses and low residential buildings, hospitals, theatres, schools etc, occupied by people*			

The limits detailed in Table 20 are based on minimising human discomfort. With respect to potential for damage to structures, the Explosives Standard refers out to limits from British Standard 7385-2 and are well below the levels likely to produce damage to buildings shown in Table 21. In South Australia quarries and mines are regulated against human comfort levels to manage potential impacts on public health, amenity and protect third-party property. Transport infrastructure including roads and railway lines can sustain much higher vibration levels. Vibration limits in the order of 100mm/s are commonly adopted to ensure a high factor of safety is maintained.[218]

Table 21: Transient vibration guide values for cosmetic damage to buildings[219]

Type of Building	**Peak component particle velocity in frequency range of predominant pulse**	
	4 Hz to 15 Hz	15 Hz and above
Type 1 Reinforced framed structures Industrial and heavy commercial buildings	50 mm/s at 4Hz and above	
Type 2 Unreinforced or light framed structures. Residential or light commercial type buildings	15 mm/s at 4Hz increasing to 20 mm/s at 15 Hz	20 mm/s at 15 Hz increasing to 50 mm/s at 40 Hz and above

[217] Table 2.2 from Appendix P1 of the Mining Proposal.
[218] Appendix P1 of the Mining Proposal.
[219] GME, 1993, BS 7385-2 *Evaluation and measurement for vibration in buildings – Part 2: Guide to damage levels from groundborne vibration* [Available online: https://www.alexandriava.gov/uploadedFiles/special/WaterfrontPlan/info/measurementforbuildingvibrations.pdf]

Existing environment

Baseline monitoring

Baseline air overpressure and ground vibration monitoring occurred over a 12-month period between May 2016 and October 2017 at two locations adjacent to the eastern boundary of the MC. While monitoring results indicate very low background levels within the project area, some localised vibration peaks with a maximum level of 0.69mm/s have been recorded. More recent monitoring recorded vibrations of 0.33mm/s, which are probably associated with the proximity to Bird in Hand Road. Air-overpressure levels recorded at Location 1 – South during the month of April 2017 highlighted the potential for extraneous sources to influence peak levels. The data indicates that 0.1% of the measured peaks were above 116dB(L), which exceeds the recommended compliance limit relating to blast-induced overpressure. This occurred for 18 of the 20 months – 0.1 % were above 115 dB(L); for 12 of the 20 months 1% were higher than 115dB(L) and for 10 months 5% were higher than 115dB(L). This was attributed to local factors such as wind, trucks on Bird in Hand Road or aircraft from the privately owned airfield nearby.[220]

Sensitive receptors

Sensitive receptors around the proposed mine consist of 16 residential properties, 3 wineries with cellar doors, a polo facility, 2 heritage listed structures (Lone Hand Chimney and Ridge Mine Chimney) and a native vegetation heritage agreement area, which may provide habitat for native fauna.[221]

DEM assesses that receptors that could reasonably be expected to be affected by blasting activities have been described and appropriately assessed in the MP.

Potential impact assessment

Terramin engaged Saros (International) Pty Ltd (Saros) to undertake the following:

- An independent assessment of the effects of construction (surface) blasting operations
- An independent assessment of the effects of development and production (underground) blasting operations
- Development of appropriate blast design and mitigation measures to ensure compliance with the AS 2187.2.[222]

Geotechnical investigations indicate that some surface blasting may be required during the construction phase of the project to develop the boxcut and cuttings for the on-site access road. Access to the underground working is proposed via a decline, from which a series of horizontal sublevel access drives will be developed into the mineralisation zone providing

[220] Summarised from Chapter 17 of the Mining Proposal.
[221] Table 17-3 of the Mining Proposal has a full list of identified sensitive receptors.
[222] Saros, 2017, *Bird in Hand Gold Project Blasting Impact Assessment* – Appendix P1 of the Mining Proposal.

access to the ore. Underground mining is proposed as a cut and fill method, which utilises development blasting techniques with one lift at a time and four lifts per sub level. As a result, the scale of blasting will not vary between the development phase (developing the decline) and the production phase (ore recovery) of the project.[223]

The predictive modelling of ground vibration and air overpressure impacts conducted by Saros was based on monitoring data obtained from mining and blasting operations that have comparable geological and/or topographic conditions and utilise similar scale blasting practices. Predictive models were developed for each phase of the mining process based on the blasting practices to be implemented and the location of the activities for that period.

Saros used a common method for the prediction of vibration from blasting, the scaled distance equation. This is a standard, well-established method, based on the relation between the level of vibration and the maximum instantaneous charge weight, and distance between the blast and the sensitive receiver or monitoring point. When there is no site constant determined for a particular site, as in this case, it is a standard practice to use the site constants determined from the multiple regression analysis from blasting undertaken on other sites in similar geological formations.

Air overpressure relates to the air vibration/change in air pressure caused by blasting energy and is influenced mostly by the explosive confinement, local topography, orientation of the blast, explosive initiation timing and atmospheric conditions (cloud cover, temperature inversions, wind). Similar to ground vibration prediction, the most common method in overpressure impacts prediction is through a scaled distance equation.

Surface blasting

Modelling associated with the initial construction phase has assumed a worst-case scenario with blasting required in both the boxcut and access road cutting. Design has assumed blasting the full depth of excavation including both 5 metre and 10 metre benches. Modelling showed that vibration and air overpressure will not exceed Australian Standard limits at any sensitive receptor.[224]

Development and production blasting

The modelling of ground vibration impacts from the development of the decline were based on a typical development heading, with a maximum charge per blasthole of 5 kilograms and assuming the previously mentioned equation. The modelling also takes into consideration the increased depth of the decline as it progresses underground. Figure 29 shows that ground vibration levels are predicted to be less than 1mm/s at sensitive receptors, which equates to vibration levels associated with walking.[225] Prediction of overpressure impacts is considered conservative as it was based on initial blasting close to the portal. Levels would attenuate as the decline progresses underground. Figure 30 shows that predicted overpressure levels will not exceed the compliance criteria at sensitive receptors.

[223] Appendix P1 of the Mining Proposal.
[224] Appendix P1 of the Mining Proposal.
[225] Figure 6.1 – Appendix P1 of the Mining Proposal.

During the production phase, peak vibration levels of 5mm/s are not anticipated to reach the surface with potential impacts from vibration decreasing with depth. Given the depth and network of the underground workings during the production phase, air overpressure levels from the production blasting are not anticipated to impact on the surface.

Potential impacts from fly rock

Blasting can result in movement of rock that, if not appropriately designed and managed, could fly onto adjoining properties causing injury and in extreme cases death. The surface blasting proposed is limited to the construction phase and like that of a small quarrying operation. Terramin have proposed strategies to manage air overpressure, mentioned above, that will also manage the potential for fly rock. All blasts will have associated exclusion zones that will not extend to receptor locations.[226]

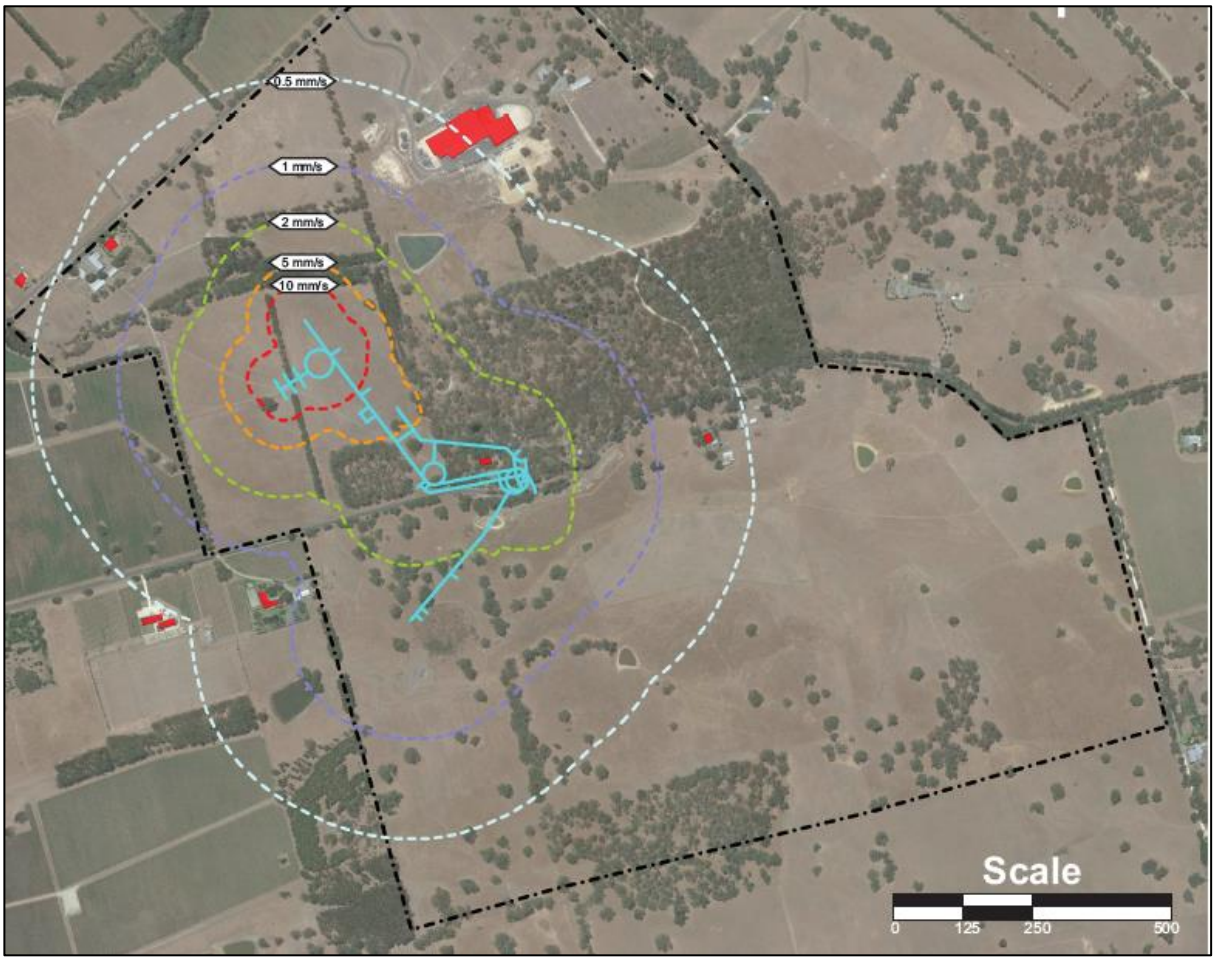


Figure 29: Predicted blast induced vibration from the decline development, receptors shown in red[227]

[226] Summarised from Chapter 17 of the Mining Proposal.
[227] Figure 7.2a - Appendix P1 of the Mining Proposal.

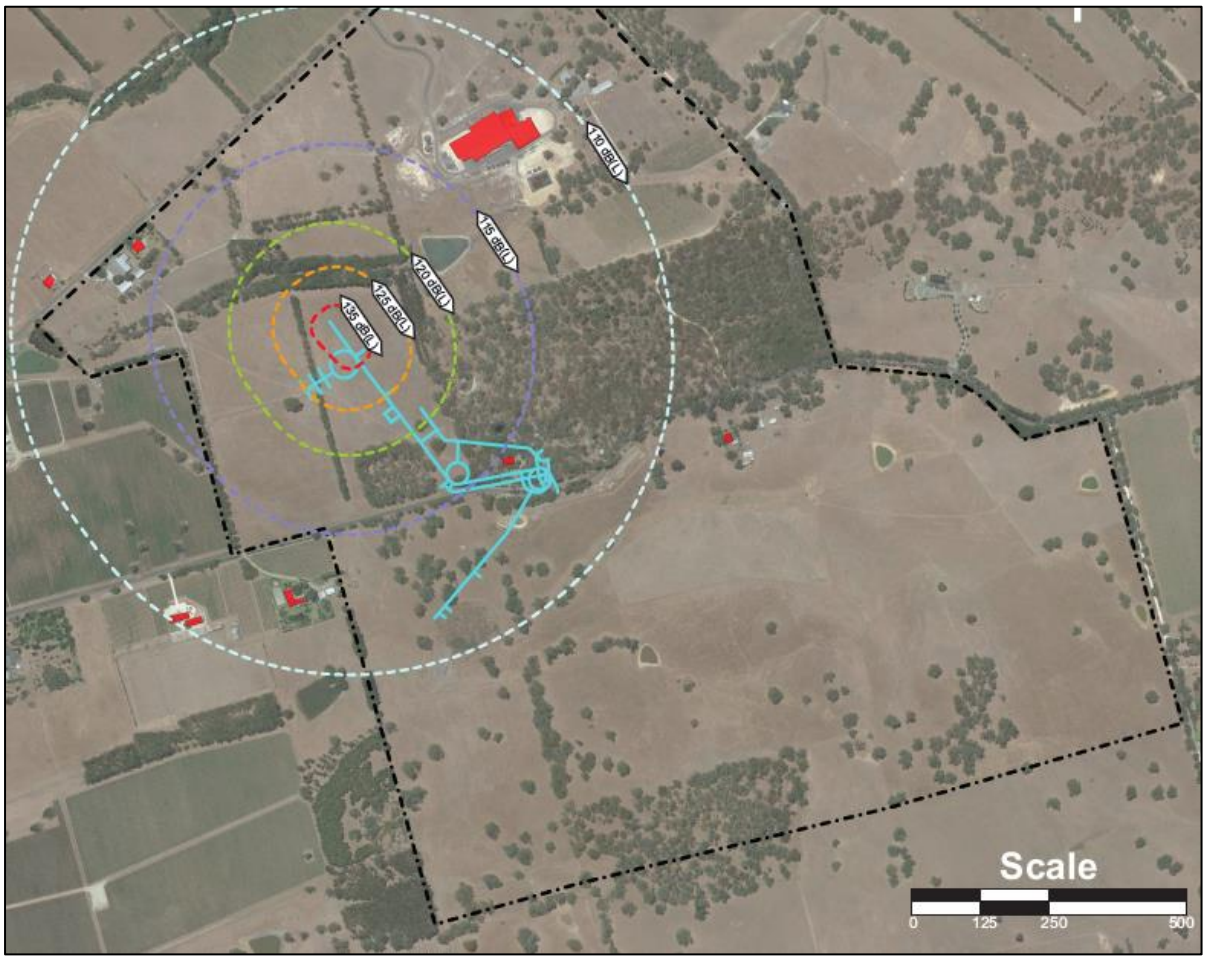


Figure 30: Predicted blast induced overpressure from the decline development[228]

Potential impacts on fauna and livestock

Baseline studies have shown bird species to be present within the MC and surrounding areas.[229] Cattle are currently run within the MC south of Bird in Hand Road and in adjoining properties. Vibration impacts to fauna are not considered credible as the blast vibration limits are predicted to be within human comfort levels outside of the mine construction or operational area. The baseline overpressure monitoring results show that overpressure of over 115dB(L) is occurring naturally - ie caused by wind or human activities such as gas guns.

Once mining operations progress underground, ground vibrations and air overpressure that fauna may be able to detect are insignificant when compared to existing background levels and hence government does not consider this to be a credible potential impact event.

[228] Figure 7.2b - Appendix P1 of the Mining Proposal.
[229] Chapter 18 of the Mining Proposal.

Potential impacts on groundwater

Terramin assessed the potential for blasting to damage wells or result in changes to water quality. Based on the available literature, Terramin do not expect any damage to wells, or impacts on water supply or quality for existing groundwater users.

Proposed blasts will use a maximum charge weight of 5kg per blast hole. The dimension and charge weights are significantly smaller than those used in the literature examples cited by Terramin in the MP.

Blasting is designed to break the rock and can be expected to impact the rock surrounding the blasting area. Past research, referred to in the MP, suggests that potential for damage depends on geology and the size of the blast, and is concentrated within the area of the blast hole. Some minor and temporary changes in water turbidity have been noted. However these changes were minor, reversible and occurred only near the bore. One of the reports cited by Terramin in the MP suggests that a vibration limit of 25mm/s should yield no apparent impacts on the bores or their water quality, and a limit of 50mm/s may see occasional instances of increased turbidity but will protect bores from any other damage. [230]

Modelling shows that vibration levels will not exceed 5mm/s at any receptor well locations.[231]

Based on the size of proposed blasts and modelling showing vibration levels to be within the compliance limits for human comfort, there is no credible impact from blasting to wells, groundwater quantity or quality.

Assessment of proposed design and control measures

To manage the social impacts of blasting on the local community, Terramin propose an opt in/out SMS blast notification system for local residents and communication of set blasting times. Construction blasting is proposed between the hours of 10am and 6pm.

Ground vibration

Terramin propose development of a Blast Management Plan to tailor the amount of explosive detonated per delay, based on the distance to nearest sensitive receptor. Modifications to blast design that could be used include:

- A reduced cut length
- A reduced blast hole diameter
- Lower density explosive products
- Downloading blast holes (decoupled charges)
- The use of electronic detonators to provide greater flexibility and accuracy in initiation timing, minimising the likelihood of vibration enhancement from multiple blast holes.[232]

[230] Golder Associates, 2005, *Blasting Impact Assessment Proposed Expansion of Duntroon Quarry*, Golder Associates Ltd, Canada.
[231] Chapter 10 of the Mining Proposal.
[232] Summarised from Chapter 17 of the Mining proposal.

Terramin is proposing to limit ground vibration to 15 mm/s at the Lone Hand Chimney, which is based on Terramin's investigations of other heritage structures near mining projects in Australia. This level presents the most conservative peak particle velocity for 'unreinforced or light framed structures', outlined in the British Standard. Modelling shows that the Ridge Chimney will experience vibration of 2mm/s, which is well below limits.

Air-overpressure and fly rock

Design measures proposed by Terramin for air overpressure include the standard measures and management strategies required to be implemented by the relevant legislative requirements and recommended in the Explosives Standard, as well as some additional strategies to manage initial development at surface:

- Shields at the portal
- Blast curtains
- Physical barriers in the decline
- Insulation

Fly rock depends on appropriate blast design and ensuring that blasts are prepared and executed per the design. Potential impacts associated with fly rock (impacts on public and livestock safety, and nearby structures) can be effectively managed through the implementation of above-mentioned air overpressure design measures and through implementation of appropriate blast exclusion zones.

Government assesses that the proposed design and management strategies would achieve the recommended blasting outcome.

Terramin propose that every blast will be monitored at the nearest sensitive receptor to confirm compliance with legal limits and that all blast times and charge weights will be recorded in a register. Government recommends that the requirement to monitor every blast and maintain a blast register be a requirement of the PEPR, if a lease is granted.

Conclusion

Based on modelling of ground vibration and air overpressure impacts, proposed blasting at the surface and underground will meet the Australian Standard limits for human comfort. As the limits for human comfort are below limits that would cause damage to structures, achievement of the proposed limits will result in achievement of the recommended blasting outcome for heritage buildings and third-party infrastructure.

Terramin have provided evidence to demonstrate that blasting will not impact on surrounding wells, groundwater quantity or quality. All blast-related impacts can be managed through industry standard design and control strategies.

Chapter 12

Existing land use and economic impact

Introduction

Government recognises the importance of existing land use to the local and state economy. To allow for a rigorous assessment of potential impacts on existing land use the Ministerial Determination for the Bird in Hand Gold Project specifically required that:

- existing commercial and community business are considered under the definition of environment as receptors
- the potential impact assessment includes detail of potential economic benefits and negative impacts on existing business
- the assessment of economic impacts is developed by an independent person experienced in economic impact assessment
- the economic impact assessment be peer reviewed by an independent expert.

The economic impact assessment was prepared by Professor Barry Burgan from Economic Research Consultants (ERC). Government considers Mr Burgan to be suitably experienced in economic impact assessment. Further information on his experience and credentials was provided in Chapter 24 of the MP.

The peer review was completed by Jim Hancock - Deputy Director at the SA Centre for Economic Studies at the University of Adelaide. Government considers Mr Hancock to be suitably qualified to undertake the peer review.

Multiple land use and economic growth

Agriculture and mining comprise 70% of South Australia's exports. In 2020 the value of the South Australia agriculture exports was $5.6 billion.[233] In 2021 wine exports made up 13.8% of SA exports with a reported 940,000 tonnes of grapes crushed, valued at $827 million.[234] With less than 1% of the state under mineral production, mineral exports accounted for 25% of state exports, valued at $6.1 billion.[235]

Government recognises the joint importance of agriculture and mining towards economic growth and following extensive engagement released a Multiple Land Use Framework that

[233] PIRSA, 2020, PIRSA Industries Scorecard 2019-20 [accessed online on 31 January 2022 at: https://pir.sa.gov.au/__data/assets/pdf_file/0009/385092/pirsa-score-card-2019-20.pdf]
[234] Wine Australia, SA Winegrape Crush Survey 2021 [accessed online on 31 January 2022 at: https://vinehealth.com.au/wp-content/uploads/SA-state-summary-2021-1.pdf]
[235] Department for Energy and Mining, 2021, *South Australian mineral resource production statistics for the six month ended 30 June 2021*, Report Book 2021/00018, Energy Resources Division. Department for Energy and Mining, South Australia, Adelaide.

recognises the value of a wide variety of land uses in contributing environmentally, socially and/or economically to the state.

Existing land use

The MC is located adjacent to existing wineries and cellar doors of Bird in Hand Winery, Petaluma Winery and Artwine. Tolly and Eureka Wines also have vineyard operations adjacent to the MC. Other economic land uses in the area include beef cattle grazing, an airfield and the Adelaide Polo Club. Strawberry growing and orchard operations are also located within the local area.

Figure 31: Land use within and surrounding the MC[236]

[236] Figure 23-4 from Chapter 23 of the Mining Proposal.

Assessment of potential impacts on existing land use

Based on feedback from community and the proximity to other agricultural land uses, Terramin concluded in the MP that any potential impacts on existing land use, resulting in negative economic impacts would be associated with:

- Traffic
- Reduction in groundwater quality and/or quantity
- Contamination of surface water or change in flow regime
- Increased weeds, pests and/or plant pathogens
- Increased dust and reduced air quality
- Increased noise
- Vibration and air overpressure from blasting
- Reduced visual amenity

If potential impacts that lead to an impact on existing land use operations can be successfully mitigated through design or control strategies, Terramin contend that there would be no economic impact[237]. Terramin commissioned FABAL[238] to assess potential impacts specific to adjacent agricultural land use. As shown in Table 22, FABAL considered potential impacts from the context of an agricultural producer.

[237] Summarised from Chapter 24 of the Mining Proposal.
[238] Keegan, A (FABAL), 2017, *Bird in Hand Gold Project – Agricultural Impact Assessment* – Appendix U1 of the Mining Proposal.

Table 22: Considered sources of potential impact on agricultural receptors[239]

Risk Grouping	Risk Category	Specific Potential Source
Airborne	Dust particulates Metalliferous contaminants Chemical contaminants Biological contaminants Genetically modified organisms	
Biological	Pests	Animal Insects
	Plant pathogens	*Phytophthora* / *Pythium* Bacterial / Fungal Exotic
	Plant pests	Weeds
Hydrological	Surface water	Contamination Erosion Pest Vector Flooding / Inundation
	Groundwater	Access / physical utility Salinity Contamination Pressurisation Managed Aquifer Recharge
Commercial	Commercial competitiveness	Visual amenity Significant incident
Physical structures	Climate	Airflow Frost Heat
	Biodiversity	Pest Birds Predator Birds Biodiversity Pests General
	Buffering capacity Aerial impedance	
Other	Fire Blasting Post closure considerations	

Government considers Terramin's approach to be reasonable. For cellar doors, potential impacts that could result in a negative visitor experience, resulting in reduced patronage, may be associated with impacts from traffic, air quality, noise, blast vibration and air overpressure and visual amenity. All these impacts can be quantified, controlled and measured against recognised standards.

Property values

Public submissions raised concern that the proposed mine would reduce the value of their property. Terramin responded that during and after operations at the AZM land values at

[239] Table 1 from Appendix U1 of the Mining Proposal.

Strathalbyn continued to rise in line with market expectations.[240] Government does not regulate matters of property value under the Mining Act. Government considers that potential impacts that could result in a decline in property value would likely be the same as those mentioned above that result in a negative visitor experience.

Government notes that if a lease is granted, Terramin would be required to achieve appropriate environmental outcomes for all identified environmental values. Further information of government's assessment of these environmental values is included in the respective chapters of this report.

Independent economic impact assessment and peer review

ERC define the economic impact of the project as:

- The economic contribution of the project
- The possibility of offsetting economic contribution linked to negative impacts of the mine development on existing or potential future land uses. [241]

The ERC report provides modelled projections of potential benefits and impacts on existing land use.

Potential negative economic impacts

To provide an indicative estimate of the potential extent of the negative impacts, ERC modelled that under a worst-case scenario, an expected value of 18 direct jobs could be lost in surrounding activities.

Table 23: Potential for offsetting impacts due to impacts on surrounding activities – total impact[242]

Assumed negative outcomes - relative to base	Probability of Occurence	Employment (FTE's)		Value Added/GRP ($m)	
		Direct	Total	Direct	Total
80-100%	0.0%	90	208	$7.7	$16.7
60-80%	1.9%	63	145	$5.4	$11.7
40-60%	9.8%	45	104	$3.9	$8.4
20-40%	25.8%	27	62	$2.3	$5.0
0-20%	62.4%	9	21	$0.8	$1.7
Probability weighted value	100%	18	42	$1.6	$3.4

[240] Table 8, Response 14 of the Response Document.
[241] Economic Research Consultants, 2017, *Economic Impact of the Bird in Hand Gold on South Australia, and Regions* – Appendix W1 of the Mining Proposal.
[242] Table 7 – Appendix W1 of the Mining Proposal.

Using multipliers from the RISE model[243] for the Adelaide Hills, adjusted as per the project impacts, for wine manufacturing and agricultural production and for food and beverage services, Table 23 shows expected results including multiplier or flow-through effects ie a consistent basis with the estimation of the project impact. A possible worse case base expected value scenario would be an offsetting loss of 42 jobs in total and $3.4 million of value added.

It is important to note that the worst-case scenario does not take into account the implementation of strategies to manage relevant impact events mentioned in the preceding part of this chapter. ERC's overall conclusion is that the risk to other economic activities in the area is low.

The peer review notes that:

"ERC's estimates of "offsetting" impacts, which effectively is an analysis of spill-over impacts on neighbouring businesses, is plausible although unavoidably speculative. This is because the scheme of probabilities adopted by ERC is necessarily dependent on speculative assumptions. ERC assumes a high probability of little or no impact and small probabilities of large impacts. This was reasonable, provided the regulatory system enforced the implementation of controls." [244]

Government considers it reasonable for ERC to assume that proposed mitigation measures would be successful in managing potential impacts on existing land uses.

If a lease is granted, Terramin would be required to abide by terms and conditions of the lease. A PEPR would have to be developed that clearly articulated how required environmental outcomes would be achieved and measured before it would be approved by Government. The regulatory framework of the Mining Act requires that all environmental outcomes are achieved. If operations were to commence the mine would be regulated in accordance with DEM's regulation, compliance and enforcement policy and provide an annual report demonstrating compliance with lease conditions and requirements of the PEPR.

Potential economic benefits

Economic benefits of the project are estimated to be:

- Gross revenues of $300 million, based on an assumption of a gold price of US$1,062 per ounce and a US/AUD exchange rate of 73¢.[245]. It is noted that the current gold price is significantly higher than what has been assumed.
- A total impact on gross state product of an estimated $220 million over 8 years, excluding the gross operating surplus of the Project itself.

