Bird in Hand Gold Project

Mining Lease Application

MC 4473

CHAPTER 3 DESCRIPTION OF PROPOSED MINING OPERATIONS

BIRD IN HAND GOLD PROJECT

MINING LEASE PROPOSAL

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COMPETENT PERSON STATEMENT

The information in this report that relates to Bird in Hand Exploration Results and Mineral Resources is based on information compiled by Mr Dan Brost, a Competent Person who is a Chartered Professional Member of The Australasian Institute of Mining and Metallurgy (AusIMM). Mr Brost is employed as a consultant to Terramin Australia Limited. Mr Brost has sufficient experience that is relevant to the style of mineralisation and type of deposit under consideration and to the activity being undertaken to qualify as a Competent Person as defined in the 2012 Edition of the 'Australasian Code for Reporting of Exploration Results, Mineral Resources and Ore Reserves'. Mr Brost consents to the inclusion in the report of the matters based on his information in the form and context in which it appears.

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CONTENTS

TABLES

FIGURES

3 DESCRIPTION OF THE PROPOSED MINING OPERATIONS

Terramin Exploration Proprietary Limited (Terramin) is proposing to develop a small, high-grade underground gold mine, which targets the historic Bird in Hand Gold deposit, located approximately 35 km east from Adelaide, and 30 km north of Terramin's existing processing facilities (Angas Processing Facility (APF)) at the Angas Zinc Mine (AZM), near Strathalbyn. The proposed mine is known as the Bird in Hand Gold Project (the 'Project' or 'BIHGP').

At a very high level, the Project has a Resource of 265,000 ounces of gold at 12.6g/t. The Project will be South Australia's highest grade gold mine and also one of Australia's highest grade gold mines. The project will provide positive employment opportunities and economic impacts to the regional communities of Woodside and Strathalbyn, economic diversification, and provide professional career paths for young South Australians, as well as provide family oriented mining opportunities close to Hills communities.

The gold bearing ore would be mined in an underground mine at the Bird in Hand Gold Project site (the 'site'), and transported via truck to the Angas Processing Facility to be beneficiated to produce a gold concentrate product for sale. No gold concentrate processing infrastructure or tailings storage is required at the Bird in Hand Gold Project site. This Mining Lease Proposal (MLP) should be read in conjunction with the submitted Miscellaneous Purposes Licence (2019/0826) for the Angas Processing Facility.

In summary it is estimated that:

- The Project will generate a total positive impact on Gross State Product of an estimated $222 million over 8 years (excluding the Gross Operating Surplus of the mining operation itself)
- This includes $185 million of estimated wages and salaries paid to households, and the provision of a modelled 2,380 person years of employment (or an average of around 600 full time equivalent jobs at peak – equating to 2350 Full time Equivalent (FTE) jobs over the life of the project). Only 25% of the jobs created are in Project operations itself. The reminder is spread through the rest of the economy and impacts on sectors such as retail trade, business services, education, health services etc. generated through a combination of the support spend for the project, but also the on-spend of wages and taxes generated.
- The economic impact will peak in years 3 and 4 of the project.
- 60% of the impact will occur in the Adelaide Hills Council area, around Woodside (an estimated 420 FTEs at peak equating to 1400 FTE over the life of the project), and 20% would be expected in the Fleurieu Peninsula, around Strathalbyn (an estimated 170 FTEs at peak equating to 500 FTE over the life of the project).

This chapter outlines the proposed gold ore mining operations for the Bird-in-Hand Mine. It includes an overview of the operation as well as information on the following:

- BIH reserves, Products and Markets;
- Exploration Activities;
- Mining Description;
- Waste Management;
- Supporting surface infrastructure;
- Mine Completion; and
- Resources inputs (workforce, energy and water).

The majority of the technical work for this chapter, was undertaken by several consultancies, selected for their competencies in their relative fields. The remainder was undertaken internally by Terramin staff, incorporating their experience from not only Angas, but from other industry experiences. Their work was based on the underground mine design and schedule developed by Terramin, as well as field work to gather baseline data. The culmination of this work has formed the basis of information presented to and discussed with stakeholders throughout the consultation process and provided the information required to meet the Ministerial Determination gazetted for the Bird in Hand Gold Project. Details on each body of work and the associated reports are provided in Table 3-1 and the list is summarised below. Reference to these works will be made throughout this and subsequent Chapters.

- Geotechnical – Mining One;
- Erosion – Landloch and University of Adelaide;
- Site layout, visual amenity – Oxigen;
- Blasting and Vibration – Saros;
- Noise – AECOM;
- Air Quality – AECOM;
- Ventilation – Mine Ventilation Australia;
- Acid and Metalliferous Drainage – Tonkin Consulting;
- Traffic – Tonkin Consulting;
- Site Layout – Tonkin Consulting;
- Stormwater management – Tonkin Consulting;
- Run of Mine (ROM) system – Ammjohn;
- Power supply – Cowell Electric/GPA Engineering;
- Water Treatment – GPA Engineering; Peer review by Golder Associates
- Groundwater – Australian Groundwater Technology. Peer Review by Innovative Groundwater Solutions;
- Grouting – Multigrout. Peer review by Golder Associates.

As required in Section 6.2.1 of the Ministerial Determination for the Bird-in-Hand Gold Project, the work undertaken on the groundwater, grouting and water treatment to identify control measures to manage, limit or remedy groundwater impact events, were all subject to separate independent peer reviews, and the results are also included in the Appendices.

Terramin would like to take this opportunity to publically thank all of the consultants and community members who have worked tirelessly to develop this mining proposal.

tonkin

GOLDER

OXIGEN

wsp

mining one
Consultants
Mining · Geology · Geotechnical

MVA

ammjohn
Project
Engineering

GPA

saros

MultiGrout
The problem solver

G.O
MINING

AECOM

D4

AGT

F·A·B·A·L
FOOD AND BEVERAGE AUSTRALIA LIMITED

Cooe
Care Of Our Environment

IGS

THE UNIVERSITY
of ADELAIDE

TABLE 3-1 SUMMARY OF WORK BY CONTRIBUTING CONSULTANTS

Aspect	Consultant		Brief Scope	Appendix	Summary of contents	Peer reviewed N/Y
Site Layout	Tonkin Consulting	Tonkin	Develop conceptual plans for the surface layout of the site, including estimates on the earthworks required (tonnes cut and filled), Conceptual design of access road, including creek crossing, conceptual drafting of 3D surface.	B1	Conceptual site layout plans, creek crossing, services layouts	N
				B2	Basis of design for conceptual layout	N
Materials Handling Concept	ammjohn Pty Ltd	ammjohn	Develop conceptual layout and design of materials handling options from ore and waste streams.	B4	Conveyor concept report	N
Power Supply Study	Cowell Electric Supply Pty. Ltd/GPA Engineering	Cowell Electric/GPA	Develop conceptual designs for the proposed Project, including identification of typical infrastructure, its layout and backup strategies. Identify the source of electricity supply from existing networks, and any potential upgrades that will be required.	B5	Power Supply Study	N
Transport Assessment	Tonkin Consulting	Tonkin	Analyse existing traffic count data and determine impact of proposed Project on the existing traffic networks. Identify preferred haulage route for ore truck, identify preferred vehicle combination for ore haulage	F1	Transport Assessment	N
Strategic Visual Amenity Plan	Oxigen Landscape Architects	Oxigen	Identify existing visual amenity of the area of the Project and provide recommendations on the design and layout of the site. Develop conceptual maps and plans illustrating the visual impact of the proposed design of the site.	G1	Strategic Visual Amenity Plan	N
Groundwater Assessment		AGT	Undertake a thorough ground water assessment for the area of the proposed Project, including field work to test existing groundwater situation	H1		Y - by IGS
Groundwater Assessment peer Review 1	Innovative Groundwater Solutions Pty Ltd (IGS)	IBS	Peer review of the modelling and proposal by AGT of their groundwater modelling to the proposed Project against the MD.	H2	Outcomes of Peer Review of Bird in Hand Gold Project Groundwater	N

Aspect	Consultant		Brief Scope	Appendix	Summary of contents	Peer reviewed N/Y
					Assessment Report	
Groundwater Assessment peer Review 2	Innovative Groundwater Solutions Pty Ltd (IGS)	IGS	Update on feedback from the initial peer review of AGT's work.	H3	Final assessment of additional work addressing IGS questions	N
Grouting Proposal	Multigrout	Multigrout	Identify the suitability of grouting technology and technique for the purpose of groundwater control, recommend processes involved and provide examples of working operations.	H4	Grouting Proposal	Y – by Golder
Grouting Proposal Peer Review	Golder Associates	Golder	Peer review of the proposal by Multigrout on the concept and suitability to the proposed Project.	H5	Grouting peer review	N/A
Managed Aquifer Recharge Investigation – Stage 1 drilling and pumping tests	Golder Associates	Golder	Report on Stage 1 – drilling and Stage 2 – pumping tests of the MAR Trial	H8	MAR drilling and pumping test report	N
Investigation into Managed Aquifer Recharge	Golder Associates	Golder	MAR investigation and update of 2017 Groundwater Impact Assessment with MAR Trial findings	H9	MAR investigation	Y – by IGS
Independent peer review of updated modelling for the Bird-in-Hand Gold Project	Innovative Groundwater Solutions Pty Ltd (IGS)	IGS	Peer review of the MAR investigation report by Innovative Groundwater Solutions	H10	MAR/GW peer review	N/A
Stormwater Management Plan	Tonkin Consulting	Tonkin	Develop a conceptual stormwater management plan for the proposed site, including identification and layout of proposed infrastructure	I3	Stormwater Management Plan	N

Aspect	Consultant		Brief Scope	Appendix	Summary of contents	Peer reviewed N/Y
Water Treatment Options Study	GPA Engineering	GPA	Identify a suitable water treatment system that will suitably address the requirements of the Project, which meets the objectives of the proposed water monument plan for the site. Identify infrastructure required and recommend mitigation measure to reduce impact of any identified impact events.	J1	Water Treatment Options Study	Y – by Golder
Water Treatment Options Study Peer Review	Golder Associates	Golder	Peer review of the proposal by GPA for the water treatment system for the Project. Provide comment on the suitability of the proposed concepts and identify any additional potential impacts and associated mitigation measures.	J2	Water Treatment Options Study Peer Review	N
Soil Erosion	Chloe Anderson	University of Adelaide	Undertake a preliminary soil erodibility assessment for the Project site and identify potential methods of stabilisation and erosion controls for site.	L5	Soil Erosion Assessment	N
Geotechnical Assessment	Mining One Consultants	Mining One	Geotechnical assessment of mine design including underground tunnels, stoping sequence, decline and boxcut design, subsidence, slope stability, and seismicity. Undertaking site field work (geotechnical test pits, and core analysis) to develop geotechnical models o for the Project .The work also included a preliminary erosion assessment of the site by Landloch, and comment on the potential for using road headers, by McMillen Jacobs Associates.	M1	Geotechnical Assessment	N
Acid and Metalliferous Drainage Assessment	Tonkin Consulting	Tonkin	Undertake assessment of results from 58 drill core samples that represent in-situ country rock to determine the presence and extent of AMD material. Determine the potential for the BIH site to generate AMD and inform management strategies to manage potential environmental risks	M2	Acid and Metalliferous Drainage Assessment	N

Aspect	Consultant		Brief Scope	Appendix	Summary of contents	Peer reviewed N/Y
Air Quality Impact Assessment	AECOM Australia Pty Ltd	AECOM	Outline the current regulatory system relevant to air quality management, analysis of baseline air quality conditions, identify potential sources of air emissions/pollutants, and undertake an air quality impact assessment of the Project and identify relevant mitigation measures.	N3	Air Quality Impact Assessment	N
Ventilation Proposal	Mine Ventilation Australia	MVA	Develop ventilation models for options in the mine design to determine optimal ventilation circuit for the Project, including recommendations on the siting of the primary ventilation shafts. Model contaminant pathways and levels in the underground ventilation system, recommend appropriate ventilation infrastructure and layouts for the Project.	N4	Ventilation Review	N
Noise impact assessment	AECOM Australia Pty Ltd	AECOM	Outline the current regulatory system relevant to noise management, analysis of baseline noise conditions, identify potential sources of noise, and undertake a noise impact assessment of the Project and identify relevant mitigation measures.	O3	Noise Impact Assessment	N
Blasting Impact Assessment	Saros (International) Pty Ltd	Saros	Investigate the effects surface and underground blasting operations proposed for the Project will have on the surrounding environment, focusing on vibration and air overpressure. Undertake modelling of blasting at various points of the mine's progress to determine potential impacts, and undertake and assessment of results against regulatory compliance limits. Recommend mitigation measures to reduce impacts if required.	P1	Assessment of Proposed Blasting Impacts	N
Agricultural Impact Assessment	FABAL Operations Pty Ltd	FABAL	Advise potential impacts associated with agricultural production in relation to the Project, complete and impact assessment review based on Project details, and provide	U1	Agricultural impact assessment	N

Aspect	Consultant		Brief Scope	Appendix	Summary of contents	Peer reviewed N/Y
			potential mitigation measures suitable.			
Concept Closure Plan	Oxigen Landscape Architects	Oxigen	Considering the proposed operation landform, provide recommendations on the potential for the site after mine closure. Identify potential to incorporate aspects for the Mine closure early on in the design of the site to avoid abortive or redundant future works.	X1	Concept Closure Plan – Landscape Component	N

3.1 GENERAL DESCRIPTION AND MAP/PLANS OF OPERATIONS

The following description provides an overview of the mining schedule, mining method and site infrastructure, including justifications for the proposed mining approach. For reference, the proposed mine site layout is illustrated in Figure 3-1.

Construction activities are planned to be contracted out to suitably qualified parties. It is proposed that the underground portion of the Project would be developed and operated by Terramin Australia Limited.

FIGURE 3-1 | PROPOSED BIRD-IN-HAND MINE SITE LAYOUT

3.1.1 Phases of Mining

The main phases of the proposed Project include:

- Surface construction;
- Underground development;
- Ore production;
- Mine closure; and
- Site Rehabilitation.

The relationship between each phase and their timing are illustrated in Figure 3-2.

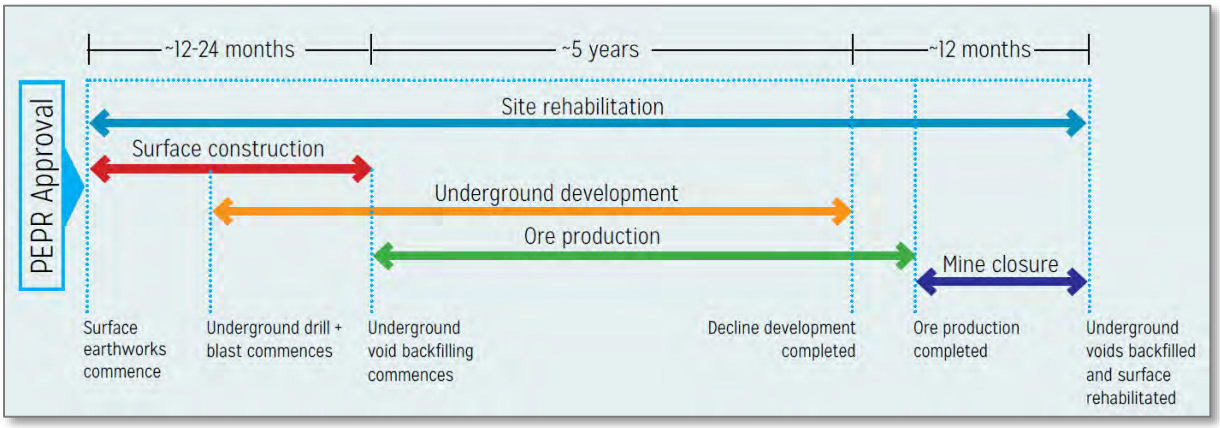


Figure 3-2 | Proposed Phases of the Project

3.1.1.1 CONSTRUCTION

The mining schedule incorporates approximately 12 months for the construction of surface facilities and excavation of the initial boxcut/portal development. This period includes the upgrade for 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.

The historical Bird in Hand Gold workings extend 125m below surface and are still in place today. To ensure an adequate standoff from the old workings and providing a suitable crown pillar, it is proposed to access the gold mineralization 150 m below the surface. A decline has been designed at 1V:7H to provide a permanent access way to the orebody and the primary ventilation fresh air intake. The upper decline to the ore is approximately 1 km long and will take approximately 16 months to construct. The initial underground access, also called capital development, includes the decline, stockpile/passing bays, underground magazine, underground substation, primary ventilation shaft and drives and secondary egress route prior to any ore being produced. The country rock mined during capital development generally contains no valuable 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 mining sequence and geotechnical support regime.

3.1.1.2 PRODUCTION

This proposal is based on the known mineralisation reaching 450 m below surface. Utilising "Cut and Fill" mining, a small scale mining method selected and discussed in section 3.1.3.1. Under this scheme 47 months of ore production has been planned. Once the decline has reached the ore, production (mining of ore) will commence with ore being brought to surface and mullock being returned as fill. As the production progresses the capital development will continue with the decline spiralling down adjacent to the orebody along with the supporting infrastructure (ventilation and secondary egress) towards the bottom of the know ore body.

As part of the cut and fill mining method, the production levels will be progressively backfilled and rehabilitated as mining progresses. Filling is an integral part of the mining method selected and provides support to the ground to prevent loosening of the rock structure and stability. The use of continuous fill minimises the amount of mullock stored on the surface at any point in time.

3.1.1.3 MINE CLOSURE

Once ore production has ceased, final backfilling of areas underground will be undertaken where required, infrastructure will be removed and the decline and raises plugged, filled and sealed to provide stability and prevent access. It is expected that setting the mine up for closure will take approximately 12 months.

Final rehabilitation on the surface will be undertaken, with key infrastructure such as access roads, shedding and dams retained for future commercial/agricultural land use.

Additional details on mine closure are provided in Section 3.10.

3.1.2 Key Characteristics

Table 3-2 summarises the key characteristics of the Project.

Table 3-2 | Key Characteristics of the Proposed Mining Lease

CHARACTERISTIC	DESCRIPTION
Location	Woodside, 3km east of the township in the Adelaide Hills, 30km east of the Adelaide CBD
Exploration Licence	EL 5469 and EL 6319
Mineral Claim	MC 4473
Area covered by proposed Mining Lease	195 ha
Mining footprint	4.5 ha
Mining Method	Underground cut and fill
Commodity to be Mined	Gold (+Copper, Silver, Lead, Zinc)
Mine Life	5 yrs. (construction, development and production phases)
Average Ore Production Rate	150,000 tpa.
Underground access method	Decline access
Depth below surface (mbs)	Down to 450mbs. Ore body from 150mbs to 450mbs
Backfill material	Rock fill (RF) and cemented rock fill (CRF) using site mullock and cement slurry, placed by underground loader.

CHARACTERISTIC	DESCRIPTION
Ore transport	Road Haulage from site to the Angas Processing Plant (APF), Strathalbyn. Hauling 300-500 tonnes a day, 7 days a week, via GAV dog and truck configurations.
Ore Processing Method	Off-site at APF, Strathalbyn. Conventional comminution – primary jaw and SAG mill, beneficiation via floatation to produce a gold concentrate
Operating Hours	24 hours a day, 7 days a week
Blasting operation	2 daily blast periods at peak production, typically at end of shift periods.
Workforce	BIH Site Personnel – 60 for construction, 100 for operation. Angas Site Office – 40 for operation.
Mullock	Mullock will be stacked either in allocated bays underground or on the surface in a dedicated storage area for subsequent returned underground for backfilling voids with RF and CRF.
Power	Annual site electricity consumption is estimated at 16GWh site a site maximum demand of 2.8MVA (2.6MW)
Water Management	Decline fracture avoidance and pre-excavation grouting will restrict groundwater inflows into the mine. A Managed Aquifer Recharge (MAR) processes will also be used to manage groundwater inflows into the mine voids created during mining. Reinjected water quality will meet the requirements of drainage well permits required for the MAR system. Any water entering the mine from the ground, (expected peak annual average of 1.4L/s in year 1, and up to peak annual average of 4.5L/s by year 5) along with surface run off, will be collected and treated via a dam/clarifier/IEX/Bio filter process. The water produced will be used for mining requirements or returned to the ground via a managed aquifer recharge (MAR) system. A MAR system is used to return water back into the aquifer recharging the groundwater volume and preventing water level drawdown.

3.1.3 Options

Throughout the design of the BIH gold project, there have been many options considered for the Proposed Mining Operations. Comparison of the available options was undertaken through a risk assessment process to eliminate higher risk proposals. The remaining options were tested throughout the various stakeholder consultation sessions held, to determine acceptability with the community and other stakeholders. Below is a brief summary of a selection of the options considered throughout the development of the Project. Further details on options considered are included throughout this chapter, Chapter 3 Description on the Proposed Mining Operations and within each of the aspect chapters discussing risk and management strategies.

3.1.3.1 MINING METHOD

3.1.3.1.1 OPEN CUT VS UNDERGROUND

The consideration of an open cut mining method versus an underground method was one of the earliest options considered during the initial scoping study for the project. Open cut mining is a cost effective mining method for outcropping orebodies and is technically feasible for the Bird in Hand deposit. The historic gold production for the Bird in Hand mine was 10,500 oz and the mine extended 125 m below the surface. The existing Resource has 265,000 oz down to a depth of 450 m. A significant amount of gold remains around the old workings that could be recovered using open cut mining. Further consideration of developing an open cut was dismissed in respect of the strong community views that an open cut mine would not suit the local amenity. Based on the feedback from community engagement it was understood that a mining project would be considered unattractive so minimising the surface expression and minimising the mine footprint became a principle design guide that leant towards underground mining. In addition to the community feedback, there were a number of other reasons why an open cut method was rejected including the impact on surrounding environment:

- size of pit – loss of vegetation, including Native Vegetation Heritage Agreement area containing listed orchid species and a high value ecosystem;
- land access –the open cut mine required control of a large area of land for the mine and overburden storage and the relocation of the Bird in Hand Road;
- exposure and drainage of ground water aquifers, and subsequent mine dewatering;
- loss of residences;
- loss of public infrastructure (i.e. Bird-in-Hand Rd);
- exposure to increased dust;
- exposure to increased noise levels; and
- exposure of existing underground BIH mine workings.

The cost of removing and storing the required overburden to access the narrow orebody at depth proved to be prohibitive for full exploitation of the Resource requiring an underground mine to access the full value of the deposit. Open cut mining was dismissed and only underground mining methods were contemplated.

3.1.3.1.2 MINE ACCESS OPTIONS SHAFT VS DECLINE

Historically the Bird in Hand mine was developed using vertical shafts stepping out in a southerly direction as the orebody extended to depth. The final shaft developed was the Main Shaft – Victoria, which was approximately 25 m to the south of the Old Main Shaft. Old Main Shaft was the deepest of the eight shafts, extending 125 m below ground level. After mining ceased, the Old Main Shaft was utilised as a water supply via an adjacent bore for Inverbrackie until 1967 (Appendix S1).

An early review of the mine access determined that a vertical shaft would have a similar capital cost to access the ore as a decline but with the shallow dip of the orebody, access from the shaft to the mineralisation would progressively increase at depth, reducing the effectiveness of the access and increasing the required development at depth. A latter review of the ground conditions and geotechnical requirements determined that the capital cost of a shaft with the required dimensions and ground support for haulage, people and materials would be more expensive than a decline access. The exploration drilling and investigation well drilling identified a fracture zone in the hanging wall, in the Tarcowie Siltstone. When intercepted by investigation wells, the fracture yielded up to 40 L/s. The fracture zone has transmissivity of 67 m^2/day (geometric mean) and is the most significant mode of groundwater flow into the mine if intercepted by mine workings. The design focus for the mine was to avoid the main aquifers and a decline approach from the northwest provided the best opportunity to achieve this.

A conventional decline access at 1V:7H provided for the best flexibility of access, opportunity to avoid the hanging wall fault and provided for better serviceability using a mechanised mining fleet.

3.1.3.1.3 OPEN STOPING VS CUT AND FILL

Open stoping is a bulk mining method that is used in mines where suitable orebody orientation and ground conditions exist. Generally it involves developing two tunnels in the ore, one overlying the other at a distance determined by the geotechnical properties of the host rock. Ore is then mined between the two drives using a design of holes between the two tunnels. The result is the efficient mining of ore, creating a large void that does not have ground support in the stope walls and has limited access for men. The open stope is then filled prior to adjacent stopes being mined. The nature of open stoping, allows for less development mining to access the ore and can also allow for larger quantities of ore to be drilled, blasted and removed at one time. It does however require the correct geometry and conditions around the ore body for the method to work. Broken rock will easily move (rill) under gravity when the slope angle of the walls of the stope are above 60 degrees. The BiH ore body is dipping at approximately 45-50 degrees, meaning that the broken ore would hang-up on the stope walls and not be accessible for removal and treatment. A geotechnical review of the host rocks was undertaken, specifically the hanging wall, to determine the likelihood of maintaining stable openings under an open stoping scenario. It was determined that the conditions of the hanging wall along with the proximity to the hanging wall fault zone were such that the hanging wall requires a good coverage of ground support to reduce any risk of potential ground failure was another reason to discount an open stoping method. An open stoping method of mining was discounted for BiH with a preference for a smaller scale mining method that provided better access for ground control and selective mining. Cut and fill mining was identified as a method that allows for improved ground control, provides for selective mining to improve the recovery of the narrow ore body, enables the ability to install ground control to all openings and minimised the hanging wall exposure. Cut and fill also provides full access to the mine opening to allow for management of any groundwater ingress should unanticipated flows occur during operations.

Cut-and-fill stoping is a method of underground mining used in narrow vein steeply dipping orebodies and in mining high-grade irregular ore bodies. The rock mass surrounding the ore deposit is usually weak—unable to support loads over an extended stoping height. As the name of the method implies, successive cutting of the ore into horizontal slices is carried out starting from the bottom of the stope and progressing upwards towards the surface. The horizontal slicing leaves a void that is backfilled with material to provide support to the hanging wall rock and provides a working floor for mining of the subsequent level of mining.

3.1.3.1.4 BLASTING VS MECHANICAL EXCAVATION (TUNNEL BORING MACHINE/ROAD HEADER)

Drill and blast using Jumbo drill rigs is considered conventional underground mining practice in Australia. The use of alternative excavation methods such as a tunnel boring machine or road header was considered for the Project. Under the right conditions a mechanised miner can achieve superior development rates and provide reduced over break and improved perimeter control (tunnel profile). A review of the geotechnical conditions of the country rock in which the mine would be excavated was undertaken.

McMillen Jacobs Associates, consultants involved in excavation of civil tunnels in the eastern states were approached through Mining One who under took the Project's Geotechnical Assessment, to understand the application of a mechanised miner for the Project and is included in Appendix M1.

Key characteristics determining the suitability of mechanised miners are; the rock strength, rock abrasiveness and the homogeneous of these properties throughout the rock mass. Due to the overall rock strength and the number of high strength and highly abrasive interspaced quartz veins, utilising mechanical methods was eliminated. Feedback from the geotechnical test work undertaken on the BIH rock properties, indicated that the rock was either too hard or too soft (leading to excessive downtimes in machinery for replacement or cleaning of headers) and the likelihood of hitting multiple quartz veins presented a high likelihood of down time.

The conventional mining method of drill and blast has been selected to develop the tunnel accesses and mine the gold bearing ore. The method has developed to be a highly specialised process that allows for very precise cutting of rock. In Australia over 500 million tonnes of explosives are used in mining each year for rock breaking by licenced experts. Underground mining utilises drill and blast to progress a tunnel to access valuable minerals buried beneath the Earth's surface. The process of tunnelling involves drilling a specific pattern of holes that once charged with explosives and fired allows for the precise breakage of rock, protecting the country rock and minimising ground vibration.

3.1.3.1.5 LOCATION OF VENTILATION FANS AND RAISES

Geotechnical analysis by Mining One, (Appendix M1) was combined with ventilation modelling that was undertaken for the Project by Mine Ventilation Australia (MVA), comparing the options available, along with the legal requirements. Results of this work by MVA are included in Appendix N4 in the Ventilation Proposal.

Mine ventilation is an integral part of a mining operation. Ventilation requirements are stipulated by law and ensure that there is adequate fresh air circulated around the mine's tunnels to provide a safe and comfortable work place. Ventilation standards relate to the quality of the air, the quantity and velocity of the air flows relative to the size of the mine, the equipment and the likely airborne products generated through the mining and excavation process. The primary ventilation system is comprised of the mine access, as a fresh air intake, and a dedicated exhaust shaft fitted with large fans to draw the air through the mine. The ventilation system is considered long-term infrastructure that should be located such that there will be no interaction with any planned or potential mine development. The location of the underground ventilation raises is selected to minimise the amount of development required to access the exhaust on each level, while placing the raise well outside the area of the orebody to maintain adequate ground conditions. Two locations were reviewed for the primary exhaust shaft location. The earliest position for the shaft was close to the orebody, proximal to the historic workings, siting within the SA Water land. The geotechnical conditions for this location were reviewed, along with the proximity of the ventilation infrastructure to neighbouring residences. It was determined that the proximity to a neighbouring residence was unsuitable, along with the poor ground conditions associated with the old workings. The first location was abandoned. A second location away from any residences and in better ground conditions was identified within the Goldwyn property. This location also allowed for establishing the ventilation shaft to provide for extending the ventilation in parallel with the decline development, providing better conditions during mine development. The location of the primary ventilation raise "Option 2 Vent" is shown in Figure 3-3. For similar reasons, Option 3 for the Egress shaft was also chosen.

The main ventilation fans will be located within the primary exhaust system on the 80m level below surface. The fans will be located underground to provide better control of the airflow through the fans, provide efficiencies within the ventilation system (resistance and shock loss) and reduce noise levels experienced on surface.

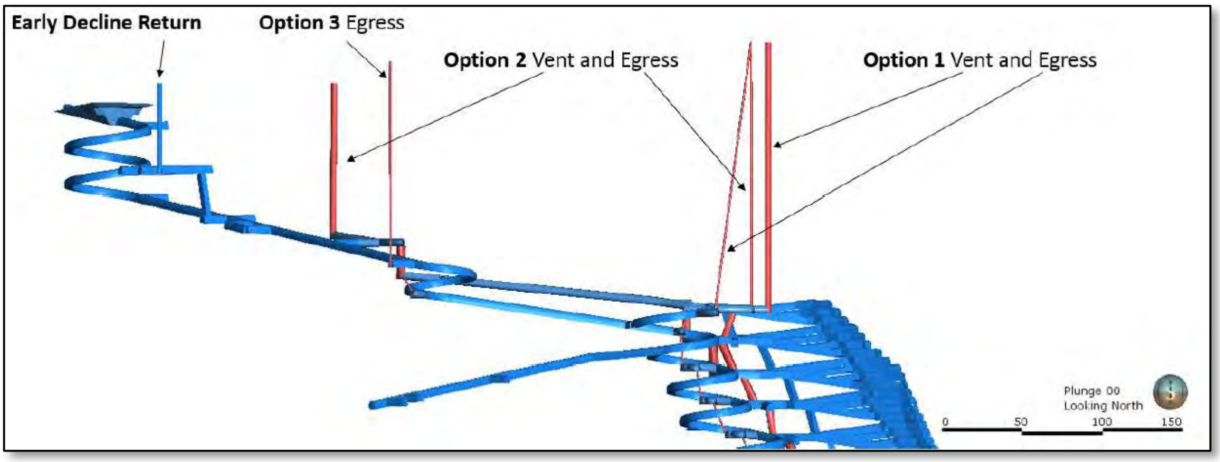


FIGURE 3-3 | ISOMETRIC SECTION LOOKING NE, SHOWING OPTIONS FOR THE LOCATION OF PRIMARY VENTILATION RISE (APPENDIX N4)

3.1.3.1.6 MAGAZINE LOCATION – SURFACE VS UNDERGROUND

South Australian Regulations (Explosives Act 1936 (SA) and Explosives Regulations 2011 (SA)) prescribe the requirements for the storage and handling of explosives. This includes the surface storage of explosives and the exclusion distances required between infrastructure, public spaces and houses etc., and magazines of particular type and size. The proximity of neighbouring businesses and residences was reviewed in regard to the property use and classifications. It was identified that the storage of explosives is an emotive topic and should be considered in respect of the neighbour's locations. It was decided that the explosives required to establish the mine could be stored at the Angas licensed magazines and brought to site as required. Once the mine is established, an underground magazine would be constructed, providing a higher level of security and a low risk of exposure to neighbours in the unlikely event of an incident. AS 2187 has been used to ensure that the best possible solution for explosives management is applied. This Australian standard provides the requirements, information and guidance for the use of explosives, the management of a site where explosives are stored and used to ensure that the risks are acceptable.

3.1.3.1.7 BACKFILL PROCESS

The cut and fill mining method utilises backfill as an integral part of the process. Mining cannot progress until the mined void is back filled. Options for backfilling mined voids include the use of tailings within a paste, rock fill and cemented rock fill amongst others. The ore from BIH will be processed in the Angas processing facility (APF) at Strathalbyn under a separate approval (Miscellaneous Purposes Licence – pending). The resultant tails will be stored in the Angas Tailings Storage Facility and will not be returned to the mine site. As a result, the use of tailings as a paste fill was not considered. The mullock removed from the mine during development will be used as backfill once the ore is removed. A combination of cemented rock fill and loose rock fill will be used, depending on the location of the void and the performance of the back fill relative to subsequent mining activities. Mullock will be returned underground and either placed directly into the void or mixed on the level with a cement slurry prior to placement into the void by underground loader. Cement slurry will be delivered underground by a concrete agitator truck and the backfill mixed in a sump designed for mixing.

3.1.3.2 SURFACE LAYOUT – PLACEMENT OF KEY AREAS

3.1.3.2.1 INTEGRATED MULLOCK LANDFORM (IML)

The mining method selected required the mining of mullock to reach the orebody. This material needs to be stored in a suitable place either permanently or temporarily until it is required. At BIH, this material will be used, as part of the mining process, to backfill the mine voids created during the mining of the gold ore. As part of the scoping study and the project development the Goldwyn property was used as a location to establish the surface infrastructure required to establish the underground mine. The scoping study determined that the two fields south of the creek line on the Western side of the property would be suitable to store the required mullock in a stockpile 5m high. After the first round of community engagement it was established that the visual amenity of any proposed operation was important and that any plans should minimise the visual impact from neighbours. The original 2013 Project scope design is shown in

Figure 3-4

A full sized copy of this site Layout is included in Appendix B5 – Figure 1

FIGURE 3-4 | 2013 SCOPING STUDY CONCEPTUAL LAYOUT (FULL SIZED VERSION REFER TO APPENDIX B5 – FIGURE 1)

The next revision of the conceptual site layout looked to minimise the footprint of the mullock stockpile and provide for integrating the mullock into the landform as quickly as possible. A plan was developed to establish an Integrated Mullock Landform (IML) into the south western corner of the Goldwyn property. This plan incorporated building an IML that had the same form as the existing hill face and which was established in the first 12 months of the project and then rehabilitated with native plants as quickly as possible. Any further activity relating to the storage and removal of mullock would occur behind the IML and out of site. The second site concept, drafted by Oxigen is shown in Figure 3-5.

A larger format of this figure is included in Appendix B5 – Figure 2).

This design was tested with the community in early consultation and specifically discussed with near neighbours. The relocation of the IML provided no vision of the IML from the western neighbour but it did concentrate activity in front of the southern neighbour (Figure 3-5). It was requested that Terramin look at other options including the removal of the mullock from site.

Removal of mullock from site was analysed as an option, however the trucking of mullock off site presented two other impacts that clashed with other community concerns. The first was that the removal of the mullock from site resulted in an increase in traffic, specifically trucks and the need for mullock in the backfill process meant that additional trucks would be required to bring in backfill material to site. The result was an increase in trucking requirements by over 130%.

The option of removing all mullock from site was eliminated as an acceptable solution. The review and repositioning of the IML into the south east paddock was undertaken (Figure 3-6)

A larger format of this figure is included in Appendix C3.

This location allowed for moving the IML away from the neighbour and shielding the IML from view obscured by the existing ridge line in a more sympathetic nature behind established vegetation buffers. With the combination of earth bunds and early vegetation programs, the IML could be hidden from view and the new location provided for better environmental control. The area to the eastern section of the property, is located. It also reduces the footprint of the area required by the mine and provides a shorter tramming distance from the portal to the IML.