[243] The RISE model is an input output model prepared for government on a regular basis to assist analysts understand the structure of the economy in the state and estimate economic impact of changes.
[244] Hancock, J, 2017, *Peer Review of ERC Economic Impact Analysis*, SA Centre for Economic Studies, Adelaide – Appendix W2 of the Mining Proposal.
[245] Note that the financial analysis used to inform the MP was based on precious metal prices of A$1,700/oz gold and A$22/oz silver. The mine was considered viable at these commodity prices. At the time of writing this report the gold price is A$2,581/oz gold and A$33/oz silver.

- This includes $191 million of estimated wages and salaries paid to households. Employment in operating roles reaching 140 persons in 2021 – in total 600 person years of employment, over a 5-year period.
- Payment of direct taxes of $37 million and royalties of $10.5 million (an assumed royalty rate of 3.5¢ per dollar of gross value). There is also an estimated payroll tax amount of $2.7 million over the life of the project. This does not include any estimate of corporate income tax as this is paid to the Commonwealth Government.
- Other operating expenditure is estimated at $45.7 million over the 5-year operating period, while there will be a total capital expenditure of $56.6 million, $29 million in the investment phase, and a further net of $26 million during operation and after operations are concluded.
- 60% of the impact is estimated to occur in the Adelaide Hills Council area, around Woodside (an estimated 1,425 person years of employment and peaking at 330 full time equivalent jobs), and 20% would be expected in the Fleurieu Peninsula, around Strathalbyn (500 person years of employment and peaking at 126 full-time equivalent jobs).

Table 24: Estimated employment by region[246]

Region	Year 1	Year 2	Year 3	Year 4	Year 5
Strathalbyn	5.2	29.2	44	44	44
Woodside	54.9	83.9	93	93	93
Adelaide	3.2	2.1	2	2	2
Total	63.3	115.3	140	140	140

Wine and mine analogues

ERC provided the Hunter Valley as an analogue of mining (large-scale coal mining) and agriculture coexisting. An economic study done on the Hunter Valley observed that the wine industry remained strong even with expansion of the region's mining industry.[247] In South Australia there are several examples of large quarries co-existing adjacent to wineries and vineyards. McLaren Vale Quarry is one of Adelaide's largest producers of construction materials and is located within 600 metres of Mollydooker Wines, and within 1km of five other wineries. The quarry has a fixed crushing and screening plant and produces over 100,000 tonnes of quarry products annually.

[246] Based on Table 24-7 from the Mining Proposal.
[247] Deloitte Access Economics, 2013, *Prospects and challenges for the Hunter region: A strategic economic study.* Regional Development Australia Hunter.

Conclusion

Government assesses that all environmental outcomes relevant to the continuation of existing land use can be achieved and that the mine would result in a net economic benefit to the state.

Government has assessed the following environmental values relevant to existing land use, groundwater, surface water, weeds and pests, traffic, air quality, noise, blast vibration and air overpressure and visual amenity. The assessment concluded proposed design and mitigation measures would result in achievement of all relevant outcomes, resulting in the opportunity for multiple land uses and adjacent industries to co-exist, if a lease was granted.

The independent economic impact assessment concluded that the risk to other economic activities would be low with the implementation of proposed controls. The independent peer review validated the modelling approach and assumptions made.

Economic modelling based on 2017 commodity prices shows that the proposed mine would contribute over $220 million to gross state product (GSP), which would be in addition to the GSP contributed by agriculture allowing both industries to jointly contribute to the state economy.

Chapter 13

Surface water

Introduction

Surface water use in the Woodside area is regulated by the LSA Act and relevant WAPs[248]. Any water captured and used for a prescribed purpose must be licenced or managed through an appropriate authorisation. Infrastructure near or within riparian zones may require a Water Affecting Activity permit prior to construction.

Water quality is regulated by the *Environment Protection Act 1993* and Environment Protection (Water Quality) Policy 2015 (Water Quality Policy).

Surface water outcome

Terramin have proposed an environmental outcome of:

"No adverse impact to the quantity or quality of water caused by the mining activities to existing and future licenced users and water-dependant ecosystems".

The outcome identifies existing users, future users and water dependant ecosystems as relevant receptors. The outcome appropriately states that mining operations should cause no adverse impact to receptors. The outcome identifies that both water quantity and quality must be considered. Government's assessment addresses each of these values below.

Refer to the Fourth Schedule of Appendix 5 for the recommended surface water outcome, should a lease be granted.

Existing watercourses, drainage and flow directions

There is an existing creek, Goldwyn Creek, which traverses the northern portion of the MC from the east to the west. Within the subject MC the creek is bounded by established vegetation, with only one discrete cleared area where a crossing has been formed. At the upstream end, beyond the eastern property boundary of the site, the watercourse is interrupted by an existing on-stream water storage (dam) located on the Petaluma Winery property. The watercourse continues under Pfeiffer Road in a west-north-west direction and ultimately discharges into Inverbrackie Creek, located west of the subject site.

There are two main catchments upstream from the proposed mine site. The largest of these (upstream creek catchment) drains into the creek that passes through the site. On the site's eastern boundary there is an existing channel that directs runoff from the adjacent Petaluma winery site into the creek. The smaller catchment (Bird in Hand Road catchment) drains through the south-western corner of the site and then passes through the adjacent property.

[248] Western Mount Lofty Water Allocation Plan and Eastern Mount Lofty Water Allocation Plan.

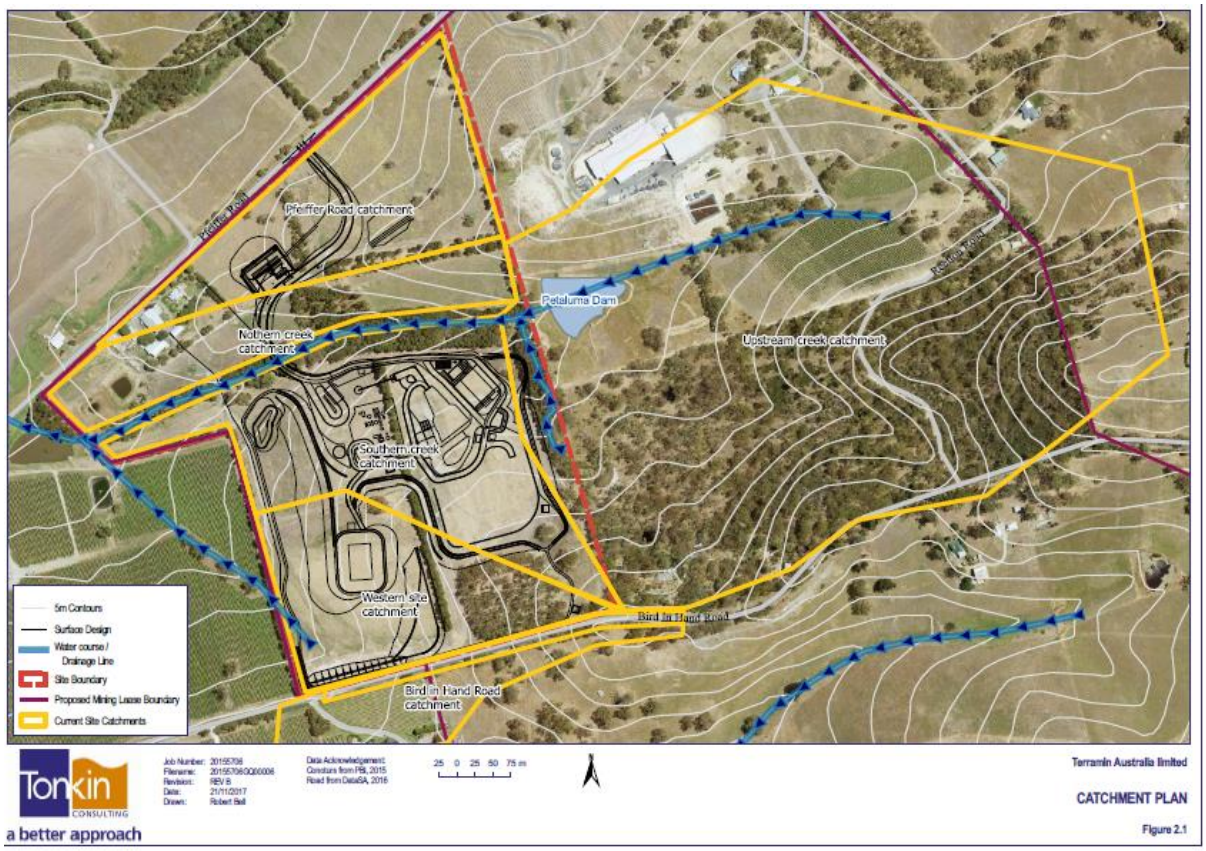


Figure 32: Catchment plan showing drainage lines near disturbed area[249]

A crest that runs from the south-eastern corner to the north-western corner of the MC creates a natural divide between the two catchments on the southern side of the creek. The eastern portion (Southern creek catchment) shown in Figure 32 drains directly into the creek, while the western portion (Western site catchment) currently drains into the adjacent property.

A ridge line passes through the section of the property to the north of the creek. This divides this region into the Pfeiffer Road catchment that drains northward towards Pfeiffer Road, and the Northern creek catchment, which drains southward into Goldwyn Creek that passes through the site.[250]

The MC contains two ephemeral drainage lines that flow with water generally less than one month in every year during winter, and only once dams located upstream have been filled and overflow. Inverbrackie Creek is part of the wider Onkaparinga River catchment and Mount Bold Reservoir, which drains to the Gulf of Saint Vincent via an estuary at Port Noarlunga. The far south-west corner of the MC forms part of the Dawesley Creek sub-catchment, which flows into Lake Alexandrina.[251]

[249] Tonkin, 2019, *Bird in Hand Gold Mine Stormwater Management Plan* – Appendix I3 of the Mining Proposal.
[250] Appendix I3 of the Mining Proposal.
[251] Summarised from Chapter 11 of the Mining Proposal.

Sensitive receptors

No users of Inverbrackie Creek were identified as reliant upon flow. The drainage lines that run through the MC are degraded. Monitoring has shown the presence of contaminates often above guideline limits and no sensitive or listed fauna readily identified – eg sensitive macroinvertebrates, fish, frogs or platypus. Nevertheless, the ecological values of the Inverbrackie Creek are considered a receptor in the assessment of potential impacts.

Potential impact assessment

Terramin confirmed potential impact events associated with contamination of surface water from either AMD from the IML, chemicals and/or hydrocarbons used onsite, and potential sediment transport from construction works and/or landforms to Inverbrackie Creek or adjacent agricultural properties.[252]

The potential for AMD has been reduced from the original proposal by relocation of the ventilation raise[253] to align with the decline, which avoids the supergene zone that was the largest contributor of PAF to the IML.[254] Government assesses that the source, pathway and receptor descriptions for confirmed surface water potential impact events are appropriately described and the consequence of the potential impact is significant, hence, an outcome is required.

Potential impacts to the Native Vegetation Heritage Agreement area, groundwater dependent ecosystems, listed fauna species and contamination of agricultural land via surface flows were not considered credible. Government assesses that there is no source, pathway, receptor link for these impact events, hence an outcome is not required.

Assessment of proposed design and mitigation measures

Terramin commissioned Tonkin to develop a stormwater management plan for the site.[255] Design and mitigation measures proposed in the plan are based on a 100-year average recurrence interval (ARI), which is used to describe the long-term average number of years between flood events. Use of a 100-year ARI for design is industry standard and as per the Adelaide Hills Council Development Plan that was in place at the time of application.

Surface water management has focused on the area of land within the MC shown in Figure 32 and has divided this area into specific catchments for management. Design measures focus on separating catchments into domains based on sources of potential contaminants. This allows for appropriate water treatment measures to be applied to relevant domains. Flood modelling was used to inform placement of development.

The retention portion of the pond has been designed to mimic the seasonal pre-development flow regime by retaining the additional volumes that are generated from the developed portions of the site and to provide additional water quality improvement. A high flow spillway

[252] Summarised from Chapter 11 of the Mining Proposal.
[253] Section 5.1 of the Response document
[254] Appendix M2 of the Mining Proposal.
[255] Appendix I3 of the Mining Proposal.

is also incorporated to allow the basin to safely discharge into the main creek that passes through the site during larger, extreme rainfall events.

The MP proposes direction of contaminated water to the treatment plant or other landscape features like swale systems, stormwater pits and wetlands. Water-sensitive urban design principles were used in the landscape design to manage runoff and reduce potential for sediment transport as shown in Figure 33.

Figure 33: Conceptual stormwater management plan[256]

[256] Figure 3.2 from Appendix I3 of the Mining Proposal.

Government assesses that the proposed design and management strategies would achieve the recommended surface water outcome.

Terramin propose the installation of live surface water quality monitoring at upstream and downstream locations on Inverbrackie Creek. Government recommends that the requirement for live monitoring at upstream and downstream locations is a requirement of the surface water measurement criteria in the PEPR, should a lease be granted.

Water licencing and permitting requirements

Surface water and watercourses are prescribed pursuant to the LSA Act. The WMLR WAP provides for the allocation and use of water, and for the transfer of and other dealings with water allocations.

Terramin have appropriately designed operations so that all contaminated water from the IML, workshop and concrete batch plant drains to a sump before being pumped to a turkey's nest dam for treatment. The MP states that this treated water may be used onsite.[257]

In accordance with the LSA Act, the taking of surface water for licensable purposes (including operations on-site) requires a water licence.

Based on current designs and information provided by Terramin, approximately 9 megalitres per annum of surface water could be captured and used for licensable purposes. Terramin will need to negotiate with other surface water licence holders and apply to transfer the required entitlement or allocation so that surface water can be used for licensable purposes.

It has been identified that there are options available under the water allocation plan to transfer this volume of water to the site, but formal approval will be subject to the relevant water licensing application(s) being made and a formal assessment by DEW against the WAP.

While the proposal is to use surface water for operational purposes, should a lease be granted, the detailed operational stormwater management plan to be finalised as part of the PEPR can allow for changes to meet WAP requirements, if necessary.

Government assesses that there is a reasonable prospect that Terramin can meet the requirements of the WAP through the options discussed above and that it is appropriate for surface water licencing to be assessed once the detailed operational stormwater management plan has been finalised in a PEPR, should a lease be granted.

Water affecting activities

The Hills and Fleurieu Landscape Board (the Board) has the regulatory responsibility to permit water affecting activities under section 104 of the LSA Act.

Any of the following activities will require a water affecting activity permit (WAAP) from the Board. To improve efficiency, one permit can be issued for multiple water affecting activities:

- s104(4)(a) Water diversion and storage – erection, construction, modification, enlargement, or removal of a dam, wall or other structure

[257] Chapter 11 of the Mining Proposal.

- s104(4)(b) Building a structure in a watercourse, lake or floodplain
- s104(4)(c) Drainage or discharge of water into a watercourse or lake
- s104(4)(d,e,f) Depositing objects or solid material in a watercourse, lake or floodplain
- s104(4)(g) Excavation or removal of rock, sand or soil from a watercourse, lake or floodplain
- s104(4)(h) Destroying vegetation growing in a watercourse or lake, or growing on the floodplain of a watercourse

Terramin will require a WAAP for construction of the road over the drainage line and, depending on the final stormwater management design, may require one for other water management structures.

Should a lease be granted, the application for and assessment of WAAP's would occur in parallel with the PEPR process.

Conclusion

Terramin have used appropriate methods to estimate potential runoff and flood risk on parts of the MC where surface infrastructure will be located. Effective control measures have been proposed with appropriate design parameters applied to manage flow associated with a high flow rain event and ensure any water discharged to the environment meets the requirements of the Water Quality Policy.

There is a reasonable prospect that Terramin can meet the requirements of the WAP through allocation transfer provisions or alternatively through altering the stormwater management plan.

Live surface water quality monitoring is proposed at upstream and downstream locations on Inverbrackie Creek, which can be used with an appropriate leading indicator to ensure achievement of the recommended surface water outcome, if a lease is granted.

Chapter 14

Other environmental values

Introduction

This chapter provides government's assessment of all other environmental values. The assessment of these values is not complex, so the assessment is focused only on assessment of the proposed outcome and government's recommended regulatory response.

Fauna

The MP[259] provided the results of fauna surveys undertaken within the MC[260]. Government assesses that fauna surveys were undertaken appropriately to allow for the assessment of potential impacts. Government confirms that the source(s), pathway(s) and receptor(s) would exist. The consequence of the potential impact is not insignificant; hence, an outcome is required.

Terramin have proposed the following environmental outcome relative to fauna:

"No fauna injuries or deaths (excluding pests) caused by mining activities that could reasonably have been prevented, due to construction, operation and closure activities".

The outcome describes that there will be no injuries or deaths to fauna that could have been reasonably prevented and notes the relevant stages of mining. Government considers closure activities to be operations. The outcome is appropriate for all confirmed potential fauna-related impact events.

Government assesses that the design and management strategies proposed in the MP are likely to result in achievement of the proposed and recommended outcome.

Refer to Appendix 5 for the recommended fauna outcome if a lease is granted.

Pest fauna

The MP provided results of pest and weed[261] surveys undertaken within the MC. Government confirms that the source(s), pathway(s) and receptor(s) would exist. The consequence of the potential impact is not insignificant; hence, an outcome is required.

[259] Chapter 18 of the Mining Proposal
[260] Appendix Q1 of the Mining Proposal.
[261] Chapter 19 of the Mining Proposal.

Terramin have proposed the following environmental outcome relative to weeds, plant pathogens and pest fauna:

"No introduction of new species of declared weeds, plant pathogens or pests (including feral animals), nor sustained increase in abundance of existing declared weed or pest species on the mining lease caused by mining activities".

The outcome is appropriate for all confirmed potential fauna related impact events. The outcome is assessed to be achievable given the proposed controls and identified assumptions and uncertainty.

Refer to the Fourth Schedule of Appendix 5 for the recommended weeds, plant pathogen and pests, should a lease be granted.

Native vegetation

The surface design requires no clearance of existing native vegetation as defined by the *Native Vegetation Act 1991* (SA). All proposed surface infrastructure has been designed to avoid and preserve significant River Red Gums (*Eucalyptus camaldulensis*) located within the Goldwyn property.

The site contains agroforestry trees located alongside the primary drainage line within the proposed site, as well as along primary fence lines. Species include New South Wales Spotted Gums (*Corymbia maculata*), Tasmanian Blue Gums (*Eucalyptus leucoxylon ssp.*) and Victorian Casuarinas *(Allocasuarina ssp.*).

Terramin propose to harvest two small areas of these agroforestry trees. This includes an area of approximately 50m x 30m to allow the construction of a culvert to gain heavy vehicle access to the site, and a single 150m line of New South Wales Spotted Gums (*Corymbia maculata*) to allow the water treatment area to be constructed.

The proposed clearance, an area of 0.24ha represents a small proportion of the existing 5.4ha of forestry plantings.[262]

The MP provided the results of vegetation surveys undertaken within the MC[263]. Government assesses that vegetation surveys were undertaken appropriately to allow for the assessment of potential impacts. Government confirms that the source(s), pathway(s) and receptor(s) identified for confirmed impact events would exist. The consequence of potential impacts is not insignificant; hence, an outcome is required.

Terramin have proposed the following environmental outcome relative to native vegetation:

"No permanent loss of abundance, condition or diversity of native vegetation (as defined by *Native Vegetation Act 1991*) on or off the lease caused by mining activities through:

- **clearance**
- **dust/contamination depositions**

[262] Chapter 3 of the Mining Proposal.
[263] Appendix Q1 of the Mining Proposal.

- **fire**
- **reduction in water supply, or**
- **other damage**

unless otherwise approved under Native Vegetation Act 1991 and Native Vegetation Regulations 2017 is obtained."

The outcome appropriately states the level of impact subsequent to controls. The outcome is assessed to be achievable given the proposed controls and identified assumptions and uncertainty.

Refer to the Fourth Schedule of Appendix 5 for the recommended native vegetation outcome, should a lease be granted.

Heritage

Aboriginal heritage

The MP provided the results of a search of the register maintained by the Aboriginal Affairs and Reconciliation Branch of the Department of Premier and Cabinet, which holds records of previously recorded heritage sites in South Australia. No sites are registered in the project area.[264] The register is not an exhaustive list and there is still potential that any land disturbance could uncover Aboriginal heritage.

Government confirms that a source(s), pathway(s) and receptor(s) would exist. The consequence of the potential impact is not insignificant; hence, an outcome is required.

Terramin have proposed the following environmental outcome relative to Aboriginal heritage:

"No disturbance to Aboriginal heritage sites, objects or remains, unless prior approval is obtained from the relevant minister, pursuant to the Aboriginal Heritage Act 1988."

The outcome appropriately states the level of impact subsequent to controls. The outcome is assessed to be achievable given the proposed controls and identified assumptions and uncertainty.

Refer to the Fourth Schedule of Appendix 5 for the recommended Heritage outcome, should a lease be granted.

Non-Aboriginal heritage

The MP provided details of existing mining heritage located within the MC. The battery and chimney stack associated with the Lone Hand Mine in the northern section of the MC are protected as a registered Heritage Place (Heritage Number 15253).

Terramin have proposed the following environmental outcomes relative to confirmed potential impact on non-Aboriginal heritage:

[264] Chapter 20 of the Mining Proposal.

"No disturbance to non-Aboriginal heritage sites or objects, unless prior approval is obtained from the relevant minister, pursuant to the *Heritage Places Act 1993*."

The outcome appropriately states the level of impact subsequent to controls. The outcome is assessed to be achievable given the proposed controls and identified assumptions and uncertainty.

Refer to the Fourth Schedule of Appendix 5 for the recommended Heritage outcome, should a lease be granted.

Land and soil

The MP provided results of soil surveys and an erosion assessment undertaken within the MC. Government confirms that the source(s), pathway(s) and receptor(s) would exist for confirmed potential impact events. The consequence of confirmed potential impact events are not insignificant; hence, an outcome is required.

Terramin have proposed the following environmental outcomes relative to land and soil:

1. **"No adverse impacts to soil quality or quantity on surrounding land caused by mining activities."**
2. **"No adverse impacts to soil quality or quantity within the mining lease caused by mining activities that could compromise the post mining land use."**
3. **"All land on the mining lease affected by mining and associated activities is rehabilitated to achieve the agreed post mining land use."**
4. **"No adverse impacts to public health as a result of any contaminated material from land disturbed by mining activities."**

Proposed outcome (1) refers to potential impact events associated with erosion and transport of sediment from the proposed mine to surrounding land. Government assesses that it is appropriate that this potential impact is managed through the proposed surface water outcome. Refer to Chapter 13 for the assessment of surface water potential impact events, proposed controls and outcome.

Proposed outcome (2) appropriately states the level of impact subsequent to controls. The outcome is assessed to be achievable given the proposed controls and identified assumptions and uncertainty. Refer to the Fourth Schedule of Appendix 5 for the recommended land and soil outcomes, should a lease be granted.

Government considers proposed outcome (3) a strategy and does not recommend this as an outcome. Rehabilitation designs and strategies to achieve the post mining land use will be developed in the PEPR in consultation with community, should a lease be granted.

Proposed outcome (4) refers to potential impacts to public health associated with disturbance of contaminated soil zones identified near and adjacent to the creek line and within areas of known historic mining activities (Ridge Mine).[265] The MP included a Site

[265] Figure 14-25 from Chapter 14 of the Mining Proposal.

Contamination Management Plan (SCMP),[266] which includes designated soil management zones with specific management options to reduce or prevent disturbance of these soils. Proposed outcome (4) appropriately states the level of impact subsequent to controls. The outcome is assessed to be achievable given the proposed controls and identified assumptions and uncertainty.

Refer to the Fourth Schedule of Appendix 5 for the recommended land and soil outcomes, should a lease be granted.

Public safety

Proposed mining has the potential to impact on public safety through an increase in dust, traffic and blasting. All these potential impacts were assessed in relevant chapters of this report. The mine site is also a potential source of fire, which could create a public safety risk, especially given its proximity to large areas of native vegetation.

Members of the public could also be injured through unauthorised access to the site.

Government confirms that the source(s), pathway(s) and receptor(s) would exist for confirmed potential impact events. The consequence of confirmed potential impact events are not insignificant; hence, an outcome is required.

Terramin proposed following environmental outcomes relative to public safety:

1. **"No public injuries or fatalities as a result of unauthorised access to the mining lease."**
2. **"No public injuries and/or deaths resulting from unauthorised entry to the operating site."**
3. **"No public injuries or deaths as a result of fires originating in the proposed mining lease that could have been reasonably prevented."**

The outcomes appropriately state the level of impact subsequent to controls. The outcomes are assessed to be achievable given the proposed controls and identified assumptions and uncertainty. DEM recommends that the proposed outcomes include relevant phases of mining and align with published model outcomes for public safety.[267]

Refer to Appendix 5 for the recommended public safety outcomes, should a lease be granted.

[266] Golder Associates, 2017, *Soil Contamination Management Plan* – Appendix L4 of the Mining Proposal.
[267] MG 30 - Developing outcomes for quarrying and mining

Chapter 15

Miscellaneous purposes licence application (MPLA)

Introduction

Terramin propose that ore from the ML at Woodside will be processed by the multi-stage flotation plant at the AZM processing facility. The AZM processing facility is located entirely within the proposed MPL area and consists of a crushing plant, processing plant, the existing tailings storage facility, workshops, stores, laydown areas, offices, magazines, laboratories and change rooms.

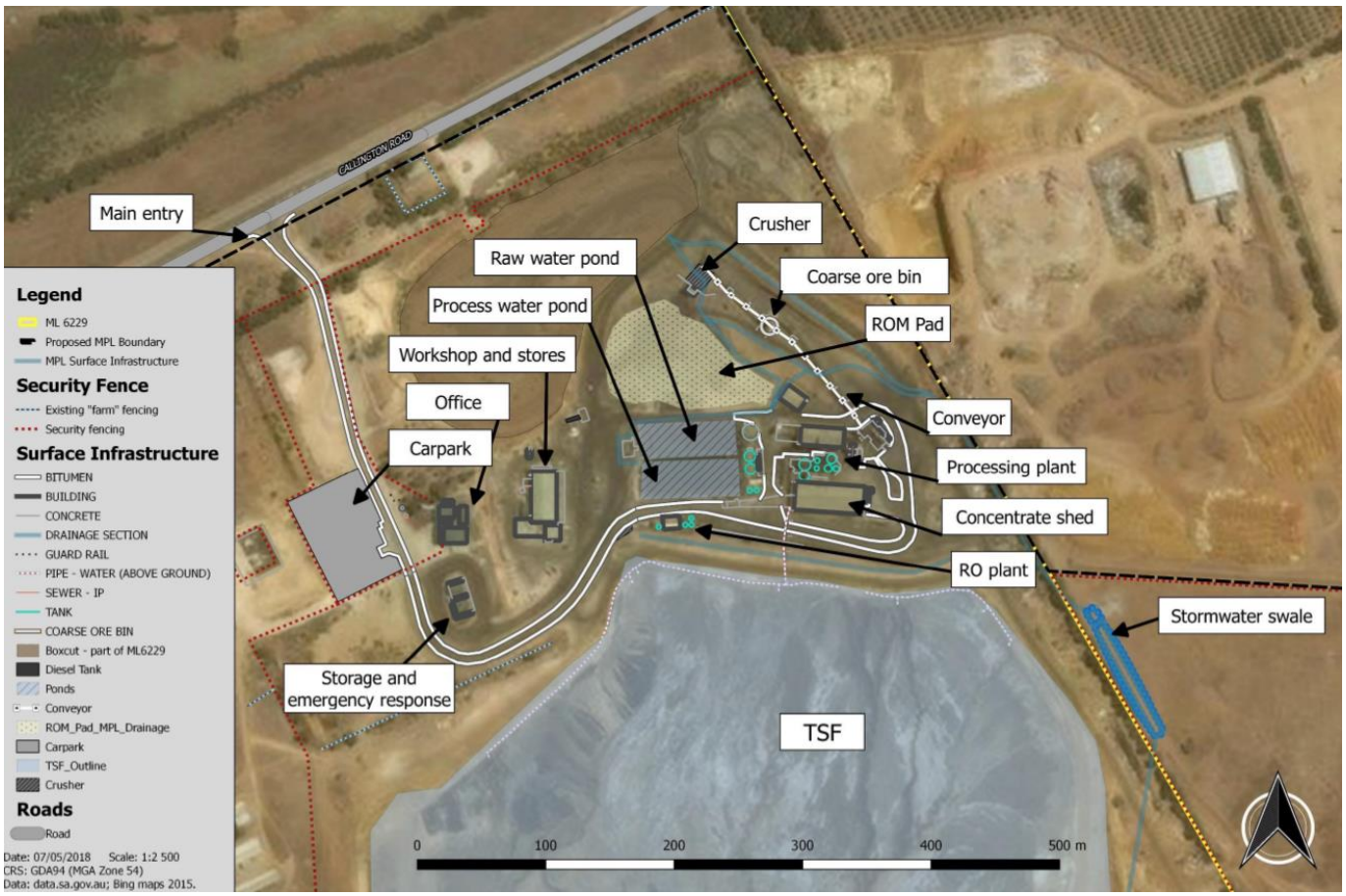


Figure 34 – Angas Mine site processing facility layout [268]

[268] Figure 3-31, Chapter 3 of the MPLA.

The facilities have been under care and maintenance since late 2013. Reinstatement and refurbishment of the existing processing plant infrastructure is expected to take 12 months.

Originally designed and constructed for the processing of lead and zinc from the AZM, Terramin propose that the plant can be switched over to a gold flotation plant, with little modification required, using as much of the existing infrastructure as possible. The first load of ore to the processing facility is expected to occur approximately 16 months after starting the underground mining activities at Woodside (Year 2 of operations). Processing is then expected to continue for 5 years followed by 27 months of rehabilitation and closure activities. The AZM processing plant has a capacity of 400,000 tonnes per annum, which provides adequate capacity to handle the proposed production rate of 130,000 tonnes per annum.[269]

Description of processing operations

The processing of the ore consists of the following activities:

- **Crushing** – Ore is fed to the crushing plant using a front end loader from site stockpiles on the ROM. Crushing activities are proposed to occur between 7:00 am and 10:00 pm on a campaign basis of 10-14 days per month, on a two-week-on, two-week-off basis.
- **Grinding** – Milling the crushed ore reducing its size.
- **Flotation** – Concentration of base metal sulphide and oxide ores using dry powder reagents, frothers and water. Flocculants are added before transferring to thickeners.
- **Thickening** – Concentrate slurry and the waste (tailings) slurry are pumped to separate thickeners to allow solids to settle and compact to yield high solids concentration (underflow) before being pumped to the next part of the process. The excess water generated (overflow) is recycled back into the process. The overflows from the concentrate and tailings thickeners are sent to the process water pond. The tailings thickener underflow is sent to the TSF.

[269] Chapter 3 of the MPLA.

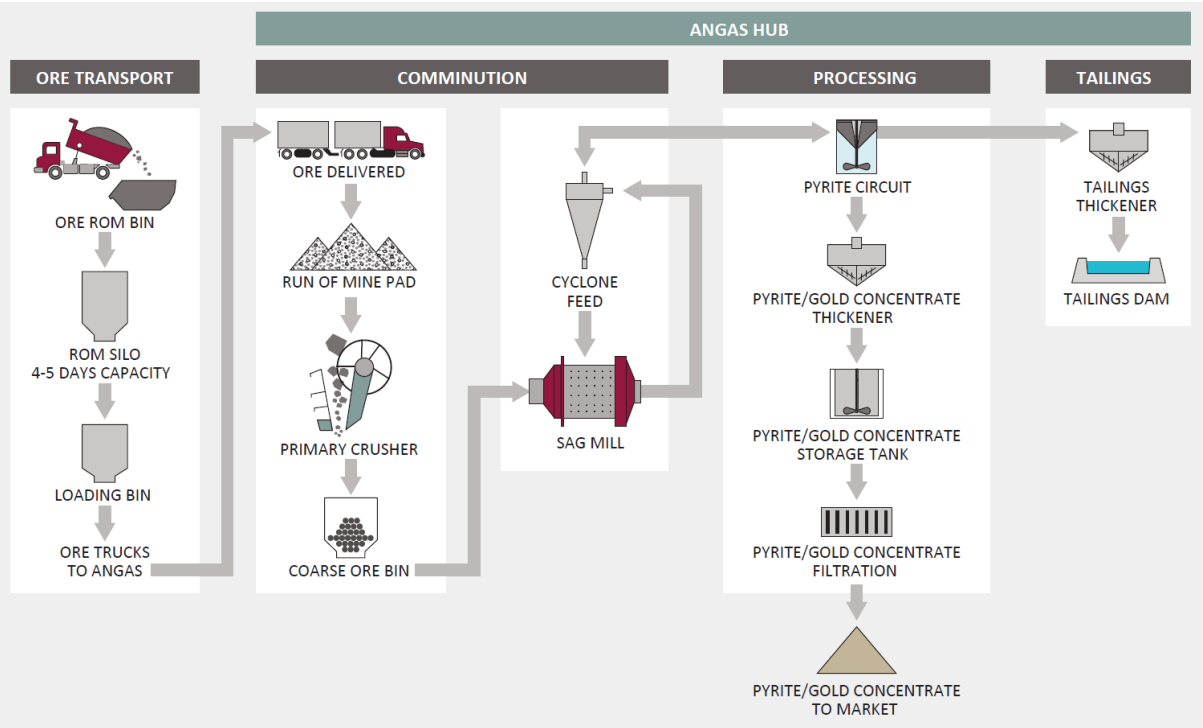


Figure 35: Proposed Angas Gold ore processing from arrival to product[270]

The thickened concentrate slurries resulting from the processing are then filtered using vacuum filtration, drawing moisture out of the concentrate. Dilute nitric acid used in this process is absorbed into the concentrate and transported to Port Pirie or Port Adelaide for further processing. The recovery of saleable gold and other trace metals (silver, copper etc) through smelting operations are expected to occur off-site by the downstream customer.[271]

The site is divided into operational and non-operational zones to effectively manage potential land and water contamination. The operational zone is designed to drain towards the process pond drains to enter the water treatment and processing water circuit, or towards the boxcut, where it is intercepted by a sump and pump system. The ROM pad, previously utilised for Angas operations is located in the operational zone and is already constructed as a lined pad and designed so all drainage from it runs into a sump where it can be pumped out for water treatment.[272]

The processing area is contained within concrete bunds. Pumps are located within each bund to allow any spills to be pumped back into relevant areas, creating a closed circuit.[273]

Disposal of Bird in Hand tailings

Processing is expected to produce approximately 522,000 tonnes of tailings. The original TSF design for AZM was developed by ATC Williams and constructed in 2007. Since then,

[270] Appendix C3 of the MPLA.
[271] Chapter 3 of the MPLA.
[272] Summarised from Chapter 13 of the MPLA.
[273] Chapter 3 of the MPLA.

annual inspections of the condition and integrity of the dam have been undertaken with the results reported to Government in the annual Compliance Report. Terramin commissioned ATC Williams as the TSF designer to assess the capacity of the TSF to receive tailings from the Bird in Hand project.

The assessment considered its location, characteristics, storage capacity and flood levels confirming its appropriateness for deposition of tailings from the Bird in Hand project. Some modification is expected with the construction of a causeway to the TSF required to allow for even distribution of tailings into the dam.[274] The MP outlines a plan for placing some PAF waste rock from the AZM within the TSF before depositing tailings from the Bird in Hand project.

The tailings management designs and plans presented to date are preliminary (MPL Proposal Appendix I2) and must be updated to detailed designs and plans in accordance with the latest relevant standards (should a licence be granted). A comprehensive set of conditions are recommended that align with commitments made by Terramin in the Response Document and recommendations made by Terramin's consultant ATC Williams in Appendix O1 of the Response Document. Specific conditions require additional assessment and optimisation of the operational designs associated with the placement of PAF waste rock within the TSF.

In line with DEM Mineral Policy 007 – Mining Act tailings and regulation standards March 2021 (or any subsequent update to the policy or department name), the condition set includes processes for governance involving design, construction, operations and closure independent auditing. The condition set acknowledges and aligns with the TSF closure planning that has already been undertaken and set out in the Angas Zinc Mine PEPR (dated May 2017).

Refer to Appendix 6 for recommended TSF conditions and requirements for the PEPR, should a licence be granted.

Geochemical assessment

A geochemical assessment was completed and included within the application. The objectives of the assessment were to:

- Evaluate the geochemical interactions over time between the existing tailings contained within the TSF at AZM and the tailings produced by the Bird in Hand Gold Project.
- Assess the potential environmental effects resulting from those geochemical interactions and the interaction of the products on the TSF's lining.
- Assess how the net acid generating potential of the existing Angas tailings might change due to the addition of tailings from processing of Bird in Hand ore.[275]

Static geochemical testing undertaken indicates that the tailings from Bird in Hand ore have moderate to high acid neutralising capacity (ANC). Mass-balance calculations suggest that

[274] ATC Williams, 2017, *Bird in Hand Gold Mine Preliminary Tailings and Water Management Study* – Appendix I2 of the MPLA.
[275] AECOM, 2017, *Technical Memorandum - Geochemical Interactions between Zn/Pb Sulphide and Gold Oxide Tailings* – Appendix M7 of the MPLA.

the deposition of 456,000 tonnes of Bird in Hand tailings into the AZM TSF would result in the minimum addition of approximately 31,180 tonnes of equivalent calcium carbonate for acid neutralisation.

The assessment found that the addition of tailings from the Bird in Hand project would reduce the net acid producing potential value of the existing tailings in the TSF by approximately 4%, thereby having a positive impact on the acid-forming characteristic of the existing tailings in the AZM TSF.[276]

The geochemical assessment concluded that the deposition of Bird in Hand tailings into the Angas TSF will not adversely impact or increase the geochemical risk profile of the existing tailings or result in conditions that would cause degradation of the TSF liner and associated seepage drain systems from a geochemical context. The addition of tailings from the Bird in Hand project is expected to reduce the net acid generating potential of the existing tailings in the AZM TSF and help improve pore water quality, should a licence be granted.

Environmental values

The MPLA is proposed over the existing mining lease (ML 6229), which is currently regulated through a PEPR, approved on 16 August 2017. The PEPR was developed through extensive engagement with government and the community through the SCCC. It includes detailed closure designs and obligations for long-term monitoring post mine completion before the lease can be surrendered.

Government assesses that the proposed activities associated with the MPLA, apart from the changes to the processing plant and make up of tailings, are largely consistent with mining operations regulated through the approved PEPR.

Terramin have proposed environmental outcomes that align with those within the approved PEPR. Government notes that ML 6229 was granted in 2006. Since then, the PEPR was reviewed four times, the last being the closure PEPR approved in 2017.

While the intent of proposing outcomes approved in the PEPR is understood, government assesses that it is appropriate for contemporary environmental outcomes to be recommended for the licence, where required, should it be granted.

Table 25 below provides DEM's assessment of proposed outcomes, specifically noting whether a contemporary outcome is required.

Table 25: DEM assessment of outcomes proposed in the MPLA

Proposed outcome	Government assessment
Public safety	
No public injuries and/or deaths to members of the public caused by mining operations.	Government confirms that the source(s), pathway(s) and receptor(s) would exist. The consequence of the potential impact is not insignificant; hence, an outcome is required.

[276] Summarised from Appendix M7 of the MPLA.

Proposed outcome	Government assessment
	The outcome appropriately states the level of impact subsequent to controls. The outcome is assessed to be achievable given the proposed controls and identified assumptions and uncertainty. Refer to Appendix 6 for the recommended outcome, should a licence be granted.
Traffic	
No adverse impacts offsite are caused by accidents, noise, dust and dragout by traffic from or to the mine operations that could have been reasonably prevented.	Government confirms that the source(s), pathway(s) and receptor(s) would exist. The consequence of the potential impact is not insignificant; hence, an outcome is required. The outcome appropriately states the level of impact subsequent to controls. Government assesses that this outcome is updated to contemporary standards and recommend a specific outcome to manage potential accidents at the access point. The recommended outcomes are assessed to be achievable given the proposed controls and identified assumptions and uncertainty. Refer to Appendix 6 for the recommended outcomes, should a licence be granted.
No impacts to third-party infrastructure caused by mining operations.	Terramin have an outcome relevant to traffic impacts on the existing road, however the impact assessment has concluded that there are no confirmed impact events as estimated traffic is within the capacity of the road system. Government have assessed the potential impact assessment and confirm that the source(s), pathway(s) and receptor(s) would not exist, hence, an outcome is not required.
Visual amenity	
No public nuisance or amenity impacts caused by lighting from the mining operations.	Government confirms that the source(s), pathway(s) and receptor(s) would exist. The consequence of the potential impact is not insignificant; hence, an outcome is required. The outcome appropriately states the level of impact subsequent to controls. The outcome is assessed to be achievable given the proposed controls and identified assumptions and uncertainty. Refer to Appendix 6 for the recommended outcome, should a licence be granted.

Proposed outcome	Government assessment
No impact to visual amenity caused by rubbish from mining operations.	Government assesses there to be a confirmed pathway for this outcome. The site is located immediately adjacent to a licenced landfill to the east. Rubbish from mining operations is not likely to result in any additional impact to visual amenity. Should a licence be granted, details on waste management will be a PEPR requirement. Government notes that waste management is adequately described and managed through the current approved PEPR for ML 6229.
Groundwater	
No adverse impact to the supply or quality of water caused by the mining operations to existing users and water dependant ecosystems.	Government confirms that the source(s), pathway(s) and receptor(s) would exist. The consequence of the potential impact is not insignificant; hence, an outcome is required. The management of groundwater impacts has been extensively assessed by government as part of the PEPR approval. Government recommends a contemporary groundwater outcome in place of the outcome proposed. The recommended outcome is assessed to be achievable given the proposed controls and identified assumptions and uncertainty. Refer to Appendix 6 for the recommended outcome, should a licence be granted.
No contamination of natural water drainage systems, streams and rivers, groundwater, land and soils occurs either on or off site resulting from permanent disposal or temporary storage of mine ore or waste material.	Government assesses that this outcome proposed by Terramin for groundwater is more appropriate to the management of potential impacts associated with the disposal of tailings as a waste outcome. A more appropriate groundwater outcome has been recommended as per above assessment. Regarding waste, this outcome appropriately states the level of impact subsequent to controls. The recommended outcome is assessed to be achievable given the proposed controls and identified assumptions and uncertainty. Refer to Appendix 6 for the recommended waste outcome, should a licence be granted.
Surface water	
No adverse impact to the supply or quality of water caused by the mining	The management of groundwater impacts has been extensively assessed by government as part of the existing ML PEPR approval. Government considers the proposed outcome, which

Proposed outcome	Government assessment
operations to existing users and water dependant ecosystems.	aligns with the outcome in the current PEPR appropriate, however contemporary alterations are proposed. Government recommends that the outcome include relevant stages of the activity and refer to quantity and quality rather than supply. Government confirms that the source(s), pathway(s) and receptor(s) would exist. The consequence of the potential impact is not insignificant; hence, an outcome is required. The outcome appropriately states the level of impact subsequent to controls. The outcome is assessed to be achievable given the proposed controls and identified assumptions and uncertainty. Refer to Appendix 6 for the recommended outcome, should a licence be granted.
Soil and land	
No adverse impacts on soil quality or quantity caused by mining operations.	Government confirms that the source(s), pathway(s) and receptor(s) would exist. The consequence of the potential impact is not insignificant; hence, an outcome is required. The outcome appropriately states the level of impact subsequent to controls. The outcome is assessed to be achievable given the proposed controls and identified assumptions and uncertainty. Refer to Appendix 6 for the recommended outcome, should a licence be granted.
Geochemistry (Closure)	
Post mine completion all mining operations left in a stable, non-polluting state indefinitely.	Government confirms that the source(s), pathway(s) and receptor(s) would exist. The consequence of the potential impact is not insignificant; hence, an outcome is required. The outcome appropriately states the level of impact subsequent to controls. The outcome is assessed to be achievable given the proposed controls and identified assumptions and uncertainty. Refer to Appendix 6 for the recommended outcome, should a licence be granted.
Air quality	
No public nuisance impacts to local residents from dust, air emissions	Government confirms that the source(s), pathway(s) and receptor(s) would exist. The consequence of the potential impact is not insignificant; hence, an outcome is required.

Proposed outcome	Government assessment
and/or odour caused by mining operations.	The outcome does not include public health as a receptor. Government assesses that potential impacts on public health are confirmed and recommends the outcome incorporates both public health and nuisance. The recommended outcome is assessed to be achievable given the proposed controls and identified assumptions and uncertainty. Refer to Appendix 6 for the recommended outcome, should a licence be granted.
Noise	
No public nuisance impacts from noise, vibration and air over pressure caused by mining operations.	The MPLA does not propose blasting, hence it is not appropriate to include vibration and air overpressure in the outcome. Government confirms that the source(s), pathway(s) and receptor(s) would exist. The consequence of the potential impact is not insignificant; hence, an outcome is required. The outcome appropriately states the level of impact subsequent to controls. The outcome is assessed to be achievable given the proposed controls and identified assumptions and uncertainty. Refer to Appendix 6 for the recommended noise outcome, should a licence be granted.
Native fauna	
No net adverse impacts from the mining operations on the native fauna.	Terramin have proposed outcomes for fauna, however the impact assessment has concluded that there are no confirmed impact events. Government confirms that the source(s), pathway(s) and receptor(s) would exist. The consequence of the potential impact is not insignificant; hence, an outcome is required.
Native vegetation	
No permanent loss of abundance, condition or diversity of native vegetation (as defined by *Native Vegetation Act 1991*) caused by mining operations.	Government confirms that the source(s), pathway(s) and receptor(s) would exist. The consequence of the potential impact is not insignificant; hence, an outcome is required. The outcome appropriately states the level of impact subsequent to controls. The outcome is assessed to be achievable given the proposed controls and identified assumptions and uncertainty. Refer to Appendix 6 for the recommended outcome, should a licence be granted.
Weeds, pests and pathogens	

Proposed outcome	Government assessment
No introduction of new species of declared weeds or pests (including feral animals), or sustained increase in abundance of existing declared weed or pest species caused by mining operations.	Government confirms that the source(s), pathway(s) and receptor(s) would exist. The consequence of the potential impact is not insignificant; hence, an outcome is required. The outcome appropriately states the level of impact subsequent to controls but omits reference to pathogens. Government recommends that the outcome include plant pathogens as a potential impact for this has been confirmed. The recommended outcome is assessed to be achievable given the proposed controls and identified assumptions and uncertainty. Refer to Appendix 6 for the recommended outcome, should a licence be granted.
Heritage	
No impact to heritage sites, places, remains or objects caused by mining operations without prior authorisation under the *Aboriginal Heritage Act 1988* and/or the *Heritage Places Act 1993*.	Government confirms that the source(s), pathway(s) and receptor(s) would exist. The consequence of the potential impact is not insignificant; hence, an outcome is required. The outcome appropriately states the level of impact subsequent to controls. The outcome is assessed to be achievable given the proposed controls and identified assumptions and uncertainty. Government recommends that the proposed outcome is updated to align with contemporary standards. Refer to Appendix 6 for the recommended outcome, should a licence be granted.

Conclusion

Government considers that the proposed activities associated with the MPLA apart from the changes to the processing plant and make up of tailings are largely consistent with authorised operations regulated through the approved PEPR. Government has assessed potential impacts associated with proposed processing activities and consider that appropriate environmental outcomes can be achieved in a revised PEPR, should a licence by granted.

The addition of tailings from the Bird in Hand project is expected to reduce the net acid generating potential of the existing tailings in the AZM TSF and help improve pore water quality.

Chapter 16

Conclusion

Terramin and stakeholders including community members have identified potential impacts associated with the application. Government has assessed the potential impacts of proposed mining operations and authorised operations based on the information provided in Terramin's application, all public submissions, the response document and other relevant evidence.

The draft Groundwater Chapter was independently peer reviewed by the CSIRO and government's recommendations endorsed.

The assessment concludes that with effective mitigation and management strategies implemented to control impacts, proposed operations can be undertaken in an environmentally responsible manner.

All duties and requirements of the Mining Act and Mining Regulations have been considered and appropriately addressed. Appendix 1, 2, 3 and 4 outline each Act and Regulation duty and requirement and set out how they have been addressed.

Assessment of ML term

It is recommended that should the mining lease be granted, the lease be subject to a term of 16 years based on the following:

Time to prepare initial PEPR	2 years
Construction stage	2 years
Mining and ore production	5 years
Rehabilitation and closure	1 year (estimate only and subject to change)
Post-closure monitoring	5 years (estimate only and subject to change)
Mine completion and surrender	1 year (estimate only and subject to change)
Total	**16 years**

The recommendation for a term of 16 years is based on the estimated production rate shown in Table 2 of this report. The 5-year timeframe for post-closure monitoring has been estimated to allow sufficient time to demonstrate achievement of closure outcomes as per Table 26. Should a lease be granted, the mine completion criteria will be finalised in the PEPR. It is important that appropriate time is allowed for required closure and completion monitoring or studies as per Table 26.

Table 26: Proposed closure monitoring and estimated timeframes

Proposed Monitoring	Estimated timeframe
Groundwater quantity and quality monitoring	Residual drawdowns have been modelled 5 years post closure under the 70% and 90% grouting effectiveness scenarios. Controlled inundation was also modelled and showed that groundwater levels would reach equilibrium in 80 days under the 70% grouting effectiveness scenario. It is appropriate that groundwater levels at receptor bores and quality are monitored for a minimum of 5 years post completion to demonstrate long-term achievement of the groundwater outcome.
Geotechnical surveys of land subsidence post backfilling of underground areas	Terramin proposes survey monitoring over a 2-year period to demonstrate no subsidence due to underground voids.
Revegetation monitoring using landscape function analysis	For the purpose of determining the term of the lease, government considers a minimum of 5 years an appropriate monitoring period to assess trends and demonstrate achievement of the land stability outcome. However, this timeframe is subject to change based on additional details that would be provided in a PEPR (should a lease be granted).
Surface water quantity and quality	Once rehabilitated, monitoring of the final landform will be required over at least a 5-year period to demonstrate achievement of the surface water outcome. However, this timeframe is subject to change based on additional details that would be provided in a PEPR (should a lease be granted).

Assessment of MPL Term

The MPL is proposed over the existing ML 6229, which is regulated through a PEPR approved on 16 August 2017. The PEPR was developed through extensive engagement with government and the community through the SCCC. It includes detailed closure designs and obligations for long-term monitoring post mine completion before the lease can be surrendered.

Government assesses that the proposed activities associated with the MPL application apart from the changes to the processing plant and make up of tailings are largely consistent with mining operations and closure obligations regulated through the approved PEPR.

Terramin submitted an agreement pursuant to section 80 of the Mining Act that sets out how the proposed MPL and existing tenements will operate together. The agreement confirms that Terramin will complete any rehabilitation required under the MPL area and existing tenements outlined in the PEPR. The approved PEPR requires post-closure monitoring of 10-20 years in relation to the TSF.

Should a licence be granted, the approved PEPR must be updated to incorporate the MPL with associated outcome measurement criteria.

It is recommended that should the MPL be granted, the licence term align with both the Bird in Hand Gold Project processing timeframes and closure monitoring obligations of the underlying ML 6229 (Angaz Zinc Mine) as follows:

Time to prepare initial PEPR	2 years
Construction stage	2 years
Bird in Hand mining and ore production	5 years
Closure and monitoring	21 years
Total	**30 years**

Project timing

Terramin has advised government that it has advanced its internal evaluation processes such that it envisages the completion of the Bird in Hand feasibility study and decision to mine within 12 months of the granting of the ML. [277]

Government recommends that should a lease and licence be granted, both include a condition requiring that Terramin must submit a proposed PEPR for the purpose of Part 10A of the Act within 24 months after the grant of the tenements or within such longer period of time as the Director of Mines or other authorised officer may allow.

Recommendations

The Government assessment recommends:

1. That in accordance with the requirements of the *Mining Act 1971*, the Minister for Energy and Mining (or delegate) considers, on the basis of the application, the results of public statutory consultation, the response document, the government assessment and any other relevant information, whether or not to grant a mining lease and a miscellaneous purposes licence to Terramin.
2. That if a decision is made to grant a mining lease and a miscellaneous purposes licence to Terramin, the body of recommended terms, conditions, requirements and clauses identified in Appendix 5 and 6 of this Assessment Report become legal requirements of the Lease and Licence.

[277] Table 4, response to matter 79 of the Response Document.

Other legislative requirements

Landscapes South Australia Act 2020

Authorised operations approved under the *Mining Act 1971* are required to comply with the requirements of the *Landscape South Australia Act 2019*.

Prescribed water resources are managed to ensure water use in these areas is sustainable. They are managed under the LSA Act and include the issuing of water licences that provide what is called a water access entitlement to the holder of the licence.

In the location of the proposed mine, water resources, both surface and groundwater are prescribed under the LSA Act. Water use is managed and regulated through the WMLR WAP.

Refer to Chapter 4 for information on groundwater licencing and permitting requirements.

Refer to Chapter 13 for information on surface water licencing and permitting requirements.

Environment Protection Act 1993

The *Environment Protection Act 1993* (EP Act) and supporting Environment Protection Policies include limits that are used by government to regulate air quality, noise and water quality in South Australia.

Section 35 of the EP Act outlines the requirements for works approvals, including for manufacturing and mineral processing. Section 36 of the EP Act requires that works to construct a building or structure for use for an activity of environmental significance must not be undertaken without an environmental licence.

Mining lease application

The following activities of environmental significance are proposed:

- Schedule 1 – 1 – Petroleum and Chemical (5) - Fuel storage facilities providing capacity for up to 50,000 L of storage will be established at the proposed project site.
- Schedule 1 – 2 - Manufacturing and Mineral Processing (5) - A concrete batching plant will be established on site to supply all concrete required for progressively backfilling the underground.

MPL application

The following activities of environmental significance are proposed:

- Schedule 1 – 1 – Petroleum and Chemical (5) Fuel storage facilities providing capacity for up to 50,000 L of storage exist at the proposed project site.

- Schedule 1 – 2- Mineral Works (9) Mineral works to processing gold ore to produce a gold mineral concentrate.

Environment Protection and Biodiversity Conservation Act 1999 (EPBC Act)

Under the provisions of the Commonwealth EPBC Act, actions that have, or are likely to have, a significant impact on a matter of national environmental significance (MNES) require approval from the Australian Government Minister for the Environment. The nine MNES to which the EPBC Act applies are:

- World Heritage properties
- National Heritage places
- Ramsar wetlands of international importance
- Threatened species and ecological communities
- Migratory species
- Nuclear actions
- Commonwealth marine areas
- The Great Barrier Reef Marine Park
- A water resource, in relation to coal seam gas development and large coal mining development.

A referral of the proposed ML pursuant to section 68 of the EPBC Act was made to the Commonwealth Department of the Environment and Energy on 20th October 2017, specifically in regard to a small population of *Caladenia Rigida* located in the Native Vegetation Heritage Agreement Area. *Caladenia Rigida*, or more commonly known as the Stiff White Spider Orchid, is listed as endangered under the EPBC Act. The proposed ML was declared to be not a controlled action on the 7 February by the Commonwealth[278].

Native Vegetation Act 1991

Mining lease application

The surface design requires no clearance of existing native vegetation as defined by the *Native Vegetation Act 1991* (SA). All proposed surface infrastructure has been designed to avoid and preserve significant River Red Gums (*Eucalyptus camaldulensis*) located within the Goldwyn property.