FIGURE 3-5 | SECOND CONCEPTUAL SITE LAYOUT (PLEASE REFER TO THE LARGE VERSION FOR DETAIL – APPENDIX B5 – FIGURE 2)

Figure 3-6 | Final conceptual Surface Layout including the Integrated Mullock Landform (Appendix C3)

3.1.3.2.2 OFFICES/WORKSHOP

Offices and workshops for the mine are designed to sit within the mine site shielded from view from neighbouring properties and close public access points. The offices and workshops include, change rooms, ablution facilities, stores and a laydown area for equipment and consumables. Access roads and storm water drainage are designed to minimise the footprint and collection of storm water. Storm water collected from the roof of the office and workshop will be collected for use in the ablutions facility.

3.1.3.2.3 RUN OF MINE (ROM)

Run of Mine (ROM) is the collective term used for the ore that is brought to surface and stored prior to further beneficiation and treatment to recover the valuable metals. Typically ore is brought to the surface and stored on a ROM pad in areas depending on the quality and composition. A ROM pad, is usually an open space of bare ground where trucks and loaders traverse for the putting down and picking up of the ore. While it is considered conventional for a mine site to have a ROM pad it is recognised that the nature of a ROM pad results in a number of environmental issues that the community has identified as undesirable. Typically a ROM pad will generate dust, it has moving vehicles that can have reversing alarms, the picking up and loading of trucks by loader creates noise and the large area required to safely move the mine vehicles increases the footprint of the mine and increases storm water collection area. The scoping study included such an area, close to the portal, where road haulage trucks would be loaded from a stockpile via wheeled front end loader. This created an additional issue in that the road going trucks would need to drive over roads that are unsealed and could pick up mud which could create carryout onto the public roads. Community engagement had identified that the potential impacts related to dust, noise, vehicle movement, traffic management/carry out and changes in visual amenity need to be well managed. Alternative solutions were investigated to provide an ore management system with less impacts. The solution was to incorporate an enclosed ore handling system where the ore could be tipped from the underground mining truck at a location near the surface, into a hopper that feeds onto a conveyor and into a storage silo. Ore will then feed into a second hopper to load the haulage trucks to take them to Strathalbyn. This solution allows for a small footprint system; reduces the need for a wheeled loader and open space that, as both can generate dust; uses covered transfer points that prevents dust and noise; and allows the road going trucks to stay on sealed roads, removing the likelihood of picking up mud and creating carry out. Using a silo also meets the visual character of the existing landscape with neighbouring businesses utilizing similar silos for advertising their business.

3.1.3.2.4 SITE ACCESS – BIH RD VS PFEIFFER RD, LOCATION OFF OF PFEIFFER RD

Terramin purchased the Goldwyn property to secure adequate land to site the required infrastructure in 2014. The property sits between Pfeiffer Road on the northwest boundary and Bird in Hand Road on the south. Both roads were assessed as an access to the Project based on the safety and practicality of building an intersection for merging traffic. Tonkin Consulting Pty Ltd (Tonkin), experts in civil engineering and road infrastructure projects, were commissioned to undertake a review of suitable options for site access, identify suitable haulage routes to the Angas processing facility and assess each for suitability for trucking use.

The boundary along Bird-in-Hand Road is located at the end of a winding section for traffic coming from the east. Vision lines along this section are limited and the start of the decent adjacent to the Goldwyn property is a cutting, limiting the scope for construction of an intersection. The remaining section of the Bird in Hand Road is a constant decline not suitable for an intersection managing traffic and turning trucks. Discussion with community members indicated that traffic along Bird in Hand Road was already a concern with trucks. For this reason the options for an access onto Bird in Hand Road were eliminated.

Pfeiffer Road runs southwest to northeast from the intersection with the Woodside/Nairne Road. Compared to Bird in Hand Road, Pfeiffer Road is straight and flat. The access road from Pfeiffer Road was chosen based on the ease of access and the line of sight for drivers entering and leaving the site. Considerations in the options analysis included the safe movement of traffic into and off of the access road, existing traffic conditions, existing accesses used by neighbours and the proposed access to the newly developed Adelaide Polo Grounds opposite the Goldwyn property (Figure 3-7).

3.1.3.2.5 ACCESS ROAD AND MAIN CAR PARK

The physical positioning of the access point was determined in regard to the most suitable position relative to the safe sight lines for both traffic moving along the road and traffic entering the road. The path of the access road on site was then positioned to avoid and preserve old mine workings and the heritage chimney and utilise the contours of the existing landscape – keeping the gradients of the roads to a minimum to assist vehicles traversing the road. The site security gate (Main gate) is positioned away from Pfeiffer Road, out of view of travelling vehicles. A visitor and employee carpark is designed adjacent to the Main gate for accommodation of vehicles in a designated location to ensure no congestion along Pfeiffer Road. The location of the main carpark underwent the same design considerations and included the types of vehicles likely to need parking etc. in the area and their turning requirements to provide safe manoeuvring for vehicles and pedestrians. The location of the access road and car park is shown in Figure 3-8.

FIGURE 3-7 | ACCESS LOCATIONS CONSIDERED FROM PFEIFFER ROAD (APPENDIX F1 – TONKIN)

FIGURE 3-8 | LOCATION OF SITE ACCESS AND MAIN CARPARK (CIRCLED IN YELLOW) (APPENDIX B1 – OXIGEN)

3.1.3.2.6 WATER DAMS

The Project proposal includes requirements for water holding facilities as part of the water management system to ensure that any water intersected by the Project can be sampled and, if required, treated to meet appropriate standards. In line with the neighbouring properties, the use of earthen dams is a cost effective way to store water for use in businesses undertakings and as containment for treatment prior to release or reuse. There were various options available on the Goldwyn property for the location of the water dams. The property has existing dams on site, once used for effluent capture from the dairy and farming operation that previously existed on site. One option was to remediate these dams, possibly combining them to create one larger dam. These dams are in close proximity to the creek line and a neighbouring property and some distance from the proposed surface infrastructure. For practical purposes and to minimise visual amenity impacts, the water storage dam will be constructed on the same side of the creek line as the operational area. The location of the mine water storage dam was chosen to allow for the safe and sensitive storage of water and in a position that the dam could be blended into the existing landscape to look like those dams owned and operated by most of the landholders in the area. A second water catchment is designed as part of the storm water management system under the principles of Water Sensitive Urban Design (WSUD) to allow passive water treatment to ensure that sediment loading is reduced prior to water leaving site. This second dam (detention/retention dam) is designed as a wetland to control volume fluctuation and velocity. The proposed location of the dams is shown in Figure 3-9.

FIGURE 3-9 | LOCATION OF SITE DAMS CIRCLED IN YELLOW (APPENDIX G1)

3.1.3.2.7 BOXCUT AND PORTAL

The location of the entrance into the mine (the Portal) is governed by the geological conditions of the host rocks, proximity to the orebody, and the geotechnical properties of the subsurface strata (below the subsoil). Once it was decided that the mine would be accessed via a decline, positioned in the footwall sequence, a geotechnical investigation was undertaken to determine a precise location. A number of test pits were dug to determine the composition, strength and extent of the subsurface rocks and the extent of clays and oxidization. Options considered for the location of the portal for the mine included:

- As close as possible to the orebody, with the portal located close to the south-eastern corner of the property; and
- Reducing the amount of development (tunnelling) required to reach the orebody by moving the portal further down the slope (at a lower RL).

In 2016 exploration works consisting of test pits and drilling, identified the geotechnical properties for the area, including the boundary of the clay material that overlays the base rock. The altered zone and clay extends 80m below surface at the top of the hill directly above the orebody. For stability purposes, it is preferable to position the portal within hard rock rather than in an altered clay. This eliminated the option to locate the portal in the south-eastern corner of the property. Avoidance of the clay zones meant suitable locations were identified in the southwestern corner of the property. However, discussions with neighbouring landholders revealed that the visible character of the landscape would be negatively affected by locating the entrance of the mine in this location.

A third location was identified near the centre of the property where the geological conditions were favourable, the position was not visible from neighbouring properties and the RL provided for a shortened decline. The location of the portal is shown in Figure 3-10. A boxcut will be temporarily excavated to provide access to a solid rock face, the decline established and an arch structure constructed on the ground surface. The boxcut will then be backfilled around the structure to form the portal. The orientation of the structures within the rock has been considered in the determination of the alignment of the initial section of the decline, trying to keep the direction as perpendicular to the structures as possible for maximum strength.

FIGURE 3-10 | LOCATION OF PROPOSED PORTAL AND BOXCUT CIRCLED IN YELLOW (APPENDIX G1)

3.1.3.2.8 ANGAS ZINC MINE INFRASTRUCTURE

The basis of the Project has been to develop a small footprint, low impact, underground mine at Woodside and transport the ore to the licensed processing facility and tailings storage facility at the

Angas Zinc Mine (AZM) near Strathalbyn. AZM has been in care and maintenance with the facilities being maintained for the eventual reopening to treat the gold ore. The Project proposes to utilize the 400,000 tonnes per annum (tpa) processing plant to treat the gold ore at a reduced rate over the production phase of the project. The infrastructure available for use by the Project includes, workshops, stores, laydown areas, offices, magazines, laboratories and change rooms. The office complex at AZM will not be fully utilised for the processing of the ore only, so potential exists to base supporting roles such as information technology, human resources, accounting, administration, logistics, planning and maintenance at the AZM site. Personnel can travel to the BIH on an as needs basis. There is also the option of using the AZM site for training purposes for all personnel across both sites.

3.1.3.3 HAULAGE ROUTES TO AZM

Tonkin were commissioned to investigate suitable haulage options, including truck size and type, haulage route and identify any possible impediments to haulage from the Project site at Woodside to the APF. Three possible routes were identified for review. As the access onto Bird-in-Hand Road was eliminated, so to was the use of Drummond Road, in order to respect the owners of the residence along the unsealed road. The location of the residence is such that the drive way is obscured by their hedging plants and there have been a number of near misses with trucks and light vehicles at that location. A submission has been made to the council to close off the road to through traffic. In addition, it is recognised that vehicles travelling along unsealed roads are a source of nuisance dust and by not using Drummond Road this issue is avoided.

The three routes are discussed further in Chapter 8 as well as in the Tonkin Transport Assessment Report – Appendix F1.

It was recognised in early discussions with the community that an increase in traffic on the local roads, specifically trucks was a concern for safety and congestion. A number of traffic monitoring surveys were undertaken to understand the existing baseline traffic conditions. The proposed additional traffic for the Project are estimated as:

- Other trucks (e.g. supply trucks) – 4 trips per day.
- Company light vehicles – 10 trips per day.
- Visitors – 6 trips per day.

In addition, there will be employee vehicle movements similar to local business in the area, based on the following employee profile:

- Dayshift – 52
- Nightshift – 15
- Weekend shifts - 15

In the event of an increase in ore or mullock as a result of design updates through Feasibility Studies, the control measures regarding traffic and haulage will continue to apply and not increase daily average truck movements of 12 trips over the life of the project.

3.1.3.3.1 ROAD HAULAGE TRUCK CAPACITY

Project design has taken account of style and size of road haulage trucks to minimise community impact. Community engagement highlighted concern about the safety of trucks on the road and when this was further investigated it was identified that B-double trucks were considered as not suitable for the local roads. As part of the work undertaken by Tonkin they analysed the options for suitable haulage vehicles. The initial investigation looked at the benefit of a reduction in the number of haulage vehicles by increasing the size and weight of trucks like a B-double. The increase in truck size did not provided a perceivable reduction in haulage vehicles compared to the existing traffic conditions. On further investigation into the suitability and efficiency of haulage vehicles, a Rigid Tip truck with a Dog Trailer (<19m length) (Truck and Dog) provided the most suitable haulage option. A Truck and Dog is considered as a general access vehicle (GAV) and can access all roads and properties for delivery of any bulk commodity. All potential haulage routes to the Angas site are approved for the use of GPV's. The haulage vehicles chosen to transport the ore to AZM are the 19m truck and dog combinations similar to those used by numerous other businesses throughout the Adelaide Hills and Fleurieu Peninsula.

Stakeholder consultation provided feedback the periods the vehicles will travel has the potential to impact on the various identified sensitive receptors. This is discussed further in Chapter 8.

3.1.3.4 EQUIPMENT SELECTION

3.1.3.4.1 DIESEL VS ELECTRIC

In order to provide the best possible outcome for the project in both efficiency and environmental management a review of equipment selection was undertaken. There are impressive developments within the industry on the use of electric powered mining vehicles. Traditionally electric vehicles were tied to mains power via umbilical cables. This was because battery technology was not sufficient for providing the power requirements or the operating life. Umbilical cables have been used for a long time in mining applications for powering drilling equipment, however for mobile equipment like loaders a cable significantly restricts the vehicles movement in underground situations. With advances in battery technology recently, cables are being replaced with batteries with improved capacity. Battery powered vehicles are starting to be offered by the various equipment manufacturers but are new technology rather than proven technology. The option of including electric powered vehicles was considered for the BIH Project. However, at this point in time, it could not be economically justified to implement battery powered vehicles. In recognition of increased environmental standards around the world, equipment manufacturers have been driven to provide improvements in the performance of their conventional vehicles. The efficiency of new diesel engines (T5) and the improved emissions provide for the new generation equipment to be cleaner and cheaper to run than ever before. At the time of writing, the following conditions associated with equipment selection were relevant.

- Cost of the equipment – there is roughly a 30% additional capital cost for equivalent electric vehicles.
- Operating periods and frequency of battery charging – this figure varies for operating conditions and the make and models selected. As an example a 165 kWh battery is able to operate a 7 tonne capacity loader for 4 hours on a single charge with a two hour recharge time. Typical operating times required will be 10 hours per shift.

- Practicalities of changing batteries for continuous operation – requirements for areas with cranes etc. needed to lift batteries into and out of the fleet would be required UG – or alternatively the fleet would need to travel to the surface for battery change outs.
- The availability of underground mining trucks and loaders with battery technology for the required capacities is currently limited.

At this stage, the mine has been designed on the basis that conventional latest technology diesel equipment will be used. This provides design criteria for ventilation requirements, haulage angles and production schedules. This decision will be reviewed as battery technology advances in the near future and throughout the life of the project.

3.1.3.5 WATER

3.1.3.5.1 WATER SOURCES: MAINS VS SA WATER RECLAIMED VS BORE

Water for human consumption, ablutions, washing down and managing environmental conditions on site will be required. Water is used for dust suppression and cooling equipment. The current available water supplies in the region are the Murray Line (Mains), recycled water from the Bird in Hand SA Water sewage treatment works and the existing groundwater allocation for the property. Suitable water will be sourced, with the intention that all groundwater intercepted by the Project outside the Goldwyn allocation will be returned to the aquifer.

3.1.3.5.2 WATER MANAGEMENT

Water management on site has the objective of complying with the objectives of the Western Mount Lofty Ranges Water Allocation Plan. In principle this means that any activity undertaken by the Project must not reduce the quality or have an adverse impact on sensitive receptors, including existing users. The understanding of water associated with the Project covers both surface water and groundwater.

Water management is covered in detail in section 3.7.9 and Chapters 10 and 11.

Prior to the acquisition of the project, it was understood that management and protection of the regional groundwater was paramount to the success of the operation and of utmost importance to the community.

Initial options considered for water supply included:

- Purchase additional allocation of groundwater sufficient for the operations;
- Purchase water from the mains line running along both Pfeiffer Road and Bird in Hand Road; and
- Purchase water from the SA Water treatment plant and treat the water to ensure suitable quality for use on site.

A significant body of work was undertaken to understand the groundwater and the interaction of regional aquifers. Once this work was completed a groundwater model was developed and calibrated against historic records, present irrigation practices and specific pump testing. The groundwater investigation work was peer reviewed to ensure it was suitable for use and then the model was used to analyse options for groundwater management and likely impacts.

3.1.3.5.3 WATER TREATMENT

As part of the mining process, water is used for dust suppression and equipment cooling. It is also anticipated that some groundwater will enter the mine. Water in the mine is pumped out using a system of pumps and pipelines and recycled. This mine water will have sediments and other possible contaminants that need to be removed prior to reuse. The objective of the water management system is to ensure that any water intersected by the Project is treated in such a way that it is the same as or better than the water in the existing environment. A number of options were investigated for the treatment of the water for the Project. Some unconventional bio-treatment was reviewed. However, the technology was not extensively proven to provide the confidence required. A conventional water treatment system incorporating four (4) stages of water treatment is proposed.

The water treatment is covered in section 3.7.9.5 and incorporates the following components:

- Mechanical sediment separation;
- Water settlement pond incorporating organic treatment of nitrates in floating beds;
- Sand filter/bio filtration;
- Ionic exchange.

The water treatment investigation was undertaken by the South Australian company GPA Engineering with the intention of supplying water that suites the environmental requirements set out for managed aquifer recharge, as well as for the various used on site.

GPA's Water Treatment Options Study report is included in Appendix J1.

3.1.3.6 SERVICES

3.1.3.6.1 ELECTRICAL – GRID VS SOLAR (AND OTHER RENEWABLES)

Electrical supply is a critical service required by the BIH Project. Several options were considered to provide a safe stable supply for the Project. Self-generation of power is considered and installed on many remote mine sites as a cost effective option. The proximity to the main 33kV powerline made the supply of power from the SA Network a suitable option. The initial review of the mains power supply indicated that a minor upgrade to the supply line is required. The use of mains power eliminates the need to run generators, this reduces the level of noise generated, reduces the number of supply trucks and provides a lower cost per kWh for power.

3.1.3.7 WASTE MANAGEMENT

Typical waste streams from the project are associated with consumables associated with operations. Wastes fall into two general categories of solid and liquid waste.

Liquid waste is transported off site for recycling.

Solid waste is classified as General solid waste – (putrescible or non-putrescible), restricted solid waste and Hazardous waste. All waste is transported off site for either disposal in licensed facilities or recycling.

Waste management is discussed in Section 3.6.

3.2 Reserves, products and market

3.2.1 Ore reserves and mineral resources

3.2.1.1 COMPETENT PERSON'S STATEMENT

The information in this Mining Lease Proposal that relates to Exploration Results and Mineral Resources is based on information compiled by Mr Dan Brost, a Competent Person who is a Chartered Professional Member of The Australasian Institute of Mining and Metallurgy (AusIMM). Mr Brost is a consultant for Terramin Australia Limited. Mr Brost has sufficient experience that is relevant to the style of mineralisation and type of deposit under consideration and to the activity being undertaken to qualify as a Competent Person as defined in the 2012 Edition of the 'Australasian Code for Reporting of Exploration Results, Mineral Resources and Ore Reserves'.

3.2.1.2 DRILLING TYPE AND ORIENTATION

The BIH deposit is sampled by 35 diamond holes and 2 reverse circulation (RC) holes. The history and general background of drilling is summarised in Table 3-3. The RC holes were drilled by Capricorn Resources Pty (Capricorn) in 1997, Maximus Resources Limited (Maximus) drilled 29 diamond holes between 2005 and 2008 and in 2016 Terramin drilled an additional 6 diamond holes. Core was typically sampled on 1 metre intervals but modified to honour geological boundaries. RC drilling was sampled at 1 metre intervals.

All drill holes since 1997 have been surveyed at the collar and by down hole methods (single-shot or gyro). The topographic control is based on collar survey and DGPS pick up of surrounding area.

Table 3-3 | Summary of Exploration and Geotechnical Drilling Campaigns at BIH

Company	Year	Hole numbers	No. of holes	Total metres	No. of resource holes	Total resource metres	Comments
SA Government	1933-1934	BH001-BH004	4	629	0	0	Not used in resource
Capricorn	1997	BH005-BH015	11	1070	2	323	RC holes, BH009 and BH010
Maximus	2005-2008	BH016-BH046	32	8618	29	7792	Incl. BH028W
Terramin	2016	BH047-BH059	13	2206	6	1350	Decline geotech – 7 holes
Total			**60**	**12581**	**37**	**9465**	

Table 3-4 | Summary of Resource drilling at BIH

Year	1997 Capricorn	2005 Maximus	2006 Maximus	2007 Maximus	2008 Maximus	2016 Terramin
Holes	BH009	BH016	BH019	BH028	BH042	BH051
	BH010	BH017	BH020	BH028W	BH043	BH054
		BH018	BH021	BH029	BH044	BH056
			BH022	BH030		BH057
			BH023	BH031		BH058
			BH024	BH032		BH059
			BH025	BH033		

			BH026	BH034		
			BH027	BH035		
				BH036		
				BH037		
				BH039		
				BH040		
				BH041		

Due to depth of the targets, steep topography and site restrictions caused by infrastructure (public road, power line, fibre optic cable), some holes were designed to be drilled at lower angles to the mineralisation than what would otherwise be preferable. However, they have provided information on geological setting, mineralisation, orientation and intercept distances. There are strong visual indicators for mineralisation observed in drill core based on intensity of silicification, abundance of pyrite and massive sulphides. Many of the mineralised intercepts are at right angles or close to right angles demonstrating that reported intercepts vary from 75% to 90% of intersected width and have been modelled in three dimensions to reflect the spatial volumes of true width. The orientation of mineralised intercepts are not creating any known bias.

Drill hole spacing is considered sufficient to establish geologic, structural and mineralisation controls of the deposit. In the resource area the drill hole intercept/ sample spacing has been completed on a 25m to 50m pattern.

The resource area and exploration potential are indicated across the BIH vicinity. In Figure 3-11, the early Capricorn holes are indicated in black, the Maximus holes in green and the recent Terramin holes in red.

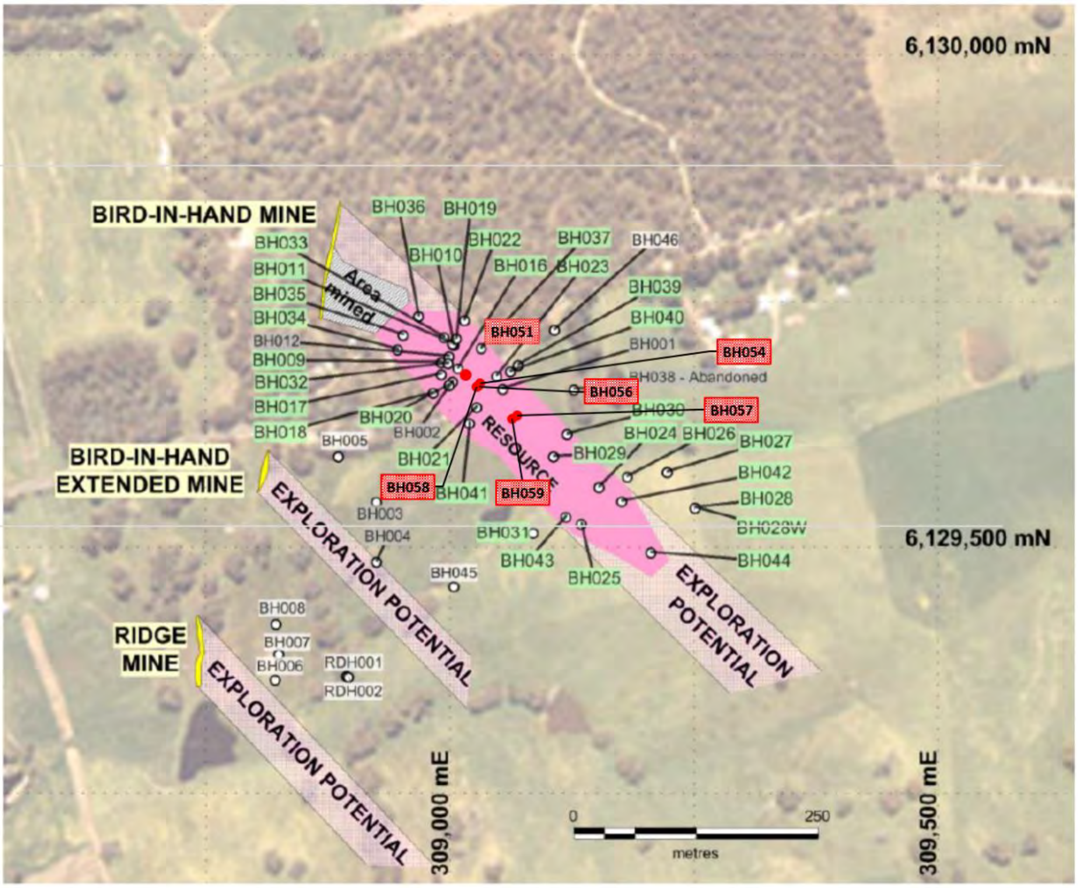


FIGURE 3-11 | DRILL COLLAR LOCATIONS AT BIH AND SURROUNDING AREA

The mineral resource holes and traces shown in Figure 3-12 are highlighted in a similar manner;

- Black = Capricorn era
- Green = Maximus era
- Red = Terramin era

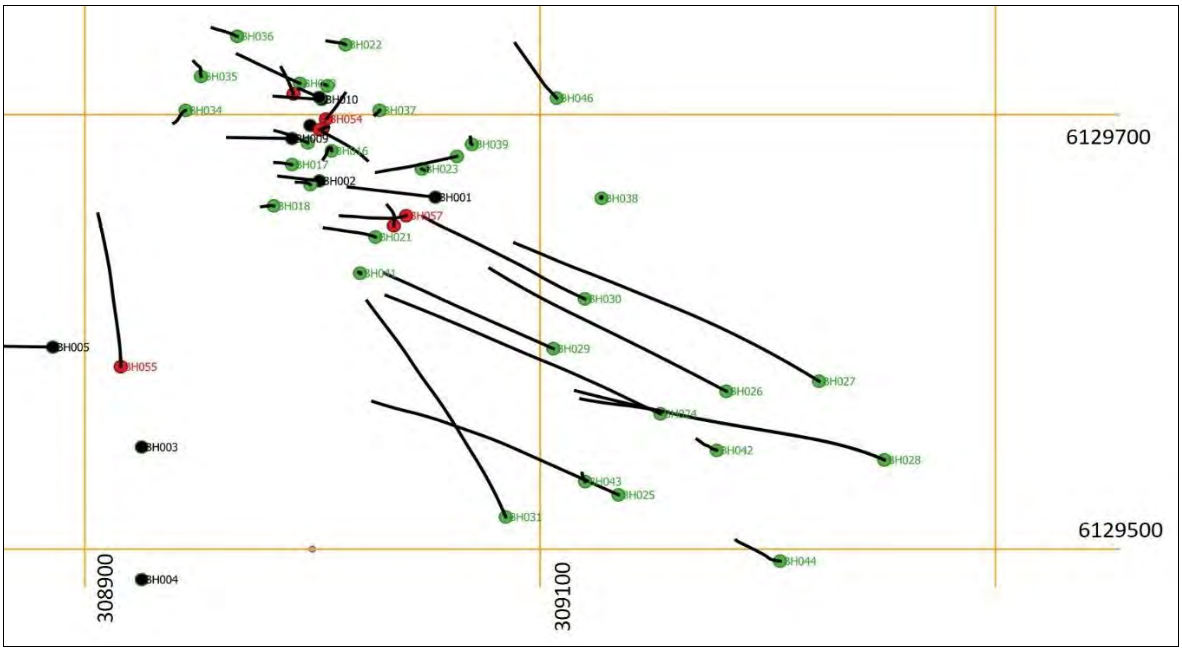


FIGURE 3-12 | RESOURCE DRILL HOLE TRACES AT BIH

The generalised district scale interpretation is shown below Figure 3-13 for the BIH deposit.

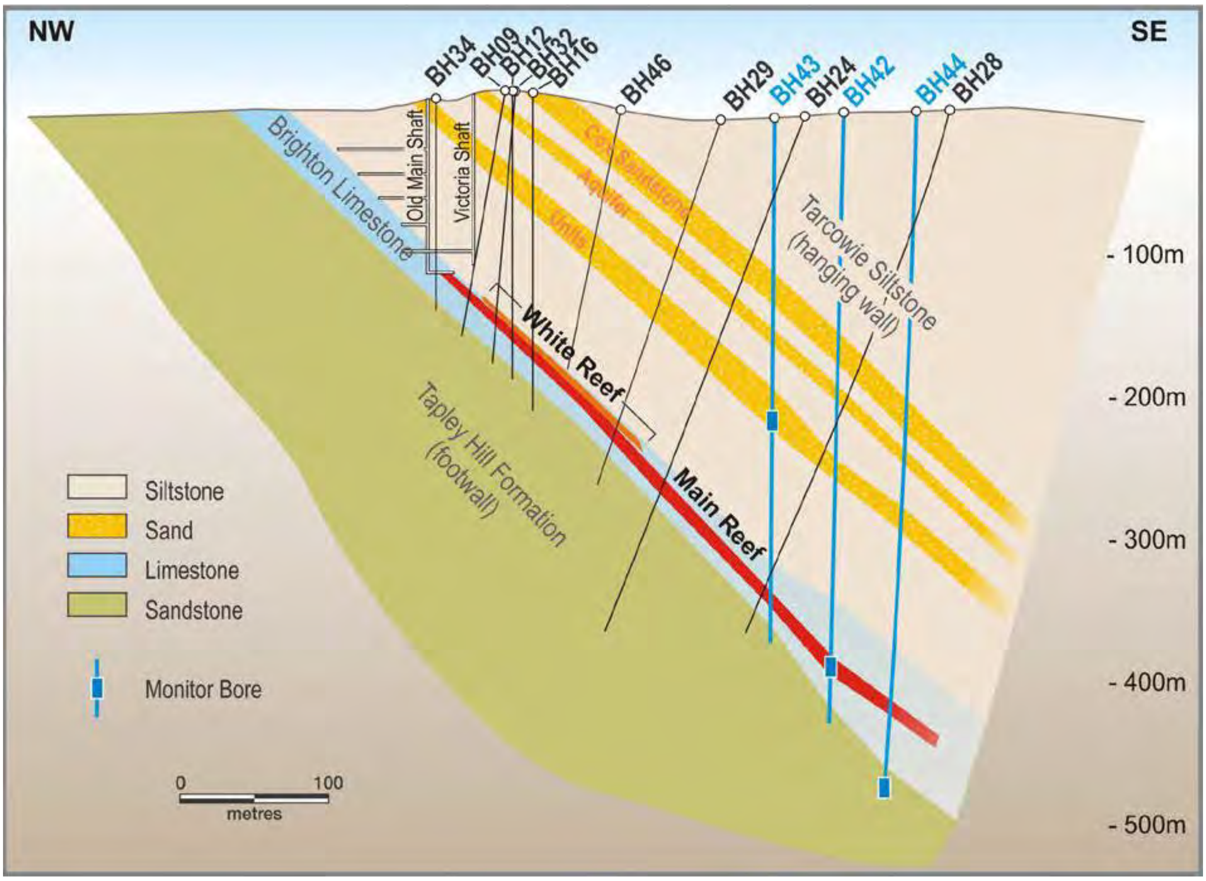


FIGURE 3-13| BIH OBLIQUE SCHEMATIC SECTION (LOOKING WEST OF NORTH) SHOWING THE BIH GEOLOGY, MINERALISED REEF INTERPRETATION AND DRILL HOLES.

3.2.1.3 RESOURCE ESTIMATION

The 2018 updated scoping study is based upon the 2018 BIH Resource Estimate released by Terramin to the Australian Stock Exchange (ASX) 30 October 2018. The 2018 Resource Estimate of 650,000 @ 12.6g/t gold for 265,000 ounces of gold at a 1.0g/t gold cut-off. The indicated and inferred breakdown is shown in the Table below.

TABLE 3-5 | 2018 BIH MINERAL RESOURCE ESTIMATE

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.

The deposit is modelled as quartz gold reef type mineralisation occurring in litho-structural control setting. The mineralised reefs are interpreted to be strata bound along structural cleavage planes located on a limb of an open regional syncline. The quartz gold reef mineralisation averages 5.4m in width and has observed 1.1 to 2.6 m sub-branches across the deformation zone. The gold mineralisation primarily occurs within two quartz vein systems that are sub-parallel to each other. An upper White Reef Zone and a lower Main Reef Zone. At depth the White and Main Reefs coalesce and form a single reef.

The interpretation shows the mineralised trends strike approx.. 100 ° to 110 ° with a dip of 40 ° to 45 ° to the east of south. The trend represents the direction of maximum continuity of mineralisation, regional lithology and the regional faulting trend.

The reefs have been modelled in three dimensions based on gold grade continuity and geological interpretation. The solid models provide the basis for the grade interpolation and methodology of the mineral resource estimate.

The domains used in the mineral resource estimate are shown below in Table 3-6.

TABLE 3-6 | 2018 BIH RESOURCE SOLID MODEL SHELLS

Domain	Numeric code	Priority	Volume (m^3)	Vulcan wireframe	Comment
Main Reef	1	10	186,200	bih_2106_main.00t	
White Reef	2	9	46,400	bih_2016_white.00t	
Orange Reef	3	8	29,400	bih_2016_orange.00t	
Footwall Reef	4	7	1,700	bih_2016_backreef.00t	
Waste	0	2	3,634,100	bih_2016_waste.00t	
Indicated				bih_2016_Ind.00t	Used only to flag Main Reef

The assays were composited and core recovery weighted to 1m lengths honouring the wireframes. Any short or residual composites were retained at the domain boundaries. The composites were top cut at the 95% percentile (90 g/t gold) resulting in around 5% of the samples being cut.

Variography and sample search strategy were based on the spatial analysis of composite data. The exploratory data analysis by geology and domains indicated all values for the coefficient of variation variable were modest (<1.0) and concluded that linear estimation methods would be appropriate.

Ordinary kriging was utilised for grade estimation in the domains. Each domain boundary was treated as a hard boundary in the grade interpolation. Search ellipses were orientated consistent with the variogram ellipsoids. A maximum of 8 composites from multiple holes and a maximum of 3 composites from any one drill hole were used. Separate bulk density values were interpolated based on specific gravity data determined from Archimedes or water immersion technique.

The resource classification scheme is shown below. The confidence system for the classification is multi-phase and relies on elevation (RL), wireframe, average distance to samples, minimum holes and minimum samples to inform the grade. The variogram work indicates maximum sill distance of between 60 – 80m. The block distance variable has a mean of 40m across all classifications. Most of the blocks are estimated within 25 and 35m average distance from informing samples.

TABLE 3-7 | 2018 BIH RESOURCE CLASSIFICATION SCHEME

Levels	Resource Classification	Wireframed	Avg-Dist.	Min. holes	Min. samples
RL			m	count	count
10-330	Indicated	Y	<=45	2	3
0-330	Inferred	Y	>=45<=75	2	1

Generally, the resource area in the reef defined wireframe is drilled on 25 to 35m spacing. The optimal geometry (azimuth and dip direction) along with surface access has produced areas where drilling is spaced at >50m. However, no blocks have been estimated at distances >85m average distances. Estimation modelling was validated by visual assessment and mean grade comparisons, swath plot validation (easting, northing and RL slices) and block variance correlation.

The Main Reef mineralised domain is shown below in Figure 3 -14 with Terramin holes in red and Maximus holes in black.

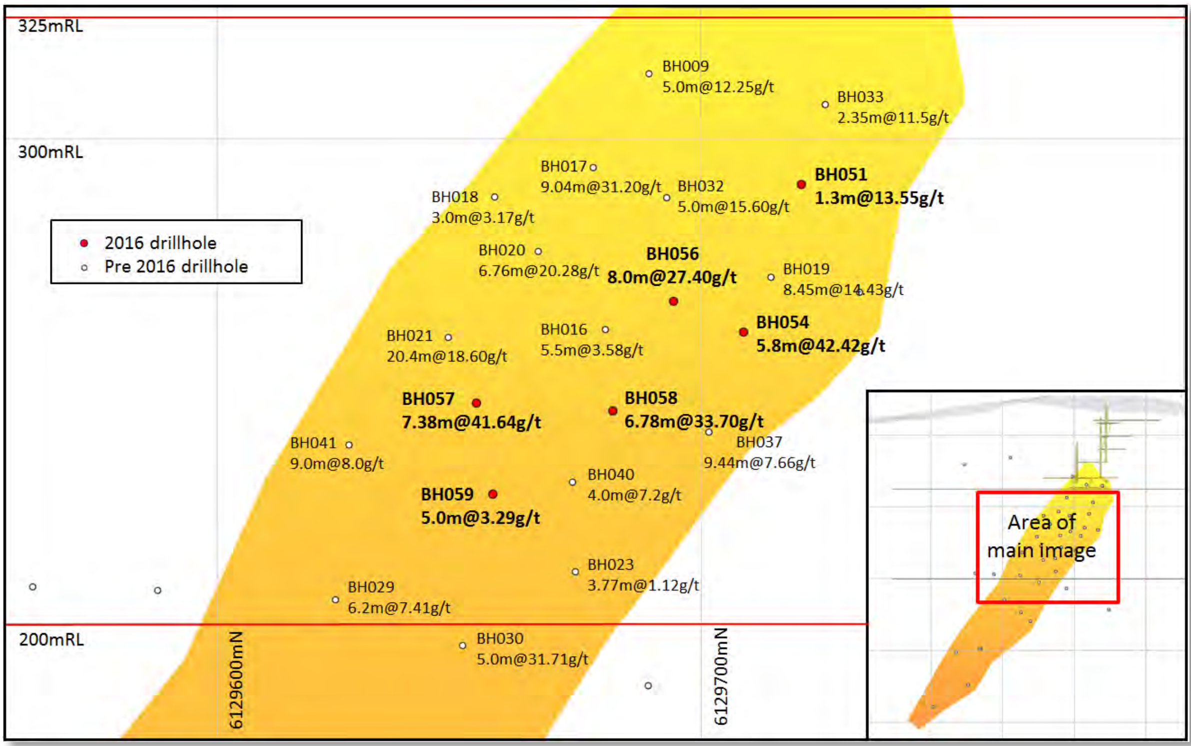


FIGURE 3-14 | BIH LONGITUDINAL SECTION (LOOKING WEST) SHOWING THE BIH RESOURCE OUTLINE. DRILL HOLE PIERCE POINTS WITH SUMMARY INTERSECTIONS SHOWN WITHIN THE INDICATED RESOURCE.