[278] Letter - Decision on referral Bird in Hand Gold Project – Appendix R3 of Mining Proposal.

MPL application

No additional native vegetation clearance is required for the handling, treatment or processing of BIH ore at the AZM Processing Facility as existing infrastructure from the AZM operation is utilised within the existing footprint.

A new wetland system will be installed in the eastern paddock to manage clean storm water from the site, however, this will not require any clearance of vegetation as detected during the site vegetation surveys undertaken to date.

Aboriginal Heritage Act 1988

The Central Archive, which includes the Register of Aboriginal Sites and Objects, administered by the Department for Premier and Cabinet–Aboriginal Affairs and Reconciliation Division, has no entry for Aboriginal sites in the MC.

The proposed ML and MPL may include areas of Aboriginal heritage significance that have not been discovered or entered on the Register. An appropriate environmental outcome and draft measurement criteria have been proposed in the MP reflecting the obligations for notification and authorisation required by the *Aboriginal Heritage Act 1988*.

Native Title (South Australia) Act 1994

The ML and MPL applications are both over freehold land in which Native Title has been extinguished. The *Native Title (South Australia) Act 1994* does not apply in this instance.

Heritage Places Act 1993

The MP provided details of existing mining heritage located within the MC. The battery and chimney stack associated with the Lone Hand Mine in the northern section of the MC are protected as a registered Heritage Place (Heritage Number 15253).

The MP proposes an appropriate outcome and controls to protect the registered Heritage Place.

Appendices

Appendix 1 – ML and MPL application validity assessments

Appendix 2 – Assessment of applicant's consultation

Appendix 3 – Statutory consultation

Appendix 4 – Application assessment summary

Appendix 5 – Recommended mining lease terms, conditions, requirements

Appendix 6 – Recommended MPL terms, conditions, requirements

Appendix 7 – CSIRO report

Appendix 1 – ML and MPL application validity assessments

In the following Appendix 1-4 the Mining Act and Mining Regulations will be referred to as follows:

- Historic Act – *Mining Act 1971* in force prior to 1 January 2021
- Current Act – *Mining Act 1971* in force from 1 January 2021
- Historic Regulations – *Mining Regulations 2011*
- Current Regulations – *Mining Regulations 2020*

Table 1: Mining lease validity assessment

Validity requirement	Assessment	Legislation
Tenure - The applicant must hold the required Act tenure to make an application.	The applicant is the holder of MC 4473 allowing a mining lease application to be validly made in respect of the whole or part of land comprised in MC 4473.	Historic Act section 34(1) Current Act section 34(1)(a)
Notices, Consents and Agreements - The applicant must have complied with notice, consent and agreement requirements.	Notices of Entry Terramin served the correct Form 21 Notice of Entry on Land on all landowners within MC 4473. All the notices served are for activities associated with pegging a mineral claim only which satisfied the requirements of the Historic Act in force at the time. Section 80 of the Act MC 4473 is pegged over the following existing tenements: MC 4113 held by Maximus Resources Limited EL 6447 and EL 6319 both held by Terramin Exploration Pty Ltd. MC 4113 Agreement MC 4113 remains active pending an open retention lease application. On 22 October 2013 Maximus Resources sold the project to Terramin. As the Mining Act does not allow the transfer of mineral claims, under the relevant sale agreement, Maximus holds MC 4113 in trust for the benefit of Terramin. On 27 November 2018 Maximus provided consent (2019D026998) under section 80	Historic Act Part 9 - Notices Historic Act section 80 Historic Regulation 5

Validity requirement	Assessment	Legislation
	of the Mining Act to Terramin pegging and lodging a new MC over the same area as MC 4113. Exploration Licence Agreement Terramin hold EL 6319 and EL 6447 over the land which MC 4473 is pegged. Terramin provided consent under section 80 of the Mining Act with themselves to establish MC 4473 over EL 6319 and 5469 (now EL 6447). The agreements provided are appropriate to support the MLA. Rights over a road, street or highway Terramin provided a letter from Adelaide Hills Council, dated 29 April 2019 which provides consent for Terramin to register a mineral claim and lodge a mining lease application over a public road, street or highway. This consent is appropriate and meets the requirements of Historic Regulation 5 for the purpose of a MLA.	
Timeframe - The application must be made within the legislative timeframe.	A valid application was made within 12 months of the MC registration of 28 May 2019.	Historic Act section 26(2)
Fee - The application must be accompanied by the correct prescribed fee.	The following prescribed fees accompanied the application and are correct: • Base Component: $1,631 • Advertising Component: $880 • Assessment Component: $78,482	Historic Act section 35(1)(c)
Form - The application must be made in the determined manner and form.	The application correctly used the determined Form 10 and the completed form included all the required information.	Historic Act section 35(1)
Boundaries - The application must correctly identify the	The applicant nominated on the Form 10 – Application for a Mining Lease that the application is made for all the area of MC 4473.	Historic Act section 35

Validity requirement	Assessment	Legislation
boundaries of the proposed lease.		
Determined Ministerial Determination	This application was prepared in accordance with the Determination for a Mining Proposal for the Bird in Hand Gold Project.	Historic Act section 35(1)
Mining Proposal - The application must be accompanied by a mining proposal that meets the legislative requirements.	The application was accompanied by a mining proposal. The mining proposal included the minimum information required to satisfy the requirements of the Act, Regulations and Ministerial Determination.	Historic Act section 35(1)(a) Historic Act section 35(1)(b) Historic Regulation 30(1) Historic Regulation 30(1)(c) Historic Regulation 30(2)
Other information - The application must be accompanied by such other information prescribed by the Regulations.	The application included information prescribed by the Regulations to support a valid application.	Historic Regulation 30
Declaration of accuracy to accompany application.	The mining proposal included an appropriate declaration of accuracy signed by the applicant declaring that the signatory had taken reasonable steps to review the information in the application and to ensure its accuracy.	Historic Regulation 30(4)

Table 2: Miscellaneous Purpose Licence Application validity assessment

Validity requirement	Assessment	Legislation
Purpose- A miscellaneous purposes licence is a tenement that is granted for ancillary operations.	The proposed licence is for processing of gold ore from the proposed mining lease at Woodside. The purpose is considered ancillary to mining operations.	Current Act section 48(1)
Notices, Consents and Agreements - The applicant must have complied with notice, consent and agreement requirements.	Notices of Entry Terramin own the majority of land subject to the MPLA. Some of the land is leased to other owners of land. All appropriate notices were served for the identification of the MPLA. Prior to undertaking ancillary operations on the area of the MPLA Terramin will be required to comply with Part 9 of the Act. Section 80 of the Act The MPLA is superimposed over ML 6229, EML 5325 and EL 5924 which are held by Terramin. Terramin Australia Limited entered into an agreement under section 80 of the Act to allow the grant of the MPL over the existing tenements. Terramin Exploration Pty Ltd as the applicant for the BIH mining lease is also a party to the agreement.	Historic Act Part 9 - Notices Historic Act section 80 Current Act section 80
Fee - The application must be accompanied by the correct prescribed fee.	The following prescribed fees accompanied the application and are correct: • Base component: $1,631 • Advertising component: $880 • Assessment component: $7,500	Historic Act section 53(1)(c)
Form - The application must be made in the determined manner and form.	The application correctly used the determined Form 17 and the completed form included all the required information.	Historic Act section 53(1)
Boundaries - The application must correctly identify the boundaries of the proposed lease.	The application correctly identified the boundaries of the land in respect of which the licence is being sought.	Historic Act section 53(1) and Historic Regulation 52
Management plan - The application must be accompanied by a	The application was accompanied by a management plan that included sufficient information to satisfy the requirements of the	Historic Act section 53(1)(a)

Validity requirement	Assessment	Legislation
management plan that meets the legislative requirements.	Act, Regulations and Ministerial Determination 006 dated 5 November 2015.	Historic Regulation 49
Declaration of accuracy to accompany application.	The application included an appropriate declaration of accuracy signed by the applicant declaring that the signatory had taken reasonable steps to review the information in the application and to ensure its accuracy.	Historic Regulation 49(4)

Appendix 2: Assessment of applicant's consultation

Assessment requirement	Assessment	Legislation
The mining proposal and management plan must set out the *results of the consultation* undertaken in connection with the proposed operations in accordance with the regulations.	Chapter 5 of the mining proposal and management plan sets out the results of consultation.	Historic Act 35(1)(a)(iv) 53(1)(a)(iv)
The consultation on the mining proposal and management plan should focus on *engagement on environmental outcomes* and must demonstrate reasonable steps have been taken to *consult with the owner of land* where the authorised operations are proposed to be carried out and any other person that may be affected by proposed operations.	The mining proposal and management plan included details on how environmental outcomes has been developed through engagement with the community and owners of land.	Historic Regulations 30(1)(c) & 49(1)(c)
The results of consultation on the Proposal must set out, any *issues of concern* raised, and the steps (if any) taken or proposed to be taken to address those concerns	Chapter 5 of the mining proposal and management plan sets out the results of consultation including issues raised and steps to address concerns.	Historic Regulations 30(1)(e) & 49(1)(e)
Consultation requirements set out in the Determination for a Mining Proposal for the Bird in Hand Gold Project and MD 006.	Chapter 5 of the mining proposal and management plan covers of on all consultation requirements set out in the respective Ministerial Determinations.	Ministerial Determinations

Appendix 3: Statutory consultation

Assessment requirement	Assessment	Legislation
The Minister must … give notice of the application— (a) to the owner of the land to which the application relates; and (b) if the land is within the area of a council—to the council. and invite written submissions.	The application was received on 21 June 2019 and notice of the application was provided to the owner(s) of land and the council on 5 July 2019.	Historic Act sections 35A(1a) & 35A(2) Historic Act section 53(4)
The Minister must publish … a notice— (a) describing the land to which the application relates and, if relevant, the particular stratum in relation to which the tenement would be, or has been, granted (as the case requires); and (b) specifying a place where the application may be inspected; and (c) inviting written submissions in relation to the application to the Minister within a time specified in the invitation.	Statutory notices specifying a 10-week consultation period for written public submissions were published as follows: 10 July 2019 • DEM Website • The Courier (Mount Barker) 11 July 2019 • The South Australian Government Gazette • The Advertiser • The Adelaide Hills Weekender Herald • Southern Argus (Strathalbyn) • The Times (Victor Harbor). Government received 254 public submissions.	Historic Act sections 35A(1) & (4) and 53(2)
The applicant is provided with a copy of all public submissions received; and are required to respond to any relevant matter raised in public submissions within a period specified.	All public submissions were provided to Terramin on 7 February 2020 with a request for response. Terramin submitted a response document on 20 April 2020. Additional information was requested in a revised response document on 23 June 2020. Terramin submitted version 2 of the response document on 5 March 2021.	Historic Act sections 35(2) and 53(3)

Assessment requirement	Assessment	Legislation
	Additional information was requested in a final response document due by 23 September 2021. Terramin submitted the final response document on 23 July 2021. Government accepted the response document on 23 August 2021.	

Appendix 4: Application assessment summary

Assessment requirement	Assessment	Legislation
Exempt land	For applications made under the Current Act that are not for the recovery of extractive or industrial minerals, the prescribed distance that defines exempt land from a building or structure used as a place of residence would be 600 metres for mining authorised operations. Amendments to the Current Act changed the exempt land prescribed distance from 400 metres to 600 metres for authorised operations in relation to minerals that are not for the recovery of extractive or industrial minerals. As the Bird in Hand tenement applications were made under the Historic Act, the exempt land prescribed distance amendments made to Current Act do not apply. The 400-metre exempt land prescribed distance will continue to apply in relation to the Application in accordance with the transitional provisions outlined in schedule 5, section 2 of the Current Regulations. Chapter 21 of the MP and Chapter 22 of the management plan set out exempt land applicable to the respective lease and licence applications. On 20 October 2021 the department requested updated information on exempt land relevant to the lease and licence applications. Terramin's response received on 1 December 2021 confirmed that there has been no change to exempt land originally identified in the applications. Refer to Chapter 3 for the Government assessment of land access.	Historic Act section 9(2)

Assessment requirement	Assessment	Legislation
Identification of existing or permissible land use and geological heritage values of an area is at the time of grant.	Chapter 2 of the MP and management plan sets out the existing and permissible land uses, which remain current at the time of writing this report. In September 2019, a development application to redevelop Bird in Hand Winery was approved under the *Planning, Development and Infrastructure Act 2016*. As the application was approved prior to a decision on the lease it was considered in the assessment of potential impacts.	Historic Act section 6(4) Current Act section 6(4)
Area of proposed lease and licence	The applicant has applied for a lease over the whole of land comprised in the MC. The area of the proposed lease is 194.78 hectares. The area of the proposed licence is 79.66 hectares.	Historic Act section 34(1)
Minister must not grant a mining lease unless the Minister is satisfied that there is a reasonable prospect that the land in respect of which the lease is sought could be effectively and efficiently mined.	Government assesses that there is a reasonable prospect that the deposit is commercially exploitable – this is demonstrated through access to land, the mining methods proposed and the JORC resource estimate. For more detail on Government's assessment of land access refer to Chapter 3. For more detail on Government's assessment of the resource estimate and mining methods refer to Chapter 2.	Current Act section 37(1)(a)(i)
Minister must not grant a mining lease or miscellaneous purposes licence unless the Minister is satisfied that appropriate environmental outcomes will be able to be achieved.	The MP, MPL proposal, public submissions and response document have been assessed and Government considers that appropriate environmental outcomes will be able to be achieved. Appropriate environmental outcomes are a requirement of the PEPR, should a lease be granted.	Current Act section 37(1)(a)(ii) and 50(1)

Assessment requirement	Assessment	Legislation
	Refer to Appendix 5 for the recommended mining lease terms, conditions and requirements. Refer to Appendix 6 for the recommended MPL terms, conditions and requirements. For Government's assessment of potential impact events, control strategies, uncertainty and proposed outcomes refer to relevant preceding chapters of this Assessment Report.	
Minister must not grant a mining lease if the Minister considers that sufficient investigations have not been carried out in order to … determine the terms and conditions.	The MP and response document contain sufficient investigations to enable the determination of the recommended lease terms, conditions and requirement (Appendix 5).	Current Act section 37(1)(b)
If an application to which this section applies relates to an area within the Murray-Darling Basin, the Minister must … take into account the objects of the *River Murray Act 2003* and the Objectives for a Healthy River Murray under that Act.	The south-eastern portion of MC 4473 and the entire MPL application area are within the tributaries zone of the Murray-Darling Basin. The objects of the *River Murray Act 2003* and the Objectives for a Healthy River Murray under that Act have been considered as part of the assessment and through referral to the Minister responsible for administering the *River Murray Act 2003* (see below for further information). The recommended environmental outcomes will ensure the objects and objectives are met.	Current Act section 56F(2) Current Act section 10B
If an application to which this section applies relates to an area within or adjacent to a specially protected area, the Minister must … refer the application to the relevant Minister and consult with the relevant Minister in relation to the matter.	In accordance with section 56G of the Act both applications were referred to the delegate for the Minister responsible for administering the *River Murray Act 2003* as they are within the tributaries zone of the Murray River Water Protection Area. The delegate provided the following advice: The proposed development generally complies with the Objects of the *River*	Current Act section 56G

Assessment requirement	Assessment	Legislation
Specially protected area means— (a) the Adelaide Dolphin Sanctuary; or (b) a Marine Park; or (c) a River Murray Protection Area;	*Murray Act 2003* and its Objectives for a Healthy River Murray and is unlikely to result in any harm to the River Murray system. However, the Minister for Energy and Mining should consider applying the following conditions (or similar) to both the ML and MPL if the proponent does not satisfactorily address these matters: Surface water monitoring of both quality and quantity indicators are to be maintained both upstream and downstream of any potential contamination or flooding points. This should take place during the construction, operation and closure phases at both the Bird in Hand mine site and the Angas Processing Facility. All relevant historical data should be utilised for analysis. Under section 20 of the Aboriginal Heritage Act 1988 (the Act), an owner or occupier of private land, or an employee or agent of such an owner or occupier, must report the discovery on the land of any Aboriginal sites, objects and remains to the Minister responsible for the administration of the Act, as soon as practicable, giving the particulars of the nature and location of the Aboriginal sites, objects or remains. It is an offence to damage, disturb or interfere with any Aboriginal site or damage any Aboriginal object (registered or not) without the authority of the Minister for Aboriginal Affairs and Reconciliation (the Minister). If the planned activity is likely to damage, disturb or interfere with a site or object, authorisation of the activity must be first obtained from the Minister under Section 23 of the Act. Penalties may apply for	

Assessment requirement	Assessment	Legislation
	failure to comply with the Act. For further information visit: http://taawika.sa.gov.au. In regard to matter (1) Government recommends that the monitoring requirements proposed are required to demonstrate achievement of the surface water outcome, should a lease and licence be granted this will be a requirement of the outcome measurement criteria. Terramin have proposed an appropriate outcome and draft measurement criteria to manage potential impacts on Aboriginal sites, object and remains. Should a lease and licence be granted a condition requiring the applicant to comply with the requirements of the *Aboriginal Heritage Act 1988* will be included.	
Other statutory referrals and interaction with other legislation	The MC is located within a schedule 14, 'Mineral Production Tenement Area', hence this application has been referred for advice to the Minister for Planning, pursuant to s 160, *Planning, Development and Infrastructure Act 2016* (PDI Act) on 23 July 2019. DEM did not receive a response from the Minister or delegate. As the PDI Act only requires that an application for a mining production tenement is referred for advice Government considers this requirement satisfied. The application area did not fall within a Regional Reserve that would require a statutory referral under the *National Parks and Wildlife Act 1972*. The objects of the *Landscapes South Australia Act 2019* have been taken into account throughout the assessment and through referral and input from the relevant government agencies and Landscape Boards.	Schedule 14(1) of the *Planning, Development and Infrastructure (General) Regulations 2017.* Current Act section 10B

Assessment requirement	Assessment	Legislation
In determining whether or not to grant an application … and, if so, the terms and conditions on which it should be granted, the Minister must have regard to any public submissions or applicant response document received under s56H subsection (3) or (4).	254 public submissions were received. The applicant provided a response document in response to the public submissions. The key matters raised in public submissions are outlined in Chapter 5 of this Assessment Report. The assessment has had regard for all public submissions and the applicant's response in setting the terms, conditions and requirements of the lease and licence, should a lease and licence be granted.	Current Act section 56H(6)
The Minister must, in determining the terms and conditions … give proper consideration to— (a) any aspect of the environment that may be affected by the conduct of authorised operations under the tenement; and (b) any other lawful activities that may be affected by those authorised operations; and (c) any Aboriginal sites or objects within the meaning of the *Aboriginal Heritage Act 1988* that may be affected by those authorised operations And may take into consideration such other factors or mattes as the Minister considers appropriate.	Environmental outcomes are recommended (refer to Appendix 5 and 6) that relate to relevant aspects of the environment, lawful activities and Aboriginal sites or objects that may be affected.	Current Act section 56I(2)
A mining lease may be granted for such term as may be determined by the	Refer to Chapter 16 for the assessment of lease term.	Current Act section 38(1)

Assessment requirement	Assessment	Legislation
Minister and specified in the lease.		
A miscellaneous purposes licence may be granted for such term as may be determined by the Minister and specified in the licence.	Refer to Chapter 16 for the assessment of licence term.	Current Act section 51(1)
Mining lease and Miscellaneous Purposes Licence is subject to such terms and conditions that may be prescribed and additional terms and condition as the Minister thinks fit.	Refer to Appendix 5 and 6 for recommended terms and conditions for the Mining Lease and Miscellaneous Purposes Licence.	Current Act sections 35(3) and 48(3)

Appendix 5 – Mining lease recommended terms, conditions and requirements

Definitions

1. In this Tenement Document, the following words have the following meanings:

   1.1. **"the Act"** means the *Mining Act 1971* of South Australia;

   1.2. **"Additional Terms and Conditions"** means the Additional Terms and Conditions authorised by section 35(3) of the Act and set out in the First and Second Schedule of this Tenement Document respectively;

   1.3. **"AMD"** means Acid and Metalliferous Drainage;

   1.4. **"Applicant"** means the person or persons who applied for the Mineral Tenement

   1.5. **"Approved PEPR"** means the document contemplated by section 70B(5) of the Act i.e. a Proposed PEPR that has received ministerial approval;

   1.6. **"Business Day"** means any day that is not a Saturday, Sunday or a public holiday in South Australia;

   1.7. **"Completion"** means the Land has been rehabilitated to an extent that the Minister could approve an application for surrender of the Mineral Tenement made in accordance with section 56X(2) of the Act;

   1.8. **"DEM"** means the Department of Energy and Mining and includes any substituted Department;

   1.9. **"DEW"** means the Department for Environment and Water and includes any substituted Department;

   1.10. "**EPA**" means the Environment Protection Authority under the *Environment Protection Act 1993* of South Australia;

   1.11. **"the Land"** means the land over which the Mineral Tenement is granted and which is described in paragraphs 5 and 6 and in the Third Schedule of this Tenement Document;

   1.12. **"Mineral(s)"** means the Minerals referred to in the First Schedule of this Tenement Document;

   1.13. **"Mining Lease"** means the Mineral Tenement granted to the Tenement Holder as referred to in paragraph 1 of this Tenement Document;

   1.14. **"Mineral Tenement"** or **"Tenement"** means the mining lease granted to the Tenement Holder, as referred to in paragraphs 1 and 2 of this Tenement Document and all of the rights and obligations encompassed in the grant;

   1.15. **"the Minister"** means the Minister for Energy and Mining (or any substituted Minister);

1.16. **“NAF”** means non acid forming;

1.17. **“PAF”** means potentially acid forming;

1.18. **“PEPR”** means Program for Environment Protection and Rehabilitation;

1.19. **“Pest”** means any pest animals declared under the *Landscape South Australia Act 2019;*

1.20. **“the Program”** means the Approved PEPR as defined above;

1.21. **“Proposed PEPR”** means the document required by section 70B(4) of the Act to be submitted for ministerial approval within a period set in the Mineral Tenement conditions, or within such longer period as the Director of Mines, or an authorised officer may allow;

1.22. **“Regulations”** means the Mining Regulations 2020 of South Australia;

1.23. **“site”** means the Land;

1.24. **“Tenement Document”** means this document;

1.25. **“Tenement Holder”** means the registered holder of the Mineral Tenement and includes:

1.25.1. in the case of a natural person, the executors, administrators and assigns of that person;

1.25.2. in the case of a body corporate, the successors, administrators or permitted assigns thereof.

1.26. “**Third Party Property and Infrastructure**” means property and infrastructure that is not owned by the Tenement Holder;

1.27. **“TSF”** means Tailings Storage Facility;

1.28. **“Weeds”** means any invasive plant that threatens native vegetation in the local area or any species recognised as invasive in South Australia.

FIRST SCHEDULE

ADDITIONAL TERMS

Explanatory note: A term is a clause that gives a right to a Mineral Tenement.

Authorised Mining Operations

1. The grant of the Mineral Tenement authorises mining operations for the recovery of minerals, including but not limited to:
   1.1. Gold; and
   1.2. Silver.

2. The grant of the Mineral Tenement authorises mining operations that are consistent with the mining operations described in the Mining Proposal document dated 21 June 2021 and subsequent Response Document dated 23 July 2021.

3. In accordance with Section 56K of the Act, the Mineral Tenement authorises the management and use of Extractive Minerals produced during the course of carrying out mining operations under the Tenement.

4. In accordance with Section 56K of the Act, Extractive Minerals produced in accordance with the authorisation provided in First Schedule Clause 3:
   4.1 are exempt from the payment of royalty; and
   4.2 must only be managed and used within the Land.

Explanatory note: Extractive minerals produced from the Mineral Tenement are not authorised to be sold.

SECOND SCHEDULE

ADDITIONAL CONDITIONS

Explanatory note: A condition is a clause that imposes a restriction on a Mineral Tenement.

Transparency

1. The Tenement Holder agrees to any reportable incident reports, submitted in accordance with the Regulations, being made available for public inspection.

Land access

2. For the purposes of this Additional Condition:

2.1. 'Preliminary mining operations' means:

2.1.1. Baseline environmental data collection (particularly if this is required for the development of measurement criteria);

2.1.2. ongoing environmental assessments (particularly if this is required for the development of measurement criteria);

2.1.3. groundwater monitoring;

2.1.4. drilling and establishment of aquifer re-injection bores for the purpose of testing, developing operational management plans and particularly if this is required for the development of measurement criteria;

2.1.5. establishment of vegetation;

2.1.6. site works to support any metallurgical test work or trials;

2.1.7. geotechnical and soil investigations to support detailed design of mining operations;

2.1.8. additional mineral resource definition and sterilisation investigations; or

2.1.9. any additional activity as determined in writing by the Director of Mines (including an activity that is defined below as a Principal mining operation).

2.2. 'Principal mining operations' means:

2.2.1. Surface construction relating to mining and infrastructure on the Land;

2.2.2. construction of the underground box cut, portal and decline on the Land;

2.2.3. blasting on the Land;

2.2.4. any pre-strip or early earthworks on the Land relating to any of the above activities; or

2.2.5. any other mining operation that is not a Preliminary mining operation as defined in Condition 2.1;

but does not include mining operations that fall within 2.2.1 to 2.2.5 to the extent that such mining operations fall within a determination under Condition 2.1.9.

2.3. The Tenement Holder may carry out Preliminary mining operations on particular exempt land after it has obtained a waiver of exemption (whether by agreement with

every person who has the benefit of the exemption, or by a court order, or a combination of a waiver by agreement and court order) from every person who has the benefit of the exemption in respect of the particular exempt land on which the Tenement Holder wishes to perform the Preliminary mining operations.

2.4. The Tenement Holder must not carry out any Principal mining operations unless it has obtained waivers of exemption (whether by agreement with every person who has the benefit of an exemption, or by a court order, or a combination of a waiver by agreement and court order) in respect of all the exempt land unless the Director of Mines is satisfied that no mining operations would be required to occur in respect of any particular exempt land for the life of the project.

Explanatory Note: The Tenement Holder can carry out principal mining operations on the land that is exempt due to a feature located outside of the Land (see subsection 9(1)(d) of the Act) provided the Tenement Holder has a waiver or waivers for that land. If the Tenement Holder does not need to perform mining operations on land that is exempt due to a feature located outside of the Land (see subsection 9(1)(d) of the Act), no waiver would be necessary.

Groundwater quality baseline

3. The Tenement Holder must obtain detailed groundwater quality baseline data.

4. The groundwater quality baseline must:

4.1. Include data that spans an appropriate time period so as to be representative of seasonal changes; and

4.2. include data that spans an appropriate number of locations and of sufficient density and depth so as to be representative of the spatial extent of the project; and

4.3. include an appropriate range of measured analytes; and

4.4. be used to inform aquifer re-injection water quality parameters; and

4.5. be presented in a groundwater quality baseline data report and submitted to the Director of Mines (or other authorised officer) for approval prior to the commencement of Principal mining operations (as defined in Second Schedule Condition 2.2).

Groundwater modelling

5. To the satisfaction of the Director of Mines (or other authorised officer), establish a groundwater modelling plan for the ongoing review and revision of the groundwater models (quantity and quality).

6. The groundwater modelling plan must:

6.1. Set out the process and scope for the ongoing review and revision of the groundwater models (quantity and quality);

6.2. set out a schedule of timing for the key milestones, commitments and deliverables identified within the plan;

6.3. include a commitment to provide revised groundwater model report(s) to the Director of Mines (or other authorised officer) within a reasonable time frame and prior to the

commencement of Principal mining operations (as defined in Second Schedule Condition 2.2);

6.4. include a commitment to review (and revise if necessary) operational groundwater management plans prior to the commencement of Principal mining operations (as defined in Second Schedule Condition 2.2); and

6.5. be provided to the Director of Mines (or other authorised officer) within 6 months of the grant of the Mineral Tenement or such longer time as the Director of Mines (or other authorised officer) approves in writing.