The 2008, 2013, 2016 and 2018 Resource Estimates, summarised in Table 3-4 are comparable both in grade and tonnage. The changes in the resource classification over the model iterations resulted from the improved drill density between 325m RL and 200m RL, increased confidence in the geological model, improved resource classification and revised bulk density interpolation. Modelling highlights and significant changes are listed in Table 3-5.

TABLE 3-4 | COMPARISON BETWEEN MAXIMUS 2008, TERRAMIN 2013, TERRAMIN 2016 AND TERRAMIN 2018 RESOURCE ESTIMATES AT 1.0 G/T GOLD CUT-OFF

Domain	Maximus 2008 Estimate				Terramin 2013 Estimate				Terramin 2016 Estimate				Terramin 2018 Estimate			
	kT	Au (g/t)	Ag (g/t)	Au kOz	kT	Au (g/t)	Ag (g/t)	Au kOz	kT	Au (g/t)	Ag (g/t)	Au kOz	kT	Au (g/t)	Ag (g/t)	Au kOz
Main Reef – Ind	160	13.6	-	70	-			-	167	16.2	13	87	387	15.0	8	187
Main Reef – Inf	406	11.7	-	153	430	14.0	6	193	319	14.2	4	146	115	14.2	4	53
Red Reef – Total	566	12.2	-	223	430	14.0	6	193	485	14.9	7	232	502	14.8	7	240
White Reef – Ind	-	-	-	-	-	-	-	-	-	-	-	-	45	8.5	2	12
White Reef – Inf	32	13.6	-	14	127	9.7	2	40	103	6.1	1	20	64	4.5	1	19
Orange Reef – Inf	-	-	-	-	-	-	-	-	-	-	-	-	41	2.4	1	3
Total	**598**	**12.3**	**-**	**237**	**557**	**13.0**	**5**	**233**	**588**	**13.3**	**6**	**252**	**650**	**12.6**	**6**	**265**

TABLE 3-5 | SIGNIFICANT CHANGES BETWEEN MAXIMUS 2008, TERRAMIN 2013, TERRAMIN 2016 AND TERRAMIN 2018 RESOURCE ESTIMATES

Change	Maximus 2008 (McLean)	Terramin 2013 (Whittaker)	Terramin 2016 (Whittaker)	Terramin -2018 (Brost)
Historic mining	In situ tonnes from Level 6 included in Resource Estimate	In situ tonnes from Level 5 and 6 included in Resource Estimate	Estimate of tonnage mine from levels 5 and 6 resulted in 2600 tonnes depleted from the estimate	No Change
Drilling	BH012 intercepted White Reef from 155 (3m @ 16.58 g/t Au) and Red Reef from 172m (8m @ 11.36 g/t Au)	BH012 excluded due to lack of downhole surveys	No Change	No Change
Void spaces	Not modelled	Void allowance equates to 6.5% reduction in tonnes	Voids excluded from model	No Change
Core loss	Not modelled	Where core loss is in excess of 90% the grade is factored down using the assumption the material lost graded 0 g/t gold	2016 Assumed that material lost graded 0 g/t gold equates to a 4.8% reduction in the gold grade from 14.0 g/t gold to the reported 13.3 g/t gold	No Change
Density	Flat 2.78t/m^3	Ordinary kriging used to assign density to blocks	Ordinary kriging used to assign density to blocks. Allowance given for voids, average dry bulk density 2.56t/m^3	Utilised revised estimation procedure that interpolated the Archimedes (water-displacement data only). A 5% increase in bulk density was noted after corrections for void spaces. Average dry bulk density = 2.63t/m^3
Intersection selection	Geology based – no minimum cut-off grade. Minimum intersectional length 1.5m	Geology based. Minimum width of 2m, +1g/t gold	Geology based. Minimum width of 1m, +1 g/t gold	No Change
Silver estimation	Not modelled	Modelled	Modelled	No Change
Estimation technique	Polygonal model	Ordinary kriging	Ordinary kriging	No Change
Block size	Not applicable	30m by 30m by 2m	20m by 20m by 2m	No Change
Modelled lodes	Red Reef and White Reef	Red Reef, White Reef, and Yellow Reef	Red Reef now the Main Reef and White Reef, Orange Reef	No Change

Change	Maximus 2008 (McLean)	Terramin 2013 (Whittaker)	Terramin 2016 (Whittaker)	Terramin -2018 (Brost)
Resource Classification	Red Reef Mineral Resource classified indicated above 200m RL (equated to 63pprox.. 30% of contained metal) and inferred below 200m RL.	All Resource classified inferred after drill hole BH012 excluded from Resource Estimate	Main Reef Mineral Resource classified indicated between 200m RL and 325m RL. Six additional drill holes.	Change classification scheme to account for confidence matrix of average distances, informing samples and wireframe interpretation.

3.2.1.4 ADDITIONAL RESOURCE POTENTIAL

The Main Reef displays a strong down dip continuity and based on structural and lithological interpretations, grade distribution (the mineralisation is open at depth), and regional large scale faulting and folding, Terramin has reasonable expectations for additional mineralisation to exist down dip of the defined resource.

For exploration and near mine exploration a range analysis for tonnes per vertical metre system was developed. The block model identified having an average of 2000 tonnes per vertical metre or 40,000 tonnes per 20m mining level. From the 0 level to the -200 level the potential exploration target tonnes is 400,000. Going further to the -400 adds another 400,000-tonne potential or around 1.4 million tonnes. Table 3-9 summarises the estimate.

TABLE 3-9 | STRAIGHT LINE ESTIMATE OF TONNES PER VERTICAL METRE

Base Extrapolation Exploration Target	Tonnes	Gold	In-situ Gold
Levels	**(kt)**	**g/t**	**(k0z)**
340 to 0	588	13	246
-20 to -200	400	13	167
-200 to -400	400	13	167
Total	1,388	13	580

As part of the analysis a 4.0 g/t gold grade shell was generated and extended to the – 400 level. The resultant calculation was tpvm potential or ~ 1098 tonnes. With average resource grade the exploration target gold ounces range from 580,000 to 460,000 for BIH at depth. Table 3-10 summarises the estimate.

TABLE 3-10 | GRADE SHELL ESTIMATE OF TONNES PER VERTICAL METRE

4.0 g/t gold shell Exploration Target	Tonnes	Gold	In-situ Gold

Levels	(kt)	g/t	(k0z)
340 to 0	588	13	246
-20 to -200	255	13	107
-200 to -400	255	13	107
Total	1,098	13	460

Figure 3-11 illustrates the exploration target projection to the -200 level. The potential assumes full strike and dip, volume, average resource grade and average dry bulk density.

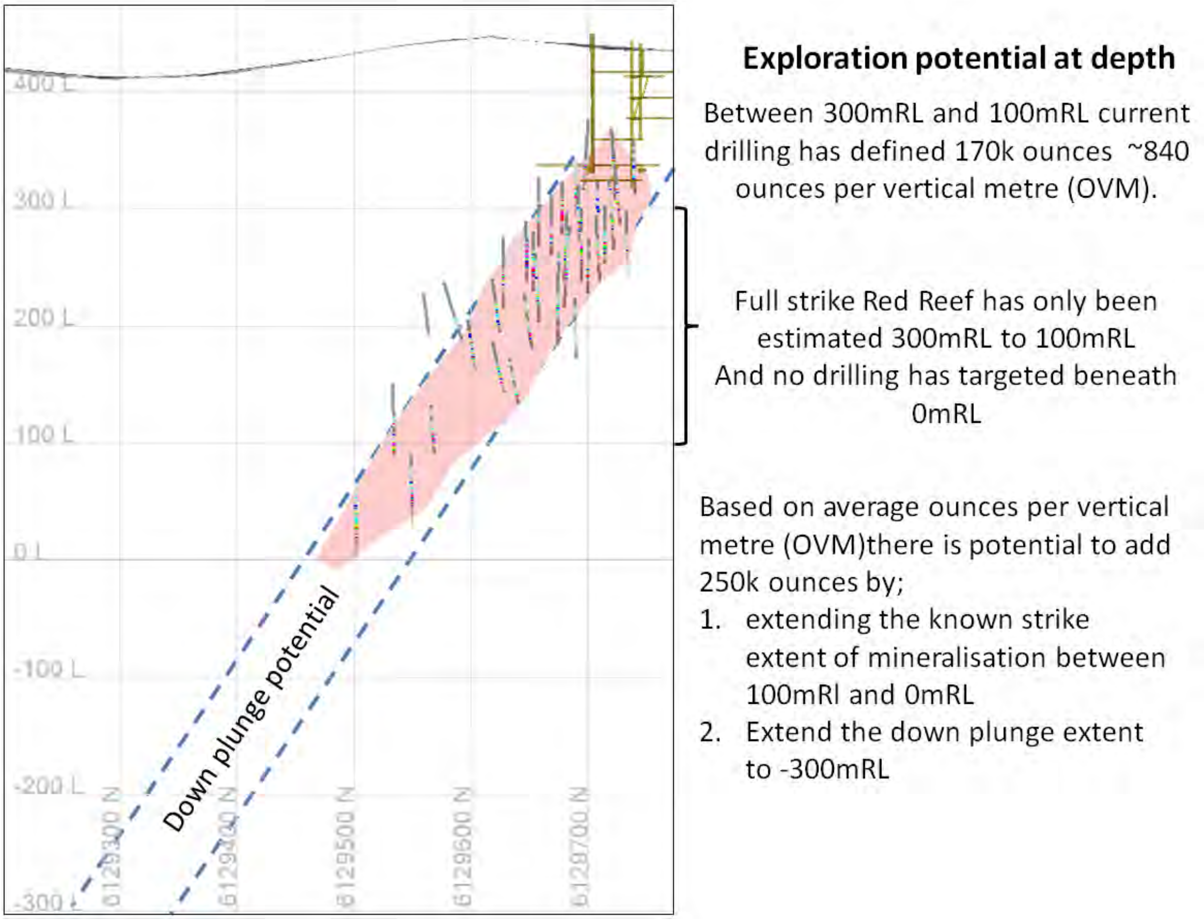


FIGURE 3-11 | BIRD-IN-HAND MAIN REEF AND DRILLING SHOWN SECTIONED ALONG THE PLANE OF MINERALISATION (20M WINDOW), VIEWED LOOKING WEST

Additionally, potential also exists in the footwall area where a single drill hole intersected gold mineralisation along a parallel shear zone. BH033 intersected from 162m, 2m @ 43.74 g/t gold located only eight metres (true width) below the Main Reef.

Potential to discover additional high-grade mineralisation further along strike is highlighted by the presence of the historic mines Bird-Extended and The Ridge (Figure 3-12) which are respectively 200m and 400m to the south. These mines were last worked in the 1890's. The Ridge has a recorded (incomplete) production of 517 ounces of gold from 2,766 tonnes at an average grade of 5.8 g/t Au but later retreatment of 6,266 tonnes of tails by cyanide leach recovered an additional 977 ounces.

Historical mines in the footwall of BIH (Figure 3-13) include Brind Mine which operated between 1884 and 1885. It is located 400m to the west of BIH and produced 136 ounces of gold from 429 tonnes processed. The Blackbird Mine, a further 400 metres to the west, produced 733 ounces from 1,493 tonnes between 1934 and 1939.

FIGURE 3-12 | LOCATION OF HISTORIC MINES AND SURFACE PROJECTIONS OF THE BIH RESOURCE AND EXPLORATION POTENTIAL BENEATH HISTORIC WORKINGS.

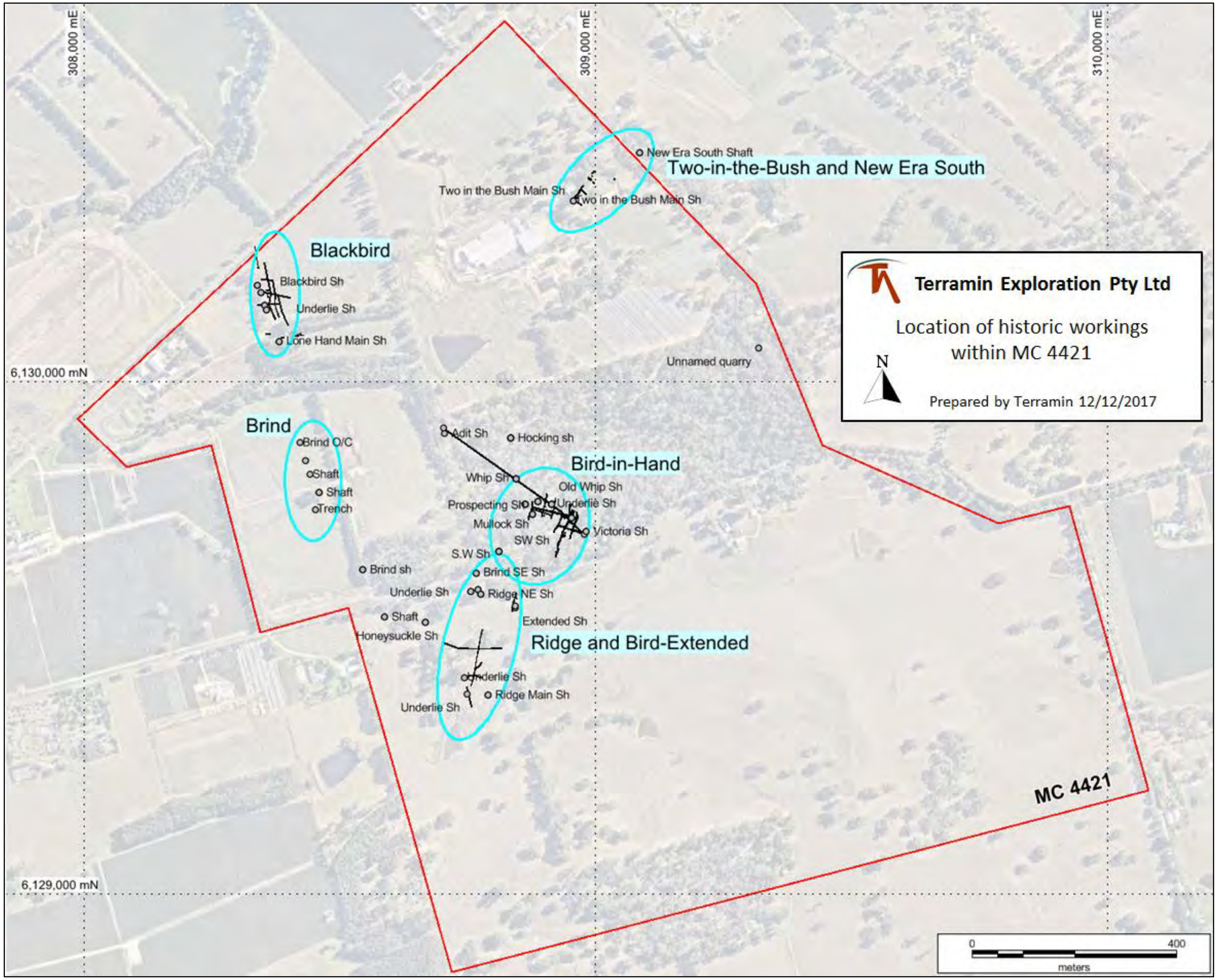


FIGURE 3-13 | HISTORICAL MINES WITHIN THE PROPOSED BIRD-IN-HAND MINING LEASE

3.2.1.5 MINERAL TENEMENT AND LAND TENURE STATUS

The BIH Project is contained within both EL5469 and an area under application for a retention lease to replace Mining Claim MC4113. Retention leases and applications for retention leases are not transferable in South Australia. Consequently, the application for the retention lease is held in trust for the benefit of Terramin.

In 2017 Terramin lodged a mineral claim for a similar area as is held by MC 4113. Maximus continue to hold MC 4113 in a trust agreement for Terramin. MC 4113 expired during 2018, however, the same area has been repegged over with approval under s. 27 of the Mining Act 1971 – MC4473 – Figure 3-14.

In addition to State royalties, Terramin have a commercial agreement with Maximus Resources which forms part of the original sale agreement.

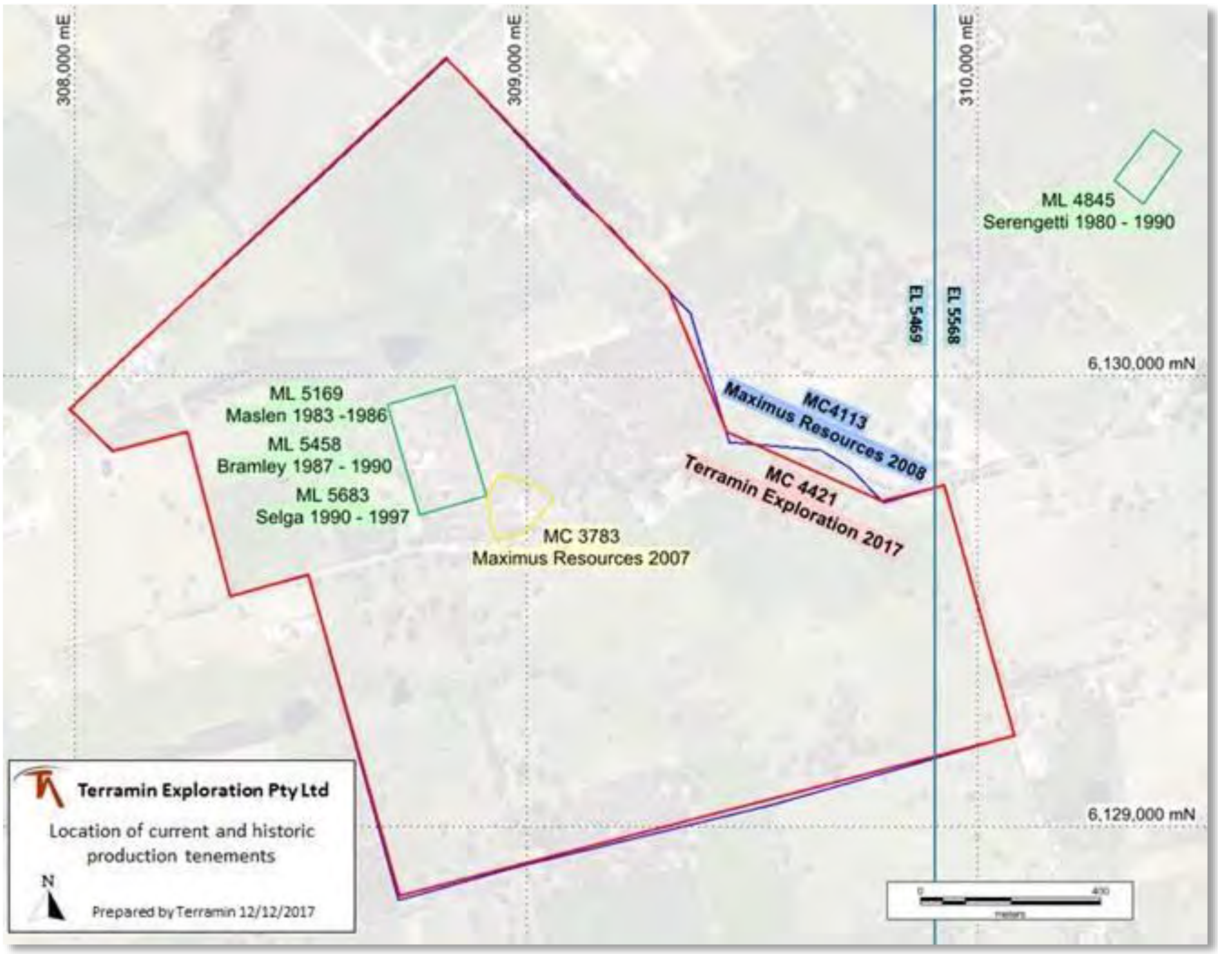


FIGURE 3-14 | IN 2017 TERRAMIN LODGED A MINERAL CLAIM FOR A SIMILAR AREA AS IS HELD BY MC 4113. MAXIMUS CONTINUE TO HOLD MC 4113 IN A TRUST AGREEMENT FOR TERRAMIN. MC 4113 EXPIRED DURING 2018, HOWEVER, THE SAME AREA HAS BEEN REPEGGED OVER WITH APPROVAL UNDER S. 27 OF THE MINING ACT 1971 – MC4473.

3.2.2 PRODUCTION RATE AND PRODUCTS

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 (Table 3-6). As the company has a processing facility at the Angas mine and the intention is to have a very small, low impact operation at Woodside, no ore will be processed at the BIH site. Ore will be transported via haul trucks to the APF at Strathalbyn. All mullock is planned to be used underground for backfilling voids as either rock fill (RF) or cemented rock fil (CRF). A summary of the expected production rate by year (with Year 1 starting at the commencement of the decline development) is below. The Resource grade is 12.6g/t and while the mining method is considered selective, modifying factors have been applied to ensure a conservative approach to mined grade is taken prior to mining.

TABLE 3-6 | SUMMARY OF PRODUCTION RATES OVER THE LIFE OF THE MINE

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

3.2.2.1 PRODUCTS

Initially the ore will be treated using conventional flotation to produce a multi-metal concentrate. It is proposed that the project is economically viable with high recoveries using flotation and provides a cost effective product for sale either to domestic or export markets. As a better understanding of the free gold is determined into the life of the project a gravity circuit could be justified for separation prior to flotation. 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. A full description of the processing of the BIH ore is covered in the Miscellaneous Purposes Licence Application for the Processing facility at Strathalbyn (application pending).

3.2.2.1.1 GOLD CONCENTRATE

There are both local and overseas markets available to deliver the final gold concentrate into.

Locally, the concentrate could be delivered to the Port Pirie Smelter, the recent upgrade/refurbishment at Port Pirie has enabled the facility to treat a broader range of inputs, including gold and other precious metal concentrates.

There are numerous overseas markets that take a high grade gold concentrate. Gold concentrate is well sought after in many gold/copper smelting facilities with favourable terms for gold payment. Based on the current metallurgical estimates of the gold concentrate composition, BIH gold concentrate would be considered high grade and with little to no deleterious elements, placement into international markets is expected to be very straight forward.

3.2.2.1.2 GOLD DORÉ

Gold doré is not included in the current processing flowsheet, mainly due to the fine grain nature of the gold in the ore. It is considered that a gravity circuit could be introduced at a later date to collect any free gold and then produce gold doré. Any gold doré production would be sold into the well-established Australian market for refining into gold bars. The inclusion of a gravity circuit and small smelter is not considered a significant alteration to the plant and will be justified once the level of free gold is determined in the initial processing.

3.2.3 Commodities List

3.2.3.1 REFINED METALS

No refined metals will be produced at the BIH site.

3.2.3.2 MINERAL ORES AND CONCENTRATES

The product produced at the BIH site will be a gold ore containing some value of silver and associated elements of Pb, Zn, Cu, and Fe, all under levels considered to be economic in the current market. Table 3-7 summarises the expected contained gold and silver grades in the BIH ore by year.

Table 3-7 | Ore and additional mineral grades by year

	Year 1	Year 2	Year 3	Year 4	Year 5
Au (g/t)	-	10.0	9.9	11.2	12.5
Ag (g/t)	-	8.2	6.3	3.0	1.9

Details regarding the concentrate produced at the Angas Processing Facility will be covered in the Miscellaneous Purposes Licence Proposal for the Angas site.

3.2.3.3 GEMS AND SEMI-PRECIOUS STONES

No gems or semi-precious stones have been identified at the BIH site as potential commodities.

3.2.3.4 INDUSTRIAL MINERALS

No industrial minerals have been identified at the BIH site as potential commodities.

3.2.3.5 EXISTING COMMODITIES NOT TO BE MINED

Contact was made with local brick making companies to determine if there was any interest in the potential clay deposits located within the site. Although potentially the right types of clay, the colours were not suitable for current processes, so further markets were not investigated.

No other existing potential commodities have been identified for current markets. No extractives (as defined by Section 6 of the Mining Act) will leave the ML.

3.3 EXPLORATION ACTIVITIES

3.3.1 PURPOSE OF EXPLORATION ACTIVITIES

Exploration activities at BiH fall into four categories:

- Infill drilling of the inferred portion of the BiH Resource to upgrade the classification to Indicated;
- Explore for down plunge extension to the BiH Resource;
- Near mine exploration; and
- Sterilisation drilling.

Past and present BIHGP exploration relies heavily on drilling. Drilling activities are undertaken in conjunction with the environment, neighbour consultation, with the intent to mitigate any detriment or nuisance. Terramin have established policies to address safety, environmental, community and operational standards and utilise a contractor selection procedure which ensures that selected drill contractors meet the minimum expected standards. To ensure that the chosen drilling contractors meet Terramin's objectives before drilling, contractors mush have adopted a safety management plan that aligns with Terramin's standards and employees must undergo site induction prior to commencing work during where they will be informed of Terramin's "Policies and Procedures". Exploration activities occuing on the ML as described in this MLP are regulated by the Department for Energy and Mining's (DEM) Compliance Team once the ML and PEPR have been approved. It is noted that any planned exploration to occur off-lease will be subject to the conditions of the relevant EL and regulated by DEMs Exploration Regulation Team.

Terramin commits to post exploration rehabilitation and those efforts are reviewed as fit for purpose by the DEM. Proposed locations of further exploration works (infill, extention down plunge and along strike) is shown conceptually above in Figure 3-12. Locations are indicative only, some of which may be explored utilising the underground decline as a base. However management strategies outlined in this mining lease proposal for exploration would apply to any surface exploration.

3.3.1.1 INFILL DRILLING

Additional exploration drilling is planned to better define the lower portion of the known mineralisation. The bottom two thirds of the 2018 Bird-in-Hand Resource contains areas where the current drilling density only allows for an Inferred Resource classification. The infill drilling will also provided additional samples for metallurgical test work.

Under the JORC Code 2012 guidelines, only mineral resources classified as either Indicated or Measured can be used for a Reserve, this is shown graphically in Figure 3-15. The majority of the 2018 BIH Resource is currently classified as Indicated. A Reserve can only be estimated on the portion of the mineralisation with an Indicated classification.

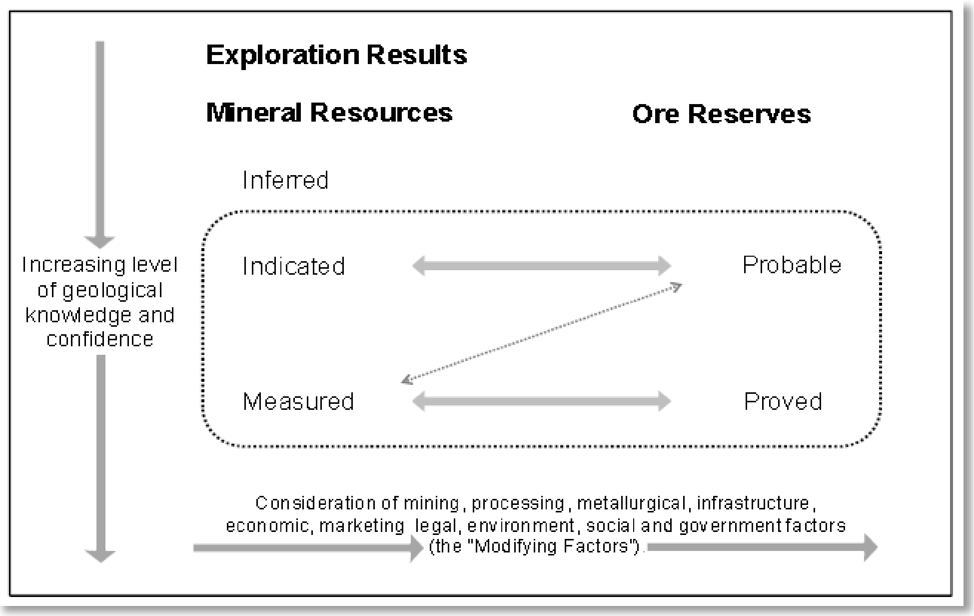


FIGURE 3-15 | RELATIONSHIP BETWEEN MINERAL RESOURCES AND ORE RESERVES, (JOINT ORE RESERVES COMMITTEE OF THE AUSTRALASIAN INSTITUTE OF MINING AND METALLURGY, 2012).

The infill drilling of the BIH mineralisation will target beneath 200mRL down to the 0mRL. Although it is not expected that all of the Inferred Resource will be required to be upgraded to Indicated for a Reserve, to convert all of the Inferred Resource to Indicated would require 18 holes for 7,550m (Table 3-8). Infill target locations are shown as red coloured dots on Figure 3-16.

TABLE 3-8 | SUMMARY OF DRILL HOLES AND METRES REQUIRED FOR INFILL DRILLING OF KNOWN RESOURCE

Interval (m RL)	Average depth (m)	Number of holes	Total metres
200-0	420	18	7550

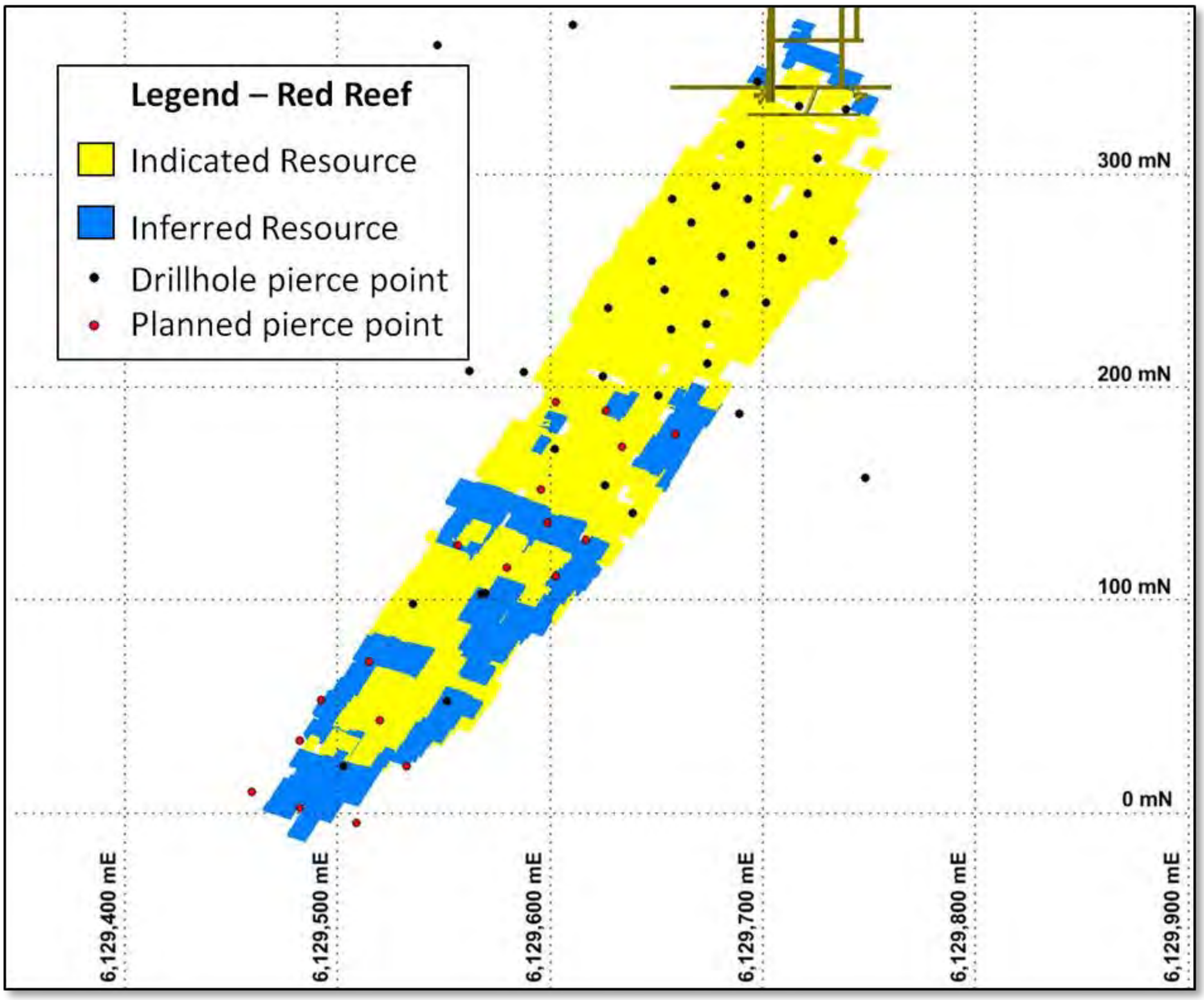


FIGURE 3-16 | BIH PROPOSED INFILL DRILLING TARGETS SHOWN AS RED COLOURED DOTS

3.3.1.2 EXTENSION DOWN PLUNGE AND STRIKE EXTENSIONS OF THE BIH RESOURCE

It is currently thought the strike extents (north and south) of the BiH mineralization are limited by post mineralisation faults. Assuming that the faults are the limits to the mineralisation's strike it is thought that the full strike of the mineralisation has only been modelled between 300mRL and 100mRL. Within this zone there are 170k ounces of gold defined which equates to 840 ounces per vertical metre. There are no indications that the BiH mineralisation does not contnue at depth. The vein style BiH deposit is broadly classified as a mesothermal vein gold deposit. Veins in mesothermal deposits can be several hundred meters long and extend to depths in excess of 1,500m.

Based on average ounces per vertical metre (OVM) predicted in the upper portion of the Resource, there is potential to add in excess of 250kOz by extending the known strike extent of mineralisation to its full width between 100mRL and 0mRL, and defining the down plunge extent to -200mRL. Proposed collar locations to test for the down pluge continuation to the Bird-in-Hand Resource are shown on Figure 3-17.

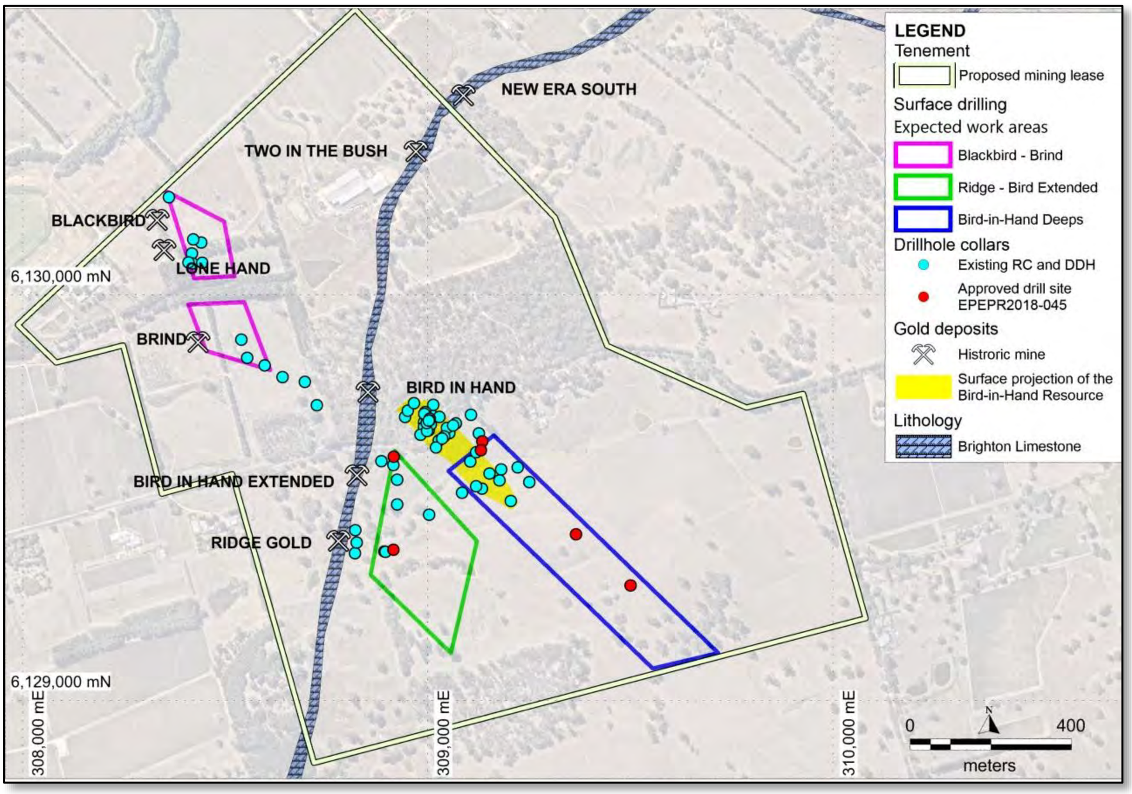


FIGURE 3-17 | PROPOSED WORK AREAS AND APPROVED SPECIFIC COLLAR LOCATIONS FOR SURFACE EXPLORATION DRILLING.

3.3.1.3 NEAR MINE EXPLORATION

There are several historic gold workings within the proposed mining lease that indicate there is good potential to discover additional high grade gold mineralization that may be amenable to underground mining, either along strike (but separate) to the BiH mineralisation as exampled by Bird-Extended and The Ridge or along separate structures such as the Brind-Black Bird trend (shown above in Figure 3-13 and Figure 3-17).

3.3.1.4 STERILISATION DRILLING

Where possible surface infrastructure has been positioned to avoid any potential mineralisation.

Sterilisation drilling is a check undertaken to prevent sterilisation of potential ore due to having located permanent infrastructure such as underground development, buildings, roads etc. in areas where it has not yet been confirmed that there is no economic mineralisation.

This has been undertaken for the majority of the planned infrastructure layout shown in Figure 3-6. Some additional sterilisation drilling is planned for the Brind and Blackbird area to understand the mineralisation in relation to surface infrastructure.

3.3.2 TYPES OF DRILLING

Terramin's preferred drilling methods to date have been diamond core and rotary mud drilling. Drill holes have either been diamond core drilled from surface or they been pre-collared using rotary mud drilling to competent (hard) ground and then diamond core drilled to their final depth.

Water for diamond core drilling is sourced from Terramin's own independent supply and where required from mains water supplied by SA Water. To minimise the cartage of water with heavy tankers, Terramin has developed a network of pipes to deliver the water to drill sites.

Future drilling methods will in part be dependent on the chosen drilling contractor, there is a possibility that reverse circulation (RC) drilling may be utilised for pre-collars and sterilisation drilling if the rigs are fitted with dust suppression and have adequate noise reducing capability.

Additional requirements for RC drilling include the need to manage drill cuttings and water air lifted from downhole. Drill cuttings are bagged at the drill site, sub samples collected as required and then excess cuttings will be disposed of at an EPA approved location. Water lifted by RC drilling is contained in sumps at the drill site. Drilling is terminated before sumps are allowed to overflow. Ground water lifted during the RC drilling of pre-collars is used for diamond core drilling.

Once underground development has commenced it will be possible to drill from underground, using both diamond core and percussion drilling methods to test targets such as the Brind-Black Bird trend and the footwall position beneath the BiH Resource. Drilling from underground will minimise environmental concerns such as visual and noise impacts.

3.3.3 GEOPHYSICAL TECHNIQUES LIKELY TO BE USED

Targeting of exploration drillholes may be aided by the use of geophysical surveys. Minergraphic studies (McArthur, 2016) have shown that gold mineralisation at BiH has a close association with disseminated sulphide minerals and records suggest that "gold sulphide" associations are present at other historic gold workings in the region. Therefore, geophysical methods such as induced polarisation (IP) surveys may be able to identify extensions, offsets and new mineralisation.

Further, the use of IP surveys may enable engineers to avoid or minimise unnecessary development within acid mine forming rocks by identifying pyritic lithologies and supergene sulphide blankets.

Electromagnetic (EM) surveys are currently not being considered as sulphides seen in drilling to date have not been "massive" and as such not expected to be continuous along strike or down dip.

3.3.4 EARTHWORKS REQUIRED

All earthworks undertaken will comply with relevant legislation and regulations and any conditions attached to approvals issued by regulatory agencies and will be conducted in line with "Statement of environmental objectives and environmental guidelines for mineral exploration activities in South Australia M33".

Terramin aims to prevent unnecessary impacts and reinstate sites where disturbance cannot be avoided. Terramin will minimise earthworks through the preferential selection of contractors with tracked equipment and by clearing and levelling the minimum area necessary for the work to be completed safely.

Where earthworks are required, the topsoil will be removed and stockpiled separately to the subsoil, for respreading on completion of the exploration program.

Work programs will be designed so there is no requirement for surface-work or access to drill sites that could potentially interfere with surface drainage lines and no earthworks will be undertaken within riparian zones. All areas of earthworks undertaken will have temporary sediment traps installed down slope to minimize sediment travel in heavy rainfall events.

Pre-existing tracks and drill pads will be used in areas where native vegetation exists. Vehicle passage and drill pads will be sited to avoid disturbing the trees.

Required earthworks for exploration activities are likely to fall into one of four categories:

- Access tracks;
- Drill pads;
- Drill sumps; and
- Rehabilitation.

3.3.4.1 ACCESS TRACKS

Although the need for new formed tracks is not currently planned, there may be a need for short lengths of formed track to be constructed where unformed tracks degrade through a combination of wear and rain events. Formed tracks may also be required for access to drill pads on steep hills.

3.3.4.2 DRILL PADS

Where there is flexibility in locating a drill site, to minimise clearance, a preferred drill site will be one which is relatively flat and have little or no vegetation. However, in areas of steep terrain level drill pads will need to be cut by either an excavator or a dozer into the slope of hills to create safe work areas.

To minimise site disturbance multiple drillholes will be fanned out from individual pads. The need for at least two drill pads to be cut into the southern side of the hill immediately south of Bird-in-Hand Road has been identified. Both of these sites, which are above the riparian zone, have been used previously by Maximus for the pads Pad I and Pad H for drillholes BH029 and BH030 respectively (Figure 3-18).

FIGURE 3-18 | PADS I AND H WERE USED FOR BH029 AND BH030 RESPECTIVELY AND ARE LOCATED SEVERAL METRES ABOVE THE RIPARIAN ZONE SHOWN AS GREEN LINE.

3.3.4.3 SUMPS

Drill sumps are required for both rotary mud and diamond drilling. Rotary mud drilling involves circulation of thick drilling muds for drillhole stability and recovery of samples. Drilling needs substantial quantities of mud which requires the addition of water. Diamond drilling also requires a supply of water, which is used to keep the drill bit cool and to clear the drill cuttings. Sumps are used for mixing and recovering drilling muds or fluids. All drilling fluids will be biodegradable and will use a viscisifier such as CR-650 that is classified as non-hazardous, non-toxic and will not ferment. As per the agricultural impact assessment (Appendix U1), no chemicals or additives containing GMO materials will be used.

For excavated in-ground sumps, topsoil will be stockpiled separate from the subsoil, adjacent to the sump excavation. The excavated sumps will be of sufficient size to contain drilling fluids and will be constructed so that they have a slope left at one end to allow the escape of native fauna and stock. The completed sumps will be barricaded to prevent inadvertent access and silt traps will be installed down slope to prevent muddy water from drill sites entering nearby water courses.

3.3.4.4 REHABILITATION

Rehabilitation is covered below under 3.3.6 and 3.3.7.

3.3.5 EQUIPMENT REQUIRED TO UNDERTAKE EXPLORATION ACTIVITIES

Prior to the commencement of mining, the priority exploration objective will be to grout historic drillholes, undertake sterilisation drilling and convert the upper Inferred portion of the BiH Resource to Indicated. This is likely to be achieved through the use of at least two drilling rigs. To minimise disturbance of neighbours at night, surface exploration drilling and earthworks will only be undertaken on day shifts.

The larger pieces of equipment required to undertake this work is detailed in Table 3-9.

TABLE 3-9 | EQUIPMENT FOR SURFACE DRILLING

Equipment	Activity/purpose
Drilling rig x 2	Rotary mud/RC/diamond capable of +800m
Support trucks x 2 – preferably truck mounted	Supply drill rods, fuel and other consumables
Compressor truck	Only required in RC drilling is used
Booster truck	Only required in RC drilling is used
Light vehicles x 4	Access to sites, pick up of core etc.
Water truck	Supply of water for drilling
Waste water truck	Remove water from sumps on completion of drilling
Dozer	Drill pad and above ground sump pad construction where required
Excavator	Drill pad and in ground sump construction where required
Cement mixer	Supply of cement grout for rehabilitation of new and historic drillholes
Loader	Site rehabilitation
Waste water truck	Remove water from sumps on completion of drilling or as required
Hilift pumps and/or generator and bore pump	Hilift pump to pump from sumps to pipelines/landholder dams, bore pump to pump from bore to pipes if required for drilling/transferring water
Disc filters x 2	Filter water if required
Layflat piping – 6”	Temporary 6’ layflat for transferring water if required

Following the commencement of mining, drilling will be required to continue the infill of the currently defined Resource, extend the Resource beneath 0mRL and undertake exploration within the mining lease. Drilling from underground may make use of both diamond and percussion drilling and is likely to operate both day and night shifts.

Equipment required for IP surveys will include light vehicles, auger rig for the insertion of electrodes and a generator.

3.3.6 Control Strategies for Exploration Activities

All exploration activities will be controlled as outlined in the Exploration Impact Assessment, included in Appendix B7. Primarily this includes

1. Stripping of topsoil,
2. Security of exploration sites,
3. Traffic management for HV access into properties on Bird in Hand Road,
4. Maintenance and rehabilitation of access tracks,
5. Control and mitigation of dust (if applicable) and noise,
6. Control and management of surface water runoff,
7. Fire prevention strategies,
8. Rehabilitation of drillpads and sumps.

All prescribed lease conditions will be applicable for any exploration works undertaken within the ML.

Access roads and earthworks for all exploration will be managed and rehabilitated in consultation with the relevant landholders as outlined in section 3.3.4.

More detailed information on the control of potential impact events associated with groundwater, surface water, soil and land quality, heritage, flora and fauna, geochemistry, dust and noise are included in the chapters outlined below:

Contents Pages
Chapter 10: Groundwater
Chapter 11: Surface Water
Chapter 12: Soil and Land Quality
Chapter 13: Existing Site Contamination
Chapter 14: Geohazards and Geochemistry
Chapter 15: Air Quality
Chapter 16: Noise
Chapter 18: Native Fauna and Pest Species
Chapter 19: Vegetation and Weeds
Chapter 20: Aboriginal Heritage / Native Title and non-Aboriginal Heritage

Importantly, the soil management plan, including the unexpected finds protocol prepared by Golder Associates (appendix L4), will apply for all exploration works. Although there are currently no soil test results indicating contamination sources, the soil management zone has been expanded to include all historic workings located on the southern side of Bird in Hand Road – shown in Figure 3-19.

More information on the soil management plan is located in Chapter 13: Existing Site Contamination. There is a concern that metalliferous drainage may exist from former tails and mine waste areas from the historic Ridge Mine. This includes a private landholder stock dam located directly downstream from the historic ridge chimney and downstream from Terramin exploration sites. Terramin do not expect to access the dam area for exploration. Terramin do not control the activities which occur on this land or own it.

Water quality obtained from the dam from 2014-2016 indicates no traces of mercury, cyanide, and within average ranges of metals as all other dams and surface water in the region – as seen in Table 3-10. The dam was cleaned out during 2015 by the landholder and waste located to the south of the dam. The dam is currently used for stock. Stock access the dam and there are a number of shallow depressions within the floor of the dam, presumably from stock pugging whilst seeking water. Stock access has resulted in a low pH during 2018 due to low water levels and animal waste. The dam is located in the riparian zone and fills each year, overflows generally each wet season and is equipped with a flow diversion for when the dam is full. This diversion flows each year and has been observed operating the last 4 years and presumably has done so since the property was used for agricultural uses. There is no additional credible risk to the water sources from Terramin's activities.

TABLE 3-10 | RESULTS OBTAINED FROM FORMER RIDGE DAM AND REGIONAL STATISTICS TO DATE (2018)

Date Sampled	pH	EC uS/cm	TDS mg/L	As Tot mg/L	Cd Tot mg/L	Cu Tot mg/L	Fe Tot mg/L	Mn Tot mg/L	Pb Tot mg/L	Zn Tot mg/L	Hg Diss mg/L	Hg Tot mg/L	Cn Tot mg/L
24-Mar-14	7.04	167	89	0.01	<0.0001	0.009	7.1	0.236	0.053	0.006	<0.0001	<0.0001	<0.004
30-Jun-14	7	156	291	0.004	0.0001	0.016	8.53	0.059	0.049	0.016	<0.0001	0.0002	<0.004
14-Jul-14				<0.001	<0.0001	0.007	1.36	0.021	0.005	0.015	<0.0001	<0.0001	
26-Nov-14	9.34	272	421	0.017	0.0003	0.021	13.2	0.276	0.093	0.05			
07-Sep-16	7.19	160	154	0.003	0.0001	0.006	1.91	0.043	0.011	0.005			
26-Apr-18	3.07	1310	769	0.033		0.027	18.4	0.805	0.153	0.041	<0.0001	<0.0001	
Regional surface water ranges (excl. former Ridge dam)	5.5-9.8	62-3930	99-3280	0.001-0.89	0.0001-0.0066	0.001-0.17	0.07-649	0.003-59.9	0.001-0.898	0.005-0.509	<0.0001	0.0012	<0.004
Sample count regionally (excl. former Ridge dam)	358	366	353	277	258	297	285	285	297	297	70	53	12

FIGURE 3-19 | EXPLORATION SUBJECT TO SOIL MANAGEMENT ZONE SOUTH OF BIRD IN HAND ROAD

3.3.7 Rehabilitation methods for exploration works (including that not yet rehabilitated from previous tenure)

Given the sensitivity of the BIHGP site, being located within the Western Mount Lofty Ranges Prescribed Water Resources Area and the proximity of residents and irrigators the rehabilitation of exploration earthworks and drillholes needs to be carried out in a timely, environmentally sensitive and technically appropriate manner and in consultation with the landholder to manage rehabilitation expectations well as well as be reasonble in relation to the exploration works undertaken.

In accordance with section 62(1) of the Mining Acta rehabilitation bond of $20,000 has been lodged with Mining Registrar to cover rehabilitation of surface exploration works undertaken to date by Terramin.

Terramin maintain a drillhole and well status register which documents the current status of all drillholes and wells drilled by Terramin.

3.3.7.1 REHABILITATION OF NEW DRILL HOLES

On completion of new drillholes all rods and steel casing will be removed from the hole. Drillholes will be finalised, and sites and access tracks rehabilitated in accordance with details in the Department of the Premier and Cabinet (DPC) Information Sheets – M21: Mineral Exploration Drillholes – General Specifications for Construction and Backfilling (Department of the Premier and Cabinet, 2012), and M33: Statement of Environmental Objectives and Environmental Guidelines for Mineral Exploration Activities in South Australia (Department of the Premier and Cabinet, 2004), and honouring any additional commitments to the Landholder.

On completion of drilling, each drillhole will be cement grouted in its entirety. At each drill site, which may include more than one drillhole, sumps will be allowed to dry before backfilling. All drilling mud additives are biodegradable and do not pose any long term waste management issues. If necessary, the fluids will be pumped out and disposed of at an EPA licenced facility. Once the water is removed the sump liners will be removed and the sump backfilled. Excess material will be mounded over the sumps to allow for compaction.

All excavations will be backfilled with the top-soil and sub-soil replaced in the correct order. Stockpiled vegetation will be spread over the backfilled excavation to assist regeneration. The vegetation will be layered on the contour to limit erosion and encourage seeding. All rubbish, contaminated soil, work debris will be disposed as appropriate in accordance with Terramin’s site Waste Management Plan.

Ground which has become compacted by the use of heavy machinery or prolonged use around a drill site will be ripped along the contour (not downslope) to loosen the soil. Contour banks will be placed at intervals across steep slopes and silt traps will be placed to prevent the formation of erosion gullies.

Terramin will compile representative before, during and after photographic evidence of all exploration related earthworks (e.g. drill sites, new track etc.) with representative photographs included within the annual exploration compliance report. Terramin’s aim will be to rehabilitate disturbed sites to as near original condition and in such a manner as to facilitate revegetation after completion of drilling operations.

3.3.7.2 REHABILITATION OF SOUTH AUSTRALIAN GOVERNMENT AND PREVIOUS COMPANY DRILL HOLES

With the exception of BH052 which was equipped as a monitoring bore after having vibrating wires installed prior to being cement grouted; all exploration drillholes completed by Terramin in 2016 were fully rehabilitated.

There are no rehabilitation records for the drillholes completed by; South Australian Mines Department, Capricorn Resources Australia NL or Maximus Resources Limited.

Drillholes that have not been rehabilitated pose several risks that include:

- Acting as a conduit for groundwater, which could cause water inflow issues into underground workings;
- Rifling during firing; and
- Void intersection during development/production drilling.

For drillholes that penetrate the BIH orebody or that are likely to be intersected by underground mining operations Terramin has developed a standard grouting procedure to minimise these risks and meets the requirements of both the *South Australia Mining Act 1971* and the *South Australia Water Resources Act 1997*.

All pre-Terramin drillholes will need to be located, cleaned out with a drill rig by reinsertion of the drill rods and flushed, backfilled with grout and their sites rehabilitated. All water will be managed to ensure compliance with the *Environment Protection (Water Quality) Policy 2015.*

Terramin's standard drill hole grouting procedure is a staged process; where grout once emplaced is allowed to set and then after at least two days the top of the grout is tagged. The tagging is to confirm that the grout has set and determine how far the grout has settled. If required more grout is pumped down hole, the procedure is repeated until the tagged grout depth is 15m above the water table. Once it is demonstrated that the grout is sufficiently above the water table the drillhole is backfilled with sand. Terramin maintains a database that is updated concurrently with grouting activities.

This procedure may be modified to include grouting of exploration drillholes under pressure and or using fine silica cement grout to assist in the sealing of fractures around the BIH Resource to limit ground water inflows into the mine voids. Terramin is planning to use pressure grouting of purpose drilled underground drillholes as a method to reduce inflow of ground water from fractures into the underground workings. Although not intended to replace the grouting of underground drillholes, the pressure grouting of exploration holes may help improve the overall effectiveness of grouting to minimise groundwater inflows.

3.3.7.3 REHABILITATION OF WATER INVESTIGATION BORES

In 2014 Terramin installed five water investigation bore holes which are still being used to collect background data. Two of these bore holes intersected the BIH Resource and a third penetrates the Brighton Limestone. These three bore holes may need to be grouted prior to the commencement of mining to prevent an inrush of ground water should they be intersected. The other two bore holes will provide useful data on ground water during the mining process and will be rehabilitated on completion of mining as outlined in the Minimum Construction Requirements for Water Bores in Australia 3rd Edition (2011) regulated by DEW.

All other wells and monitoring piezometers will be rehabilitated on completion of closure, once no longer required as per the Minimum Construction Requirements for Water Bores in Australia 3rd Edition (2011) regulated by DEW.

Prior to decomissioning of all water related bore holes a permit (for each bore) will be applied for to "backfill (decomission) or seal a well" from DEW and an appriopriately licenced groundwater drillier will be engaged to undertake the work.

All land disturbed by the MAR pipelines, MAR bores (as shown in Figure 3-112) and investigation bores will be ripped and reseeded in consultation with the appropriate landowner.

3.3.7.4 REHABILITATION OF ACCESS TRACKS

3.3.7.4.1 SOIL TYPE

The soil classification at all proposed exploration areas is a combination of skeletal acidic sandy loam over red clay on rock and skeletal acidic loam over clay on rock. Terramin will repair farm tracks damaged in the course of exploration activities. Access tracks to exploration sites constructed by Terramin that are no longer required will be rehabilitated with appropriate soil management and plant species, as agreed with the landowner. Once access tracks are rehabilitated they will remain permanently closed. Currently, only the sheeted track and carpark initially constructed for the 2014 water investigation drilling require rehabilitation.

Photographic evidence of "before and after" Figure 3-20 will be maintained to demonstrate that all tracks are closed and will be provided in the 'Rehabilitation' section of the annual exploration compliance report.

FIGURE 3-20 | BEFORE REHABILITATION OF DRILL SITE (MARCH 2007) AND AFTER REHABILITATION OF DRILL SITE (AUGUST 2008) PHOTOS OF THE DRILL SITE FOR BH029

3.4 MINING ACTIVITIES

This section describes the various mining activities proposed for the BIH Gold Project. It covers topics including

- Mining method;
- Underground workings;
- Material movements;
- Use of explosives;
- Types of mining equipment;
- Mine dewatering;
- Sequence of mining; and
- Rehabilitation strategies.

3.4.1 TYPE OR TYPES OF MINING OPERATIONS TO BE CARRIED OUT

A review of the approach to mining the Bird in Hand gold deposit was undertaken in recognition of the location of the mineralisation. In 1881 when the deposit was first mined on the outcropping deposit the mine was excavated from surface in a form of trench mining. As the mineralisation extended to depth, the mining method changed to shaft sinking and following the mineralisation with blind drives. At the end of the first period of mining there were eight shafts sunk, the deepest reaching 125m below surface. These historic mines remain in place today and have filled with groundwater as part of the regions aquifer system. It was recognised through early engagement and understanding community expectations related to visual impact, that open cut mining was not a practical option. A review of historical mining and early scoping studies showed that a shaft access approach would have to intersect the overlying hangingwall fault zone (major water bearing structure associated with historic mining) and, with the 45^{o} ore dip, required excessive access development at lower levels, eliminating its efficiency as the mine progressed at depth. The decision was taken during the scoping process to evaluate an underground mine, accessing the gold mineralisation below the old workings and use the Angas Zinc Mine (AZM) to beneficiate the ore. This provided for a stand-alone mine with haulage along established roads to the processing facility at AZM.

Under good mine design principles, the access was designed in the footwall sequence, this provided the mine access to be placed away from the hangingwall fault, identified by previous mining endeavours to produce 80% of the original groundwater inflows, providing a significant benefit to water volume management. The proposed method for developing the Bird-in-Hand Gold Project is mechanised, underground, decline access, small scale, conventional mining. The proposed stoping method is cut and fill using a combination of cemented rock fill (CRF) and loose rock fill to replace the mined ore using the mullock taken from the mine access. Mining will be undertaken using standard equipment and processes such as Jumbo drill and blast, and truck and loader haulage, as commonly used in civil and mining tunnelling projects. All ore produced will be transported in general access vehicles (truck and dog trailer) via existing roads to the processing facility near Strathalbyn, the Angas Processing Facility (APF). Mullock mined will be temporarily stored on the surface, if storage space is not available in underground stockpiles, prior to it being used either as rock fill or cemented rock fill for backfilling the stoping voids as the production front progresses.

The following sections describe the proposed operations in further detail.

3.4.1.1 MECHANISED CUT AND FILL

The most suitable mining method identified for the BIH ore body and its location was conventional mechanised cut and fill mining. The method is depicted in Figure 3-21. This method provided for selective mining of the ore, full access to mined surfaces for management of mine conditions and the reuse of mullock as fill in mining voids to reduce stockpiling requirements on surface.

The mining method uses the same equipment as used for the mine development process (tunnelling). Once the ore is reached, progressive, limited height stages or "lifts" are mined along the ore using Jumbo development drills, with cycles of mining and back filling. The hanging wall ground conditions are considered to be poor and potentially wet (Appendix M1), due to the rock types and proximity to fractured rock aquifers and fault zones. The cut and fill method allows full access to the hanging wall for ground support and groundwater management techniques such as cabling, grouting and shotcreting, that other methods, such as open stoping, limit. The cut and fill mining method also limits the up-dip exposures of the hanging wall rock, with suitable fill material being placed back into the mined void as mining progresses. This prevents extensive voids remaining open for long periods, controls ground expansion, improves mining conditions and reduces the risks of ground failure or subsidence events.

The ore body is accessed via a decline tunnel (decline) developed using conventional Jumbo drill and blast. Once the orebody is reached, the ore can be mined to the full width. Where geotechnical conditions prevent the full width of the ore to be opened in one drive, the wider sections of the orebody will be mined in 2 or more adjacent narrower headings. Stopes are mined as 20m levels with 4 x 5m high lifts, each, supported, conditioned and backfilled prior to the next lift above being mined. Ore is drilled, blasted in small, controlled, timed sequences. The resulting broken rock is then removed by loaders accessing the stope by intermediate ramps from the main level access off of the decline. Ore is placed either into trucks to take to surface or into the level's ore stockpile system for later removal. Non-mineralised material (mullock) mined will be stockpiled temporarily within available passes underground or on the surface in the integrated mullock landform (IML) in preparation to be transported back underground as backfill material. The backfill placed provides both wall support and a working platform for the subsequent lift, as stoping progresses in a bottom up sequence Figure 3-22. As ore mining is undertaken, the decline is progressed in a downward spiral adjacent to the ore in the footwall sequence to provide access to the next level. This allows for increased production rates, providing ore production on subsequent levels.

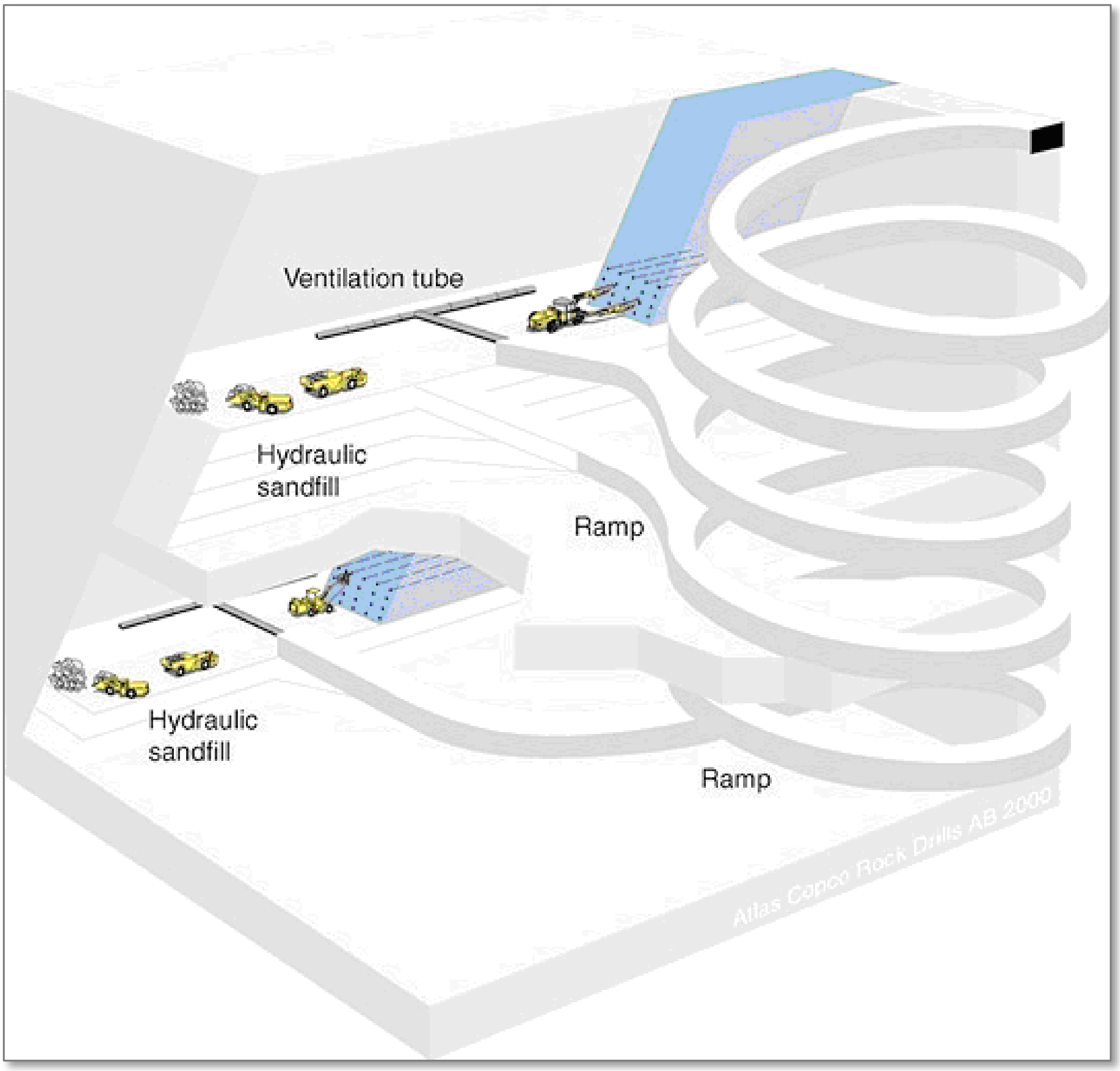


FIGURE 3-21 | GENERIC MECHANISED CUT AND FILL MINING METHOD (ATLAS COPCO, 2016)

Backfilling is an integral part of the mining method and mining of subsequent lifts cannot occur without prior backfilling. The use of hydraulic fill or paste fill is not practical at the BIH site, as there are no processing facilities and no tails available on site. Hence, It is expected that two main types of backfill will be used at BIH; a Cemented Rock Fill (CRF) on the lower lifts and an unconsolidated Rock Fill (RF) in the upper or adjacent lifts. The use of fill type is determined in the mining schedule depending on the fill performance required in subsequent adjacent stopes, or if ground conditions at the location required additional strength. The different fill types will be designed relative to the strength of support required for the next mining stage (underhand mining or mining next to the fill). CRF was used at AZM as a fill solution, the method and procedure used at AZM will be applied for the cut and fill mining. Fill quality and strength will be subject to ongoing QAQC process during the life of the operation to ensure that subsequent mining can be undertaken safely and efficiently.

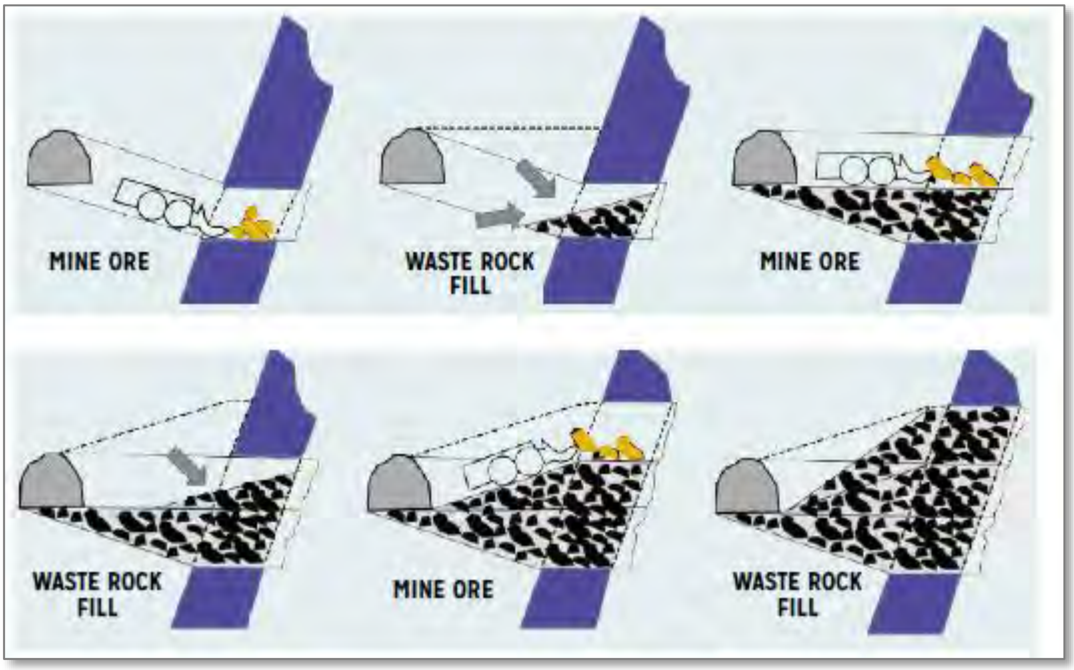


FIGURE 3-22 | SEQUENCE OF MINING FOR CUT AND FILL MINING METHOD (FIGURE FROM APPENDIX C3)

Benefits of a cut a fill method include (Harraz, 2014)

- Suitable for shallower dipping orebodies (BIH dips at 45-50 degrees);
- Provides selectively and flexibility (good for narrow ore bodies (BIH varies from 2m-9m) and aids in the minimisation of ore sterilisation;
- Minimal surface disturbance, as open void volumes are minimised (backfilled as it progresses); and
- Reduction of surface mullock storage, as it is used to backfill voids.

In addition, cut and fill mining allows full access to exposed mine surfaces for the ability to control factors such as surface ground support systems, installation of rock bolts or cables and the ability to apply any groundwater control if required post excavation.

Key factors in the selection of the mining method were:

- Orebody geometry; and
- Geotechnical properties.

3.4.1.2 OREBODY GEOMETRY

The modelled orebody is continuous along strike, with typical average thickness of 6-7m. The orebody has a dip of ~45 – 50° to the east.

3.4.1.3 ORE BODY STERILISATION

Due to the nature of the narrow ore body, the full width of the practically extractable mineralisation is taken as the ore drives are mined. Potential for sterilisation occurs at the extremities of the ore drives, where face grades are not high enough to mine at the time of extraction or hazards from water ingress are present, and in lodes that are either uneconomic, too wide, or narrow and too close to the main production lodes to mine separately but too far away to take with the main lodes either from a practicality/safety/geotechnical perspective or economic consideration. These considerations are taken into account as part of the mine design process.

If left, it would be difficult to extract these areas after the main lodes have been mined, however under the right economic conditions and metal prices, and following experience with the mine in practice, they may be revisited at a later date.

3.4.1.4 GEOTECHNICAL

Geotechnical assessment undertaken to date, on both core drilled by Terramin and of the drill core that was recovered by Maximus, using Deere's classification (Table 3-11) is that the hanging wall conditions are poor-fair, the ore conditions are fair and the footwall conditions are good. Further geotechnical investigations (drilling) during the life of the project will assist in defining these properties further.

Design measures which will be undertaken in regards to geotechnical stability are included in Chapter 13: Geochemistry and Geohazards, section 13.6.1.

Further details on the Geotechnical Assessment is discussed in Appendix M1

TABLE 3-11 | CORRELATION BETWEEN RQD AND ROCK QUALITY (DEERE, 1964)

RQD (%)	Rock Quality
90 to 100	Excellent
75 to 90	Good
50 to 75	Fair
25 to 50	Poor
0 to 25	Very Poor

3.4.2 UNDERGROUND WORKINGS

The planned underground workings for the Project are illustrated in Figure 3-24 and Figure 3-25 and will include the following:

Capital Development (longer term excavations, generally mullock):

- Access boxcut (to be backfilled around a prefabricated structure) and decline;
- Level cross cuts and access drives, ore passes;
- Ventilation return air drives, internal ventilation raises, primary ventilation raises;
- Emergency egress system – access drives, raises and main raise;
- Underground pump station; and

- Miscellaneous cuddies for underground infrastructure (electrical, services, backfill mixing bays etc.)

Operational Development (shorter term openings, generally ore):

- Level access drives (4 per level); and
- Ore drives.

The size, shape, excavation method and timing of the underground workings are influenced by (Queen's University, 2015):

- The purpose of the excavation;
- The service requirements;
- Rock characteristics, ground conditions in the area;
- Intensity and nature of mining activity near the excavation;
- Intended life of use; and
- Equipment clearance requirements, including whether or not the haulage route allows for one or two-way traffic.

To minimise the dilution of the ore and to minimise damage to the hanging wall, it is proposed that shanty back drive profiles are used due to the geometry of the ore body. Studies undertaken by AMC consultants indicate that minimum dilution for a 5m vein width is 11% in fair ground conditions. (Salmenmaki, 2017).

The concept of utilising shanty back profiles is discussed in the geotechnical assessment undertaken by Mining One (Appendix M1).