7. The revised groundwater model(s) must address the following:

7.1. Incorporate data obtained from ongoing groundwater monitoring; and

7.2. incorporate data obtained from the establishment and/or testing of aquifer re-injection wells including hydraulic properties and anisotropy; and

7.3. testing of injection wells must include (at a minimum):

7.3.1. Determination of sustainable injection flow rate; and

7.3.2. head response to injection and/or extraction; and

7.3.3. analysis of the movement of injectant; and

7.3.4. inform operational groundwater management plans to ensure the effectiveness of injection wells at a small scale.

Groundwater monitoring public reporting

8. The Tenement Holder must monitor Groundwater quality and quantity on a continuous basis (where practicable) and report that data in real time to the public on an unrestricted internet site. The monitoring data must be retained and remain accessible on the unrestricted internet site for the life of the mine.

Underground mine geotechnical assessment

9. The Tenement Holder must review and revise the underground mine geotechnical assessment.
10. The purpose of the review is to inform the following operational plans and designs:
    10.1. mine and stope design; and
    10.2. crown pillar design; and
    10.3. ground support planning; and
    10.4. grouting plan and design.
11. The Tenement Holder must prepare a revised geotechnical assessment report.
12. The revised geotechnical assessment report must be audited by a suitably qualified independent expert approved by the Director of Mines (or other authorised officer).
13. The expert must prepare a report of the findings of the audit including any recommendations.
14. The revised geotechnical assessment report must be updated to address recommendations (if any) from the audit report.
15. The final revised geotechnical assessment report and the audit report must be provided to the Director of Mines (or other authorised officer) for approval prior to the commencement of Principal mining operations (as defined in second scheduled condition 2.2).

16. The final revised geotechnical assessment must address the following:
    16.1. An improved understanding of the Mining Proposal and Response Document geotechnical recommendations through further analysis to provide additional reliability of the following key inputs: rock strength, in-situ stress field, major and minor structure understanding, including the rock mass domain characteristics; and
    16.2. provide a program and schedule for validation of the key inputs and characteristics once mining is underway; and
    16.3. revised ground support recommendations based on the final adopted mine design and water management strategies; and
    16.4. Include the results of revised numerical modelling (stress modelling) based on improved understanding of the key inputs and rock mass characteristics; and
    16.5. Include evidence to demonstrate that the geotechnical assessment supports achievement of all relevant outcomes and the protection of worker safety.

Underground mine backfill

17. The Tenement Holder must develop, implement and maintain an Underground Mine Backfill Management Plan to the satisfaction of the Director of Mines (or other authorised officer).
18. A draft plan and audit report (required by Second Schedule Condition 17) must be provided to the Director of Mines (or other authorised officer) for approval prior to the commencement of Principal mining operations (as defined in second schedule condition 2.2).
19. A final plan and audit report (required by second schedule condition 17) must be provided to the Director of Mines (or other authorised officer) for approval prior to the commencement of backfill operations.
20. The draft plan and final plan must be audited by a suitably qualified independent expert approved by the Director of Mines (or other authorised officer).
21. The expert must prepare reports of the findings of the audits (required by Second Schedule Condition 19) including any recommendations.
22. Prior to submission to the Director of Mines (or other authorised officer), the draft plan and final plan must be updated to address recommendations (if any) from the audit reports.
23. The Underground Mine Backfill Management Plan must (at a minimum):
    23.1. Describe the process and timing for undertaking site-specific analysis, field testing and studies to inform and validate the adopted backfill strategy; and
    23.2. include a process for benchmarking and confirmation of fill strength requirements including considerations associated with the drift and fill mining method; and
    23.3. include evidence to demonstrate that the adopted backfill strategy and associated management plan would be effective to achieve all relevant outcomes and ensure the protection of worker safety; and
    23.4. include detailed descriptions, designs and plans to describe the backfill strategy and operations; and
    23.5. include a process for adaptive management and continuous improvement; and
    23.6. include governance and quality assurance / quality control processes.

Grouting governance

24. The Tenement Holder must develop, implement and maintain a Grouting Governance Policy and Grouting Management Plan to the satisfaction of the Director of Mines (or other authorised officer). The policy and plan must be provided to the Director of Mines (or other authorised officer) for approval prior to the commencement of Principal mining operations (as defined in second schedule condition 2.2).

Noise monitoring public reporting

25. The Tenement Holder must monitor noise emissions on a continuous basis (where practicable) and report that data in real time to the public on an unrestricted internet site. The monitoring data must be retained and remain accessible on the unrestricted internet site for the life of the mine.

Air quality monitoring public reporting

26. The Tenement Holder must monitor air quality on a continuous basis (where practicable) and report that data in real time to the public on an unrestricted internet site. The monitoring data must be retained and remain accessible on the unrestricted internet site for the life of the mine.

Public road infrastructure

27. The Tenement Holder must consult with the Department for Infrastructure and Transport (includes any substituted Department) and the Adelaide Hills Council in relation to design and construction of upgrades to the public road network used for the haulage route. The results of consultation must be provided to the Director of Mines (or other authorised officer) prior to submission of the Proposed PEPR.

Additional information in the PEPR

28. In accordance with section 70B(2)(d) of the Act it is a condition of the grant of the Mining Tenement that a Proposed PEPR submitted in accordance with Part 10A of the Act must include reports on:
    - 28.1. The capacity of the Tenement Holder to achieve compliance with the Act and the Proposed PEPR in light of its management systems, personnel, policies, procedures, practices and resources.
    - 28.2. The effectiveness of the detailed operational strategies in the Proposed PEPR in achieving the environmental outcomes identified in the Proposed PEPR in relation to, at least:
        - 28.2.1. The effectiveness of groundwater models to inform detailed operational groundwater management strategies and plans; and
        - 28.2.2. grouting strategies, management and governance effectiveness to ensure appropriate mitigation of groundwater inflows into the underground mine; and

28.2.3. water storage, treatment and operational management to ensure aquifer re-injection water quality parameters are achieved; and

28.2.4. injection of water into the aquifer to ensure effective mitigation of impacts to groundwater users and regional groundwater.

28.3. Additionally, the reports in Condition 28.2 must include identification of any risks, assumptions and uncertainties associated with the relevant strategies.

Explanatory Note: Independent peer review reports were provided by the Tenement Holder as part of the Mining Lease Application for the purpose of environmental impact assessment. The expert reports required as part of this condition are for the purpose of the Proposed PEPR and relate to detailed operational strategies and plans set out by the Tenement Holder.

29. The reports required by Condition 28 must be provided by independent and suitably qualified experts or persons previously approved by the Director of Mines (or other authorised officer). To apply for approval the Tenement Holder must:
    29.1. Apply in writing; and
    29.2. provide the person's Curriculum Vitae showing their academic qualifications, publications (if any) and practical experience; and
    15.3 provide the Terms of Engagement as between the person and the Tenement Holder or other documentation that identifies:
        15.3.1 The assumptions, if any, the expert has been asked to make for the purpose of providing their report; and
        15.3.2 a list of the materials provided to the expert for the purpose of providing their report; and
        15.3.3 the matters on which the expert is asked to report.

PEPR submission – Principal mining operations

30. The Tenement Holder must submit a Proposed PEPR (which sets out Principal mining operations) for the purpose of Part 10A of the Act within 24 months after the grant of the Mineral Tenement or within such longer period as the Director of Mines (or other authorised officer) may allow.

Commencement of operations – Principal mining operations

31. The Tenement Holder must commence Principal mining operations in accordance with the Approved PEPR under Part 10A of the Act within 12 months after the program has been approved or within such longer period as the Director of Mines (or other authorised officer) may allow.

Continuation of operations – Principal mining operations

32. After commencement of mining operations, the Tenement Holder must continue mining operations in accordance with the requirements of the Approved PEPR or any subsequent revised PEPR.

Notification of cessation of operations

33. Within 30 days of becoming aware of any event or decision which is likely to give rise to the cessation of mining operations for a period of more than seven days and where possible prior to the cessation of mining operations, the Tenement Holder must notify the Director of Mines in writing of the event or decision. The notice must specify the date upon which the mining operations are expected to cease or have ceased and an estimate of the period of cessation.

Decommissioning and Rehabilitation Plan (DRP)

34. If the Tenement Holder decides to cease mining operations or an event occurs that is likely to give rise to the permanent cessation of mining operations, the Tenement Holder must develop a DRP and submit it to the Director of Mines (or other authorised officer) for approval within 30 days of the decision or event (or such longer period as approved by the Director of Mines (or other authorised officer)).

35. The DRP must:

    35.1. Set out the activities and scheduling required for the carrying out of the rehabilitation works specified in the Approved PEPR; and

    35.2. be prepared in accordance with any requirements provided by the Director of Mines (or other authorised officer) in writing.

36. The Tenement Holder must carry out decommissioning and rehabilitation in accordance with the approved DRP and the Approved PEPR.

37. If, in the opinion of the Director of Mines, mining operations have substantially ceased for a period of two consecutive years, the Director of Mines may direct the Tenement Holder:

    37.1. To develop and submit a DRP (which must address the requirements of condition 34) for approval within 30 days of the direction or such longer period as the Director of Mines may allow; and/or

    37.2. to carry out decommissioning and rehabilitation in accordance with the approved DRP and the Approved PEPR.

Community Engagement Plan (CEP)

38. The Tenement Holder must prepare, implement, and maintain (to the satisfaction of the Director of Mines or other authorised officer) a revised CEP that:

    38.1. Sets out the purpose, objectives and parameters of engagement with the community; and

    38.2. is focussed on engagement on the proposed PEPR, any future PEPR reviews, construction, operation, rehabilitation, closure and opportunities for post mining land use; and

    38.3. identifies all community stakeholders likely to be affected by authorised operations and the post mining land use; and

    38.4. includes a process for engagement on the opportunities for post mining land use;

    38.5. includes a process for identifying, analysing and responding to mine related social issues identified through engagement with community; and

38.6. outlines an annual action plan to commence the proposed engagement activities; and

38.7. sets out the Tenement Holder's ongoing capacity and resources to effectively implement and maintain the CEP; and

38.8. includes a description of the qualifications and experience of the Tenement Holder's resources responsible for implementation and maintenance of the plan; and

38.9. uses acknowledged public participation processes that set out the reasoning, the tools and the specific engagement techniques that the Tenement Holder intends to use for;

38.9.1. identifying community attitudes and expectations; and

38.9.2. providing information to the community, including but not limited to, real time monitoring data required by conditions set out in the Second Schedule of the Tenement; and

38.9.3. receiving feedback from the community; and

38.9.4. analysing community feedback and considering community concerns or expectations; and

38.9.5. registering, documenting and responding to communications from members of the community; and

38.10. addresses any further matters that the Director of Mines (or other authorised officer) requires in writing.

Explanatory note: The department required a CEP to be provided as part of the Mining Lease Application process. This condition requires a revision to that CEP to specifically address development of the PEPR, construction, operations, and closure.

39. The revised CEP must either be prepared by, or audited by, a suitably qualified expert approved by the Director of Mines (or other authorised officer).

40. The revised CEP must be submitted to the Director of Mines (or other authorised officer) for approval within three months of the grant of the Mineral Tenement or within such longer period as the Director of Mines (or other authorised officer) may allow.

41. As part of maintaining the CEP, the Tenement Holder must, to the satisfaction of the Director of Mines (or other authorised officer), review and update the CEP annually considering the feedback raised by the community in the previous year and in a way that involves the community.

Community Engagement Plan Reporting

42. The Tenement Holder must submit a CEP annual report that:

42.1. Provides details of community engagement activities undertaken during that year, including, but not limited to:

42.1.1. Why the activities were undertaken and the methodologies adopted for those activities; and

42.1.2. person(s) engaged with and the date the engagement occurred; and

42.1.3. a summary of the community complaints register (Second Schedule Condition 49) that delineates the type and scope of the issues of concern; and
42.1.4. the different methods of engagement undertaken specific to the community; and
42.1.5. follow up actions that arise from community engagement and the complaints register.

42.2. Assesses the performance of the engagement against the objectives set out in the CEP including any relevant performance indicators and metrics.

Social Management Plan (SMP)

43. The Tenement Holder must prepare, implement and maintain a SMP.
44. The SMP must be submitted to the Director of Mines (or other authorised officer) within 12 months from the date of the grant of the Mineral Tenement, or within such longer period as the Director of Mines (or other authorised officer) may allow.

45. The SMP must be implemented as soon as possible after its preparation.

46. The Tenement Holder must make the SMP publicly available.

47. The SMP must:
47.1. Be prepared in consultation with relevant State Government agencies and key community stakeholders; and
47.2. be informed by the socio-economic data gathered as part of the Mining Proposal as a baseline; and
47.3. identify potential social issues that may arise from mining operations and how the company will respond to, as far as practicable, those issues; and
47.4. set out strategies, initiatives and commitments to be adopted; and
47.5. integrate with the CEP process for identifying, analysing and responding to mine related social issues identified through engagement with community; and
47.6. explain how the company will maximise and measure the potential socio-economic benefits of the mine within its area of influence, in particular as it relates to;
47.6.1. community preparedness and opportunities for collaboration during both mine development, operations, closure and planning for the post mining land use; and
47.6.2. supporting regional business development, local and regional employment with proportionate metrics and targets; and
47.6.3. Aligning with local socio-economic development and LGA and council development; and
47.6.4. integration with closure planning and opportunities for post mining land use appropriate to the socio-economic environment where the Mineral Tenement is granted; and
47.7. address any further matters that the Director of Mines (or other authorised officer) requires in writing.

48. The SMP must contain a process for an audit of the implementation of the SMP, and, if appropriate, an improvement review process to update strategies, initiatives, metrics, targets and issues.
    48.1. The audit must be conducted annually or such longer period as the Director of Mines (or other authorised officer) may specify by notice in writing.
    48.2. The audit must be conducted by an independent and suitably qualified expert.
    48.3. The expert must prepare a report of the findings of the audit and this report must be made publicly available within one month of completion of the audit.
    48.4. If the audit recommends updating strategies or initiatives, the Tenement Holder must consult with relevant State Government agencies and key community stakeholders about those recommendations.
    48.5. If the recommendations are adopted by the Tenement Holder, the SMP must be updated, implemented and made publicly available as soon as possible.

Complaints Register

49. The Tenement Holder must establish and maintain a public complaints register. The public complaints register must, as a minimum, record the following detail in relation to each complaint received in which it is alleged that environmental harm (including an environmental nuisance) has been caused by the authorised operations:
    49.1. The time at which the complaint was received; and
    49.2. all personal details of the complainant which were provided by the complainant or, if no such details were provided, a note to that effect; and
    49.3. the subject-matter of the complaint; and
    49.4. the action taken by the Tenement Holder in relation to the complaint, including any follow-up contact with the complainant; and
    49.5. if no action was taken by the Tenement Holder, the reasons why no action was taken.

50. All records in respect of the public complaints must be maintained for a period of at least 7 years.

51. The Tenement Holder must make the public complaints register publicly available except for the name and contact details of each complainant.

Other Legislation

52. The Tenement Holder must comply with all State and Commonwealth legislation and regulations applicable to the activities undertaken pursuant the grant of the Mineral Tenement including (but not limited to) the:
    52.1. Aboriginal Heritage Act 1988;
    52.2. Dangerous Substances Act 1979;
    52.3. Environment Protection Act 1993;
    52.4. Environment Protection and Biodiversity Conservation Act 1999;
    52.5. Heritage Places Act 1993;
    52.6. Landscape South Australia Act 2019;
    52.7. Mines and Works Inspection Act 1920;
    52.8. National Parks and Wildlife Act 1972;
    52.9. Native Vegetation Act 1991;

52.10. Planning, Development and Infrastructure Act 2016;
52.11. Public and Environmental Health Act 1987;
52.12. Road Traffic Act 1961; and
52.13. Work Health and Safety Act 2012.

FOURTH SCHEDULE

ENVIRONMENTAL OUTCOMES

AND ASSOCIATED CRITERIA AND STRATEGIES PURSUANT TO
SECTION 70B(2)(b)(i) OF THE MINING ACT 1971

Explanatory note: The Fourth Schedule of this Tenement Document sets out outcomes contemplated in section 70B(2)(b)(i) of the Act, that the Tenement Holder is required to address in any program submitted in accordance with Part 10A of the Act. The Fourth Schedule may also specify requirements for strategies and criteria relevant to the outcomes set out in that Schedule.

Groundwater Outcome

1. The Tenement Holder must, during construction, operation, and post Completion, ensure that there is no adverse impact to the quantity or quality of groundwater available to existing users, future users and groundwater dependant ecosystems as a result of mining operations.

Groundwater Quantity Criteria

2. The Tenement Holder is required to address the following matters for the purposes of Regulation 63(1)(c) of the Regulations in relation to Fourth Schedule Clause 1 for groundwater quantity:

    2.1. Establish compliance groundwater monitoring bores that are at appropriate locations and of sufficient density and depth to measure or infer the groundwater elevations for all relevant groundwater receptors; and

    2.2. design of the monitoring and measurement criteria framework must consider a mechanism to determine groundwater drawdown that is caused by mining operations as distinct from other sources of impact; and

    2.3. the measurement parameters and values that are taken to demonstrate achievement of the outcome must appropriately measure potential impacts to all relevant groundwater receptors, and must include (but not limited to):

        2.3.1. Compliance criteria for groundwater elevation for all relevant receptors; and

        2.3.2. the compliance criteria for groundwater elevation for all relevant receptors must be based on appropriate data, which can include (but not limited to);

            2.3.2.1. appropriate baseline groundwater data; and

            2.3.2.2. appropriate groundwater model predictions including the uncertainty analysis; and

            2.3.2.3. physical properties relating to a relevant receptor, including groundwater levels required to maintain bore pumping and water supply; and

            2.3.2.4. any other appropriate data; and

            2.3.2.5. any combination of that data; and

    2.4. frequency of measurement that is appropriate to ensure demonstration of achievement of the outcome; and

    2.5. measurement criteria is to be determined through consultation with DEM, DEW, EPA and any other relevant government department.

Groundwater Quantity Leading Indicator Criteria

3. The Tenement Holder is required to address the following matters for the purposes of Regulation 63(1)(d) of the Regulations in relation to Fourth Schedule Clause 1 for groundwater quantity:

    3.1. Leading indicator criteria for all relevant groundwater receptors; and
    3.2. leading indicator criteria based on groundwater elevations; and
    3.3. leading indicator criteria based on groundwater inflows to the underground mine and/or pump discharge to surface storage; and
    3.4. the frequency of leading indicator measurements must be appropriate to ensure there is an early warning of failure of any strategy; and
    3.5. leading indicator criteria must be integrated with the Trigger, Action and Response Plan (Fourth Schedule clause 4.2); and
    3.6. specific leading indicator criteria must be included which results in the action of commencement of controlled inundation; and
    3.7. specific leading indicator criteria must be included which results in the action of total flooding of the mine to ensure restoration of baseline groundwater elevations; and
    3.8. leading indicator criteria is to be determined through consultation with DEM, DEW, EPA and any other relevant government department.

Groundwater Quantity Strategy

4. The Tenement Holder is required to address the following matters for the purposes of Regulation 63(1)(b) of the Regulations in relation to Fourth Schedule Clause 1 for groundwater quantity:
    4.1. The aquifer re-injection system must:

        4.1.1. Be designed with sufficient injection capacity to provide appropriate contingency for higher than expected groundwater inflow rates;
        4.1.2. describe the number, location and injection capacity of all operational aquifer re-injection wells;
        4.1.3. define the total injection capacity of the system;
        4.1.4. describe the process for permitting and bringing into operation subsequent injection wells should they be required.

    4.2. Develop a Trigger, Action and Response Plan to proactively manage the aquifer re-injection system.

Groundwater Quality Criteria

5. The Tenement Holder is required to address the following matters for the purposes of Regulation 63(1)(c) of the Regulations in relation to Fourth Schedule Clause 1 for groundwater quality:
    5.1. Establish compliance groundwater monitoring bores that are at appropriate locations and of sufficient density and depth to measure or infer the groundwater quality for all relevant groundwater receptors.

5.2. Design of the monitoring and measurement criteria framework must consider a mechanism to determine changes in groundwater quality that is caused by mining operations as distinct from other sources of impact.
5.3. The measurement parameters and values that are taken to demonstrate achievement of the outcome must appropriately measure potential impacts to all relevant groundwater receptors, and must include (but not limited to);
5.3.1. compliance criteria for groundwater quality for all relevant receptors; and
5.3.2. the compliance criteria for groundwater quality for all relevant receptors must be based on appropriate data, which can include (but not limited to);
5.3.2.1. appropriate baseline groundwater quality data as defined in the report required in Second Schedule Clause 4.5.
5.4. The frequency of measurement must be appropriate to ensure demonstration of achievement of the outcome.
5.5. Measurement criteria is to be determined through consultation with DEM, DEW, EPA and any other relevant government department.

Groundwater Quality Leading Indicator Criteria

6. The Tenement Holder is required to address the following matters for the purposes of Regulation 63(1)(d) of the Regulations in relation to Fourth Schedule Clause 1 for groundwater quality:
6.1. Leading indicator criteria for all relevant groundwater receptors; and
6.2. leading indicator criteria based on groundwater quality; and
6.3. leading indicator criteria based on the quality of water treatment plant outflows; and
6.4. leading indicator criteria designed to measure the potential for AMD through identification of changes in water quality at appropriate locations; and
6.5. The frequency of leading indicator measurements must be appropriate to ensure there is an early warning of failure of any strategy; and
6.6. leading indicator criteria must be integrated with the Trigger, Action and Response Plan (Fourth Schedule clause 7.1); and
6.7. specific leading indicator criteria must be included which results in the action of cessation of mining operations that have the potential to result in a breach of the groundwater quality outcome measurement criteria; and
6.8. Leading indicator criteria is to be determined through consultation with DEM, DEW, EPA and any other relevant government department.

Groundwater Quality Strategies

7. The Tenement Holder is required to address the following matters for the purposes of Regulation 63(1)(b) of the Regulations in relation to Fourth Schedule Clause 1 for groundwater quality:

7.1. Develop a Trigger, Action and Response Plan to proactively manage water quality for the water treatment plant; and
7.2. The geological model must be updated with a revised analysis of AMD to develop an AMD block model and enable refinement of waste rock types and volumes; and
7.3. The AMD block model must be used to inform mining schedules of PAF and NAF and to form the basis for AMD planning, including, but not limited to,

7.3.1. inclusion of results from any additional drilling, which if relevant must be tested and analysed for AMD purposes; and

7.3.2. final design of the Integrated Mullock Landform; and

7.3.3. the Underground Mine Backfill Management Plan; and

7.3.4. groundwater management; and

7.3.5. detailed rehabilitation and post Completion landform plans.

Noise Outcome

8. The Tenement Holder must, during construction and operation, ensure no public nuisance impacts from noise as a result of mining operations.

Noise Strategy

9. The Tenement Holder is required to address the following matters for the purposes of Regulation 63(1)(b) of the Regulations in relation to Fourth Schedule Clause 8 for noise:
   9.1. Develop a Trigger, Action, Response Plan to proactively manage noise emanating from mining operations.

Noise Criteria

10. The Tenement Holder is required to address the following matters for the purposes of Regulation 63(1)(c) of the Regulations in relation to Fourth Schedule Clause 8 for noise:
    10.1. The compliance limit for the ore production stage must be 52 dB(A) for daytime and 45 dB(A) for night-time.
    10.2. Establish a real time noise monitoring network located as per the Environment Protection (Noise) Policy 2007.
    10.3. Report real time noise monitoring data to a publicly accessible webpage.

Noise Leading Indicator Criteria

11. The Tenement Holder is required to address the following matters for the purposes of Regulation 63(1)(d) of the Regulations in relation to Fourth Schedule Clause 8 for noise:
    11.1. Leading indicator criteria for construction and ore production stages of mining.

Air Quality Outcomes

12. The Tenement Holder must, during construction and operation, ensure there are no public health impacts as a result of airborne emissions and/or dust generated by mining operations.

13. The Tenement Holder must, during construction and operation, ensure there are no public nuisance impacts from airborne emissions and/or dust generated by mining operations.

14. The Tenement Holder must ensure no impacts to agricultural productivity for third-party land users on or off the Land during construction and operation, from dust generated by mining operations.

Air Quality Strategy

15. The Tenement Holder is required to address the following matters for the purposes of Regulation 63(1)(b) of the Regulations in relation to Fourth Schedule Clauses 12, 13, 14 for air quality:
    15.1. Develop a Trigger, Action, Response Plan to proactively manage air quality.

Air Quality Criteria

16. The Tenement Holder is required to address the following matters for the purposes of Regulation 63(1)(c) of the Regulations in relation to Fourth Schedule Clauses 12, 13, 14 for air quality:
    16.1. Establish a real time air quality monitoring network.
    16.2. Report real time air quality monitoring data to a publicly accessible webpage.

Traffic Outcomes

17. The Tenement Holder must, during construction and operation, ensure no unauthorised damage to public property and infrastructure as a result of traffic movements from mining operations.

18. The Tenement Holder must, during construction and operation, ensure no traffic accidents involving members of the public and mine related traffic that could have been reasonably prevented by the Tenement Holder.

Heritage Outcome

19. The Tenement Holder must, during construction and operation, ensure there is no damage, disturbance or interference to Aboriginal or Non-Aboriginal heritage sites, objects or remains unless it is authorised under the relevant legislation.

Weeds and Pest Outcome

20. The Tenement Holder must, during construction and operation, ensure no introduction of new species of environmental weed, plant pathogens or pests (including feral animals), nor sustained increase in abundance of existing weed or pest species on the Land.

Land and Soil Outcomes

21. The Tenement Holder must ensure the existing (pre-mining) soil quality and quantity is maintained.

22. The Tenement Holder must, during construction and operation, ensure that there is no adverse impact to public health from disturbance of contaminated land as a result of mining operations.

23. The Tenement Holder must ensure there is no contamination of land and soils either on or off the Land post Completion as a result of mining operations.

24. The Tenement Holder must ensure post Completion, that the land is left in a geotechnically stable, non-polluting state indefinitely.

Waste Outcome

25. The Tenement Holder must, during construction, operation and post Completion, ensure that all commercial, industrial and domestic waste is disposed of in accordance with relevant legislation.

Blasting Outcome

26. The Tenement Holder must, during construction and operation, ensure there are no adverse impacts to:
    26.1. Public safety;
    26.2. human comfort;
    26.3. third party property (including stock);
    26.4. adjacent land use;
    26.5. adjacent infrastructure and operations;
    26.6. adjacent heritage buildings; and
    26.7. other receptors

from vibration, air overpressure or fly rock caused by mining operations.

Blasting Criteria

27. The Tenement Holder is required to address the following matters for the purposes of Regulation 63(1)(c) of the Regulations in relation to the Fourth Schedule Clause 26:
    27.1. all blasts must be measured and monitored; and
    27.2. locations of monitoring must include (as a minimum) a site that is appropriate to measure potential impact to receptors; and
    27.3. the measurement parameters and values that are taken to constitute achievement of the outcome must comply with the relevant Australian Standard;
    27.4. blast times and charge weights must be recorded in a register.

Visual Amenity Outcomes

28. The Tenement Holder must, in construction, operation and post Completion, ensure that the form, contrasting aspects and reflective aspects of mining operations are visually softened to blend in with the surrounding landscape.

29. The Tenement Holder must in construction and operation ensure that there are no public nuisance impacts from light spill generated by mining operations.

Visual Amenity Strategies

30. The Tenement Holder is required to address the following matters for the purposes of Regulation 63(1)(b) of the Regulations in relation to the Fourth Schedule Clause 28:

    30.1. plant a variety of mid storey, local native plant species within the existing fenced areas adjacent to the Bird in Hand Winery site (CT 5261/544) boundary as soon as reasonably possible following Mineral Tenement grant;

    30.2. the site layout must be as per the design in the Strategic Visual Amenity Plan (Appendix G1 of the Mining Proposal);

    30.3. unless the Director of Mines (or other authorised officer) has approved (in writing) an alternative agreement between the Tenement Holder and a land owner relating to the removal of infrastructure, the Tenement Holder must ensure that all infrastructure is decommissioned and removed from the Land at mine completion.

Visual Amenity Criteria

31. The Tenement Holder is required to address the following matters for the purposes of Regulation 63(1)(c) of the Regulations in relation to the Fourth Schedule Clause 28:

    31.1. Photo points used in the Strategic Visual Amenity Plan must be used in the criteria.

    31.2. A construct to design audit against the Strategic Visual Amenity Plan must be done during and post construction.

Surface Water Outcome

32. The Tenement Holder must, during construction, operation and post Completion, ensure that there is no adverse impact to the quantity and quality of surface water caused by the mining operations to existing and future licenced surface water users and surface water dependant ecosystems.

Surface Water Criteria

33. The Tenement Holder is required to address the following matters for the purposes of Regulation 63(1)(c) of the Regulations in relation to the Fourth Schedule Clause 32:

    33.1. Establish real time surface water monitoring of water quality and quantity at appropriate upstream and downstream locations.

Protection of Third-Party Property Outcome

34. The Tenement Holder must, during construction and operation, ensure there are no adverse impacts to third party public or private property on or off the Land as a result of mining operations.

35. The Tenement Holder must, during construction, operation and post Completion, ensure that no damage occurs to third party infrastructure and/or public injuries and/or deaths result from the collapse of underground mine workings.

Protection of Third-Party Property Strategy

36. The Tenement Holder is required to address the following matters for the purposes of Regulation 63(1)(b) of the Regulations in relation to the Fourth Schedule Clause 35:

    36.1. Ensure all underground voids are filled to the extent that subsidence cannot occur at any time post Completion.

Public Safety Outcomes

37. The Tenement Holder must during construction and operation ensure that unauthorised entry to the site does not result in public injuries and/or deaths that could have been reasonably prevented.

38. The Tenement Holder must during construction and operation ensure that uncontrolled fires caused by mining operations do not result in public injuries and/or deaths that could have been reasonably prevented.

39. The Tenement Holder must demonstrate that post Completion, the risks to the health and safety of the public so far as it may be affected by mining operations are as low as reasonably practicable.

Native Vegetation Outcome

40. The Tenement Holder must during construction and operation ensure there is no loss of abundance and/or diversity of native vegetation on or off the Land through:

    40.1. Clearance;
    40.2. dust/contaminant deposition;
    40.3. fire; and/or
    40.4. other damage;

    unless a significant environmental benefit (SEB) has been approved in accordance with the relevant legislation.

Native Fauna Outcome

41. The Tenement Holder must during construction and operation ensure that there are no native fauna injuries or deaths due to mining operations that could reasonably have been prevented.

Appendix 6 – Miscellaneous purposes licence recommended terms, conditions and requirements

FIRST SCHEDULE

ADDITIONAL TERMS

Explanatory Note: A term is a clause that gives a right to a Mineral Tenement

Authorised Ancillary Operations

1. The Mineral Tenement is granted for the purpose of ancillary operations directly related to the mining operations authorised under Mining Lease XXXX for the Bird in Hand Gold Project.

2. Ancillary operations on the Land must be consistent with the activities described in the Miscellaneous Purposes Licence Proposal dated 21 June 2021 and subsequent Response Document dated 23 July 2021.

3. The Tenement Holder understands and accepts that pursuant to section 80(2) of the Act, the rights granted by this Mineral Tenement are modified by, and are subject to, the terms of the Deed of Consent and Collaboration between Terramin Australia Ltd and Terramin Exploration Pty Ltd dated 13 May 2019 and the associated Deed of Variation dated 3 July 2019.

SECOND SCHEDULE

ADDITIONAL CONDITIONS

Explanatory Note: A condition is a clause that imposes a restriction on a Mineral Tenement.

Transparency

1. The Tenement Holder agrees to the Approved PEPR and any compliance reports and reportable incident reports, submitted in accordance with the Regulations, being made available for public inspection.

Tailings Storage Facility (TSF)

2. The Tenement Holder must, post Completion ensure all final landforms, including the TSF, are left in a geotechnically stable, non-polluting state indefinitely.

TSF Construction and Operation Design

3. The Tenement Holder must develop design criteria, detailed designs and plans for the construction and operation of the TSF. The detailed designs and plans must (at a minimum):
    3.1. Be prepared in accordance with the DEM Mineral Policy 007 – Mining Act tailings and regulation standards March 2021 (or any subsequent update to the policy) which includes the requirement to adhere to the most recent version of the ANCOLD Tailings Dam Guideline; and
    3.2. be based on additional metallurgical and geochemical testing of representative samples of the Bird in Hand ore and additional tailings and geochemical laboratory testing undertaken on representative tailings samples to validate the outcomes of the “Preliminary Tailings and Water Management Study” (Miscellaneous Purposes Licence Proposal Appendix I2); and
    3.3. include a reassessment of the TSF capacity and water storage requirements; and
    3.4. include a reassessment of the spillway including its geometry; and
    3.5. include an updated site-specific hazard analysis and should this analysis result in an increase of the current design peak ground acceleration, the original stability analysis must be updated and included; and

3.6. ensure that any causeway and discharge ramp is constructed from non acid forming (NAF) waste rock; and

3.7. include a review and optimisation of the strategies and design options for the integration of any potentially acid forming (PAF) waste rock from the Angas Zinc Mine into the TSF; and

3.8. describe the strategy and design options that were considered for the integration of PAF waste rock into the TSF; and

3.9. include an assessment of the final adopted design for the integration of PAF waste rock into the TSF that demonstrates appropriate mitigation of AMD and achievement of the second schedule condition 2 in the long term; and

3.10. include detailed designs and plans for the integration of any PAF waste rock within the TSF.

4. Following completion of the final detailed design and plans for the TSF, the following documentation for the TSF (including integration of any PAF waste rock) must be developed and maintained:

4.1. Construction documentation; and

4.2. design drawings and quantity schedule; and

4.3. technical specifications; and

4.4. Construction Quality Assurance (CQA) Manual; and

4.5. Operations, Maintenance and Surveillance (OMS) Manual; and

4.6. TSF Safety Emergency Plan.

Explanatory Note: the above tailings management and TSF conditions have been developed consistent with commitments made by the Tenement Holder in the Response Document and recommendations made by the Tenement Holder's consultant ATC Williams in Appendix O1 of the Response Document.

TSF Construction and Operation Design Audit

5. The final detailed design and plans for the TSF construction and operation as required by Second Schedule Conditions 3 and 4 must be audited by a suitably qualified independent expert approved by the Director of Mines (or other authorised officer).

6. The audit must be undertaken against the DEM Mineral Policy 007 – Mining Act tailings and regulation standards March 2021 (or any subsequent update to the policy) which includes the requirement to adhere to the most recent version of the ANCOLD Tailings Dam Guideline.

6.1. The expert must prepare a report of the findings of the audit including any recommendations.

6.2. The final detailed design and plans for the TSF construction and operation must be updated to address recommendations (if any) from the audit report.

6.3. The final detailed design and plans documentation as required by Second Schedule Conditions 3 and 4 and the audit report must be provided to the Director of Mines (or other authorised officer).

6.4. Construction of the TSF (including placement of any PAF waste rock) must not commence until the Tenement Holder has received acceptance of the documentation set out in Second Schedule Condition 6.3 from the Director of Mines (or other authorised officer) in writing. Such acceptance is not to be unreasonably withheld or delayed.

6.5. The reports and documentation set out in Second Schedule Conditions 6.1 and 6.3 must be made publicly available by the Tenement Holder in a reasonable timeframe after completion.

7. The TSF construction and operation must be audited by a suitably qualified independent expert approved by the Director of Mines (or other authorised officer), against (i) the design criteria, final detailed design and plans that have been adopted for the TSF construction and operation as required by Second Schedule Condition 3, (ii) all of the documentation listed in Second Schedule Condition 4, (iii) DEM Mineral Policy 007 – Mining Act tailings and regulation standards March 2021 (or any subsequent update to the policy) and (iv) the most recent version of the ANCOLD Tailings Dam Guideline:

7.1. For the initial preparation and construction of the TSF (including placement of any PAF waste rock); and

7.2. On an annual basis for TSF operations or at a frequency as the Director of Mines (or other authorised officer) may specify by notice in writing.

7.3. The expert must prepare reports of the findings of each audit required by Second Schedule Conditions 7, 7.1 and 7.2, including any recommendations.

7.4. For each of the audit reports prepared in accordance with Condition 7.3, the Tenement Holder must prepare a report which describes how the audit report recommendations (if any) have or will be implemented.

7.5. The expert report for the audit of the initial preparation and construction of the TSF (as required by Second Schedule Condition 7.1 and 7.3) and the associated Tenement Holder report (as required by Second Schedule Condition 7.4) must be provided to the Director of Mines (or other authorised officer).

7.6. Initial placement of tailings in the TSF must not commence until the Tenement Holder has received approval from the Director of Mines (or other authorised officer) of the reports described in Second Schedule Condition 7.5 in relation to Second Schedule Condition 7.1. Such approval is not to be unreasonably withheld or delayed.

7.7. All operational audit reports (as required by Second Schedule Condition 7.2 and 7.3) and the associated Tenement Holder reports (as required by Second Schedule Condition 7.4) must be provided to the Director of Mines (or other authorised officer) within one month of completion of the audit.

7.8. All reports required by Second Schedule Conditions 7.3 and 7.4 must be made publicly available by the Tenement Holder in a reasonable timeframe after completion.

TSF Rehabilitation and Closure Design

8. The rehabilitation and closure designs and plans relating to the TSF included in the Angas Zinc Mine PEPR (dated May 2017) must be reviewed and revised to incorporate and consider changes resulting from the deposition of Bird in Hand tailings.

9. The Tenement Holder must develop a project plan for the rehabilitation and closure of the TSF to the satisfaction of the Director of Mines (or other authorised officer) which includes (but is not limited to):

9.1. A description of the process to be undertaken to develop the final detailed TSF rehabilitation and closure designs; and

9.2. a description of the required tasks, studies, modelling, test work and field trials required to develop the final detailed TSF rehabilitation and closure designs; and

9.3. a detailed project schedule, which sets out the timing for the process, tasks, studies, modelling, test work, field trials and completion of the final detailed TSF rehabilitation and closure designs.

TSF Rehabilitation and Closure Audits

10. The TSF rehabilitation and closure (including preparation and construction of the TSF cover system) must be audited by a suitably qualified independent expert approved by the Director of Mines (or other authorised officer), against the design criteria, final detailed design, and plans that have been adopted for the TSF rehabilitation and closure.

10.1. The expert must prepare a report of the findings of the audit including any recommendations.

10.2. The Tenement Holder must prepare a report which describes how the audit report recommendations (if any) have or will be implemented.

10.3. The audit report and Tenement Holder report must be provided to the Director of Mines (or other authorised officer) within one month of completion of the audit.

10.4. The reports must be made publicly available by the Tenement Holder in a reasonable timeframe after completion.

PEPR Submission

11. The Tenement Holder must submit a Proposed PEPR for the purpose of Part 10A of the Act within 24 months after the grant of the Mineral Tenement or within such longer period of time as the Director of Mines (or other authorised officer) may allow.

Commencement of Operations

12. The Tenement Holder must commence ancillary operations in accordance with the Approved PEPR under Part 10A of the Act within 12 months after the program has been approved or within such longer period as the Director of Mines (or other authorised officer) may allow.

Continuation of Operations

13. After commencement of ancillary operations, the Tenement Holder must continue ancillary operations in accordance with the requirements of the Approved PEPR or any subsequent revised PEPR.

Notification of cessation of operations

14. Within 30 days of becoming aware of any event or decision which is likely to give rise to the cessation of authorised operations for a period of more than seven days and where possible prior to the cessation of authorised operations, the Tenement Holder must notify the Director of Mines in writing of the event or decision. The notice must specify the date upon which the authorised operations are expected to cease or have ceased and an estimate of the period of cessation.

Decommissioning and Rehabilitation Plan

15. If the Tenement Holder decides to cease authorised operations or an event occurs that is likely to give rise to the permanent cessation of authorised operations, the Tenement Holder must develop a DRP and submit it to the Director of Mines (or other authorised officer) for approval within 30 days of the decision or event (or such longer period as approved by the Director of Mines (or other authorised officer)).

16. The DRP must:

16.1. set out the activities and scheduling required for the carrying out of the rehabilitation works specified in the Approved PEPR; and

16.2. be prepared in accordance with any requirements provided by the Director of Mines (or other authorised officer) in writing.

17. The Tenement Holder must carry out decommissioning and rehabilitation in accordance with the approved DRP and the Approved PEPR.

18. If, in the opinion of the Director of Mines, authorised operations have substantially ceased for a period of two consecutive years, the Director of Mines may direct the Tenement Holder:

18.1. To develop and submit a DRP (which must address the requirements of condition 16) for approval within 30 days of the direction or such longer period as the Director of Mines may allow; and/or

18.2. to carry out decommissioning and rehabilitation in accordance with the approved DRP and the Approved PEPR.

Community Engagement Plan (CEP)

19. The Tenement Holder must prepare, implement, and maintain (to the satisfaction of the Director of Mines or other authorised officer) a revised CEP that:

19.1. Sets out the purpose, objectives and parameters of engagement with the community; and

19.2. is focussed on engagement on the proposed PEPR, any future PEPR reviews, construction, operation, rehabilitation, closure and opportunities for post mining land use; and

19.3. identifies all community stakeholders likely to be affected by authorised operations and the post mining land use; and

19.4. includes a process for engagement on the opportunities for post mining land use;

19.5. includes a process for identifying, analysing and responding to mine related social issues identified through engagement with community; and

19.6. outlines an annual action plan to commence the proposed engagement activities; and

19.7. sets out the Tenement Holder’s ongoing capacity and resources to effectively implement and maintain the CEP; and

19.8. includes a description of the qualifications and experience of the Tenement Holder’s resources responsible for implementation and maintenance of the plan; and

19.9. uses acknowledged public participation processes that set out the reasoning, the tools and the specific engagement techniques that the Tenement Holder intends to use for;

19.9.1. identifying community attitudes and expectations; and

19.9.2. providing information to the community, including but not limited to, real time monitoring data required by conditions set out in the Second Schedule of the Tenement; and

19.9.3. receiving feedback from the community; and

19.9.4. analysing community feedback and considering community concerns or expectations; and

19.9.5. registering, documenting and responding to communications from members of the community; and

19.9.6. addresses any further matters that the Director of Mines (or other authorised officer) requires in writing.

Explanatory note: The department requires a revised CEP specifically for the PEPR, construction, operations, closure etc.

20. The revised CEP must either be prepared by, or audited by, a suitably qualified expert approved by the Director of Mines (or other authorised officer).

21. The revised CEP must be submitted to the Director of Mines (or other authorised officer) for approval within three months of the grant of the Mineral Tenement or within such longer period as the Director of Mines (or other authorised officer) may allow.

22. As part of maintaining the CEP, the Tenement Holder must, to the satisfaction of the Director of Mines (or other authorised officer), review and update the CEP annually considering the feedback raised by the community in the previous year and in a way that involves the community.

Community Engagement Plan Reporting

23. The Tenement Holder must submit a CEP annual report that:

    23.1. Provides details of community engagement activities undertaken during that year, including, but not limited to:

        23.1.1. Why the activities were undertaken and the methodologies adopted for those activities; and

        23.1.2. person(s) engaged with and the date the engagement occurred; and

        23.1.3. a summary of the community complaints register (Second Schedule Condition 30) that delineates the type and scope of the issues of concern; and

        23.1.4. the different methods of engagement undertaken specific to the community; and

        23.1.5. follow up actions that arise from community engagement and the complaints register.

    23.2. Assesses the performance of the engagement against the objectives set out in the CEP including any relevant performance indicators and metrics.

Social Management Plan (SMP)

24. The Tenement Holder must prepare, implement and maintain a SMP.

25. The SMP must be submitted to the Director of Mines (or other authorised officer) within 12 months from the date of the grant of the Mineral Tenement, or within such longer period as the Director of Mines (or other authorised officer) may allow.

26. The SMP must be implemented as soon as possible after its preparation.

27. The Tenement Holder must make the SMP publicly available.

SECOND SCHEDULE

28. The SMP must:

28.1. Be prepared in consultation with relevant State Government agencies and key community stakeholders; and

28.2. be informed by the socio-economic data gathered as part of the Mining Proposal as a baseline; and

28.3. identify potential social issues that may arise from mining operations and how the company will respond to, as far as practicable, those issues; and

28.4. set out strategies, initiatives and commitments to be adopted; and

28.5. integrate with the CEP process for identifying, analysing and responding to mine related social issues identified through engagement with community; and

28.6. explain how the company will maximise and measure the potential socio-economic benefits of the mine within its area of influence, in particular as it relates to;

28.6.1. community preparedness and opportunities for collaboration during both mine development, operations, closure and planning for the post mining land use; and

28.6.2. supporting regional business development, local and regional employment with proportionate metrics and targets; and

28.6.3. Aligning with local socio-economic development and LGA and council development; and

28.6.4. integration with closure planning and opportunities for post mining land use appropriate to the socio-economic environment where the Mineral Tenement is granted; and

28.7. address any further matters that the Director of Mines (or other authorised officer) requires in writing.

29. The SMP must contain a process for an audit of the implementation of the SMP, and, if appropriate, an improvement review process to update strategies, initiatives, metrics, targets and issues.

29.1. The audit must be conducted annually or such longer period as the Director of Mines (or other authorised officer) may specify by notice in writing.

29.2. The audit must be conducted by an independent and suitably qualified expert.

29.3. The expert must prepare a report of the findings of the audit and this report must be made publicly available within one month of completion of the audit.

29.4. If the audit recommends updating strategies or initiatives, the Tenement Holder must consult with relevant State Government agencies and key community stakeholders about those recommendations.

29.5. If the recommendations are adopted by the Tenement Holder, the SMP must be updated, implemented and made publicly available as soon as possible.

Complaints Register

30. The Tenement Holder must establish and maintain a public complaints register. The public complaints register must, as a minimum, record the following detail in relation to each complaint received in which it is alleged that environmental harm (including an environmental nuisance) has been caused by the authorised operations;

30.1. the time at which the complaint was received; and

30.2. all personal details of the complainant which were provided by the complainant or, if no such details were provided, a note to that effect; and

30.3. the subject-matter of the complaint; and

30.4. the action taken by the Tenement Holder in relation to the complaint, including any follow-up contact with the complainant; and

30.5. if no action was taken by the Tenement Holder, the reasons why no action was taken.

31. All records in respect of the public complaints must be maintained for a period of at least 7 years.

32. The Tenement Holder must make the public complaints register publicly available except for the name and contact details of each complainant.

Other Legislation

33. The Tenement Holder must comply with all state and Commonwealth legislation and Regulations applicable to the activities undertaken pursuant the grant of the Mineral Tenement including (but not limited to) the:

33.1. *Aboriginal Heritage Act 1988;*

33.2. *Dangerous Substances Act 1979;*

33.3. *Environment Protection Act 1993;*

33.4. *Environment Protection and Biodiversity Conservation Act 1999;*

33.5. *Heritage Places Act 1993;*

33.6. *Landscape South Australia Act 2019;*

33.7. *Mines and Works Inspection Act 1920;*

33.8. *National Parks and Wildlife Act 1972;*

33.9. *Native Vegetation Act 1991;*

33.10. *Planning, Development and Infrastructure Act 2016;*

33.11. *Public and Environmental Health Act 1987;*

33.12. *Road Traffic Act 1961; and*

33.13. *Work Health and Safety Act 2012.*

FOURTH SCHEDULE

ENVIRONMENTAL OUTCOMES, CRITERIA AND STRATEGIES

AND ASSOCIATED CRITERIA PURSUANT TO SECTION 70B(2)(b) OF THE

MINING ACT 1971 AND STRATEGIES PURSUANT TO REGULATION 63(1)(b)

Explanatory note: The Fourth Schedule of this Tenement Document sets out outcomes contemplated in Section 70B(2)(b) of the Act, that the Tenement Holder is required to address in any program submitted in accordance with Part 10A of the Act. The Fourth Schedule may also specify requirements for strategies and criteria relevant to the outcomes set out in that Schedule.

Public Safety Outcomes

1. The Tenement Holder must during construction and operation ensure that unauthorised entry to the site does not result in public injuries and or deaths that could have been reasonably prevented.
2. The Tenement Holder must demonstrate that post Completion, the risks to the health and safety of the public so far as it may be affected by ancillary operations are as low as reasonably practicable.

Traffic Outcome

3. The Tenement Holder must during construction and operation and ensure that there are no traffic accidents involving the public and mine related traffic that could have been reasonably prevented by the Tenement Holder.
4. The Tenement Holder must, in construction and operation, ensure that no public impacts are caused by, noise, dust and/or dragout associated with mine related traffic to and from the Land.

Visual Amenity Outcome

5. The Tenement Holder must during construction and operation ensure that there are no public nuisance impacts from light spill generated by ancillary operations.

Waste Disposal Outcome

6. The Tenement Holder must during construction, operation and post Completion ensure that no contamination of natural water drainage systems, streams and rivers, groundwater, land and soils occurs either on or off site resulting from permanent disposal or temporary storage of mine ore or waste material.

Groundwater Outcome

7. The Tenement Holder must during construction, operation and post Completion, ensure that there is no adverse impact to the quantity or quality of groundwater available to existing users and groundwater dependent ecosystems as a result of ancillary operations.

Surface water Outcome

8. The Tenement Holder must during construction, operation and post Completion, ensure that there is no adverse impact to the quantity or quality of surface water available to existing users and groundwater dependent ecosystems as a result of ancillary operations.

Soil Outcome

9. The Tenement Holder must during construction, operation and post Completion ensure that there is no adverse impact to the quantity or quality of soil as a result of ancillary operations.

Geotechnical and Geochemical Stability

10. The Tenement Holder must post Completion ensure all ancillary operations are left in a geotechnically stable, non-polluting state indefinitely.

Air Quality

11. The Tenement Holder must ensure there are no public health and/or nuisance impacts as a result of airborne emissions and/or dust generated by ancillary operations.

Aboriginal and Non-Aboriginal Heritage Outcome

12. The Tenement Holder must during construction, operation and post Completion ensure that there is no damage, disturbance or interference to Aboriginal and non-Aboriginal heritage sites, objects or remains unless it is authorised under the relevant legislation.

Native Vegetation Outcome

13. The Tenement Holder must ensure there is no loss of abundance and/or diversity of native vegetation on or off the Land through clearance unless a significant environmental benefit (SEB) has been approved in accordance with the relevant legislation.

Explanatory Note: the legislation that applies to this outcome is the Native Vegetation Act 1991.

Weeds, Pests and Pathogens Outcome

14. The Tenement Holder must during construction and operation ensure no introduction of new species of environmental weed, plant pathogens or pests (including feral animals), nor sustained increase in abundance of existing weed or pest species on the Land.

FOURTH SCHEDULE

Definitions

"Act" means the Mining Act 1971 (South Australia);

"additional terms and conditions" means the additional terms and conditions authorised by Section 48(3) of the Act and set out in the First and Second Schedules of this Tenement Document respectively;

"AMD" means Acid and Metalliferous Drainage;

"ANCOLD" means Australian National Committee on Large Dams;

"Applicant" means the person or persons who applied for the Mineral Tenement;

"Approved PEPR" means the program for environment protection and rehabilitation under Part 10A of the Act, which has received ministerial approval;

"business day" means any day that is not a Saturday, Sunday or a public holiday in South Australia;

"contamination" and "contaminated" mean the presence of chemical substances in concentrations greater than the background concentrations (if any), where the presence of the chemical substances in the greater concentrations has resulted in

1. actual or potential harm to the health or safety of human beings that is not trivial, or
2. actual or potential harm to water that is not trivial, or
3. other actual or potential environmental harm that is not trivial.

"**Completion**" means the Land has been rehabilitated to an extent that the Minister could approve an application for surrender of the Mineral Tenement made in accordance with Section 56X of the Act;

"DEM" means the Department of Energy and Mining and includes any substituted Department;

"Mining Lease" means the Mineral Tenement granted to the Tenement Holder as referred to in the First Schedule of this Tenement Document;

"Miscellaneous Purposes Licence" means the Mineral Tenement granted to the Tenement Holder as referred to in paragraph 1 and 4 of this Tenement Document

"Mineral Tenement" means the Miscellaneous Purposes Licence granted to the Tenement Holder as referred to in paragraph 1 of this Tenement Document and all rights and obligations encompassed in the grant;

"Minister" means the Minister for Energy and Mining (or any substituted Minister);

"NAF" means non acid forming;

"PAF" means potentially acid forming;

"PEPR" means Program for Environment Protection and Rehabilitation;

"the Program" means the Approved PEPR as defined above;

FOURTH SCHEDULE

"Proposed PEPR" means the document required by Section 70B of the Act to be submitted for ministerial approval within the timeframe specified within Second Schedule, Clause 2 of this lease;

"Regulations" means the Mining Regulations 2020 of South Australia;

"site" means the Land;

"Tenement Document" means this document;

"Tenement Holder" means the registered holder of the Mineral Tenement and includes;

1. in the case of a natural person the executors, administrators and assigns of that person;
2. in the case of a body corporate the successors, administrators or permitted assigns thereof.

"the Land" means the land over which this Mineral Tenement is granted and which is described in paragraphs 5 and 6 of this Tenement Document and in the Third Schedule of this Tenement Document;

"**third party land users**" means the owner of land (as defined by the Act) and any persons lawfully occupying land with the licence of the owner, or the consent of the owner and "**third party land use**" has a corresponding meaning;

"TSF" means Tailings Storage Facility;

"weeds" means any invasive plant that threatens native vegetation in the local area or any species recognised as invasive in South Australia.

Appendix 7 – CSIRO review of groundwater chapter of SA DEM assessment of the Terramin Bird in Hand MLA

Australia's National
Science Agency

Review of groundwater chapter of SA DEM assessment of the Terramin Bird in Hand MLA

Luk JM Peeters

Sarah Marshall

28 January 2022

Citation

Peeters LJM and Marshall S (2022) Review of groundwater chapter of SA DEM assessment of the Terramin Bird in Hand MLA. CSIRO, Australia

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Important disclaimer

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1 Introduction

The South Australian Department of Energy and Mining (DEM) engaged CSIRO to review the groundwater chapter of the government assessment of the Terramin Bird in Hand Gold Mine Lease Application (MLA). DEM provided a draft version of the groundwater chapter on 08/11/21 together with the documents the assessment is based on. On 07/12/21, an additional document, the Terramin response to DEM's letter dated 20 October 2021, was provided. On 15/12/21, an updated draft of the groundwater chapter was provided, in which the section on controlled inundation was updated. This document will be referred to as DEM groundwater advice (2021).

Dr. Luk Peeters and Dr. Sarah Marshall met with Paul Thompson (DEM), Andrew Querzoli (DEM) and Dr. Juliette Woods (Department for Environment and Water) on 05/11/21 to provide background to the MLA and discuss the scope of the review. On 7/12/21, Dr Peeters and Dr Marshall presented their preliminary findings to Paul Thomson, Andrew Querzoli, Dr. Juliette Woods and Gabor Bekesi (DEM). The final review report was approved for publication after a CSIRO internal peer review and discussed with representative of DEM, DEW and EPA on 13/1/22. The report was delivered to DEM on 28/01/22.