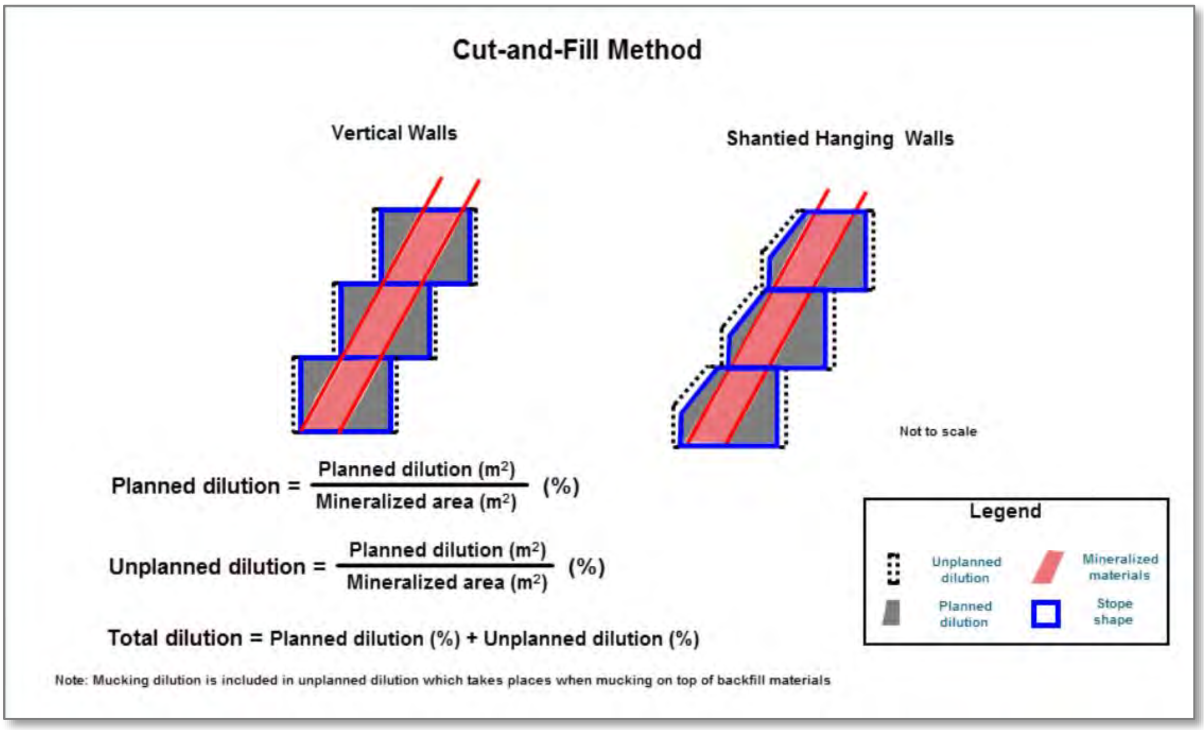


FIGURE 3-23 | BENEFITS OF SHANTY BACKED ORE DRIVES IN CUT AND FILL MINING (SALMENMAKI, 2017)

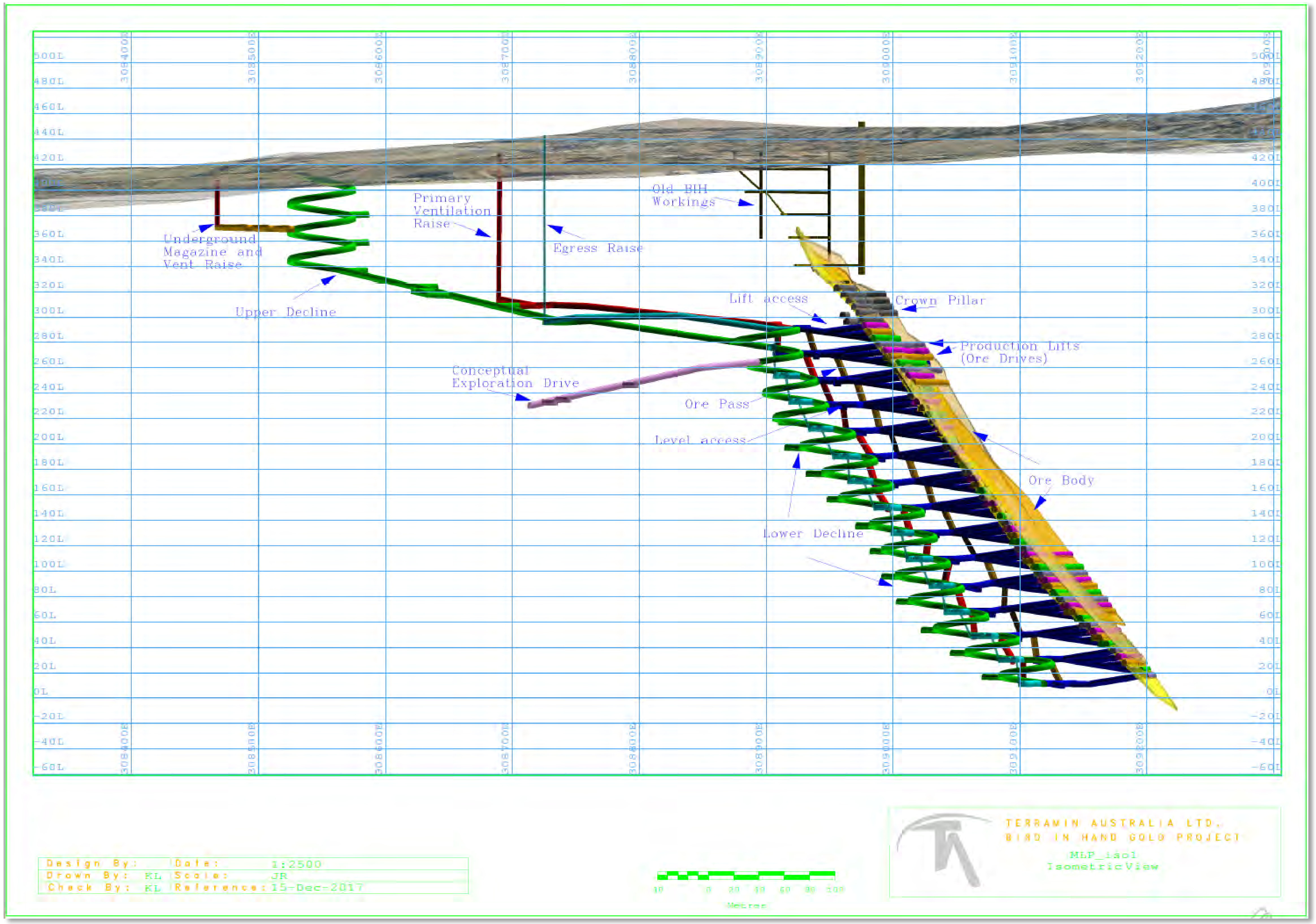


FIGURE 3-24 | ISOMETRIC VIEW OF UNDERGROUND WORKINGS LOOKING NORTH

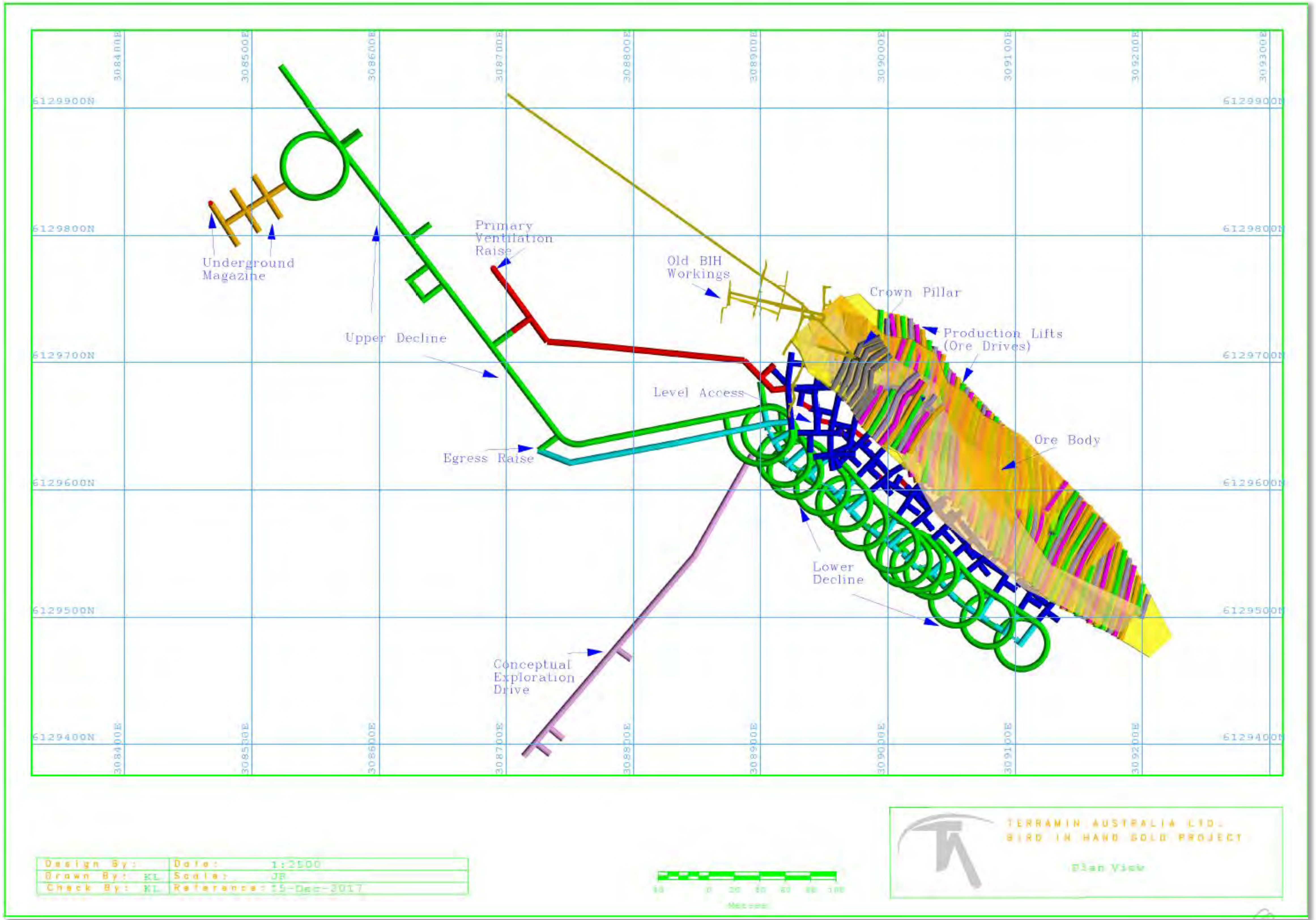


FIGURE 3-25 | PLAN VIEW OF UNDERGROUND WORKINGS ONLY

Figure 3-26 | Plan View of Underground Workings showing satellite image and proposed Mining Lease Boundary

3.4.2.1 BOXCUT AND PORTAL

A series of geotechnical test pits and geological drilling was undertaken to aid in the identification of the most suitable location for the box cut and portal. This access method was selected over a shaft and hoist option due to the size and location of the ore body relative to the Goldwyn property. Evaluations of the mineral claim and deposit geometries have identified that the best location to access the underground is by a portal within the south eastern paddock of Goldwyn (Figure 3-27).

FIGURE 3-27 | SELECTED LOCATION FOR THE BOXCUT AND FOR THE COMMENCEMENT OF THE DECLINE CIRCLED IN YELLOW (FIGURE FROM APPENDIX G1)

Alternative access points add extra development, require the decline to progress through known poor ground conditions and/or place the portal and other key infrastructure in close proximity to adjacent roads and houses.

Risk mitigation for the decision in the location of the boxcut and portal included:

- Minimise visual and noise impact for surrounding neighbours by maximising distance from sensitive receptors such as neighbouring residences/businesses, public roads.
- Selection of competent ground types for excavation and development work
- Centrally located to the "operational" areas of the mine to reduce traffic movements on surface
- Minimise length of underground development to reach the ore body

To further reduce the impact on receptors, it is planned to construct a pre-fabricated access tunnel (i.e. BEBO™ type structure, Figure 3-32) through the boxcut and backfill around it to:

- Reduce noise and dust impacts on the surface;
- Increase the available usable space on the surface (and reduce the space otherwise required to be disturbed on the existing surface); and
- Reduce the risks associated with open boxcut surfaces (wall failures, erosion, stormwater capture etc.)

3.4.2.1.1 BOXCUT GEOMETRY

Due to the location and geometry of the BIH orebody, the ore will not be mined using open pit methods. Access to the underground mine, will be via decline from the surface. The decline construction will commence within a boxcut on surface. The boxcut is designed to excavate a stable working face in solid rock, below the overlying soils and clays. This allows the tunnelling to commence in suitable strength rock.

Vulcan 3D software was used to prepare the mine design based on the location of the geological models, and within design limits on the surface (Figure 3-29). Initial geotechnical analysis was undertaken by Mining One as part of the Geotechnical assessment, including excavation of test pits (Figure 3-28) to determine rock types (weathered/partly weathered, clay/siltstone/quartzite etc.), nature and orientation of rock properties (dip/strike of bedding, fractures, hardness etc.) in the vicinity of the chosen area, to identify the most stable shape and orientation of the boxcut walls. These pits were also used to confirm the access for the portal would be in competent rock, rather than highly weathered clays, to minimise ground support hazards.

FIGURE 3-28 | PHOTO OF ONE OF THE GEOTECHNICAL TEST PITS USED BY MINING ONE TO IDENTIFY THE ROCK PROPERTIES USED TO DESIGN THE BOXCUT AND PORTAL LOCATION

Further details on the design of the boxcut is discussed in the Geotechnical Assessment Report, Appendix M1).

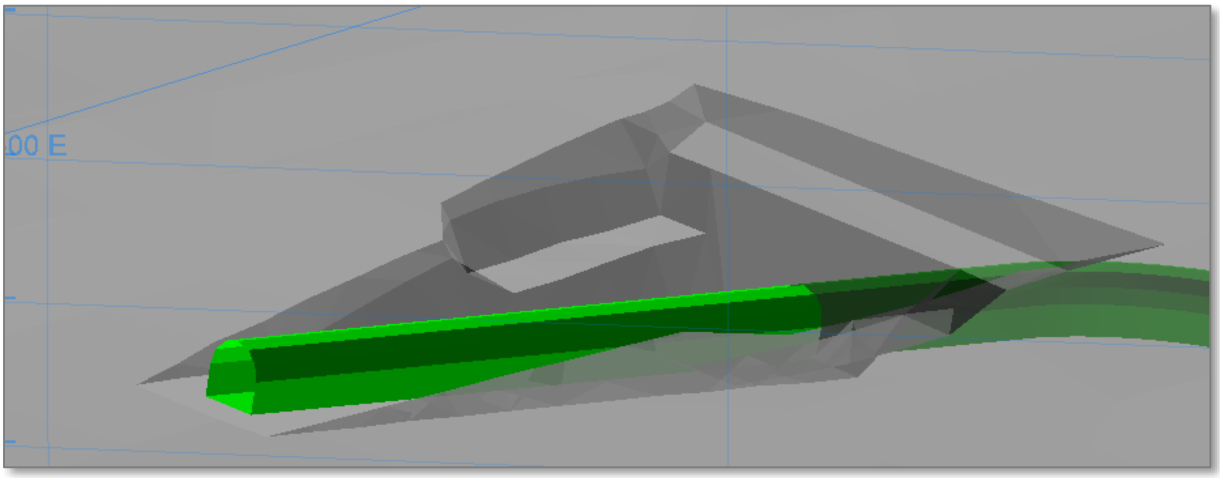


FIGURE 3-29 | CONCEPTUAL ISOMETRIC VIEW OF THE PROPOSED BOXCUT (WITHOUT FILL) SHOWING THE PORTAL AND INITIAL DECLINE THAT WILL BE FORMED FROM A PRE-FABRICATED TUNNEL LINING (LOOKING SE)

The proposed boxcut will be approximately 60m in length and 14m deep benched at angles and heights based on geotechnical stability review on data known to date. (Figure 3-30 and Figure 3-31).

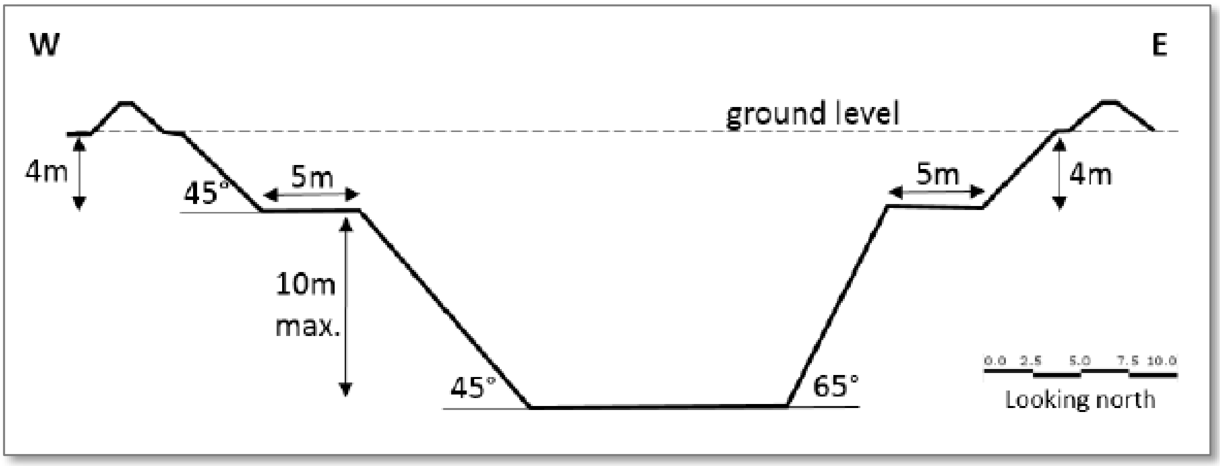


FIGURE 3-30 | CROSS SECTION OF PROPOSED BOXCUT SHOWING BENCH ANGLES AS DETERMINED FROM GEOTECHNICAL INVESTIGATIONS (FIGURE FROM APPENDIX M1)

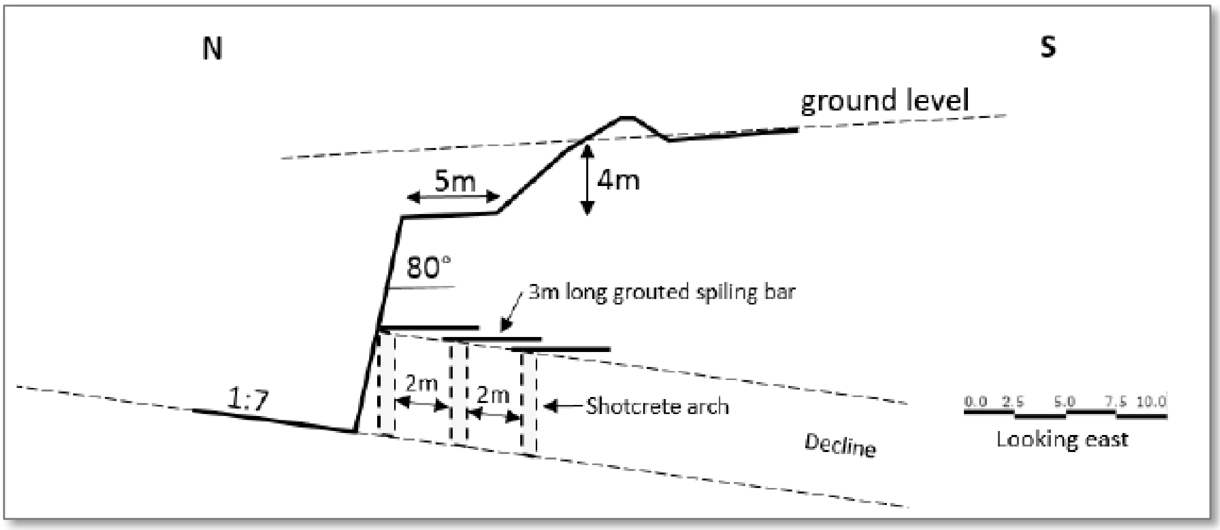


FIGURE 3-31 | LONG SECTION OF PROPOSED BOXCUT SHOWING BENCH ANGLES, AS WELL AS INITIAL PORTAL GROUND SUPPORT RECOMMENDATIONS AS DETERMINED FROM GEOTECHNICAL INVESTIGATIONS (FIGURE FROM APPENDIX M1)

Once the portal has been established, a pre-fabricated tunnel will be installed within the box cut from the start of the decline to the original surface (Figure 3-32, (Humes, 2015)). The boxcut will be backfilled with suitable engineered material (type(s) to be determined by the manufacturer of the BEBO structure and the final design specifications) to provide for additional surface space above the access tunnel such as an area for storing mine consumables and stocks. It is anticipated that the excavated material from site will be suitable for backfilling.

FIGURE 3-32 | EXAMPLE OF A TYPICAL INSTALLATION OF PRE-CAST TUNNELS USED IN MINING (HUMES, 2015)

3.4.2.2 DECLINE CONSTRUCTION

The decline is designed to be developed below the extremely weathered, clay/rock surface identified in the geotechnical investigations undertaken by Mining One (Appendix M1) (Figure 3-33). It was also redesigned to pass below the supergene zone indicated as possibly containing potentially acid forming (PAF) material (Figure 3-34). The decline will be developed to a depth of approximately 150m below surface prior to it passing beneath adjacent properties and public roads.

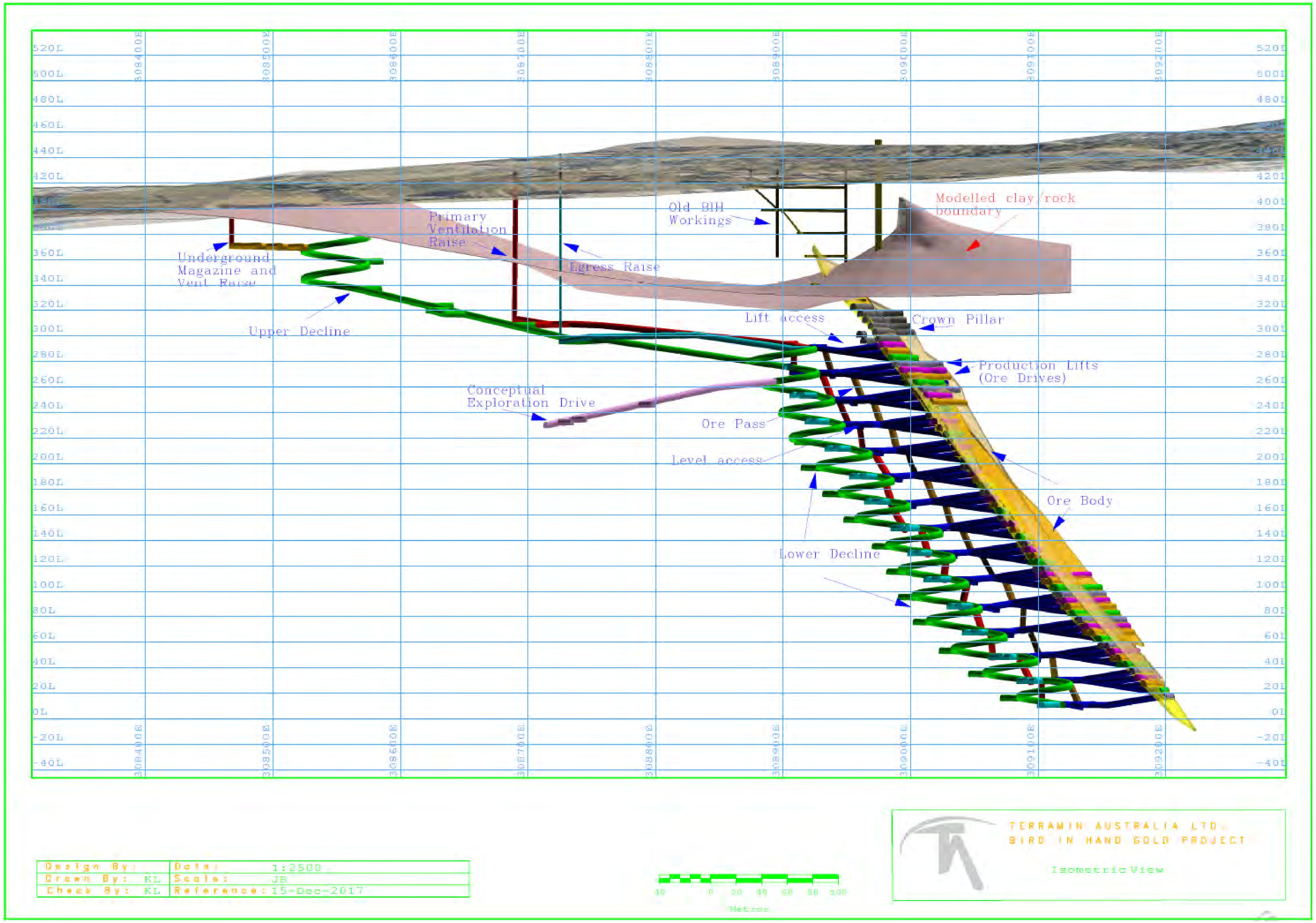


FIGURE 3-33 | ISOMETRIC VIEW OF THE PROPOSED UNDERGROUND BIH MINE SHOWING THE MODELLED CLAY/ROCK SURFACE AS MODELLED BY MINING ONE, AS WELL AS THE RELATIVE LOCATION OF THE OLD BIH WORKINGS

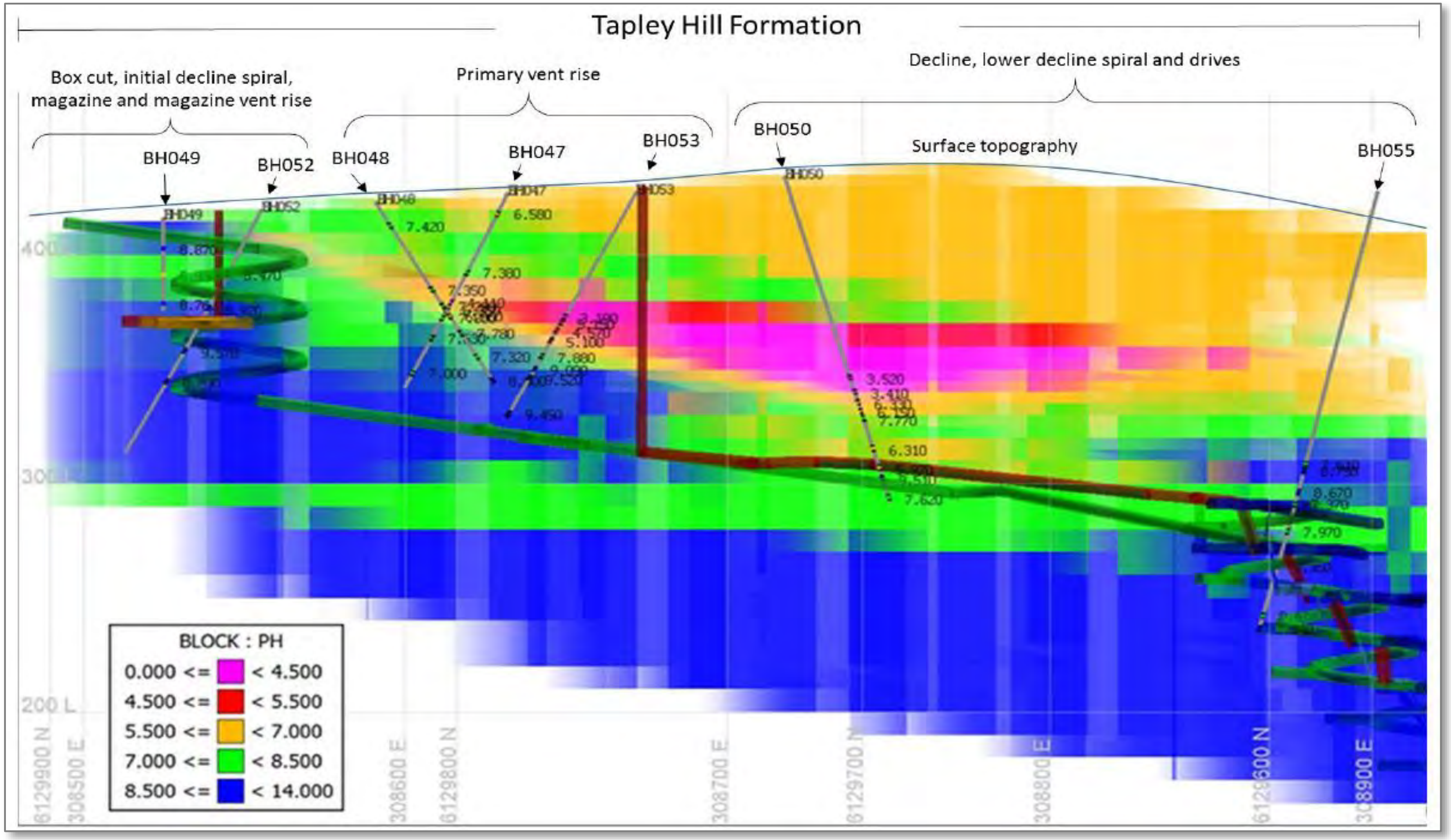


FIGURE 3-34 | ISOMETRIC SECTION VIEW (LOOKING EAST) SHOWING THE MODELLING LOCATION OF THE POTENTIAL AMD ZONE (RED/PINK) AND THE REASON FOR LOCATING THE MINE DECLINE AT A LOWER RL TO AVOID THIS ZONE (APPENDIX M2)

Design parameters for the decline, shown in Figure 3-35, are summarised below:

- Dimension: 5.0m W x 5.5m H;
- Profile: Arched;
- Max gradient: +/- 1V:7H;
- Min Turning radius: 20m;
- Method: Convention jumbo drill and blast;
- Cut length: 3.5m; and
- Stockpiles: max 20m length, every 100m (102pprox..)

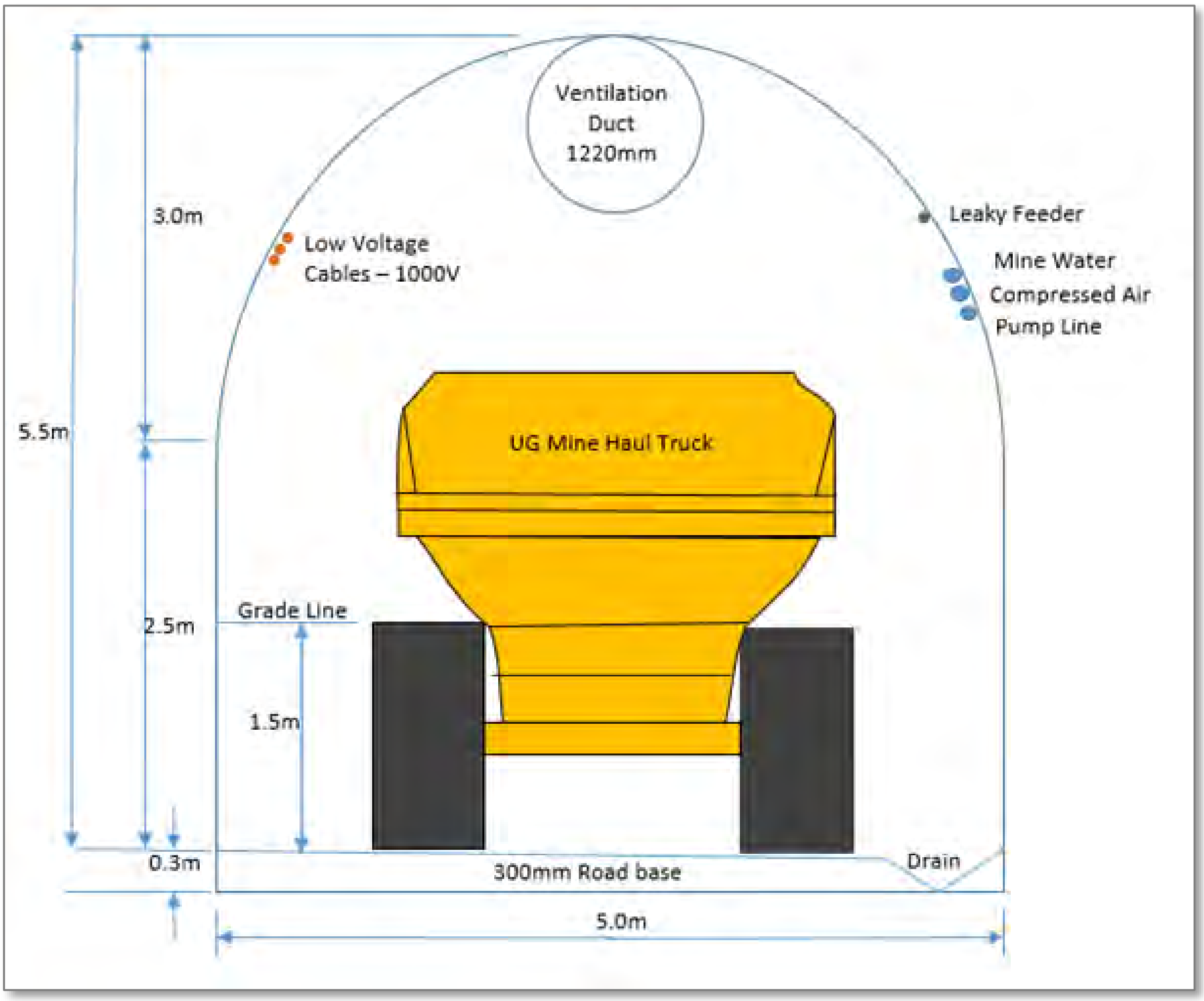


FIGURE 3-35 | TYPICAL CROSS SECTION OF THE 5.5M X 5.0M ARCHED PROFILE DECLINE SHOWING SERVICES AND AN UNDERGROUND HAUL TRUCK

The decline will be the primary fresh airway intake and travel way for all underground equipment and personnel. In the upper sections of the decline, 20m long stockpiles have been designed to facilitate development cycles and will be utilised as turning bays and/or temporary storage areas (Ground support, services consumables etc.) as development progresses.

A secondary exploration decline has been included in the initial design to allow for suitable underground drilling platforms to target ore extensions along strike and at depth. The design of this exploration decline will be dependent on additional geological drilling and modelling undertaken during future exploration work and is included in the current design as indicative only. Further discussion on the planned exploration for the project is covered in Section 3.3.

Probe drilling campaigns will be utilised to identify areas where the development will likely intercept groundwater and /or existing voids. Due to the decline being designed through a fractured rock aquifer similar to tunnelling projects such as the Melbourne Metro, determining the location and extent of the fractures along the length of the decline path is beneficial to design with the intent to avoid these areas in order to avoid the cost of water reinjection and plan development schedules. This will allow for preparation of pre-emptive ground support and groundwater management systems. Delays due to unexpectedly poor ground conditions and/or unexpected groundwater inflows have significant capacity for project delay.

Details of the probing strategies are discussed further in Section 3.4.2.3.9 of this chapter, as well as in Chapter 10, as well as in the Grouting Proposal undertaken by Multigrout – located in Appendix H4.

3.4.2.3 DEVELOPMENT

3.4.2.3.1 FOOTWALL

Ground conditions in the footwall (Tapley Hill Formation) have been classified as “good” using Deere’s classification system (Table 3-11), thus all capital infrastructure in the proposed design has been located within this rock type. The decline will be supported appropriately depending on the ground conditions encountered. From current assessments, it is expected that in-cycle mesh and bolts will be used, as well as in cycle shotcreting (Appendix M1). It is also assumed that pre-excavation grouting will be applied in regions where the development is in close proximity to any underground aquifer (i.e. within 30m, or as detected through probe drilling).

3.4.2.3.2 ORE DRIVES

Conditions in ore drives are expected to be fair and geotechnical recommendations to date (Appendix M1) advise in-cycle shotcreted to a thickness of up to 100mm. Friction bolting or resin bolting will be undertaken after shotcreting with an appropriate bolt spacing to be determined after further and ongoing geotechnical review. Drive intersections are expected to require cables for ground support. It is expected that the majority of the hanging wall will require pre-excavation grouting for groundwater management, again determined by a probing regime used within the development cycle.

3.4.2.3.3 CROWN PILLAR

The integrity of the crown pillar is important to any underground operation, in particular to avoid the incidence of subsidence on the surface above the mining operation. As historic workings are present, a conservative approach has been taken with a standoff of 35m (vertically) allowed for between the lowest known levels of the historic workings, a 1.8m x 1.8m drive, to the highest planned level (accessed from the decline) of the new operation, a 5m x 5m drive (Figure 3-36).