The groundwater outcome recommended by DEM is[1]:

The Tenement Holder must, during construction, operation and post Completion, ensure that there is no adverse impact to the quantity or quality of groundwater available to existing users, future users and groundwater dependant ecosystems as a result of mining operations.

The CSIRO review will evaluate the material provided in the context of this groundwater outcome. More specifically, CSIRO will examine if:

1. the Government assessment and recommendations are consistent with the groundwater outcome and the documentation provided,
2. the model predictions the Government assessment and recommendations rely on are conservative, i.e. that they overestimate negative impacts,
3. any issue identified during the review is material, i.e. that addressing the issue has the potential to change the predictions to the extent that a revision of the assessment or recommendation would be warranted.

To this end, CSIRO adopts the framework presented in Table 1 for evaluating the priority of any identified issue. The issues and their priority pertain to particular aspects of the reporting, modelling or analysis, not the overall risk of the project.

The next section summarizes the key Government assessments and recommendations and provides an overview of what CSIRO considers to be the key predictions that the Government assessment is based on. Note that a prediction is the quantity of interest together with its

[1] p.3 in DEM groundwater advice (2021)

likelihood, such as for instance the 95th percentile of mine water inflow. The following sections discuss the issues identified in relation to groundwater quantity and quality.

Table 1 Review framework

Priority	Description
High	demonstrates that key predictions are not conservative: potential to lead to a **substantial** change in key predictions or their range (e.g. more than 25%), such that predictions **increase**
Medium	affects the degree of conservatism: potential to lead to **minor or moderate** change in key predictions or their range (e.g. less than 25%), such that predictions **increase or decrease**
Low	does not affect the degree of conservatism: potential to lead to **minor or no** change in key predictions or their range, such that predictions are **not expected to change**

2 SA Government assessments and recommendations

The proposed mine site is situated approximately 2 km east of Woodside. The mine proposal consists of a decline to be created in the Tapley Hill formation with mine stopes in the Brighton Limestone formation which hosts the gold mineralisation, associated with the Nairne Fault. The mine design plans to mitigate groundwater inflow in the mine by grouting ahead of excavation and by avoiding known high yielding areas, such as the hanging wall fracture zone. Potential drawdown on nearby existing groundwater users and potential reduction in baseflow to the nearby Inverbrackie Creek is planned to be mitigated by aquifer reinjection of treated mine water in the Tapley Hill formation to the west of the mine and the Tarcowie Siltstone Formation to the east.

Terramin provided documentation of the hydrogeological characterisation of their site, including pumping tests and aquifer injection tests, hydrogeological conceptualisation, numerical groundwater modelling and uncertainty analysis. In addition, documentation is provided pertaining to potential impacts on groundwater quality, including the potential for acid mine drainage, salinity changes in the aquifers and changes in groundwater quality associated with reinjection of treated mine water.

The key groundwater quantity predictions SA government used in their assessments and recommendations, as identified by CSIRO are:

1. Predicted mine water inflows, and their range, for different scenarios of effectiveness of the grouting (70% reduction in inflow, 90% reduction in inflow, 90% reduction in inflow for the mine decline and 70% reduction in inflow for the mine stopes).
2. Predicted drawdown under different scenarios of grouting effectiveness and mine water reinjection
3. Predicted change in baseflow to Inverbrackie Creek under different scenarios of grouting effectiveness and mine water reinjection.

The scenario in which grouting reduces inflow in the mine declines by 90% and in the mine stopes by 70% is considered the most realistic by SA government. In assessing the adequacy of the mine reinjection scheme with 8 wells, SA government used the predicted 95th percentile of mine inflow, 28 L/s in year 5 of mining, for this scenario as a conservative estimate. The median or 50th percentile of inflow in year 5 of mining for this scenario is 18 L/s. To allow for sufficient contingency, Terramin have proposed that the MAR system will be designed to accommodate the conservative 70% grouting effectiveness scenario with higher inflow, pumping and injection rates. The 95th percentile of mine water inflow in this scenario after 5 years of mining is 39 L/s.

The combination of scenarios with formal uncertainty allows for a more comprehensive exploration of potential impacts. CSIRO does however note that mixing qualitative and quantitative assessments of likelihood does pose a challenge in communication. If the calibrated

language for expressing probability of the Intergovernmental Panel of Climate Change (IPCC)[2] is adopted, where an event with probability between 1 and 10% is described as *very unlikely*, the following can be stated:

1. In the scenario considered *most realistic* by SA government (see above), it is *as likely as not* for mine inflow to exceed 18 L/s, while it is considered *very unlikely* for modelled mine inflow in year 5 of operations to exceed 28 L/s
2. In the scenario considered *conservative* by Terramin (see above), it is *very unlikely* for modelled mine inflow in year 5 of operation to exceed 39 L/s.

These groundwater quantity predictions, especially the mine water inflow, provide boundary conditions for the impact assessment of groundwater quality.

CSIRO summarised the SA government's assessments and recommendations in DEM's groundwater assessment (2021) on groundwater quantity in Table 2 and on groundwater quality in Table 3. The issues identified by CSIRO and their level of concern, as assessed by CSIRO, based on the framework in Table 1, are discussed in more detail in section 3 and 4 for groundwater quantity and quality respectively. Overall, SA government's assessment is comprehensive and CSIRO has not identified any other issues warranting further scrutiny, beyond those listed in Table 2 and Table 3.

Table 2 SA Government assessments and recommendations pertaining to groundwater quantity with indication whether issues have been identified and if so, their priority, as assessed by CSIRO. Items in square brackets in italics are added by the authors to provide context. For the assessments or recommendations for which no issue is identified, CSIRO concurs with the Government statement. For the assessments or recommendations for which an issue is identified, CSIRO does not concur with all or part of the Government statement, which is elaborated upon in section 3.

Nr	Government assessment or recommendation	Issue identified	CSIRO's assessment of priority
1	Terramin collected adequate field data and presented it in the MP to inform development of conceptual hydrogeology and provide a baseline to assess potential impacts on groundwater quantity receptors	no	none
2	Terramin developed an appropriate conceptual hydrogeological understanding that served as the basis for the numerical groundwater flow model to assess potential impacts of mining on receptors	yes	low
3	These numerical models have appropriate choices of model domain, spatial and temporal discretisation, aquifer parameters, boundary conditions and initial conditions. The main uncertainty identified is that the numerical model simulates fractured rock as equivalent porous media. This is a common and necessary	yes	medium

[2] Table 1 in Mastrandrea et al. 2010. Guidance Note for Lead Authors of the IPCC Fifth Assessment Report on Consistent Treatment of Uncertainties. Report. Intergovernmental Panel on Climate Change (IPCC) https://www.ipcc.ch/site/assets/uploads/2017/08/AR5_Uncertainty_Guidance_Note.pdf

	assumption for a model domain of the required size. However, it means that model outputs are representative over medium and large scales but will be inaccurate over small scales…. This means multiple parameters sets can provide a model with a good match to observations.		
4	Government questioned the use of a single method *[chloride mass balance]* as use of additional methods would have provided a more detailed approach…. Using a potentially underestimated rainfall recharge in the model may result in uncertainty in the predicted mine inflows. This was addressed in the uncertainty analysis where recharge rates were varied.	yes	low
5	…modelling fractured groundwater flow with the equivalent porous media approach acceptable at a scale larger than REV. The consequence of a REV at several hundred meters (approximately 700 m based on hydrogeological experience) is that predictions on smaller scales may be uncertain or incorrect. If a lease is granted, it is recommended that the model would need to be reviewed to incorporate tested hydraulic properties as a requirement for the PEPR *(program for environment protection and rehabilitation)*.	yes	low
6	… while 90% may be achievable it is appropriate that allowance is made for predicted inflows associated with a 70% grouting effectiveness for at least the stoping area to allow for sufficient contingency…Based on this, DEM considers the hybrid scenario to be more likely than the 70% or 90% effectiveness scenarios which apply a broad grouting effectiveness over the whole mine which is not realistic	no	none
7	… eight wells are likely to be effective in managing the P95 *[hybrid scenario]* peak flow in year 5 of 28 L/s	no	none
8	Terramin provided a hydrogeological risk assessment for the proposed MAR system that used predictions from the modelling to demonstrate that the proposed MAR system will meet the relevant principles of the WAP	no	none
9	The conservative P95 70% grouting effectiveness *[+ MAR]* scenario shows an increase in water available at all wells.	no	none
10	If the mine was completely flooded and Terramin did not attempt to recover the mine at all, modelling results shows that under a worst case 70% grouting effectiveness scenario existing users would still be able to access groundwater, and after 80 days groundwater would	yes	low

	return to steady state levels. Under the 90% grouting effectiveness scenario, existing users would once again not be impacted, and groundwater recovery would take place within approximately 10 days.		
11	The model predicts MAR will mitigate any reduction in baseflow to the *[Inverbrackie]* creek.	no	none
12	the mitigation measures were modelled adequately to predict effectiveness in reducing impacts on receptors. Government notes that the implementation of mitigation measures in the BIH numerical groundwater flow model are based on the following: - An assumption that the grouting will represent a 'hybrid', 70% (or 90%) reduction of the unmitigated mine inflow. - An assumption that the grouting-mitigated mine inflow is reinjected to the groundwater system	no	none
13	Terramin evaluated model uncertainty adequately to present plausible ranges for predicted impacts. The ranges and distribution for each of the parameters were considered appropriate by SA Government.	yes	high
14	all potential impact events identified in the Mining Proposal where an outcome was not proposed and confirms that the source, pathway and receptor do not exist, hence, an outcome is not required for those impact events Table 10-6 of the Mining Proposal.	no	none

Table 3 SA Government assessments and recommendations pertaining to groundwater quality with indication whether issues have been identified and if so, their priority, as assessed by CSIRO. Items in square brackets in italics are added by the authors to provide context. For the assessments or recommendations for which no issue is identified, CSIRO concurs with the Government statement. For the assessments or recommendations for which an issue is identified, CSIRO does not concur with all or part of the Government statement, which is elaborated upon in section 4.

Nr	Government assessment or recommendation	Issue identified	CSIRO's assessment of priority
1	…additional baseline groundwater quality data is required to support detailed design of mitigation strategies and compliance criteria. The information provided in the MP, and the response document, demonstrates that there are likely to be a sufficient number of appropriately located wells (targeting each hydrostratigraphic unit) to enable the establishment of baseline groundwater quality.	no	none

2	Terramin have proposed that all water from underground and the IML will report to a turkey's nest dam before undergoing treatment to remove contaminants	no	none
3	… that the groundwater model used to inform the water quality impact assessment has used appropriate inputs and provides qualitative results that could be reviewed further with baseline data	yes	low
4	The risk of AMD *[acid and metalliferous drainage]* is considered low as the proposed mine design avoids the supergene zone which has been identified as highest risk of encountering PAF material.	yes	low
5	Government considers that appropriate strategies have been proposed to manage the risk of AMD and support the recommendations made by Tonkin and recommend that should a lease be granted they be a requirement of the PEPR	no	none
6	Government considers that the proposed method of water treatment is well understood and the conceptual design is appropriate to manage identified contaminants.	no	none

3 Groundwater quantity

Table 2 lists 6 issues;

- high priority: the range of predictions based on the uncertainty analysis
- medium priority: the implementation of the conceptual hydrogeological model in the numerical groundwater model
- low priority: the groundwater model conceptualisation, recharge assessment, the need to review the groundwater model in the vicinity of the mine and the controlled inundation

The following sections provide an in-depth discussion of these issues, starting with the high concern, followed by medium and low concern.

3.1 Range of predictions based on the uncertainty analysis

As indicated in section 2, the range of predicted inflows at year 5 of mining operations is a key groundwater model prediction. Particular emphasis is on the 95th percentile under various scenarios, as it represents an extreme which is used to evaluate the adequacy of the mine reinjection scheme.

CSIRO is of the opinion that the estimated 5th and 50th percentiles of predicted mine inflows across the various scenarios are adequate. The rejection sampling approach chosen to simulate the range of predictions results in a robust estimate of the 5th and 50th percentile. The 95th percentiles are however considered to be underestimated in the uncertainty analysis because:

1. The sample size after constraining the Monte Carlo ensemble is not sufficient to reliably estimate the 95th percentile and,
2. The sampled distribution of effective hydraulic parameters (i.e. those averaged across a flow path) cover a smaller range than the range of each individual zone's distribution.

In the following sections, we provide a more in-depth discussion of this finding. We start with evaluating if the rejection sampling approach is able to reduce predictive uncertainty, followed with an illustrative example of how the random sampling of hydraulic conductivity zones can lead to an underestimate of the 95th percentile.

3.1.1 Rejection sampling

In the uncertainty analysis, 10,000 random realisations are evaluated from the prior distributions for the 117 parameters. Appendix A of Appendix B7A[3] provides the prior and posterior parameter distributions. Parameters are log-normally distributed, with the exception of the recharge parameters, which are uniformly distributed. Each parameter is considered independent in the

[3] Golder (2021) Bird in Hand groundwater modelling – nonlinear uncertainty analysis

sampling, with exception of the recharge parameters (excl. recharge zone 'rch_10'), which are tied together to maintain their relative spatial distribution.

The report does not specify which sampling algorithm is used to generate the 10,000 realisations or how the covariance between recharge parameters is maintained. We note that recharge zone 11 ('rch_11') in the SE of the model domain (Fig. 45) appears not to be included in the uncertainty analysis. We also note that recharge zone 7 ('rch_7') directly to the NW of the planned mine site is assigned zero mm/yr recharge, which does not vary in the Monte Carlo sampling. We could not find what hydrogeological feature this recharge zone represents as it is not present in Appendix H1[4] or the model update in Appendix H9[5].

The model has a large number of parameter zones defined, especially for the horizontal hydraulic conductivity. While the prior distribution of each hydraulic conductivity parameter is very wide, varying over at least four orders of magnitude, the range of the equivalent hydraulic conductivity is much smaller. Equivalent hydraulic conductivity is a measure of the hydraulic conductivity averaged across a hydraulic flow path.

From the ensemble 10,000 parameter combinations, only those are retained that satisfied the following criteria:

1. Convergence in steady state simulation
2. SRMS of less than 10%
3. Simulated inflow to Inverbrackie Creek less than 1800 ML/yr
4. Less than 1 % error in the simulated water balance for steady state simulation
5. Convergence in transient simulation for the unmitigated, 70% effective, 90% effective and hybrid grouting scenario
6. Less than 5 % error in the cumulative simulated water balance for transient simulation at the end of mining (year 5.25 of simulation) with the head change criterion for convergence relaxed from 0.1 m to 0.2 m
7. Achieving target grouting effectiveness (within 2.5% of target) with PEST optimisation of drain conductance value

The large number of realisations that fail to produce a water balance with an acceptable error in the predictive transient simulations is an indication that the model is not very robust when used to simulate stress on the system (i.e. mine water extraction). In this context, a robust model is a model that is numerically stable for a wide range of parameter combinations, not only the parameter combinations during the calibration process. Middlemis and Peeters (2018) recommend to stress-test a model to ensure that the model converges for a range of realistic parameter combinations. The model might fail to produce an acceptable water balance mismatch either because the parameter combinations are unrealistic (e.g. very high K with very low S) or

[4] AGT (2017) Bird-in-Hand Gold Project Groundwater Assessment

[5] Golder (2019) Bird-in-Hand Gold Project – Investigation into Managed Aquifer Recharge. Stage 2 Injection tests and Stage 3 Groundwater model validation

because of the numerical implementation. If the latter, this would result in incorrectly rejecting parameter combinations which in turn compromises the range of predicted impacts and the level of conservatism in the estimated inflows. This can be assessed by comparing parameter combinations that do meet the water balance criterion with parameter combinations that do not meet the criterion. Should the water balance criterion preferentially reject elevated values for the hydraulic conductivity parameters in the vicinity of the mine, it is possible that the P95 is underestimated.

Table 4 shows the evolution of the ensemble size during the various stages of the rejection sampling. This table is based on section 3.0 Results in Appendix B7A[6]. We note a discrepancy between the number of realisations in the ensemble size in section 3.2.3 and what we deduced from sections 3.2.1 and 3.2.2 for the transient 70% effective grouting (resp. 146 and 148) and the hybrid scenario (resp. 101 and 114).

The large number of realisations that fail to produce a water balance with an acceptable error in the predictive transient simulations is an indication that the model is not very robust when used to simulate stress on the system (i.e. mine water extraction). In this context, a robust model is a model that is numerically stable for a wide range of parameter combinations, not only the parameter combinations during the calibration process. Middlemis and Peeters (2018)[7] recommend to stress-test a model to ensure that the model converges for a range of realistic parameter combinations. The model might fail to produce an acceptable water balance mismatch either because the parameter combinations are unrealistic (e.g. very high K with very low S) or because of the numerical implementation. If the latter, this would result in incorrectly rejecting parameter combinations which in turn compromises the range of predicted impacts and the level of conservatism in the estimated inflows. This can be assessed by comparing parameter combinations that do meet the water balance criterion with parameter combinations that do not meet the criterion. Should the water balance criterion preferentially reject elevated values for the hydraulic conductivity parameters in the vicinity of the mine, it is possible that the P95 is underestimated.

Table 4 Ensemble sizes as result of rejection sampling (HCLOSE is the head change criterion for convergence)

Description	**Realisations retained in ensemble**
Initial sample size	10,000
Steady state converged (HCLOSE < 0.1m)	6,602
Steady state SRMS < 10%	624
Steady state Baseflow < 1800 ML/yr & losing/gaining ratio > 20%	301
Transient unmitigated converged (HCLOSE < 0.2 m)	220

[6] Golder (2021) Bird in Hand groundwater modelling – nonlinear uncertainty analysis

[7] Middlemis H, Peeters L J M (2018) Uncertainty analysis—Guidance for groundwater modelling within a risk management framework. A report prepared for the Independent Expert Scientific Committee on Coal Seam Gas and Large Coal Mining Development through the Department of the Environment and Energy Commonwealth of Australia

Transient 90% effective grouting converged (HCLOSE < 0.2 m)	220
Transient 70% effective grouting converged (HCLOSE < 0.2 m)	219
Transient hybrid grouting converged (HCLOSE < 0.2 m)	219
Transient unmitigated water balance error < 5%	218
Transient 90% effective grouting water balance error < 5 %	135
Transient 70% effective grouting water balance error < 5 %	165
Transient hybrid grouting water balance error < 5 %	112
Transient 90% effective grouting, target effectiveness achieved	125
Transient 70% effective grouting, target effectiveness achieved	148
Transient hybrid grouting, target effectiveness achieved	114
Transient unmitigated, final ensemble size	218
Transient 90% effective grouting, final ensemble size	125
Transient 70% effective grouting, final ensemble size	146
Transient hybrid grouting, final ensemble size	101

The goal of the rejection sampling process is to generate an ensemble of simulated predictions that is consistent with the observations and knowledge of the system that is sufficiently large to allow to reliably estimate the range of relevant predictions. In this case, the 95th percentile (P95) is used to represent the upper range of a prediction. However, uncertainty in predictions is only reduced through rejection sampling if the criteria constrain the parameters to which the predictions are sensitive. A formal sensitivity analysis can help identifying to which parameters the predictions are most sensitive.

The numerical modelling reports do not provide a formal sensitivity analysis in which it is identified which parameters can be constrained by the observations (historical groundwater levels, Inverbrackie baseflow) and which parameters are most influential to the mine inflow and drawdown predictions. The modelling report[8] does not provide the post-calibration values, but the differences between prior and posterior parameter ranges[9] is provided in Appendix A of Appendix B7A[10]. Table 5 summarizes the 15 parameters that changed the most between prior and posterior. A change between prior and posterior indicates that a parameter can be constrained by the observations. Cross-reference with maps with the spatial distribution of the parameters (Fig. 23 to 47 in Appendix A of Appendix B7A), indicates that the parameters that can be constrained are recharge and hydraulic properties in the shallow parts of the model, generally in the west and in the vicinity of Inverbrackie Creek. The changes are towards an increase in hydraulic conductivity and a decrease in recharge. This indicates prior parameter distributions are overestimating groundwater levels, which is corrected in the posterior.

[8] AGT (2017) Bird-in-Hand Gold Project Groundwater Assessment

[9] Prior parameter ranges are the initial parameter ranges at the start of the uncertainty analysis. Posterior parameter ranges are the parameter ranges at the end of the uncertainty analysis, where parameter values and combinations that lead to model predictions that are not consistent with the observations are removed

[10] Golder (2021) Bird in Hand groundwater modelling – nonlinear uncertainty analysis

It is noteworthy that none of the parameter fields of hydraulic conductivity or storativity in the vicinity of the mine change between prior and posterior. On theoretical grounds, the mine inflow predictions will be most influenced by hydraulic conductivity and storativity in the vicinity of the location of water extraction. While not conclusive, similar prior and posterior parameter distributions for the parameters to which the prediction is most sensitive, is an indication that the calibration process, or in this case the rejection sampling, has not reduced predictive uncertainty. In other words, the calibration process has not increased confidence in some of the parameters and the model predictions therefore rely partly on initial, uncalibrated values. A formal sensitivity analysis can help identifying which parameters the mine inflow is most sensitive to and help guide data collection (both in constraining the initial parameter estimates or including different calibration targets).

Table 5 The 15 parameters with the largest difference between prior and posterior mean

Parameter name	Geological unit (model layer)	Prior mean (m/d)	Posterior mean (m/d)	mean % change
Kh_44	Kanmantoo Fm. (Layer 1)	0.0051	0.01	96
Kh_48	Tapley Hill Fm. (Layer 7)	0.16	0.28	75
Kv_6	Tapley Hill Fm. (Layer 6)	4.90E-04	8.40E-04	71
Kh_3	Tapley Hill Fm. (Layer 6)	0.2	0.34	70
rch_8	Tapley Hill Fm. (Layer 6)	24	13	-46
rch_9	Tarcowie Siltstone (Layer 1)	40	22	-45
rch_6	Tapley Hill Fm. (Layer 6)	29	16	-45
rch_2	Tapley Hill Fm. (Layer 6)	15	8.3	-45
rch_3	Tapley Hill Fm. (Layer 6)	18	10	-44
rch_5	Tapley Hill Fm. (Layer 6)	69	39	-43
rch_4	Tapley Hill Fm. (Layer 6)	170	97	-43
Kh_40	Kanmantoo Fm. (Layer 2)	0.049	0.07	43
rch_1	Tapley Hill Fm. (Layer 6)	110	63	-43
Kh_8	Tapley Hill Fm. (Layer 6)	0.1	0.14	40
Kh_53	Tapley Hill Fm. (Layer 7)	0.01	0.014	40

3.1.2 Equivalent hydraulic conductivity distribution

The predicted mine inflow is a function of the equivalent horizontal hydraulic conductivity assigned to the model grid cells in the vicinity of the proposed mine site, which, for the flow equivalent for hydraulic conductivity zoned along the main direction of flow, is the harmonic mean of horizontal hydraulic conductivity values:

$$K_{eq} = \frac{\sum_{i=1}^{n} l}{\sum_{i=1}^{n} \frac{l_i}{K_i}} \qquad \text{Eq. 1}$$

where l_i $[L]$ is the length of a parameter zone i and K_i $[L/T]$ the horizontal hydraulic conductivity of zone i.

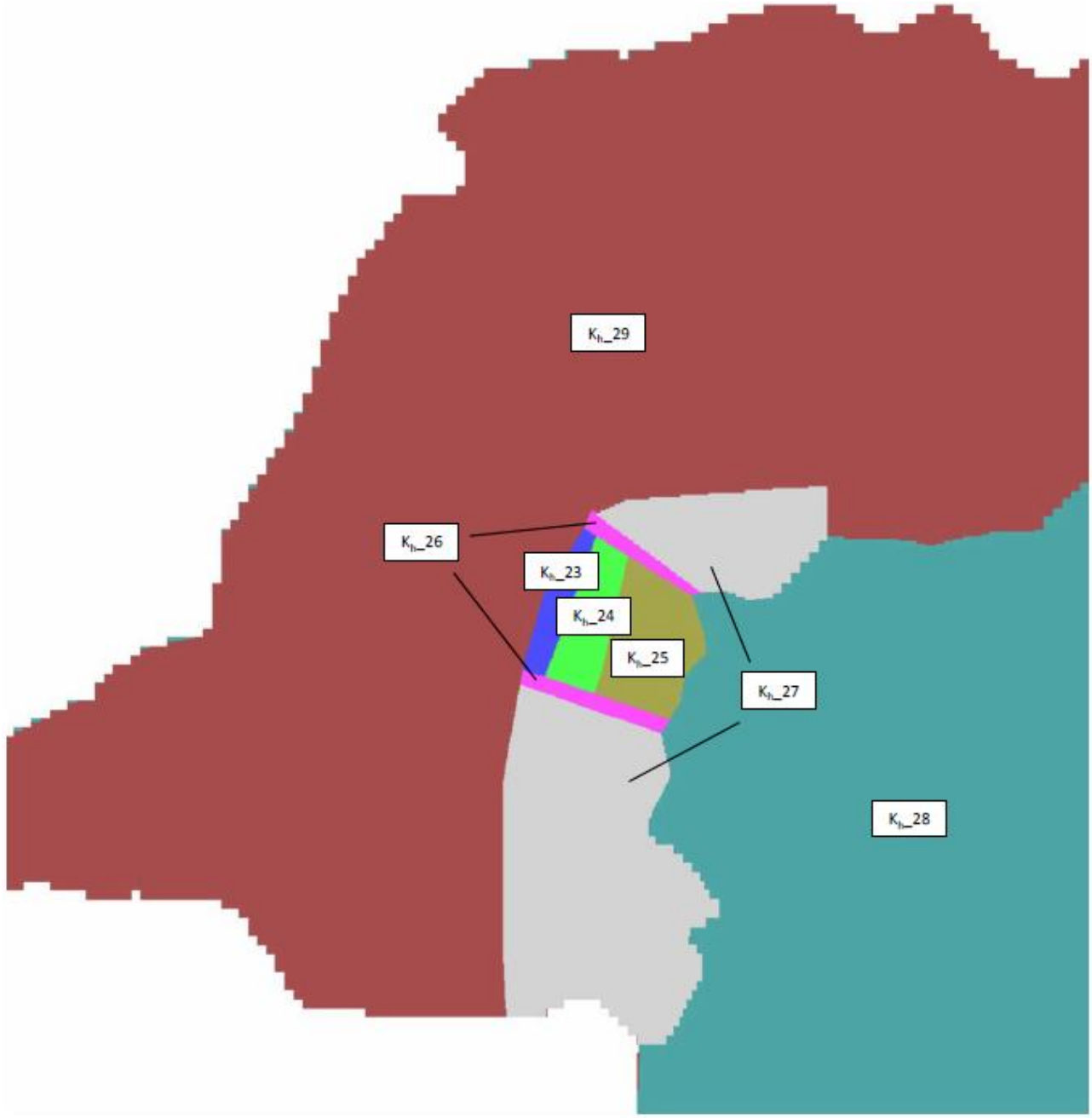

Figure 1 Parameter zonation in Layer 5 (Fig. 25 in Appendix B7A)

Consider the area in which the mine stopes will be developed in layer 5, which comprises parameter zones Kh_23 and Kh_24 (Figure 1). The equivalent K for this area (assuming zones have similar length and flow is perpendicular to the longest side of each K-zone) is:

$$K_{eq} = \frac{2}{\frac{1}{K_h\_23} + \frac{1}{K_h\_24}} \qquad \text{Eq. 2}$$

The posterior distribution after rejection sampling is very similar to the prior distribution for both parameter zones, with a standard deviation that is designed to cover 2 orders of magnitude (0.67 of log10 K). Figure 2 shows the equivalent log10 hydraulic conductivity distribution calculated using Eq. 2 for 10,000 random samples drawn from the normal distribution with mean and standard deviation for Kh_23 and Kh_24 taken from the prior values in table 7 in Appendix B7A.