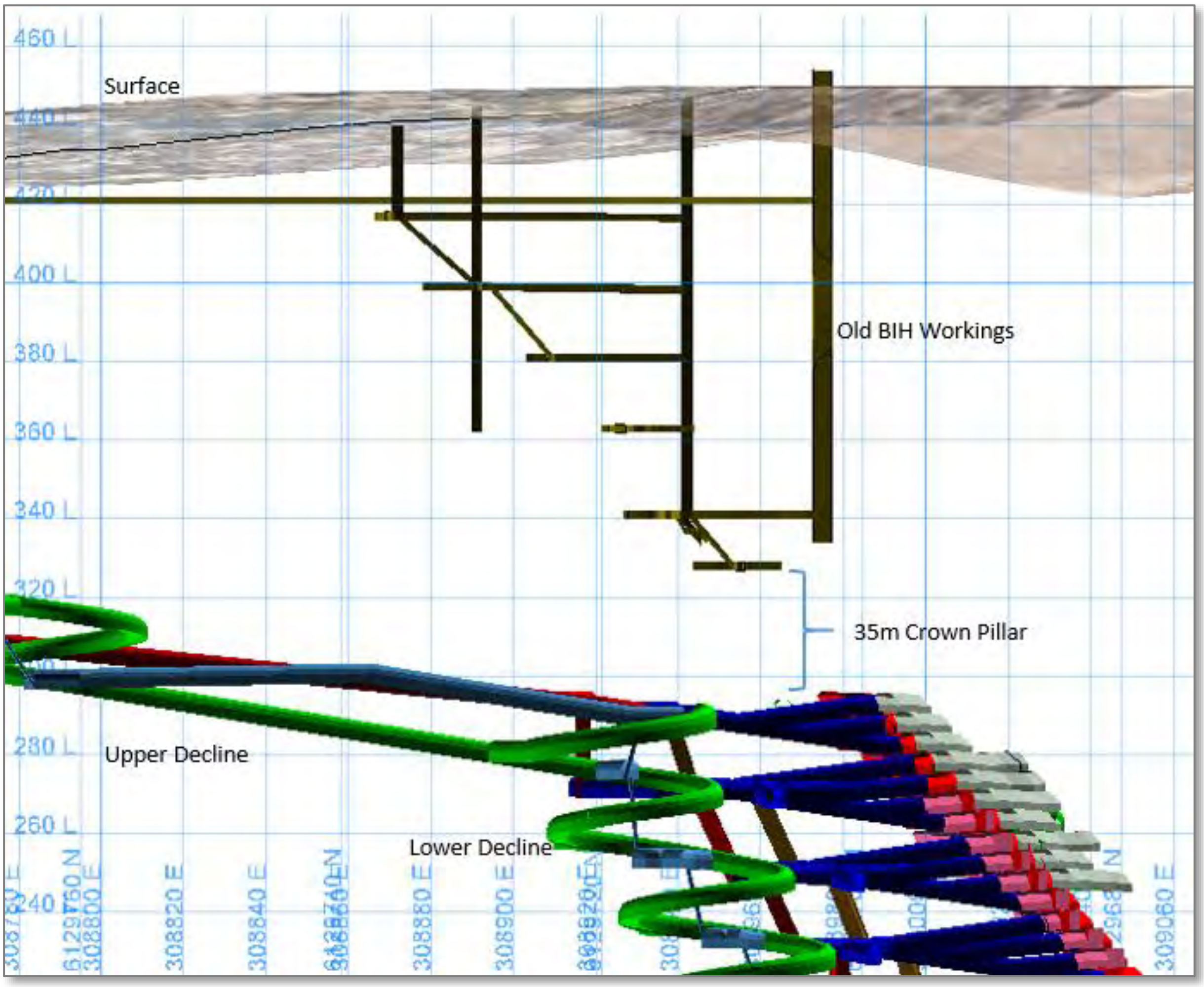


FIGURE 3-36 | ISOMETRIC VIEW (LOOKING NNE) SHOWING THE PROXIMITY OF THE OLD BIH WORKINGS AND THE PROPOSED NEW BIH DRIVES. A ~35M CROWN PILLAR IS CURRENTLY INCLUDED IN THE DESIGN, WITH POTENTIAL FOR MINING LATE IN THE MINE LIFE

3.4.2.3.4 SURFACE SUBSIDENCE

The current design has ~140m of rock between the mine decline and the nearest residence located directly above and ~170m of rock between where the possible mine exploration decline passes perpendicularly underneath Bird-in-Hand Road, no impact due to subsidence on this road is expected according to the modelling undertaken by Mining One (Appendix M1). In order to measure unlikely surface movement, monitoring prisms have already been installed in the vicinity of the Bird-in-Hand Road (Figure 3-37), to obtain baseline data, and is planned to continue monitoring throughout the life of the mine.

FIGURE 3-37 | LOCATION OF SUBSIDENCE MONITORING POINTS RELATIVE TO PROPOSED UNDERGROUND AND SURFACE EXCAVATION

The current mine design uses excess mullock material as fill. All upper areas within the orebody of the new mining areas are planned to be backfilled as mining progresses. This is an integral part of the cut and fill mining system, with filling taking place prior to mining the subsequent lift. Backfilling provides a shorter option for mullock haulage and provides storage underground rather than on surface. The fill provides wall support and prevents ground relaxation, further reducing the unlikely potential occurrence of any crown pillar issues or surface subsidence affecting sensitive receptors.

3.4.2.3.5 LEVEL CROSS CUTS

These drives will be developed off the decline and will allow access to the required infrastructure. Each level will generally consist of the following capital development: (Figure 3-38)

- Cross Cut drive;
- Level Sump;
- Ventilation return access (connected to the level above and below);
- Ore pass access (connected to the level above and below);
- Egress access (connected to the level above and below); and
- Stockpile/backfill mixing bay.

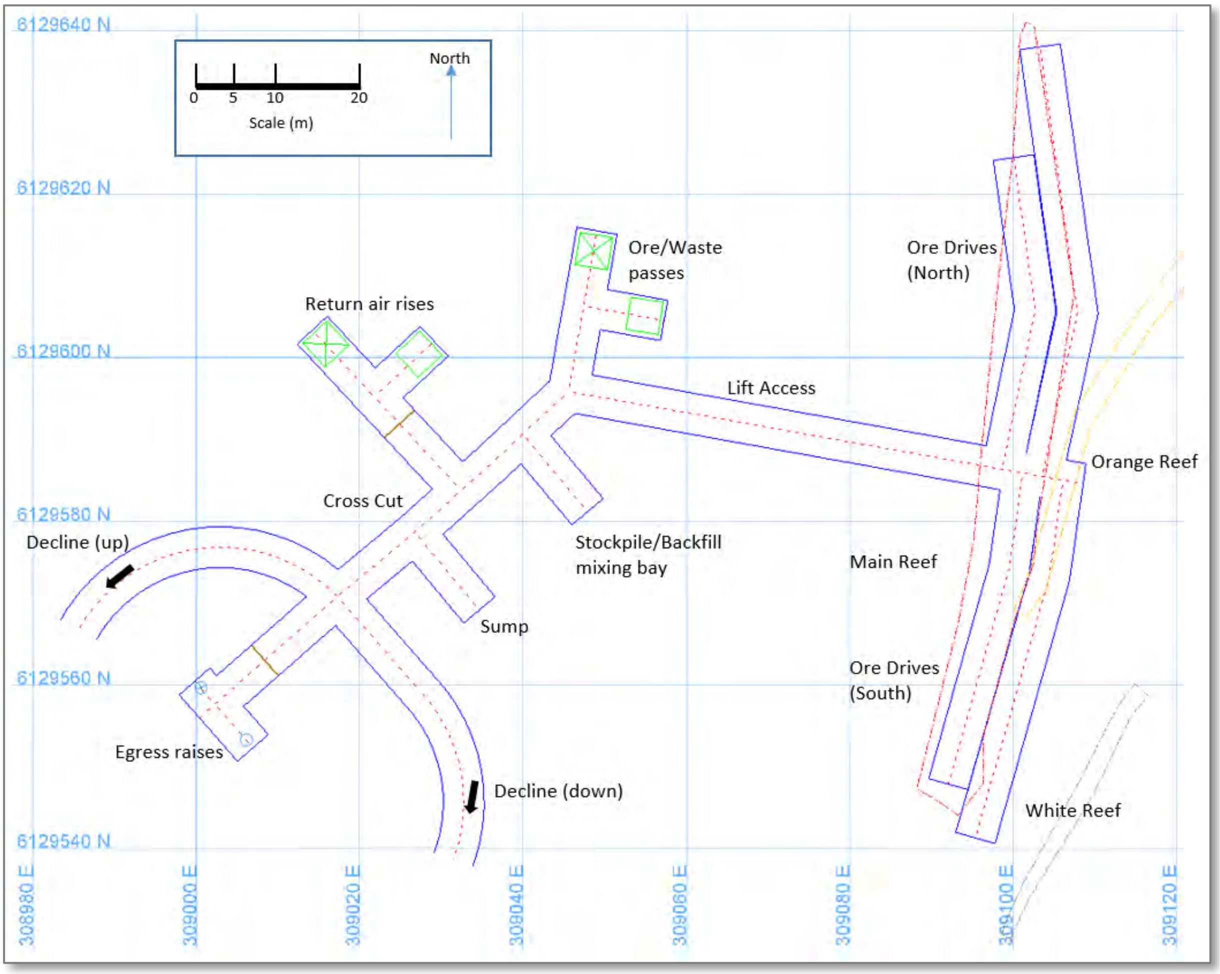


FIGURE 3-38 | TYPICAL LEVEL LAYOUT CONCEPT

3.4.2.3.6 ORE ACCESS DEVELOPMENT

To access the orebody from the cross cuts, access ramps have been designed at a gradient of -1:7 to access the first level in each set of four lifts. The access development will be backfilled with cemented rock fill (CRF) and then new access drives mined progressively to access the subsequent lifts in the orebody, until the final 4th ramp is inclined at a maximum 1:7. The access drives are designed with a 5.0mW x 5.0mH arched profile to allow loader, drill and charge vehicle access, along with the required services (ventilation, compressed air, water etc.).

Geotechnical recommendations (Appendix M1) are for these drives to be offset vertically to manage ground support as upper lifts approach the lower lifts of levels above.

3.4.2.3.7 ORE DRIVES

Ore drives will be designed to extract the maximum width of the orebody in a single pass, where ground conditions allow, giving ore drive widths of between 4.5m-6.5m. Drive heights will be typically 5m high resulting in each 20m ore block is mined in four lifts. Ore drives will be developed at a gradient of 1V:50H to allow water to be free draining back to the access point of the level where it can either be pumped to the nearest sump or run through a drain hole to the level below (if available at the time). The ore drives will be excavated with a shanty-back profile, following the geometry of the orebody, to minimise hanging wall dilution and to maximise ore recovery from the footwall. Where the orebody is wider than 7m, twin ore drives have been considered, dependent on ground conditions.

It is planned that all ore will be mined via ore drive development methods and no long hole or other stoping methods will be used, subject to actual conditions encountered and any developments in technologies.

The ore body will be accessed from the centre and the ore drives turned out heading in opposite directions to allow for two active headings, north and south, at any one time (Figure 3-38).

3.4.2.3.8 UNDERGROUND STOCKPILING

Stockpile drives will be mined in the cross cut between the return air drive and the access drives. These will be used for temporary ore/mullock storage during production and for cemented backfill mixing and storage. The stockpile cuddies are designed so that a system of ore passes can be developed to optimise ore production and haulage. The ore pass system will also be used to increase backfill rates as it allows for mullock and aggregate to be stored underground close to where it is required, rather than double handling the material and stockpiling it on the surface.

3.4.2.3.9 PROBE DRILLING

Probe drilling is used for several reasons in underground mining, in particular to identify details in the immediate vicinity of mine drives and excavations. Probe drilling acts in a similar method to the geological resource drilling, just on a much smaller scale and information is gathered from drill performance (based on the hardness of the rock) and the drill cuttings and groundwater inflows, rather than drill core to provide feedback on the ground properties immediately surrounding the excavated face.

These include:

- Geological verification – identification of rock types within the region ahead of the cut, as well as for the collection of drill cuttings for QAQC/Assay purposes.
- Geotechnical verification – rock strength properties, potential fault/change in rock properties etc.
- Void identification – drilling ahead of planned development to identify/confirm the presence of voids, either man made (i.e. old mine workings, adjacent mined infrastructure) as well as the content – fill, water, void etc.
- Hydrogeological verification – identification of the presence of groundwater structures, the volume and pressure of water they contain. Probe holes are also used to confirm if grouting (and other groundwater management applications) are successful. This aspect is discussed further in section 3.4.2.7.

3.4.2.4 VENTILATION

This section discusses information found in the Ventilation Study – **Appendix N4**.

The ventilation system proposed for the BIH Mine, as modelled by MVA is a standard underground mine ventilation system used throughout Australia, with the exception of the primary fans being located underground at the base of the primary ventilation exhaust raise (similar to the system used at Terramin's previous operation at the Angas Zinc Mine). Benefits of the proposed system includes:

- Minimises noise exposed to surface;
- Adequately disperses exhaust released to surface;
- Minimises risk of shaft failure due to known poorer ground conditions near the orebody; and
- Minimises expected water inflows being located away from known water bearing fracture rock zones.

There will be three ventilation raises connected to the surface installed for the underground operations – a dedicated exhaust raise for the underground explosives magazine, the primary exhaust raise to surface and a rise to be used as second means of egress. Modelling undertaken by MVA (Appendix N4) indicates that to meet all the regulatory requirements by peak production, a total of 180m^3/s of air will be required. The top of the raises will be covered with a collar and a small stack of up to 5m in height to assist with the dispersion of exhausted dust particles (Appendix N3).

The ventilation system (Figure 3-39) will incorporate several stages from when the mine undergoes initial development (portal development) until the final primary ventilation system is established. The reverse of this process will occur as the mine ceases production and mine rehabilitation and closure is undertaken.

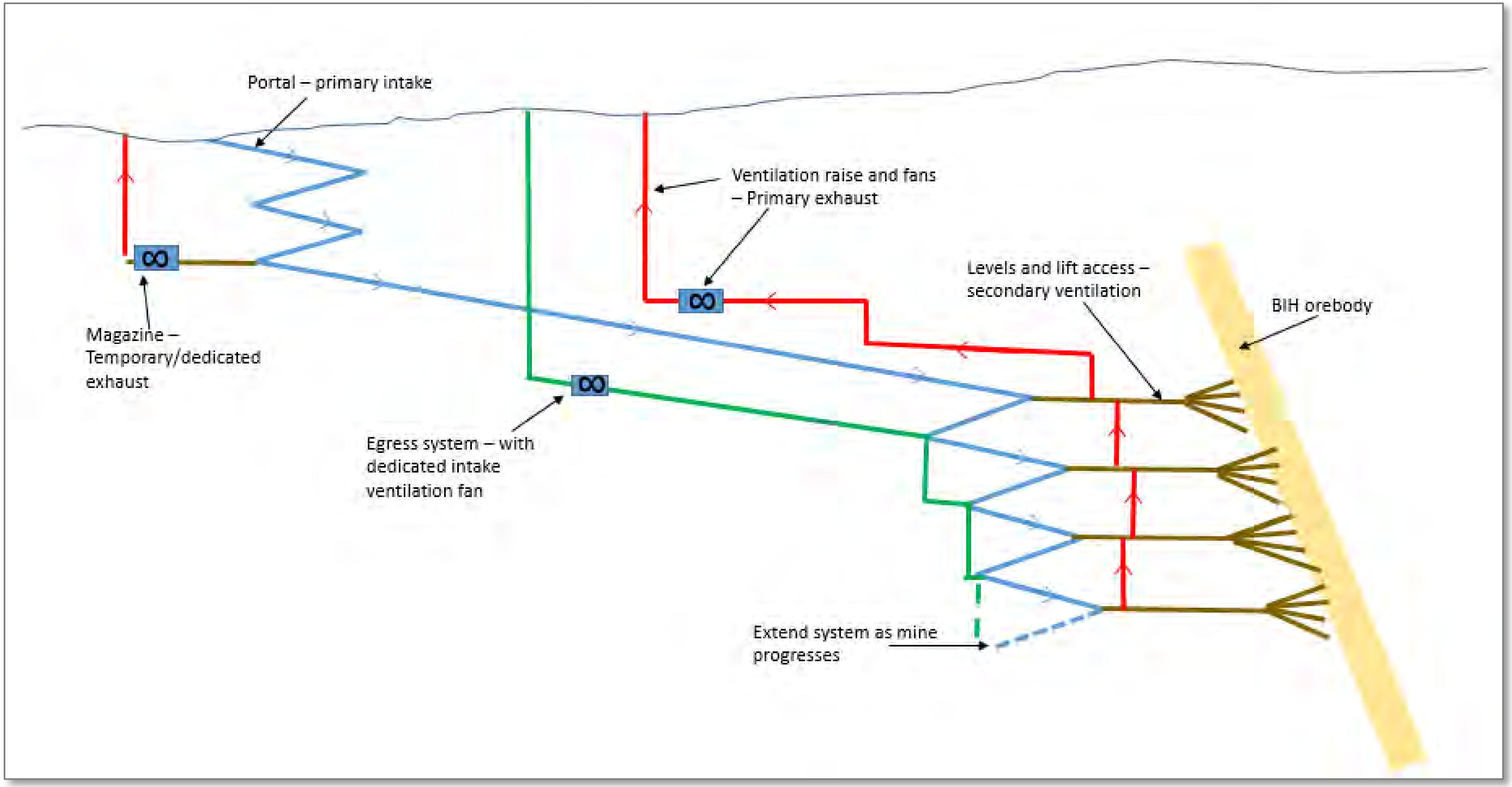


FIGURE 3-39 | CONCEPTUAL LINE DIAGRAM OF THE BIH VENTILATION CIRCUIT

3.4.2.4.1 PRIMARY VENTILATION STAGES

Stage 1 – Portal and Initial development

Twin auxiliary fans with silencers attached will be placed on the surface to provide adequate ventilation from the surface via ducting to the development face until the underground magazine is developed and the exhaust raise installed. Raises are proposed to be raise bored from the surface (Figure 3-40).

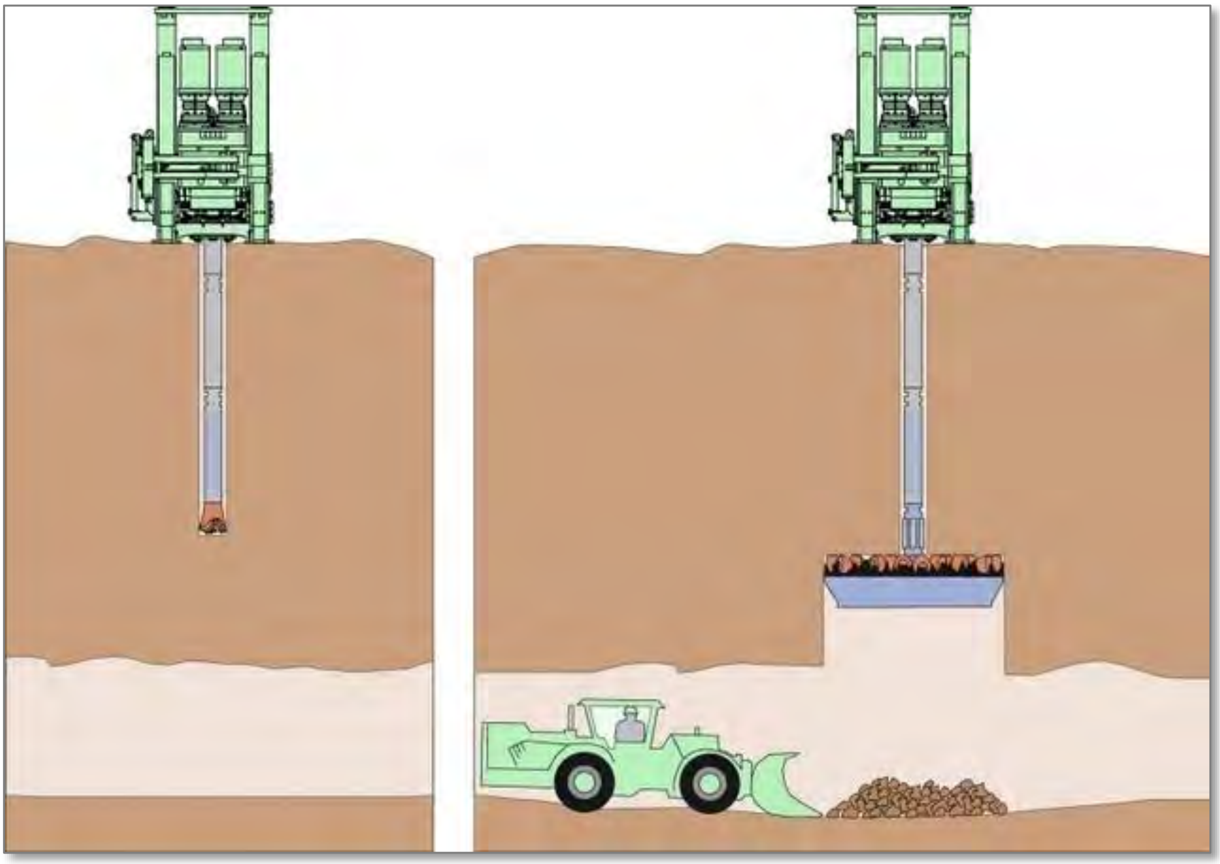


FIGURE 3-40 | PROPOSED CONSTRUCTION METHOD OF VENTILATION RAISES AND ESCAPE WAY RAISE USING RAISE DRILLING METHODS (TUNNEL SWISS POWER, 2017)

Stage 2 – Magazine exhaust used as temporary mine exhaust

Once this raise is installed (~50m deep, 3.0m diameter raise bored raise), the surface fans will be relocated underground at the base of the magazine exhaust shaft and act as the primary exhaust for the mine until the permanent raise is accessed and installed. Auxiliary fans will be placed in the decline above the magazine level and fresh air ducted down to the working face.

Stage 3 – Primary ventilation raise installed

Once the primary ventilation raise location has been accessed, ~100m deep, a 4.0m diameter shaft will be raise bored from the surface. This diameter raise provides sufficient capacity should the ore body be extended beyond 450m below surface.

3.4.2.4.1.1 VENTILATION RAISE AND PRE-EXCAVATION GROUTING

The ventilation raises will be subject to a similar process as the rest of the underground workings in regards to probe drilling and pre-excavation grouting. In summary, for vertical development:

- Holes are drilled outside the defined perimeter, parallel to the intended rise.
- These holes are pressure grouted to form a halo around the intended excavation.
- Holes are then drilled into the rise area to test or verify the extent of water exclusion.
- These holes are subsequently pressure grouted.
- Once grouted the area can be excavated.

This process for ventilation raises has been detailed by Multigrout specifically in Appendix H4 and includes examples.

3.4.2.4.2 LEVEL VENTILATION

Fresh air will be taken from the decline via auxiliary fans (55kW) located in the decline (Figure 3-41) and ducted into the working area (Figure 3-42). The return air will report to the return air rise located on each level, with airflows controls using regulators.

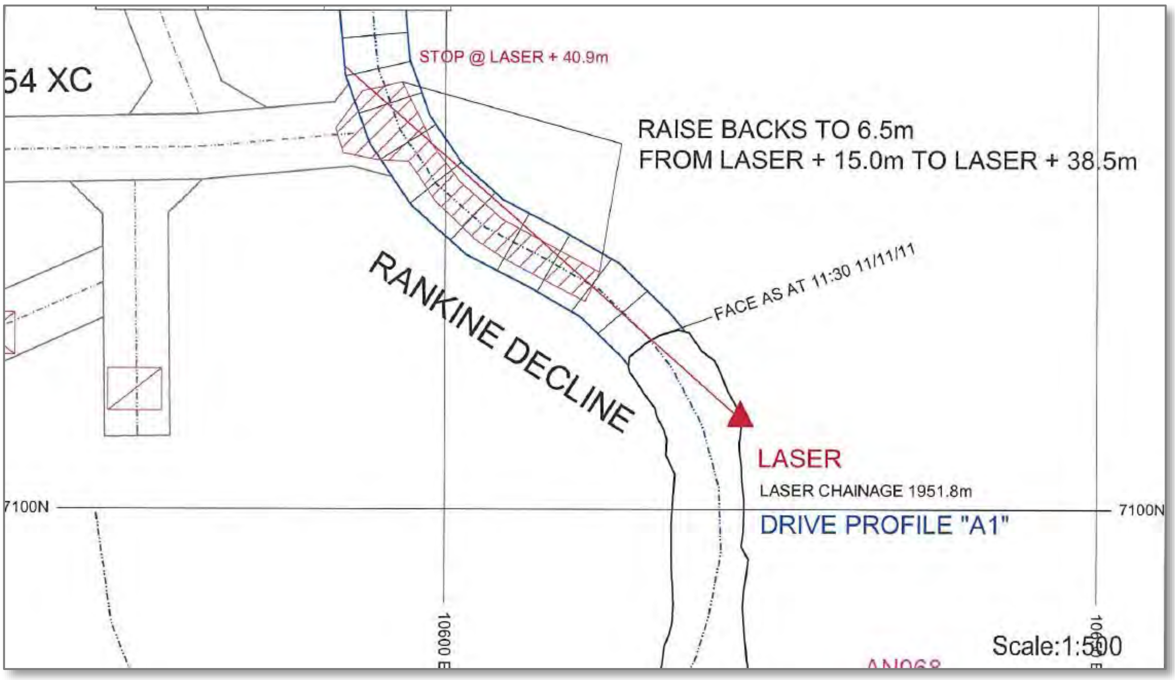


FIGURE 3-41 | EXTRACT FROM A DEVELOPMENT PLAN FROM AZM SHOWING AREA (HASHED) TO BE STRIPPED FOR HANGING AUXILIARY VENTILATION IN DECLINE (AZM AFC 623). A SIMILAR PROCESS IS PROPOSED FOR THE BIH UNDERGROUND DESIGN.

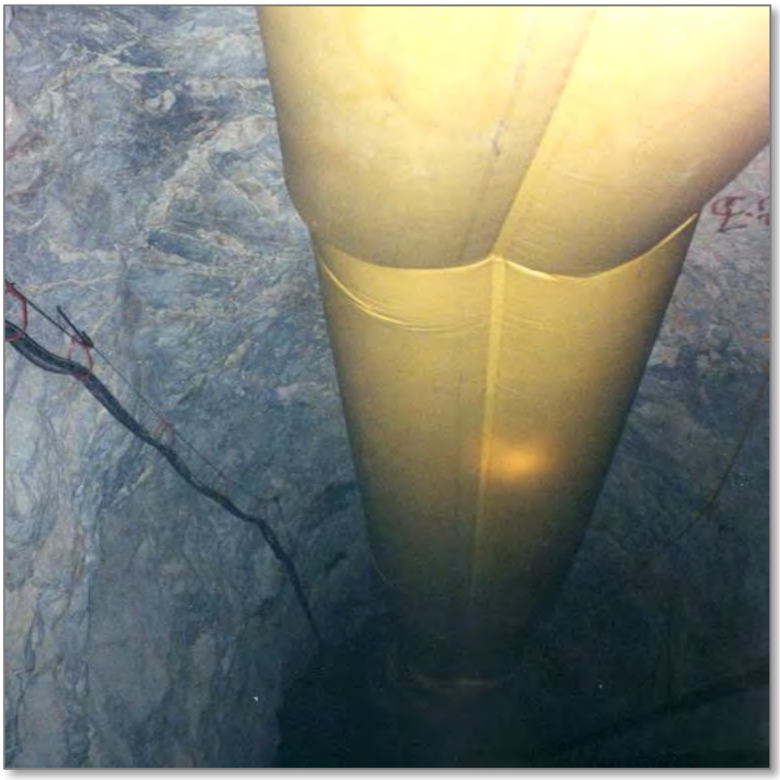


FIGURE 3-42 | EXAMPLE OF A TWIN FLEXIBLE DUCTING INSTALLATION USED IN MINING (ROCVENT INC., 2017)

3.4.2.4.3 SILENCERS

Noise modelling undertaken by AECOM (Appendix O3) recommends fan silencers for use on intake and discharge of industrial fans to mitigate the level of noise produced while in operation. They consist of two concentric perforated cylinders lined with acoustical absorption material (Figure 3-43).

FIGURE 3-43 | TYPICAL TYPE FAN SILENCER (ROCVENT INC, 2017)

TABLE 3-12 | SUMMARY OF VENTILATION SYSTEM DETAILS FROM VENTILATION REPORT (APPENDIX N4)

Aspect of system	Description
Intake	Decline
Exhaust	Primary Exhaust raise (4.0m diameter) Magazine exhaust (3.0m diameter), both raise bored
Total Volume of Air (m3/s)	180
Primary fan	2 x 200kW parallel axial fans, with silencers
Primary fan location	Underground 113pprox.. 100mbs
Auxiliary ventilation	55kW axial fans and 1.2m ducting into levels
Return air raises	4m x 4m blasted raise ~ 20m high connecting levels

The Bird-in-Hand site is close to receptors such as public roads, businesses, residential houses and revegetation zones, so positioning of the exhaust shaft is critical in minimising sound, contaminant impact and visual impact. To achieve this, the shaft has been positioned within the land acquired for the project (Goldwyn). The ventilation infrastructure will be screened from sight and noise projection by the use of bunding and/or screening around the shaft location.

To accommodate the projected total mine ventilation requirements (~180m^3/s at full production), the primary ventilation shaft has been designed at 4.0m diameter. The shaft will be excavated using a raise bore from surface to connect into the underground development.

The shaft will be dedicated as an exhaust shaft to minimise restrictions to airflow and to enable the ventilation circuit to be upgraded in the future if the orebody continues at depth.

FIGURE 3-44 | TYPICAL UNDERGROUND PRIMARY VENTILATION FANS INSTALLATION PROPOSED FOR BIH (APPENDIX MV). NOTE: SILENCER WILL BE ADDED TO DAMPEN NOISE LEVELS.

3.4.2.4.4 INTERNAL EXHAUST VENTILATION RAISES

All internal exhaust ventilation rises connecting each level in the mine design have been designed as blasted rises of either 4m diameter or 4m x 4m square profile. The rises are 15m-25m in length and are able to be drilled with a typical production type long-hole drill as either all down holes or a combination of up holes and down holes. The airflow into these raises will be controlled with the use of regulators

FIGURE 3-45 | TYPICAL DROP BOARD REGULATOR INSTALLED UNDERGROUND (ANGAS ZINC MINE, TERRAMIN)

3.4.2.4.5 SECONDARY EGRESS

An independent egress way (aka escape way) and fresh air system has been designed from surface, separate to the primary ventilation circuit. The system will provide an escape route should access via the decline be inhibited for any reason. It will also minimise the reliance of the mine on refuge chambers, while meeting all requirements of legislation.

The system proposed will be similar to that installed at AZM in the lower levels of the mine. A raise bored or blasted rise (dependent on ground conditions) measuring 1.1m-1.5m in diameter will be mined and a caged ladder way will be installed between each level (Figure 3-46). A small ventilation fan in the upper section of the escape way system will provide a positively pressured flow of fresh air from the surface, independent from other workings. The ladder ways are designed to be accessible from each production level of the mine and are scheduled to be installed before ore production commences from each level.

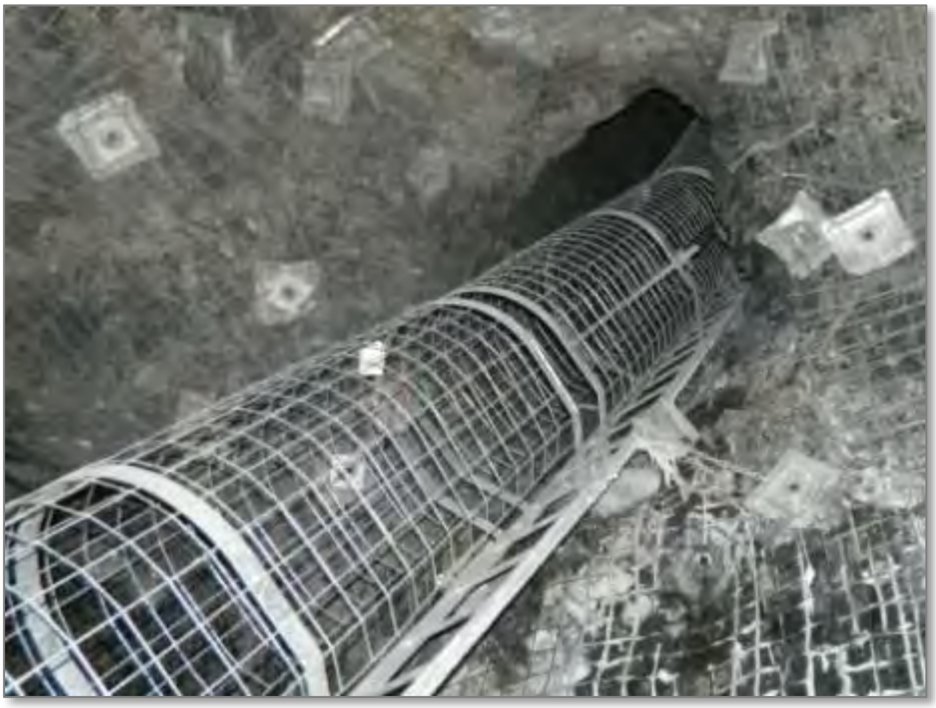


FIGURE 3-46 | EXAMPLE OF THE CAGED EGRESS RISE PROPOSED FOR BIH (WILSHAW, 2017)

3.4.2.4.6 FRESH AIR BASES

All emergency egresses will have access to an independent fresh air intake. Portable 4, 8 or 10-man refuge chambers will be purchased include an extra low voltage back up power supply to be positioned appropriately during mining operations (Figure 3-47)

FIGURE 3-47 | TYPICAL UNDERGROUND REFUGE CHAMBER (MINEARC SYSTEMS, 2016)

3.4.2.5 MISCELLANEOUS CAPITAL DEVELOPMENT

Level cross cuts will be mined to the same 5m width as the decline to enable truck and bogger access. Where necessary the backs will be stripped to 6.5 metres high to allow both truck loading and secondary fan installation in the decline.

Ventilation access drives will be connected to the level cross cuts. Appropriate ventilation walls and controls such as regulators will be constructed at the start of each return air drive to allow adequate control of airflow on each level.

Each level will have a ~10m long sump located on the level to catch any excess water. All water generated on the level from natural inflow, drilling, washing down operations and decline development below the level will report to this sump and exit the mine via the dewatering network.

All intersections are designed at ~90° and (dependent on ongoing geotechnical assessment) are planned to be supported using double strand cable bolts. The number of cable bolts will be determined by the span of the intersection, with additional bolts installed as required after initial geotechnical inspection. Cables will be installed, grouted and plated prior to mining the branches of the intersection. Cable holes are planned to be drilled with a cable bolt rig or similar production drill.

A dedicated surface compressor will supply air to the underground workings at ~1,000cfm at 100psi through 110mm diameter HDPE pipe in the main decline and 63mm HDPE pipe in the levels.

The underground mine communication service will be via leaky feeder UHF radio and possibly a telephone system through the egress system.

3.4.2.5.1 PUMP STATION

A conceptual pump station has been included in the underground mine design to allow for a single point where all water collected in the underground workings will be pumped to the surface via a rising main. Approximately 60m of 5 x 5.5m drive has been allowed for to house 2 Mono pumps (i.e. E103 Monos) and associated infrastructure, where all water will be pushed to the surface via a dedicated rising main.

3.4.2.5.2 MAGAZINE

An underground magazine has been included due to the small surface space available for the site, and the fact that no compliant area on surface, suitable to store expected explosives is available. Until this underground magazine is developed and commissioned (including licencing), explosives will be brought into site from the licenced magazine facilities at AZM. It is planned that the magazine will be located directly off the main decline with direct ventilation access to a dedicated exhaust ventilation raise and fan. A surface backup deluge system via drill holes or the ventilation shaft will be installed directly into the area will be included in the design. The magazine will comply with all statutory requirements, including licencing through SafeWork SA.

3.4.2.5.3 UNDERGROUND WORKSHOPS, CRIB ROOMS AND OTHER

No provision has been made for any underground maintenance workshops or crib rooms and ablutions due to the small nature of the proposed mine. All such needs will be serviced with the infrastructure on the surface.

3.4.2.6 UNDERGROUND FILL

Reliability and flexibility are key features of a backfill system that effectively supports a mining operation (Bloss, 2014). The method of mining selected for the BIH Gold Project requires the use of back fill to progress the production of ore. As described in the overview of the cut and fill method (Section 3.4.1.1), the filling of a production drive is required prior to mining the lift above. The following sections describe in detail the proposed fill and the placements method for the BIH Project.

Backfill at BIH will be managed and controlled under a Backfill Management Plan. Two backfill types are envisioned for BIH:

1. Cemented Rock Fill (CRF)

   Comprising of development mullock material and added cement, CRF will be used in the base level of the 4 level lifts to form supporting pillars that can be mined underneath and to provide a firm bogging floor to reduce dilution and prevent the loss of gold into the floor. Unconfined Compressive Strength (UCS) testing will be undertaken along with an extensive QAQC processes to ensure that a high quality, engineered product is placed to enable the safe working underneath this fill. CRF will be placed by underground loaders after mixing in assigned stockpile cuddies with cement slurry delivered in a bulk cement delivery truck or cement agitator trucks ("agis") from the surface cement batching plant.

2. Unconsolidated Rock Fill (RF)

   Comprising unprocessed mullock rock hauled direct from work areas, underground ore passes and stockpiles and/or from surface stockpiles, will be used to backfill the voids remaining in the upper lifts of the mined levels. RF may also be used to fill the access drives and cross cuts once mining is complete in each ore block to minimise the mullock stockpiled on the surface.

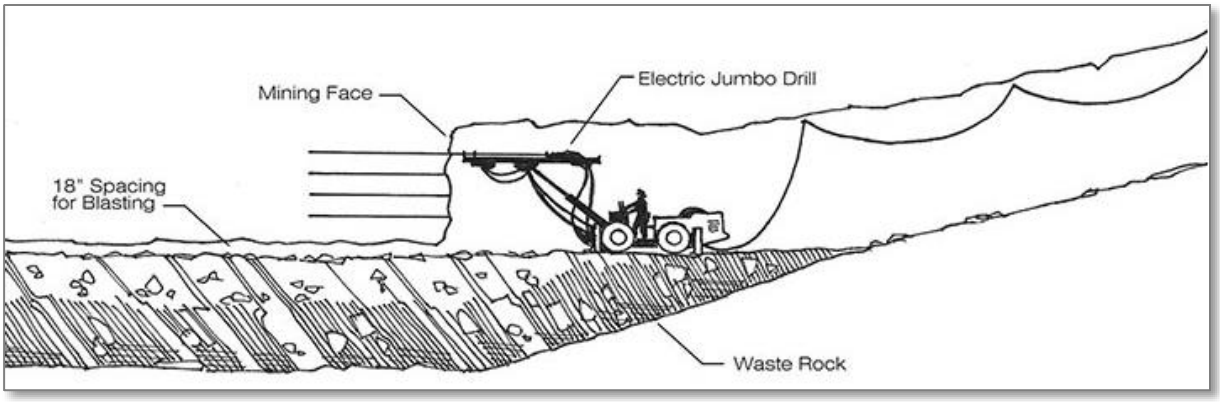


FIGURE 3-48 | EXAMPLE OF THE SECOND LIFT OF PRODUCTION BEING UNDERTAKEN ON THE BACKFILLED FIRST LIFT. (STILLWATER MINING COMPANY, 2016)

Further geotechnical studies to be undertaken during the development stage, as well as once the actual mullock material to be used is available, will investigate the appropriate required fill strength to be used at each stage of the operation and may look at the use of cemented aggregate fill (CAF). This type of fill would require a more uniform aggregate, so a crushing and screening process might need to be incorporated into the mining sequence.

3.4.2.6.1 CHEMICAL STABILITY OF THE PROPOSED FILL

Cemented Rock Fill will utilise general purpose (Portland) cement which complies with AS3972-2010 *General Purpose and Blended Cements*. This includes AS2350.2 which includes Method 2: Chemical composition. General Purpose cement is ideal for use in structural concrete, mortars, renders, grouts and cement based products, and can also be used as a general binder in areas such as soil stabilisation (Adelaide Brighton Cement, 2018). Tonkin Consulting completed an Acid and Metalliferous Drainage assessment on the proposed mullock, which will be used as backfill, and is located in detail in Appendix M2. Unconsolidated raw fill or rock fill (RF) is comprised of development mullock placed into excavated voids to provide a working floor to mine the subsequent lift. Primarily, waste rock will be from the decline and drives, which are classified as Non-Acid Forming or Acid Consuming. Minimal Potentially Acid Forming (PAF) material is likely to be encountered. Regardless, any identified PAF material will be separated and prioritised for CRF.

Typical chemical properties of general purpose cement, as outlined by Adelaide Brighton Cement, is included below in Table 3-13.

Further detail on the chemical stability of additional grouts has been covered extensively by Multigrout in Appendix H4.

TABLE 3-13 | TYPICAL CHEMICAL PROPERTIES OF GENERAL PURPOSE CEMENT (ADELAIDE BRIGHTON, 2018)

Test	Units	Max (AS3972)	Typical values
Sulphur Trioxide	%	3.5	2.8
Loss on Ignition	%	-	3.2 – 4.0
Chloride	%	0.1	0.05
Equivalent Alkalies	%	-	0.5
Hexavalent Chromium	mg/kg	-	Trace
Crystalline Silica	%	-	Trace
Components			
Portland Clinker	%	-	85 – 93
Gypsum	%	-	5 – 7
Mineral Addition	%	7.5	Up to 7.5

3.4.2.6.2 TYPE OF FILL

Fill type is selected based on two primary functions: sill pillar stability and wall stability for adjacent drives and surrounding rock (i.e. hanging wall).

Sill pillar stability needs to be assured to allow mining of stopes immediately beneath a filled drive. Sub-level fill also provides an adequate working surface to allow for mining of a stope immediately above the filled drive. Backfill serves the secondary purposes of providing hanging wall and regional stability as well as utilising excess development mullock to minimise the surface footprint of the operation.

Cemented rock fill (CRF) or cemented aggregate fill (CAF) and unconsolidated Rock Fill (RF) were selected for consideration as suitable backfill methods. Due to offsite processing, no available process tailings were available to consider cemented hydraulic fill or paste fill as viable alternatives.

Sill pillars will require sufficient strength to enable horizontal exposure when mining the crown pillar of each sub-level. Final design and strength requirements will be determined by an external geotechnical/backfill engineering consultant once the actual mullock is available for strength testing. A literature review of other operations indicates that an achievable target strength of 3.5Mpa with 5% cement addition is stable for a 5m thick exposure (Blake, et al., 2005)(Figure 3-49). As part of the site's Backfill Management Plant (BMP) an extensive test program will be undertaken prior to backfilling to optimise the mix design and ensure sufficient CRF strength is achievable. Ongoing QAQC measurements will be continued throughout the usage of the CRF.

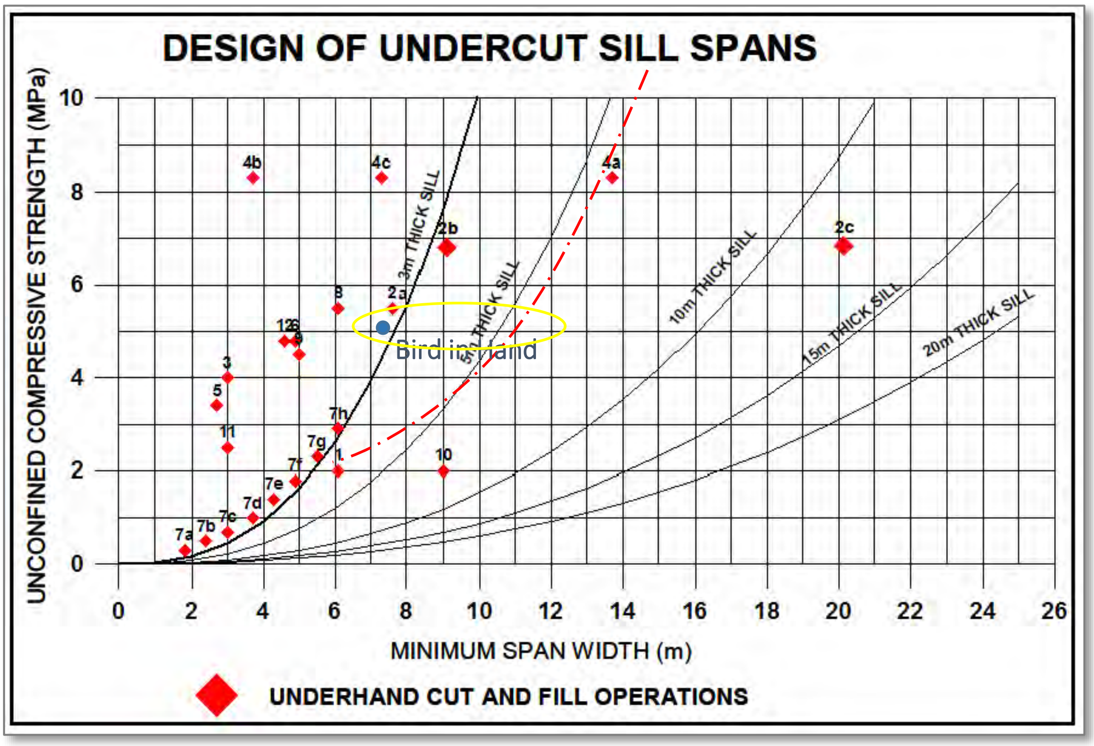


FIGURE 3-49 | STABILITY CHART FOR THE DESIGN OF UNDERHAND SILLS SHOWING THE ESTIMATED VALUES FOR THE BIH DESIGN – CIRCLED IN YELLOW (BLAKE, ET AL., 2005).

3.4.2.6.3 SILL PILLAR CONSTRUCTION

The construction of sill pillars similar to that proposed for the Bird in Hand operation have, amongst many other operations, been previously undertaken at Crusader, Agnew Gold, Western Australia. The process by which they were constructed is outlined in a paper by Finn & Dorricott (Finn & Dorricott, 2002). The first, 4m lift was mined and supported before the floor was benched a further 5m down to a total of 9m. Shear pins and hanging wall cable bolts were installed before the CRF sill pillar was constructed up to a thickness of 5m (Figure 3-50).

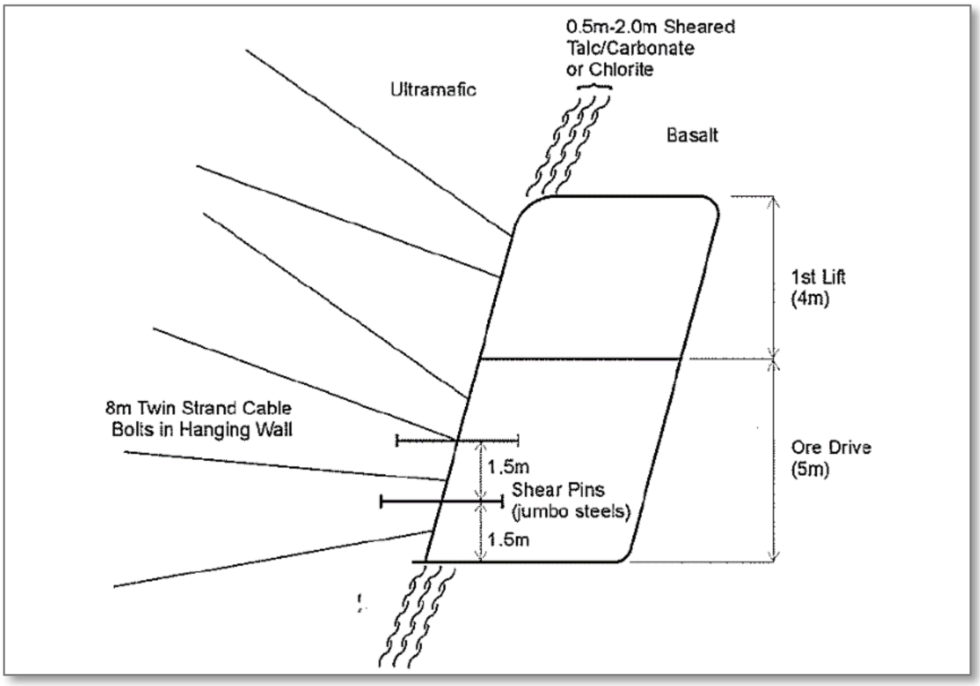


FIGURE 3-50 | DRIVE CONSTRUCTION FOR SILL PILLAR PLACEMENT (FINN & DORRICOTT, 2002)

If geotechnical analysis of the rock mass indicates a 9m exposure is not possible, the floor can be benched to the maximum safest depth and CRF filled as per the method detailed above. Once tramming over the fill is no longer possible cement addition will be increased and CRF pushed to form a 5m thick sill pillar. In the case of the orebody at BIH being at a shallower dip, the approach of exposing double lifts may not be possible at all times, but could be considered.

3.4.2.6.4 AGGREGATE SIZING

Development mullock will be suitable for use as aggregate in CRF mix, as the development blasting, can be controlled to result in a high percentage of sub 300mm rock being produced. Some control of the particle size distribution is required, with particles greater than 300mm unable to be used within the CRF mix (Ravell, 2016). The ability to use material up to 300mm means the crushing and screening infrastructure for CAF production will not be required and a cheaper, simpler CRF mix can be used. It also assists in eliminating the noise and dust associated with CAF batching plants. Removal of oversize from development mullock can be achieved through various screening options which can be set up underground to reduce the risk of producing dust and noise on the surface.

3.4.2.6.5 MIXING BAYS

Mixing bays are required to be constructed of maximum 20m long drives with a 1:10 gradient benched into the floor as per Figure 3-51 and will double as temporary stockpiles during production. The required volume of screened development mullock is loaded into the mix bay along with the required volume of cement slurry. The fill is then mixed thoroughly with the loader bucket and transported to the stope. Filling should commence from the brow of the stope to ensure compaction through repeated tramming of the LHD during placement. Good compaction of the CRF is a key step in producing a competent sill pillar. Continuous filling also prevents the formation of cold joints within the fill (Finn & Dorricott, 2002).

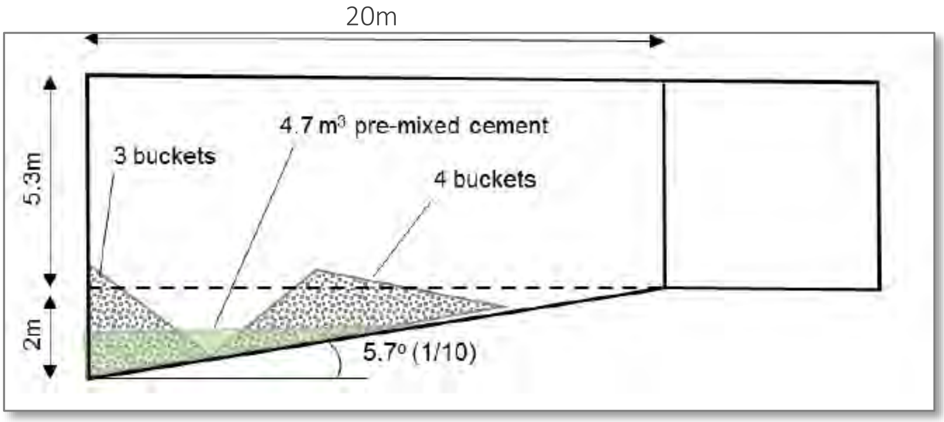


FIGURE 3-51 | LONG SECTION OF A MIXING BAY SYSTEM FOR 5% CEMENT (SAINSBURY & SAINSBURY, 2014)

3.4.2.6.6 QAQC REQUIREMENTS

Test work is required during the initial development stage using the mullock from the decline development to determine the optimal mix of aggregate, cement and water to give the desired properties. Figure 3-52 illustrates the process flow in designing backfill mix design (Tahzibi, Nasiri, Mashoof, & Lotfi, 2016)

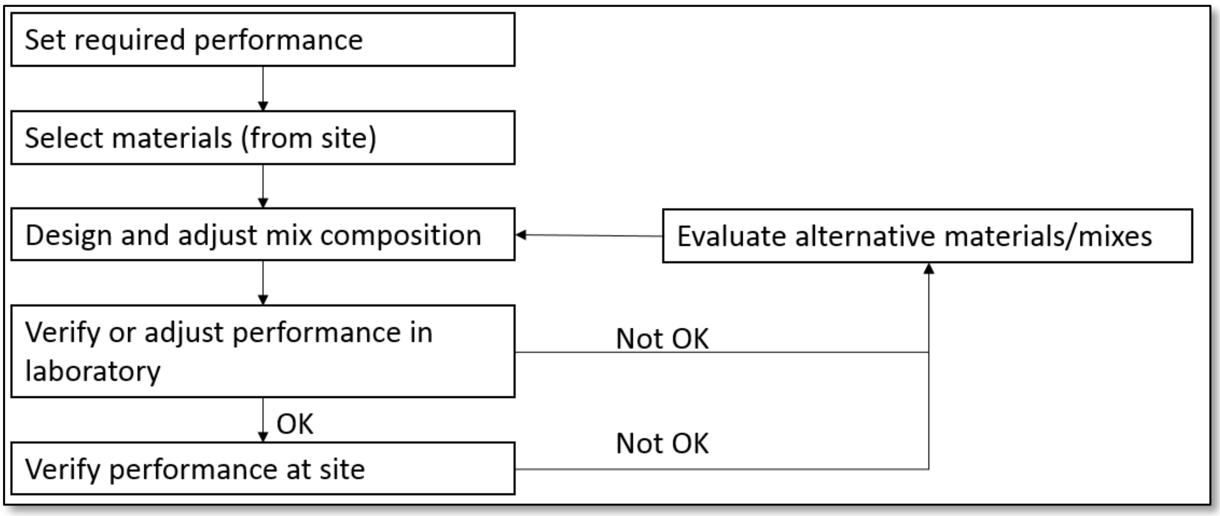


FIGURE 3-52 | PROCESS FOR BACKFILL DESIGN (TAHZIBI, NASIRI, MASHOOF, & LOTFI, 2016)

Discussions with Monash University (Sainsbury, 2016) advise this test work will likely involve casting 406mm x 812mm *Formatube* cylinders with batches of CRF of varying cement contents for uniaxial compressive strength (UCS) testing as per Figure 3-53, as is standard practice. Results of these tests will define the relationship between cement addition and strength for the given mullock used. *Formatube* is a waxy cardboard cylinder which is used for concrete pillar construction and is readily available throughout Australia.

Screening tests are also required to determine the factor of safety on particle size variability of the mullock. Small cylinders of the cement slurry will also be cast for UCS testing to build up a baseline data set of target slurry strength. All test work can be undertaken through Monash University where there is a lab capable of testing large diameter cylinders and where there are people experienced in CRF backfill optimisation for many mining operations.

Once operational, a set of CRF cylinders will be cast each month for quality control testing. Random, on the spot tests of the cement slurry will be undertaken as outlined in the site's backfill management plan and will be dependent on the mining schedule, (backfilling may not be a continuous activity). This will monitor quality of the cement slurry and keep operators accountable for the quality of the backfill. After the performance of the initial sill pillar mix has been investigated, there is an opportunity to investigate further optimisation of the CRF mix.

FIGURE 3-53 | FORMATUBE CRF CYLINDERS AND UCS TESTING APPARATUS AT MONASH UNIVERSITY (SAINSBURY, 2016)

3.4.2.6.7 ROCK FILL

Unconsolidated raw fill or rock fill (RF) is comprised of development mullock placed into excavated voids to provide a working floor to mine the subsequent lift. On completion of a production drive (stope) a survey line is marked 0.8-1m from the backs, RF is trammed into the drive and pushed up to the line. This allows for monitoring of the quality of the backfill and ensures the height of fill is consistent across the void. The remaining gap will allow the subsequent lift to be blasted into the void eliminating the need for a burn in the development face.

3.4.2.6.8 MULTIPLE DRIVES

In areas where the ore body width exceeds the maximum span, two or more drifts (adjacent ore drives) will be mined along one level (Figure 3-54). In this case CRF will be required to fill the primary drift to allow for extraction of the adjacent drift in a safe manner. The CRF is only required to support a vertical exposure and therefore a weaker cement slurry could be used (subject to strength testing). Final design strength required will be determined by an external geotechnical consultant prior to commencement of the backfill. Other options include the spraying a thick layer of shotcrete to the wall of the adjacent drive prior to placing RF. The adjacent drive can then be mined on survey control up to the shotcrete wall.

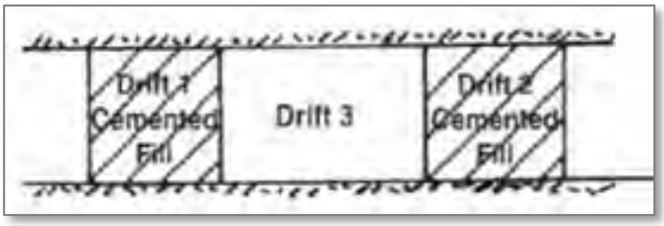


FIGURE 3-54 | SECTION SHOWING TYPICAL FILL TYPES IN ADJACENT DRIVES (DRIFTS) (HUSTRULID & BULLOCK, 2001)

3.4.2.6.9 VOLUME PERCENTAGE OF UNDERGROUND VOID TO BE FILLED

The regions of the mine to be backfilled are shown in Figure 3-56 and Figure 3-57, using section shown in Figure 3-55. Not all voids will be backfilled as they will pose no measurable risks with credible pathways to sensitive receptors. Instead, the areas to be backfilled have been selected based on risk assessment processes, geotechnical analysis, as well as those required for the mining method chosen.

Table 3-14 summarises the quantity of fill by type proposed for the BIH Mine, excluding cement. Conservatively, the remaining void percentage includes space left at the top lift and underground development after rock fill which cannot be filled due to void space (approximately 25%). Volume of backfill assumes industry standard swell factor of 0.3, and a rate of 2.7t/m^3 S.G. has been derived from geological testing of core, and calculated as Loose Cubic Metres (LCM). This will be further refined through Feasibility Studies and PEPR development.

TABLE 3-14 | PERCENTAGE OF UNDERGROUND VOID TO BE FILLED AND UNFILLED (NEAREST KT)

2018	Type	Mass (t)	Volume (m^3)	Volume (LCM)	% of total mined mass/volume
Mined	Ore	595,000	220,000		46%
	Mullock	690,000	255,000		54%
	Total Mined	**1,285,000**	**475,000**		100%
Backfilled	RF	481,000		231,000	**49%**
	CRF	208,000		100,000	**21%**
	Total Backfilled	**690,000**		**331,000**	**70%**
Remaining Void			144,000m^3		30%

FIGURE 3-55 | SECTIONS USED FOR BACKFILL CROSS SECTIONS

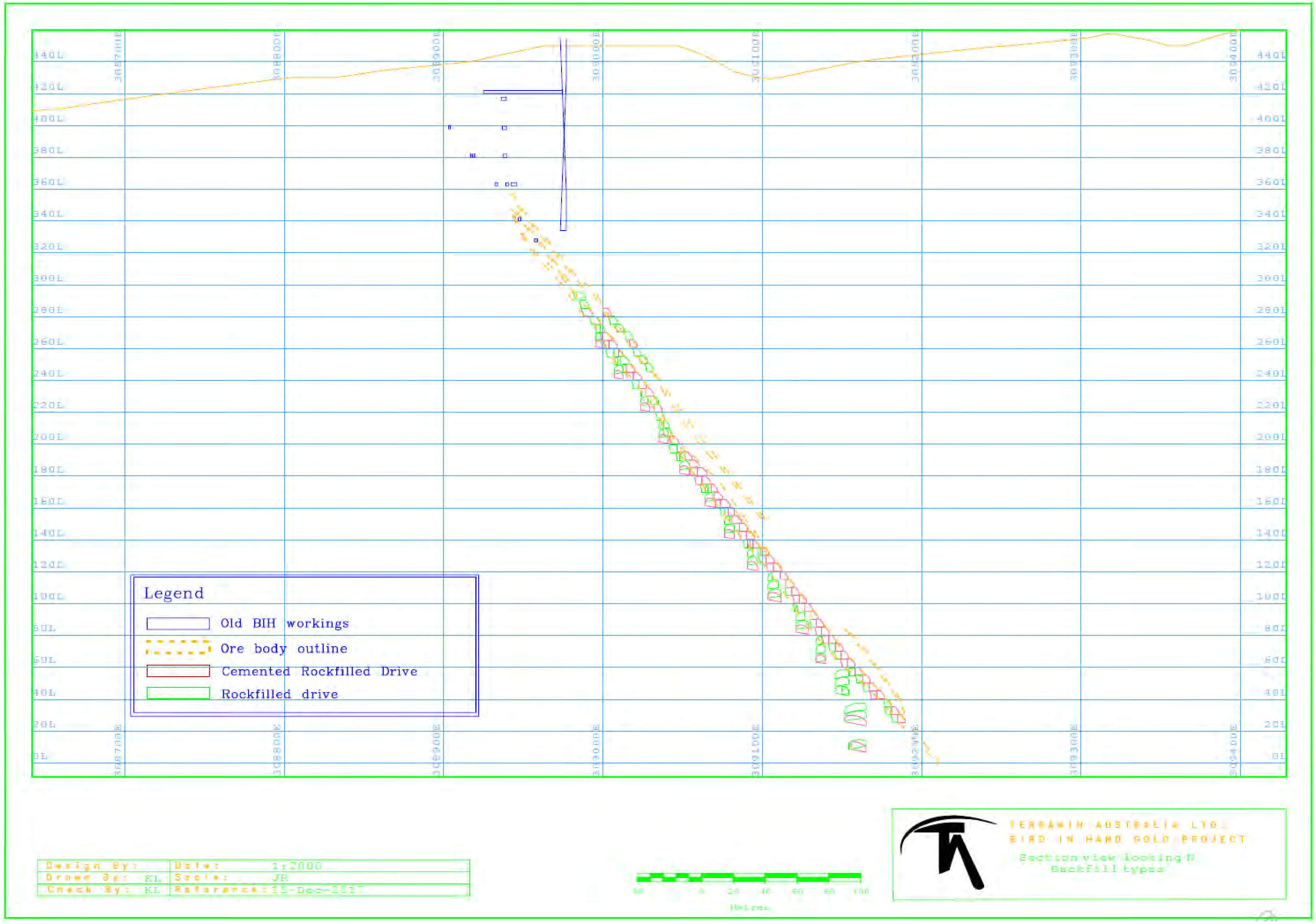


FIGURE 3-56 | CROSS SECTION THROUGH ORE DRIVES LOOKING NE, SHOWING DRIVES PROPOSED TO BE FILLED (RED = CEMENTED ROCK FILL, GREEN = ROCK FILL, BLUE = NOT FILLED)

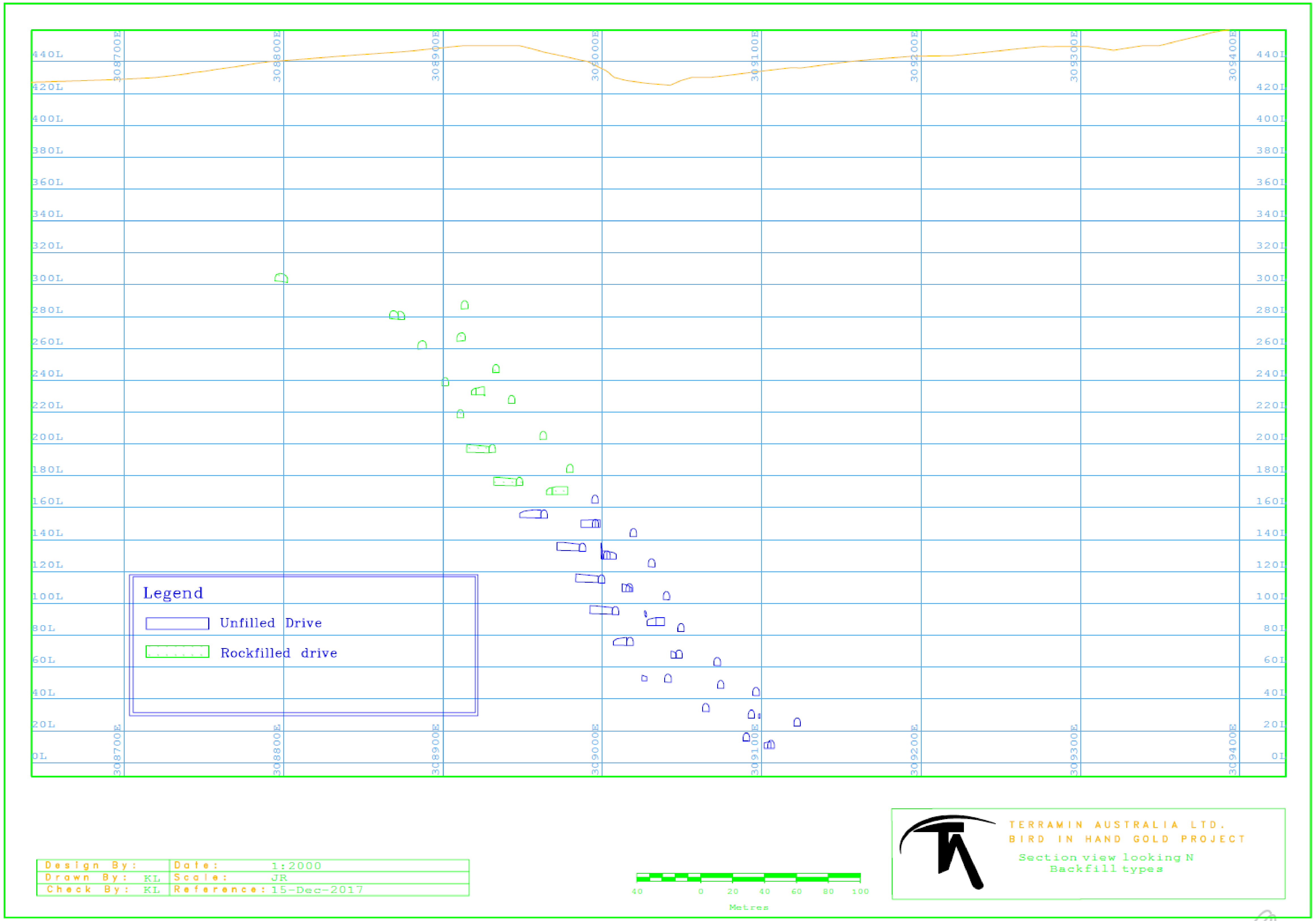


FIGURE 3-57 | CROSS SECTION THROUGH LOWER DECLINE LOOKING NE, SHOWING DRIVES PROPOSED TO BE FILLED

3.4.2.6.10 SEQUENCE OF FILLING

Backfilling of ore drives will occur as each lift is completed and is illustrated in Figure 3-22. This is a requirement as the fill provides a base to allow lifts above to be mined, as well as providing a permanent storage of mullock mined during the life of the mine.

3.4.2.6.11 SOURCES AND PROPORTION OF FILL

Raw rock fill material will be sourced directly from underground or surface mullock stockpiles and placed in excavated stopes and drives, to form passive support, a working floor for the subsequent level as well as minimise the surface stockpile size.

Mullock required for use within sill pillars may require screening depending on the size of the material and the results from the blasting and particle size distribution tests undertaken during mine development. This would be done with simple grizzly type separators located in underground stockpiles and ore passes. Figure 3-58 summarises the fill by type and year over the life of the proposed mine. Ultimately, all remaining mullock on the IML would be placed underground at the end of mining.

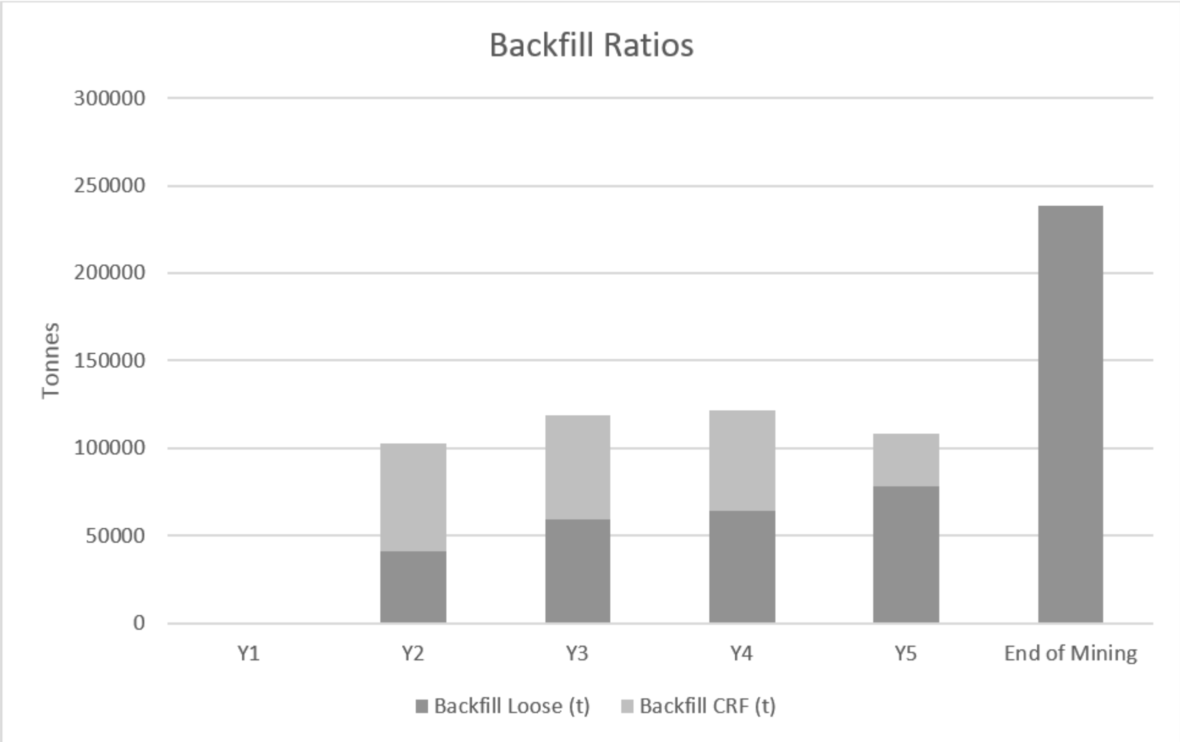


FIGURE 3-58 | ANNUAL BACKFILL TONNES PLACE BY TYPE (NOTE Y1 = START OF DECLINE DEVELOPMENT)

Any potentially acid forming material temporarily stockpiled on the IML will be prioritised for CRF applications to minimise the likelihood of oxidation and acid forming potential. Investigations to date undertaken by Tonkin (Appendix M2) have indicated that the volume of PAF material is likely to be minimal, and if it does occur, the surrounding host rock that would be brought up as mullock with it would neutralise any PAF effects.

Further test work will need to be undertaken once the actual mullock is available in order to determine the strength and mix ratios required for backfilling the BIH drives as described above. Cemented rock fill material will be comprised of development mullock, cement and water in proportions (based on conceptual information) outlined in Table 3-15.

TABLE 3-15 | PROPOSED CRF MIX PROPORTIONS

Element	Proportion (/m^3)	%
Mullock	1.86 t	88.3
Cement	0.11 t	5.3
Water	0.13 t	6.4
Water/Cement Ratio	1.2	

3.4.2.7 GROUTING OF UNDERGROUND WORKINGS

3.4.2.7.1 PRE-EXCAVATION GROUTING

In order to significantly reduce groundwater inflows into the mine, pre-excavation grouting will be utilised as the primary method to control groundwater.

Pre-Grouting is a process of injecting grout material into boreholes drilled into the rock mass around an excavation, with the purpose of sealing any fissures or joints that intersect the borehole. Thus, pre-grouting results in a less permeable and more stable rock mass around the excavation. The main objective of the pre-grouting is:

- To reduce the rock mass permeability and thereby control the water leakage to the acceptable levels, and
- To enhance the rock mass strength thus leading to reduced support system and increased productivity.

A balanced approach to pre-grouting has the potential to reduce the ground water inflow substantially. Strategy for pre-grouting is shown conceptually in Figure 3-59 and explained below:

- A predetermined number of probe holes are drilled ahead of the tunnel face;
- A water loss test is carried out by water pressurizing of the holes;
- The water losses are expressed in terms of Lugeon (L). The measurements give an indication of the water tightness of the rock and are taken into account for determination on the type of grout material that shall be used;
- The probe holes are grouted until a predetermined counter pressure is achieved;
- If leakages as measured in the probe holes are greater than acceptable, a new round of control holes between the first ones is drilled. Water losses are measured and grouting is carried out according to the same criteria as for the probe holes; and
- The procedure is repeated until the criteria for water tightness are fulfilled (Subash, Abhilash Urs, Ananth, & Tamilselvan, 2016).

In regard to the BIHGP, Multigrout Australia have prepared a pre-excavation grouting proposal based upon the site specific information of the BIH geology and hydrogeology, and pre-excavation grouting is expected to reduce inflows by 90%. This view is supported by various grouting reviewers, including Golder Associates and Sovereign Hydroseal. This proposal and additional information in conjunction with investigations on geotechnical grouting design by Mining One has been included in Appendix H4.

In Pre-Excavation Grouting design, the Lugeon unit is commonly used internationally. It is a relatively simple site based test using a drilled hole into the rock, pumping water into the rock at a defined pressure and measuring the degree to which the rock accepts water. This, in turn, provides a measure of the openness or permeability of the particular rock mass.

1 Lugeon unit is defined as a water take of 1 litre per metre of hole test length per minute at 10 bars (1,000kPa or 150 psi) above static pressure. The Lugeon scale is sensitive at low values between 1 to 5 but with higher values of 50 or more and accuracy of +/- 10 Lugeons is adequate, and at more than 100 Lugeons an accuracy of +/- 30 Lugeons is appropriate.

Through analysis of the known geology and a review of the conceptual model, along with investigation drillhole water inflow yields form the IB bores, it is evident that the primary focus for ground treatment will be the hanging wall (HW) and adjacent fractured zones within the Tarcowie Siltstone formation.