This figure shows that the standard deviation of the distribution of the equivalent hydraulic conductivity values is 0.61, which is smaller than that of the individual parameter zones.

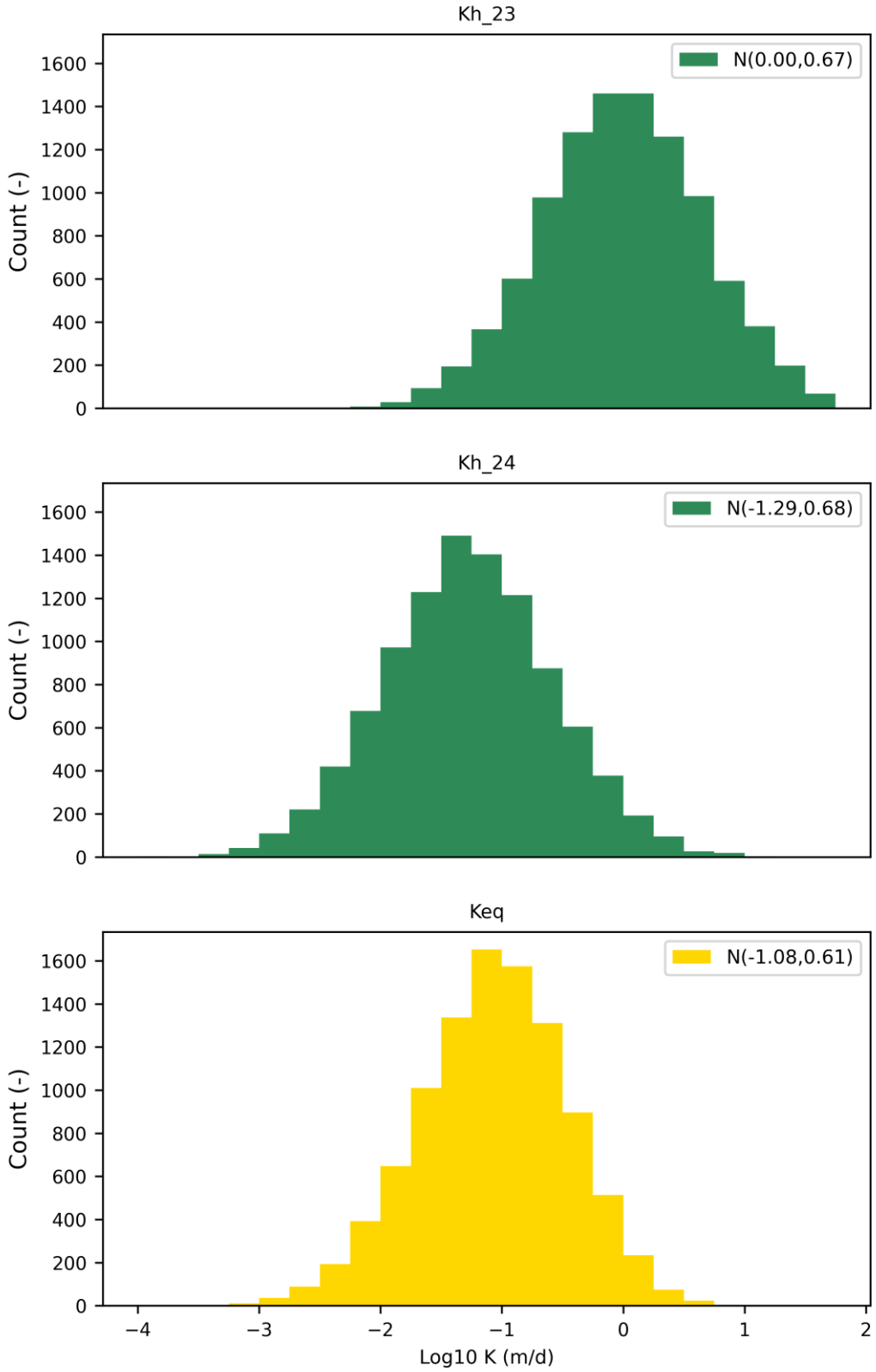

Figure 2 Histograms of equivalent hydraulic conductivity of zones Kh_23 and Kh_24 (Layer 5, proposed mine area), based on 10.000 random samples. The numbers in brackets are respectively the mean and standard deviation.

Without rerunning the groundwater model and uncertainty analysis again, it is difficult to quantify the effect of sampling a narrower range of K values on the 95th percentile estimate of mine water inflow. We can however illustrate what the effect would be using a much simpler model. We chose the analytic solution to estimate inflow to a tunnel by Perrochet (2005)[11]:

$$Q \cong \frac{2\pi T s_0}{\ln\left(1 + \sqrt{\frac{\pi T t}{S r_0^2}}\right)} \qquad \text{Eq. 3}$$

where Q $[L^3/T]$ is the inflow, T $[L^2/T]$ is the aquifer transmissivity, s_0 $[L]$ is the drainage or drawdown level, t $[T]$ is time, S $[-]$ is storativity and r $[L]$ is the diameter of the tunnel. This equation cannot represent the complexity of the numerical groundwater, but it does capture the essence of unmitigated mine dewatering. Evaluating this equation is very rapid, so it is possible to evaluate a large number of parameter combinations. The equation is developed for confined aquifer conditions. At the depth of mining, the aquifer can be considered confined.

Figure 3 shows the result of evaluating 10,000 parameter combinations randomly selected from the equivalent hydraulic conductivity distribution estimated in Figure 2 (Keq_1) and the same distribution with standard deviation equal to 0.67 (Keq_2). Storativity is based on posterior parameter distribution for specific storage of layer 5 (Table 7 in Appendix B7A). The following parameters are chosen to be of a similar order of magnitude as the condition represented in the groundwater model. The saturated thickness is chosen to be 50m. Time period is set to 5 years, drawdown to 100 m and diameter of tunnel to 1 m.

The predicted inflow distributions shown in Figure 3 are very skewed, with a long tail. This means the prediction interval is not symmetric; the 5th percentile will be close to the 50th percentile, but the higher percentiles (70th, 80th, 95th percentile) will be much larger than the 50th percentile.

The distributions of predicted inflow are very similar, but because the distributions are very skewed (i.e. have a long tail), the 95th percentile estimated from the equivalent K distribution with standard deviation of 0.67 is about 40% greater than the 95th percentile estimated from the equivalent K distribution with standard deviation of 0.61. We note that this potential underestimate is of a similar order of magnitude as the difference in inflow between the grouting scenarios (P95 70% effective grouting is 39 L/s, P95 hybrid grouting is 28 L/s).

This is an indication that sampling a narrower equivalent K range can lead to an underestimate of the 95th percentile of inflow. It is not possible to unequivocally assess the magnitude of this underestimate without rerunning the model, but this analysis indicates that the value of mine inflow after 5 years that is considered to be very unlikely to be exceeded in the most realistic scenario may be closer to the value considered very unlikely in the conservative scenario.

We also note that the histograms for SRMS (Fig 1 in Appendix B7A) and calculated baseflow (Fig 2 in Appendix B7A) also show skewed distributions, but the distribution of predicted inflow (Tables 1

[11] Perrochet P (2005) A simple solution to tunnel or well discharge under constant drawdown. Hydrogeology Journal 13:886–888. https://doi.org/10.1007/s10040-004-0355-z

to 3) are symmetric (i.e. the difference between P50 and P95 and between P50 and P5 is similar). This is not consistent with the expected skewed distribution on theoretical grounds. Without a comparison of parameter values retained in the ensembles against the prior or posterior, it is not possible to conclusively evaluate whether this an artefact of the modelling or an adequate representation of reality. We speculate that higher values of transmissivity or storativity cause numerical issues, leading to large water balance errors. If these values are rejected because they cause numerical instability rather than because they are physically not realistic, it will also lead to an underestimate of the P95 of inflows.

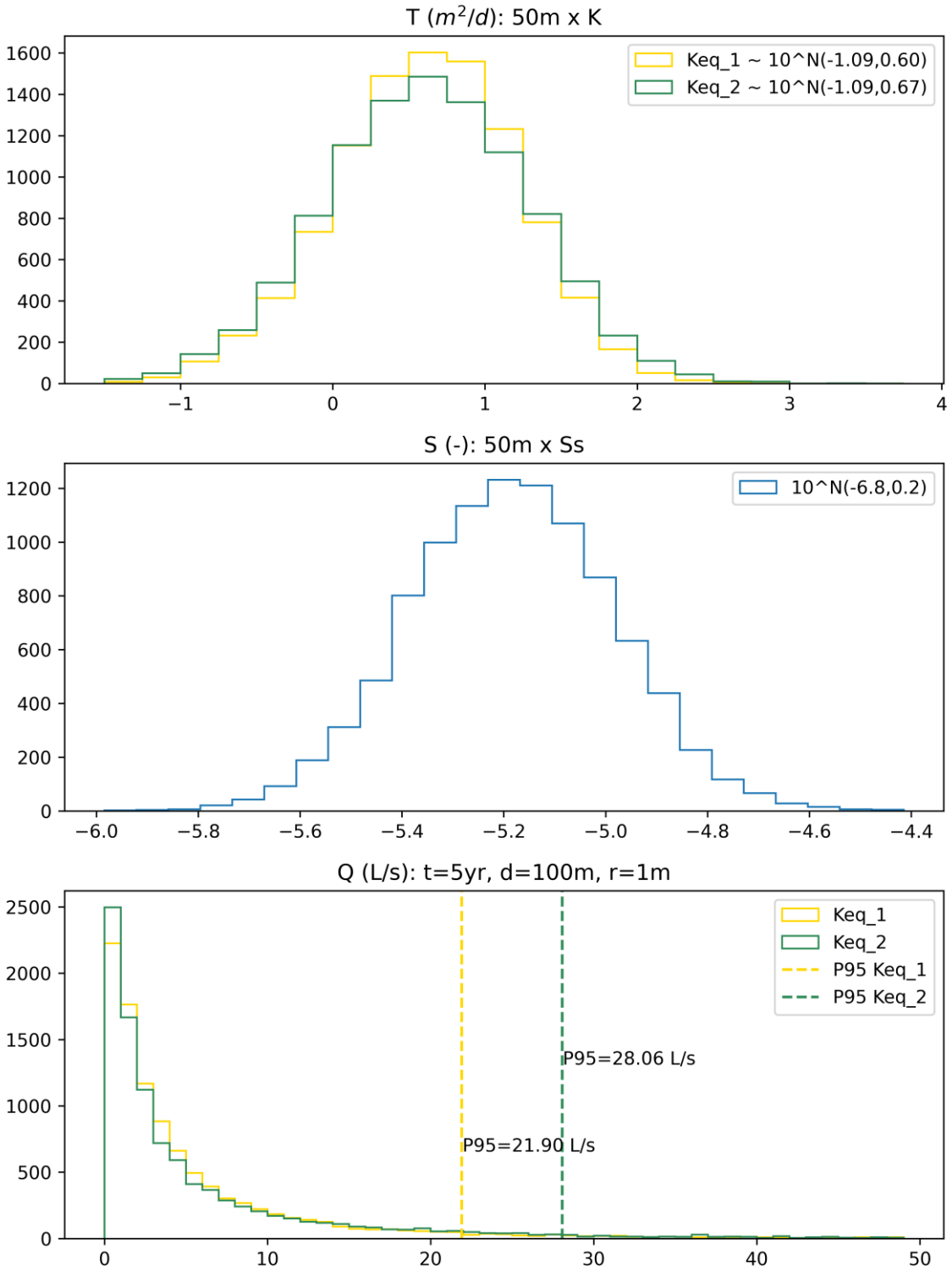

Figure 3 Mine inflow calculated using Eq. 3 (Perrochet, 2005) for 10,000 parameter combinations randomly selected from the equivalent hydraulic conductivity distribution estimated in Fig. 2 (Keq_1) and the same distribution with standard deviation equal to 0.67 (Keq_2). Storativity is based on posterior parameter distribution for specific storage of layer 5 (Table 7 in Appendix B7A). Saturated thickness is chosen to be 50m. Time period is set to 5 years, drawdown to 100m and diameter of tunnel to 1m.

3.1.3 Convergence

The results in Figure 3 also allow to test for convergence of the percentiles (Figure 4). Convergence means that the predicted values stabilise with increasing number of realisations. The top plot shows the convergence for 5th, 50th and 95th percentile for inflows calculated with Keq_1 and Keq_2 for the entire ensemble of 10,000 samples. It shows that the 5th and 50th percentiles converge rapidly, but that the 95th percentile only starts to converge after 2000 realisations.

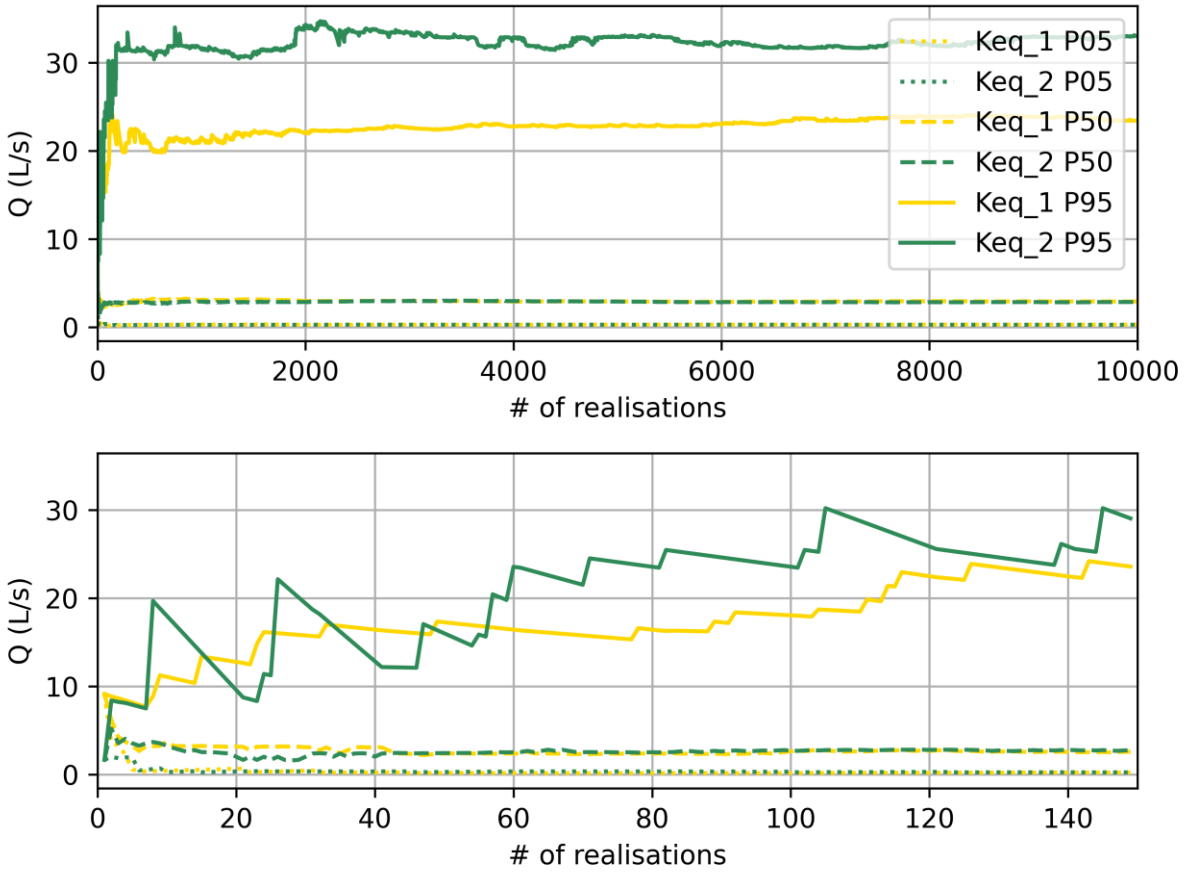

Figure 4 Convergence of 5th, 50th and 95th percentile for inflows calculated with Keq_1 and Keq_2. The bottom plot shows the first 150 realisations only.

The bottom plot of Figure 4 shows only the first 150 realisations. This plot is similar to those presented in Appendix B7A (Figure 46 to Figure 52). Considering the bottom plot in isolation may lead to a conclusion that the results have converged, but comparison with the top plot illustrates that this conclusion is not justified. In this specific case, the P95 for inflows calculated with Keq_2 is underestimated. It has to be noted that insufficient sampling can lead to either an underestimate or an overestimate.

Figure 4 also shows that the 5th and 50th percentile for the inflows calculated with Keq_1 and Keq_2 are almost identical. This provides confidence in the median mine inflow rates calculated with the numerical groundwater model.

3.2 Implementation of conceptual model in numerical model

The MLA is in a fractured rock aquifer, where hydraulic parameters are dominated by the secondary permeability (faults and fractures) with less influence of lithology. The hydrostratigraphic units in the hydrogeological conceptualisation do largely follow stratigraphy (Figure 5). This is consistent with the information presented in the groundwater assessment reports.

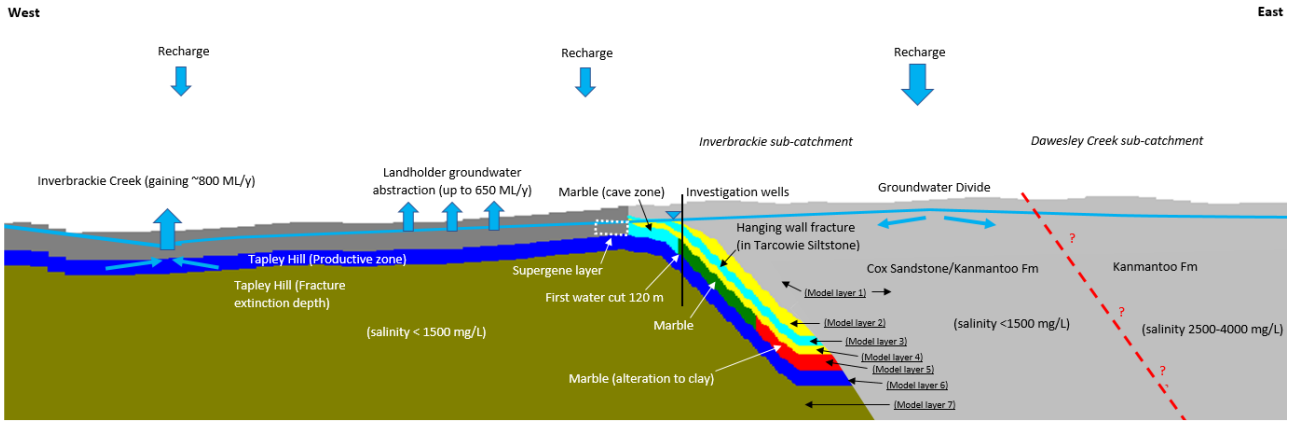

Figure 5 Conceptual hydrogeological cross section (Fig F3 in Appendix H1)

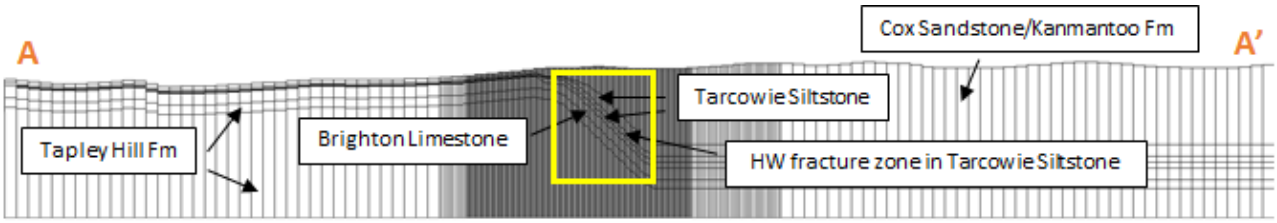

Figure 6 Model discretisation and layering (Fig. F4 in Appendix H1)

Figure 6 shows how this conceptualisation of hydrostratigraphic units is translated in the discretisation and layering of the numerical model. Hydrostratigraphic units are largely represented as individual layers. The layers in the vicinity of the fault zone and the mineralisation are steeply dipping. This creates following issues:

1. Horizontal and vertical conductivity in the model represent flow along and perpendicular to the dip of the model layer. Lateral flow is a combination horizontal and vertical conductivity. This makes it almost intractable to infer from the model report which parameters are controlling mine water inflow and whether this represents an adequate representation of the conceptualisation.
2. Layers 1-5 are very thin and unsaturated in the west of the model. This makes that:
    a. Hydraulic parameters assigned to zones in the west of the model are irrelevant (they are excluded from the calculations)
    b. Lateral drawdown in layer 5, which hosts the drainage features for mine stopes, cannot directly propagate to the west. The drawdown can only propagate westwards by propagating downward into layer 6.

   c. The watertable is hosted in layer 6 in the west and layer 1 in the east. The report[12] does not show which layers are simulated as confined or unconfined where in the model. This can have a large impact on simulated results as the storativity in unconfined layers is up to four orders of magnitude larger than storativity in confined layers.

We note the response to similar comments raised by DEM, justifying the steeply dipping layers to represent along strike hydraulic conductivity as horizontal hydraulic conductivity and across strike hydraulic conductivity as vertical hydraulic conductivity[13].

Rapid changes in geometry and thin, unsaturated layers are known to deteriorate the numerical stability of a numerical model. While this does not seem to affect the calibrated model, the rejection sampling illustrates that especially the transient model is not very robust, with a large number of model runs failing to meet the water balance error target. As discussed earlier, this can affect the estimation of the 95th percentile of mine inflows.

It is not possible to conclusively make a statement whether the issues mentioned above will lead to an over- or underestimate of the entire range of mine inflows:

1. Potential overestimate of mine inflow in the mine decline from the west as drawdown propagates into layer 6, the productive part of the Tapley Hill formation, instead of the less productive part of the Tapley Hill formation
2. Potential underestimate of mine inflow in the mine stopes from the west as drawdown cannot propagate to the west in layer 5 but has to propagate vertically into layer 6.
3. Potential underestimate of mine inflow from the east as drawdown propagates in the Tapley Hill and Tarcowie siltstones instead of the Cox Sandstone / Kanmantoo layer.

The complexity of the layer structure makes the model less transparent and tractable. An alternative layer structure would be to use horizontal layers with uniform thickness and represent the hydrostratigraphic units through different parameter zones.

Other issues identified with the implementation of the conceptual model are:

1. The layer 3 (Tarcowie siltstone) vertical hydraulic conductivity (2.5 m/d) and specific storage (2.2 x 10^{-4}) are high. This is appropriate to represent the hanging wall fracture zone, but it is unlikely that these values should be applied across the entire model domain in layer 3. Potential impact on predictions is considered medium:
   a. May lead to an overestimate of the potential for re-injection
   b. May lead to an underestimate of drawdown in the Tarcowie siltstone towards the south east
   c. Likely to have limited impact on predicted mine inflow as mine drainage is applied in layers 5 and 6

[12] AGT (2017) Bird-in-Hand Gold Project Groundwater Assessment

[13] Comment 30 in Table 4 in Terramin (2021) Bird in Hand Gold Project Response Document

2. Layers 6 and 7 (Tapley Hill formation) have a very large number of parameter zones. There is limited discussion in the reports what this zonation is based on. Impact on predictions is considered medium:
    a. Large number of zones allow to compensate for structural issues during calibration
    b. Increases the number of parameters for the uncertainty analysis and may lead to insufficient sampling of parameter space (see section 3.1)
3. The increase in horizontal conductivity of the Kanmantoo formation with depth in the south east of the model is not explained. Horizontal conductivity often decreases with depth, especially in fractured and weathered aquifers as intensity of weathering and aperture of fractures generally decreases with depth. Impact on predictions is likely to be low as it is at a relatively large distance from the proposed mine site.
4. Recharge zone 11 is not included in the table 9 of Appendix B7A (prior and posterior distributions for uncertainty analysis). Recharge zone 7 has zero recharge assigned to it, but explanation is not provided in the model reports.

3.3 Need to review the groundwater model in the vicinity of the mine

We concur with the SA government finding the groundwater model needs refinement within the vicinity of the mine development. While the groundwater model is suited to simulate median predictions of mine water inflow, drawdown and potential for reinjection at the regional scale, it is less suited to predict local impacts. Should local impact estimation be necessary, such as in the development of a groundwater management plan, it is recommended to revise the model, with particular attention to the model structure and numerical stability of the model.

3.4 Hydrogeological conceptualisation

The hydrogeological conceptualisation is generally well supported by the results of the field investigations. The only aspect that is less supported is the position of the groundwater divide. This is mentioned in the review by IGS[14] . The position of the groundwater divide is based on a single measurement location and alternative interpretations of the potentiometric surface are possible. The impact on predictions on the position of this groundwater divide is minimal. The mine water inflow or drawdown predictions are not a function of the potentiometric surface. The parameters that are relevant for inflow and drawdown predictions are not likely to be constrained by potentiometric observations.

[14] Innovative Groundwater Solutions (2017) Peer Review of Bird in Hand Gold Project Groundwater Assessment Report

3.5 Recharge assessment

We concur with SA government that recharge assessment can be made more robust by using multiple recharge estimation techniques. While this will improve overall confidence in the groundwater model, it is unlikely that improved recharge estimates will greatly reduce uncertainty in mine water inflow or drawdown estimates.

3.6 Controlled inundation

The simulation of controlled inundation is based on the base case parameter combinations for two scenarios (hybrid and 70% effective). The analysis would be more comprehensive if more parameter combinations were evaluated to quantify the predictive uncertainty in drawdown and recovery.

However, extrapolating from the range of drawdown predictions presented in the uncertainty analysis, it is expected that predicted range of drawdown and recovery under controlled inundation is relatively symmetric around the median. It is not expected that the range of simulated drawdown and recovery would include simulations that would indicate groundwater users would not have access to water from their bores. CSIRO therefore concurs with the government assessment that groundwater users would still be able to access groundwater under controlled inundation, for both scenarios.

4 Groundwater quality

Table 3 identifies 2 issues of low concern:

- appropriate inputs to solute transport model
- avoidance of supergene zone to mitigate risk of AMD

4.1 Inputs for solute transport model

The solute transport model to simulate the migration of saline water to the east of the mine site is based on the groundwater flow model. The issues identified in section 3.2 may affect the predicted fluxes which in turn may affect the simulation of solute transport. It is however unlikely that these changes in simulated flux will substantially alter the simulated salinity distribution.

4.2 Avoidance of supergene zone to mitigate risk of AMD

The mitigation strategy for acid and metalliferous drainage is to avoid the supergene zone, which has the highest likelihood of containing potential acid forming rocks. The mine design is based on the current mapped extent of the supergene zone and probe drilling during mining, in combination with testing for potential acid forming rocks, will be used to update the mapping of the supergene zone. It is however not clear how flexible the mine design is, should potential acid forming rock be encountered where it is currently not mapped.

5 Conclusion

The review of the groundwater chapter of the government advice on the Terramin Bird in Hand Gold Mine Lease Application established that the Government assessment and recommendations are consistent with the groundwater outcome and the documentation provided.

The review identified that while the median predictions of outflow are conservative, the parameterisation and sampling of parameters in the uncertainty analysis are likely not to result in a conservative estimate of the 95th percentile of mine water inflows.

For the other issues identified in the review, mainly pertaining to the implementation of the conceptual hydrogeological model in the numerical groundwater model, it cannot be unequivocally established whether they would lead to an over or underestimate of predicted impacts or whether they would lead to a material change in outcome.

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