The Lugeon values, above 20 and 200+ in the Tarcowie formation are indicative of highly fractured, open jointed rock of extremely high fracture permeability. Grouting will be a critical aspect of groundwater control practices. The rock conditions are likely to be conducive to grouting and result in significant groundwater inflow reduction.

The Marble formation, with relatively low Lugeon values, may need ground treatment in a much reduced scale to the Tarcowie Siltstone fracture zone. However, subsequent additional investigation bores have identified some fractured conditions within the Marble formation that have the potential to transmit high water volumes if encountered.

The Tapley Hill formation, generally appears to have low fracture permeability and typically may not require grouting.

On the provided information, the following assumptions have been made by Multigrout:

- Decline development, said to be largely within the Tapley formation, not considered for ground treatment (unless reassessed to be included)
- Vertical infrastructure development, shafts and escapeways have some high potential zones where they are developed through the HW.
- Access drives and ore drives will be subject to extensive probing and grouting when in close proximity to, and developed through, the HW fracture zone
- Probe drilling and assessment will be impportant to decision making in both mine development and production

As a general rule, Multigrout have based the following recommendations on extensive Scandinavian experience, and demonstrated more broadly around the world, certain cement types used in cementitious grouting have the potential to achieve groundwater inflow reductions into a tunnel down to limits as follows;

- Normal GP Type cement — 30 – 50 litre/min/100m
- Micro-fine cement — 10 – 15 litre/min/100m
- Ultra-fine cement — 2 – 5 litre/min/100m

More information on grouting types is provided in the groundwater impact and risk assessment – Chapter 10: section 10.7.1.7.2.

In summary, the pre-excavation grouting process will follow an established procedure, which will evolve over time as experience is gained in changing ground conditions, review and analysis of the outcomes. Grouting is a dynamic process and includes analysing and modifying the process over time to ensure that groundwater inflow requirements are being met and process continually refined for efficiency and economy.

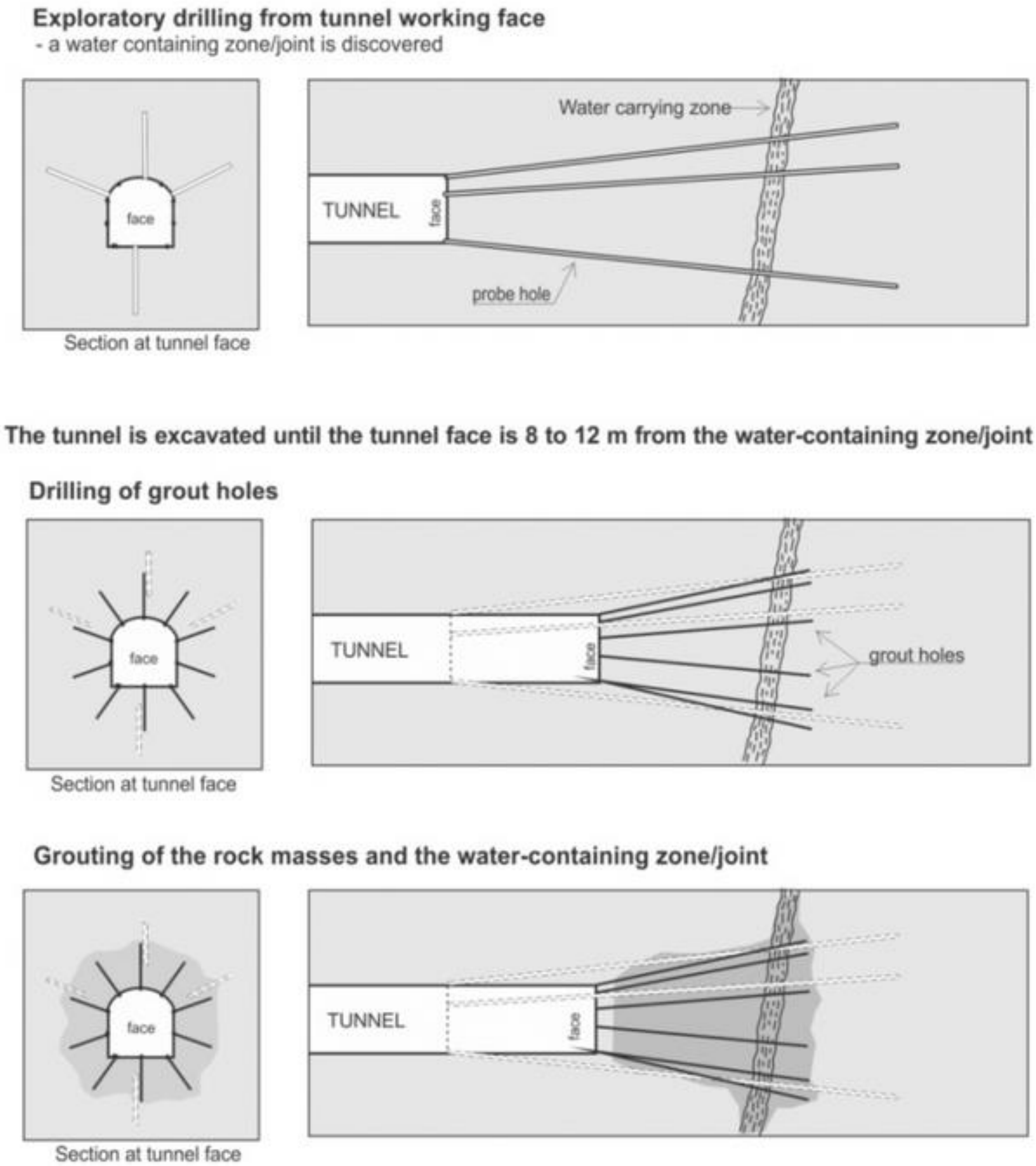


Figure 3-59 | Principles of probe drilling and pre-grouting. Typical length of probe drilling is 25-30m and the overlap is typically about 5m (from Nilsen and Palmstram, 2013)

3.4.2.7.2 POST EXCAVATION GROUTING

Post excavation grouting is used in cases where unexpected water inflows occur. These cases can occur during/after a blast or a seismic event; in cases where drilling intercepts an unknown aquifer; or with an increase in aquifer water pressure.

The method selected to apply post excavation grouting will be determined by the rate of water inflows. If the inflow is minimal, grouting may not be required immediately and would be easily applied in a similar fashion to the pre-excavation grouting technique described above where grouting holes are drilled, grout applied and the test holes drill to check the source has been plugged.

To undertake any required post grouting applications, the project will utilise trained personnel, as well as using suitable equipment in the application of the grout in such conditions. Post grouting applications, although not the preferred method of grouting compared to pre-grouting, are not uncommon in the mining, construction and civil industries, and have been successfully applied in many situations. There are internationally experienced companies, such as Sovereign Hydroseal, available who specialise in this work, and could be a resource in such cases. Multigrout have identified various strategies for contingency in this case, outlined in Appendix H4.

A recent example of Sovereign Hydroseal's post grouting success includes the Wallaby Gold Mine's (Laverton, Western Australia) ventilation shaft where they encountered 20l/s during shaft construction and with post grouting were able to reduce this to 1l/s. On another shaft at the same site, flows were reduced from 20L/s to 0.2L/s (Sovereign Hydroseal, 2017).

At another site, the Saracen Deep South Gold Mine in Western Australia, *"while raise drilling the 4.5m diameter primary vent shaft at the Deep South Gold Mine, a water bearing structure was intersected approximately 30m below the surface. This structure was producing between 20-30ltr/sec. This volume of unexpected water ingress meant that installing the primary vent fans which were planned to be installed on the surface would not have been possible. Sovereign Hydroseal were called in and with a series of only 9 holes drilled and approximately 4 days of grouting the water was successfully reduced to just a few litres."* (Sovereign Hydroseal, 2017).

3.4.2.7.3 GROUT TYPES

The type of grout used can vary depending on the properties required such as:

- Viscosity – the less viscous, the smaller the fractures that can be sealed, also requiring less pressure for the grout to be pumped under
- Setting time – minimises the time for the inflow to be sealed – similar to quick set cement
- Strength – depending on the pressures of the inflows, the strength of the grout may need to be adjusted

The type of grout used is also dependent on the equipment available for the application of the solution.

1. Particulate Grouts (suspension or cementitious) having Bingham performance
2. Colloidal solutions which are evolutive Newtonian fluids in which viscosity increases with time
3. Pure solutions in which viscosity remain essentially consistent with the adjustable setting period
4. Miscellaneous materials

These comprise mixtures of water and one of several particulate solids such as cement, pozzolans, clays, sand and additives to modify viscosity.

Depending on the mix it may be stable or unstable (having significant bleed >5% bleed in 2 hours). Particulate grouts remain highly popular due to their basic characteristics and relative economy and remain the most commonly used for routing waterproofing and ground strengthening.

Water to solids ratio is the prime determinant of their properties and basic characteristics of stability, fluidity, rheology, strength and durability.

3.4.2.7.4 WHERE GROUTING WILL OCCUR

The three main purposes for using grout at BIH will be for the following

- Groundwater management (underground development and vertical shafts);
- Ground support installation and stabilisation; and
- Drill hole and bore hole rehabilitation

Grouting for ground water control will be used in zones where water ingress is predicted to occur when mining excavations breech the fractured aquifer (Figure 3-60). Based on geological and hydrogeological models as well as results from probe drilling, the likelihood of water inflows will be predicted and a grout strategy will be implemented.

In the case of the BIH mine design, the expected areas will require pre-grouting include limited fractures intersected by the decline, as well as the hanging wall of the ore drives, particularly at the horizontal extremities of the ore body. Due to the depth of the mine workings, and the lateral distance to and relatively shallow depth of all operational bores (one exception), existing wells are not expected to be compromised by the proposed pre-excavation grouting. Pre-excavation grouting has a limited zone of influence, or metres, not tens or hundreds of metres. More information on existing operation bores within 1km of the proposed underground workings has been outlined in section 3.7.9.6.5.3 as well as in detail in chapter 10.

Post-grouting will be used in cases where water inflows occur unexpectedly.

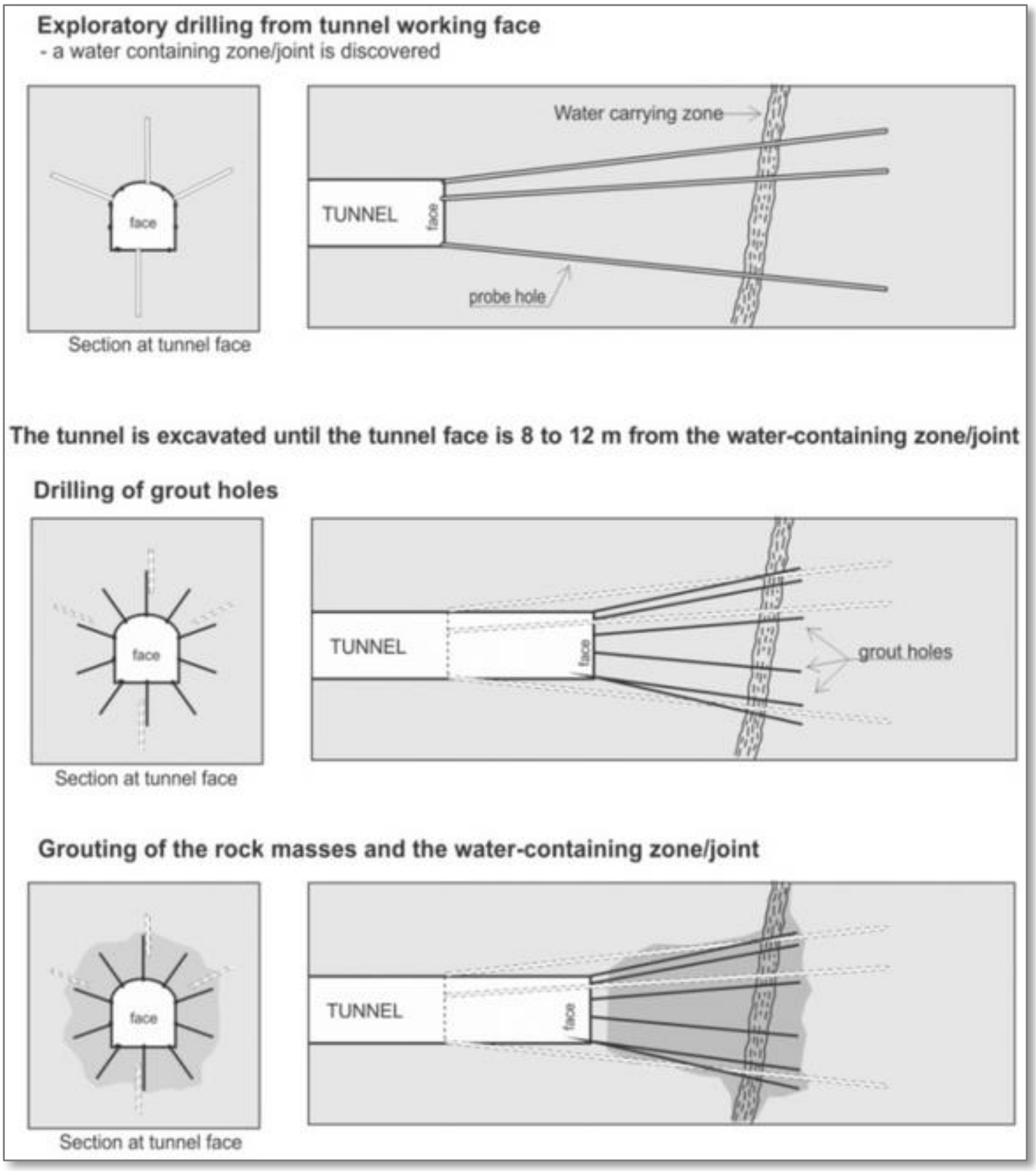


FIGURE 3-60 | LOCATION OF GROUTING MINING ACROSS FRACTURES (NILSEN, 2015)

Geotechnical review of the mine design has recommended that grouted rock bolts and cables be implemented in the ground support management plan for the project.

All geological drill holes will be rehabilitated using grouting products as per the regulatory guidelines.

3.4.2.7.5 CASE STUDIES FOR GROUTING

3.4.2.7.5.1 ERNEST HENRY, QUEENSLAND

Unless otherwise specified, this information is taken from (Purvis, Calverd, & Greve, 2014)

"The Ernest Henry Mining (EHM) underground mine is situated adjacent to the Great Artesian Basin in North Queensland and within a fracture zone. Underground development commenced in February 2008 and has extended to approximately 1000 vertical meters below the surface.

Groundwater has been encountered in numerous locations throughout the mine, predominantly on the eastern side of the ore body. And often related to fault structures. Most of the groundwater encountered has been managed with conventional pumping systems; however, on occasions large water inflows have been encountered, which have had a significant impact on the planned development of the mine. Some of the intersections encountered had the potential to compromise the mine from a combination of high temperature (over 45°C), high pressure (3500kPa) and high flows (50-100L/s)"

"Different stand piping and grouting methods have been used to manage and mitigate the risks of water inflows and a targeted dewatering strategy has been developed to lower the water pressure in high water risk zones."

In their paper, (Purvis, Calverd, & Greve, 2014) outline three different cases

1650 mid-shaft access

"In January 2010 the 1650 mid-shaft heading was being developed to access the shaft (Purvis and Carr, 2011). Work on the heading had just commenced and it was known to pass through the F1 and F4 faults. A probe hole was designed to identify the structure and determine the presence of water in front of the face. This probe hole didn't intersect water. However, on January 26 2010 during the process of installing the ground support a significant water inflow was intersected (Figure 4)."

FIG 4 – Water flowing from the F1 fault – 25 January 2010.

FIGURE 3-61 | EXAMPLE OF GROUNDWATER INFLOW EXPERIENCED AT ERNEST HENRY MINE, 2010, WHICH WAS MANAGED THROUGH A GROUTING PROGRAM

1625 to 1474 fresh air rise – raise bore pilot hole

"In early 2011 the pilot hole for the 1625 to 1475 FAR on the eastern side on the orebody intersected water approximately 15m from breakthrough. The water flow was estimated at 10L/s at its collar and it was considered too risky to drill the hole to breakthrough as the quantity of water that could be released was unknown and potentially uncontrollable. As a result the hole was stopped and the raise bore removed from the hole"

"The groundwater was controlled by pressure grouting the raise bore footprint utilising similar techniques and equipment to the mid-shaft drive. A series of 30m grouting holes were drilling from the planned breakthrough location on 1475 to allow grouting to commence…..The area was consolidated with cementitious grout, and following the initial grouting program, additional holes were drilled to ensure the grout had formed a complete curtain…..Following the grouting campaign the raise bore was re-established on the pilot hole and the hole was completed with no further issues.

1325 Shaft access

"The 1352 shaft access was designed to decline from the 1325 level to the hoisting shaft's conveyor head end and was to be developed through several regions of ground that had a high likelihood of containing water."

The heading was developed under a risk assessment, which required probe holes to be drilled in advance of the development face. The option to standpipe the holes in order to control any water inflow was considered, but, based on previous experience with fitting plugs and standpipes, it was deemed unnecessary to implement.

In March 2012, a series of 64mm diameter probe holes were being drilled in the face when one intersected water of high pressure (3500 kPa) and high temperature (49°C). The hole was low in the face and the heading had commenced declining therefore the hole was underwater almost immediately. Water was flowing from the hole at an estimated 75-100L/s.

The time taken from the water being intersected to getting it under control with the packer placed in the hole was approximately four weeks.

The 1325 shaft access was developed for a distance of 330m through the water bearing zone (Figure 13). This required the probe drilling and grouting of 19 zones and took approximately 12 months to complete. Except for the water intercepted at the beginning of the heading the work was completed successfully without any other events of uncontrolled water inflow.

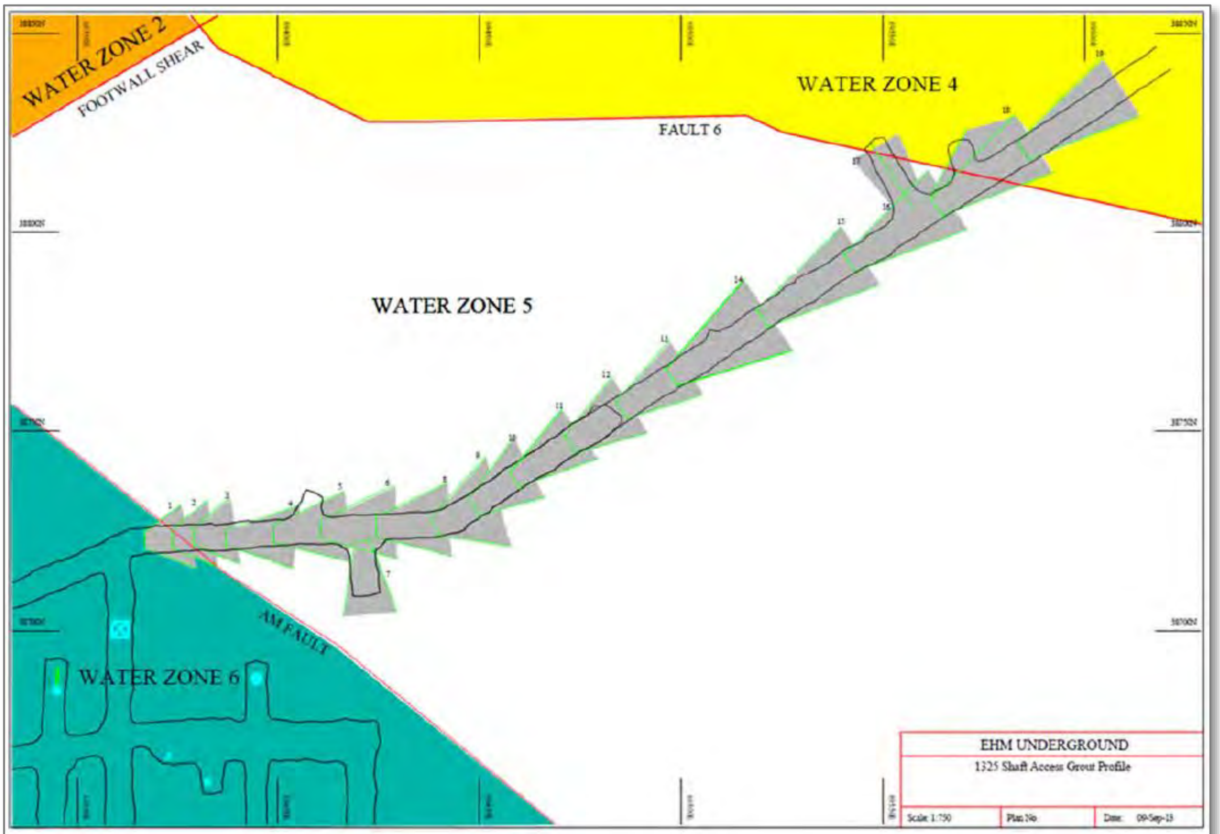


FIG 13 – Grout program for the 1325 shaft access (19 zones).

FIGURE 3-62 | A PLAN VIEW OF A DEVELOPMENT DRIVE, INCLUDING THE GROUT PROGRAM USED AT ERNEST HENRY (PURVIS, CALVERD, & GREVE, 2014)

3.4.2.7.5.2 JARRAH DECLINE, BODDINGTON GOLD MINE, WESTERN AUSTRALIA

"Feasibility study estimates of predicted water flow, being 20 litres per second (l/s) and doubled to 40l/s as a contingency (Anon, 1992), did not prepare the operation for the actual water inflows encountered.

Water poses a serious threat to viable contractor mining at the Jarrah Decline. Flows in excess of 50L/s are greater than the ability of the face pumps…. The water pressure also makes placement of explosives difficult and requires packaged types instead of ANFO, which increases the cost. Flooding is another concern as there is the threat to equipment and personnel. Deterioration of working condition and increased machine maintenance costs are other problems. Cover grouting reduced these problems to an acceptable level.

Acceptable rates of advance at the Jarrah Decline have been achieved by a combination of initiatives. Injection of a cement and water into the country rock have proved to be an effective means of diverting water away from the mine openings. Cover grouting methods adopted at Jarrah Decline have been developed to suit the operation.

Dewatering using pumps is considered the major objective in dealing with the water, i.e. reducing the water table below or near the lowest level of working. Until achieved, grouting will remain an integral part of the operation." (Broad, 1995)

3.4.2.7.5.3 FRANCOEUR MINE SHAFT SINKING, VAL D'OR, QUBEC

"In spite of systematically drilling pilot holes, a steeply dipping, water bearing fault zone went undiscovered during a shaft sinking operation at the Francoeur Mine. After blasting a round, a major in-rush of water occurred on one side of the shaft under high pressure (4.5 Mpa (630psi)). An emergency bulkhead was created at the bottom of the shaft to channel the flow through relief pipes. Hydrophobic polyurethane in conjunction with stable cement based suspension grout was injected to stop the flow. The water-bearing feature was systematically grouted with a combination of polyurethane and cement grouts. This approach made is possible to blast within one hour after completing a grouting operation. The shaft sinking was only interrupted for 5 days. This system has been used numerous times to eliminate down-time when driving tunnels through unstable water bearing rock formation." (Naudts, 2003)

3.4.2.7.5.4 GASCOIGNE WOOD NO.1, SELBY, UK – DRIFT

"At the Gascoigne Wood drift site the exploratory borehole programme had indicated a fractured and vuggy Lower Magnesian Limestone aquifer, with a potential inflow in excess of 380L/s (5000 gpm) between depths of about 125 and 150m, corresponding to drift chainages of 540 to 650m approximately. This aquifer directly overlaid the highly permeable and relatively weak Basal Permian Sands, which were frozen in order to achieve the required stabilisation and impermeability required for drift excavation. It was decided that the limestone would be treated by a series of overlapping grout covers, each 30m long with a 12m advance between faces. The final grout cover would "interlock" with frozen ground, with special construction procedures required in the area." (Daw & Pollard, 1986)

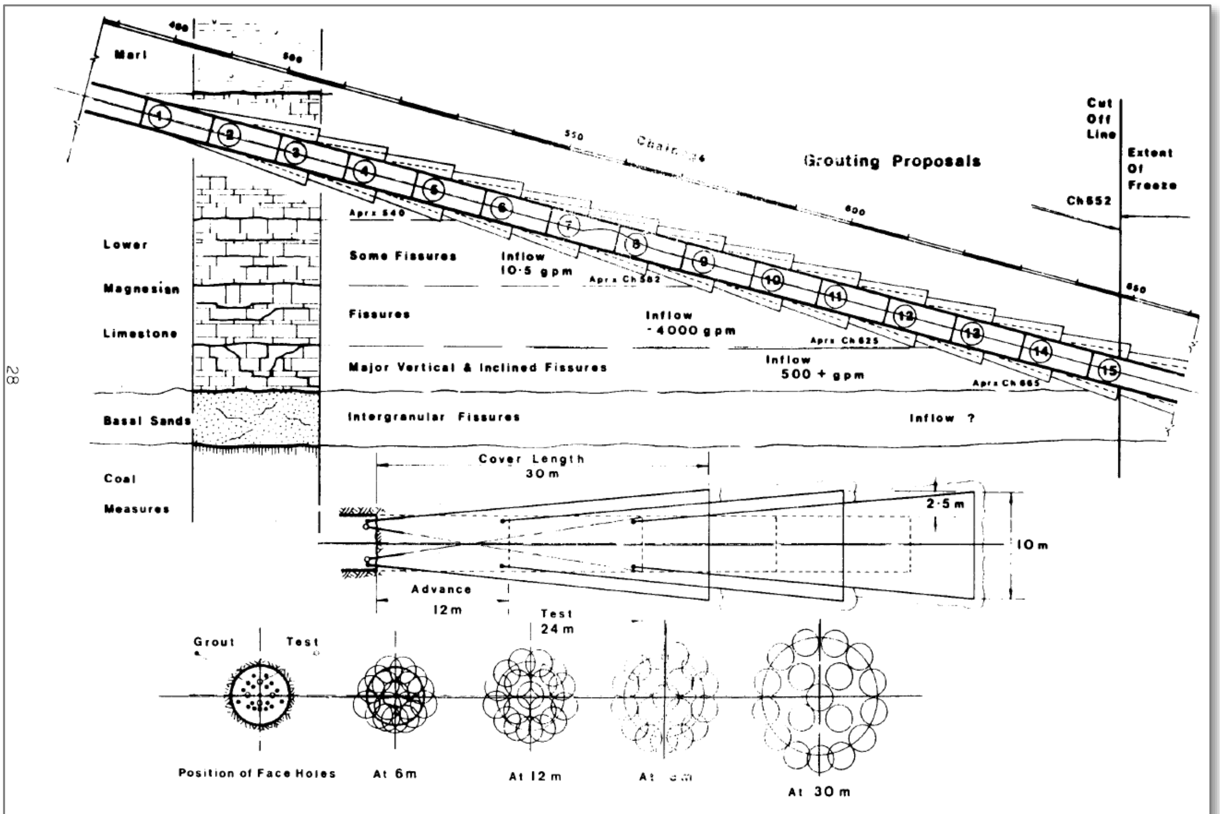


Figure 11 :- Arrangement of Grout Covers & Hole Patterns for Gascoigne Wood Drift Nº 1.

FIGURE 3-63 | EXAMPLE OF PRE-EXCAVATION GROUTING USED AT GASCOIGNE WOOD DRIFT NO1, 1979 (DAW & POLLARD, 1986)

"In practice, ground water was encountered at a higher level than anticipated and the grouting sequence was commenced from a chainage of 473m, and a total of 14 grout covers were then required to reach the frozen zone."

"For the first eleven covers the time taken for drilling and grouting procedures ranged from 8 to 18 days per cover. Somewhat longer was taken with the last two covers with the increased number of injection holes and the very careful approach required in the vicinity of the ice wall.....The complete operation spanned the period from January to October 1979, with a comparable programme carried out almost simultaneously in the No 2 drift. The total residual inflow to the drift through this zone was reduced to less than 4 L/s (52 gpm) by the grouting operation."

3.4.2.7.5.5 BANEHEIA TUNNEL PROJECT, KRISTIANSAND, NORWAY

"The Public Road Administration (PRA) in Norway has had similar experience to the Rail Authorities. At the Baneheia Tunnel project in Kristiansand, a very careful grouting programme was carried out to maintain the groundwater table in a sensitive recreation area near the centre of the town. Lowering the groundwater would lower the water level in three beautiful lakes used for swimming and fishing (Tveide, 2000, paper at the Norwegian tunnelling conference 1999). According to calculations made by the PRA, the cost saving in rock support, water shields and ice protection compensated and saved overall time."

"Underground construction has developed quickly during recent decades. Highly mechanised drilling equipment, TBMs robotic shotcrete equipment and numerous materials and scaffolding systems have all improved. However, grouting has perhaps not developed at the same speed and to the same level, except in very special cases. Environmental problems due to lowering of the groundwater table, hazardous inflows of water or lifetime problems of the tunnel-fixed equipment due to wet conditions in the tunnel have been common almost all over the world. As lack of free space in the urban areas requires more and more tunnelling, it is important to have an overall philosophy that tunnels should be constructed without influencing their surroundings. The same philosophy must often be applied outside urban areas because environmental issues are important in areas of recreation."

3.4.2.7.6 OTHER TYPES OF GROUTING

3.4.2.7.6.1 GROUND SUPPORT

Grouting is a common technique used in civil and mining industries, to adhere and secure ground support such as cables and bolts into the ground they are supporting. The grout used is generally a cement and/or resinous based product and adheres to the sides of holes and around the apparatus being used. To reach the end of these holes (sometimes 12+m in length in the case of cables) this grout is pumped into the holes under pressure, and it is not unknown for it to transgress along fractures within the surround rock. This process has the additional benefit of improving the strength and coherence of the surrounding rock. (Figure 3-64 and Figure 3-65)

Grouting as a ground support management strategy was successfully trialled at Ballarat East in extremely poor ground conditions and has been described as a "*management tool that will be utilised where geotechnical drilling reveals large weathered fault zones or difficult to manage ground conditions."* (Williams, 2006)

In dry conditions, pre-grouting will improve the rock quality within the order of one quality class. In wet conditions, pre-grouting will improve the rock quality by two to three quality classes. The overall result of efficient pre-grouting will be reduced permeability, deformation and reinforcement requirement when tunnelling, increased deformation modulus and seismic velocity. Each can be linked in a simple way to Q-value increases. (Barton, Buen, & Roald, 2002)

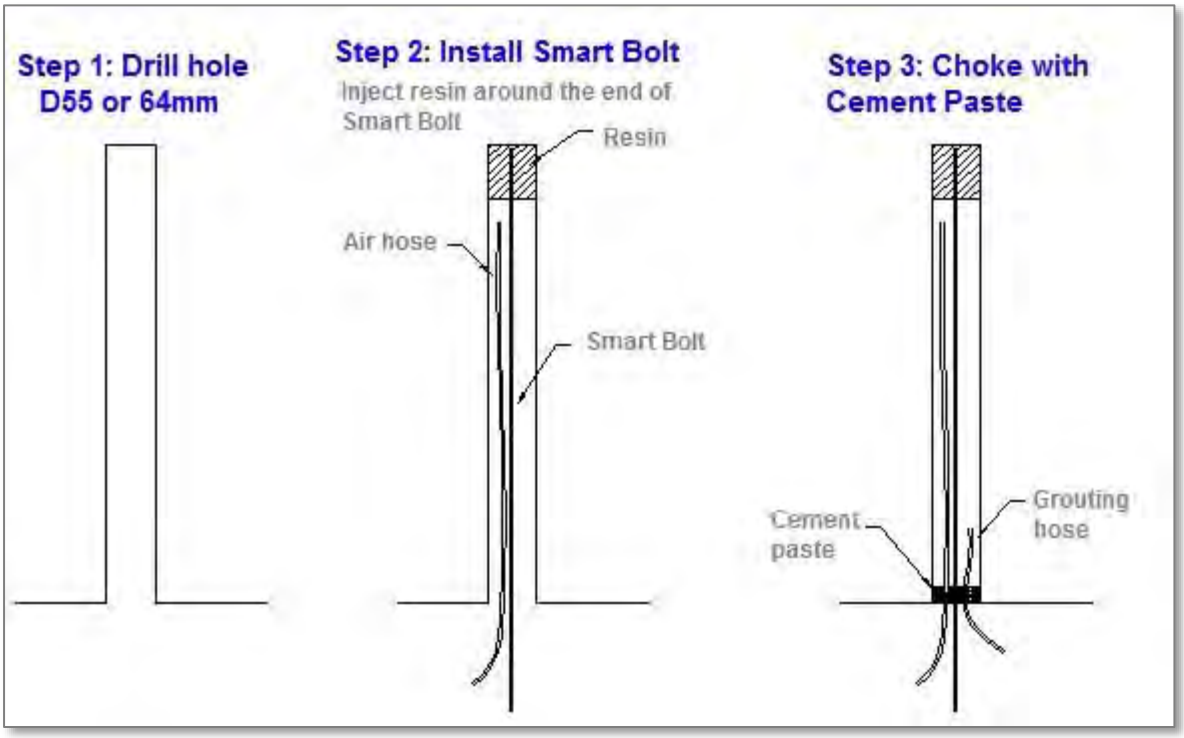


FIGURE 3-64 | STEPS ONE TO THREE OF GROUTING A ROCK BOLT (SMARTSENSYS, 2017)

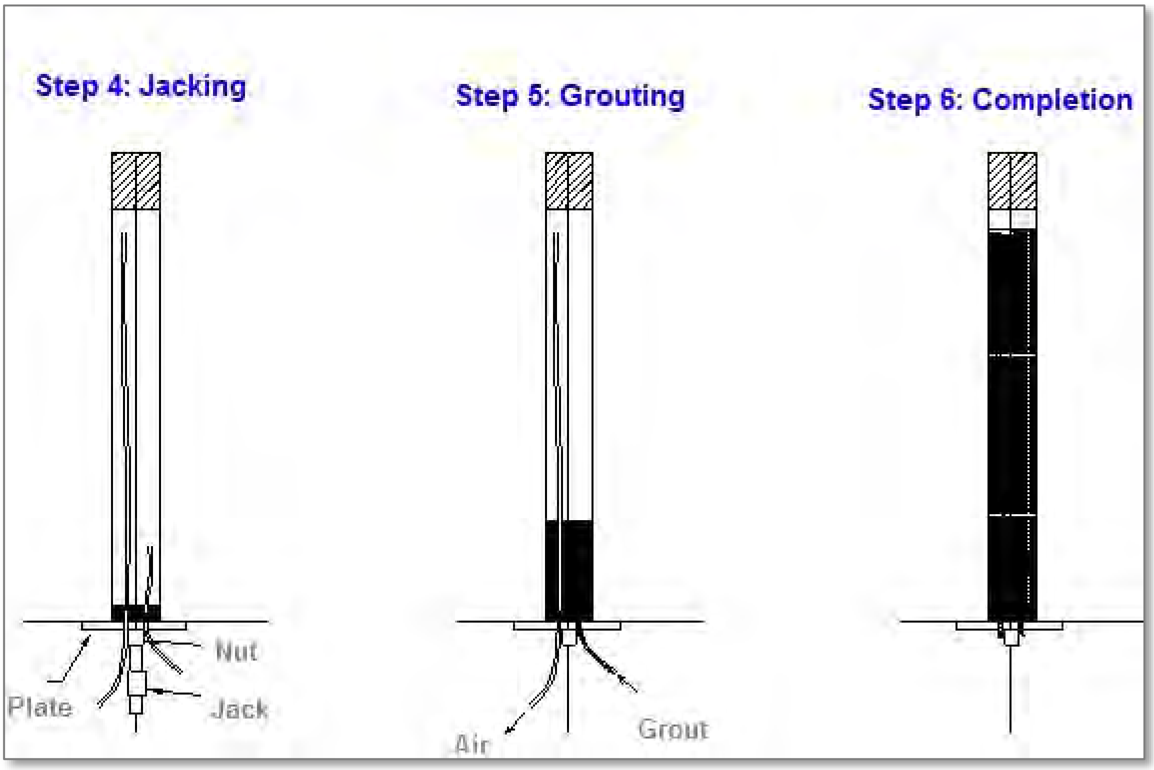


FIGURE 3-65 | STEPS FOUR TO SIX OF GROUTING A ROCK BOLT (SMARTSENSYS, 2017)

3.4.2.7.6.2 BORE HOLE CASING AND REHABILITATION

It is within the required standards for casing, backfilling and rehabilitation of bores and exploration drill holes that the holes be filled (or lined) with grout (Figure 3-66 and Figure 3-67). This acts to seal the holes and prevent them acting as conduits for groundwater. This method will be used at BIH for the rehabilitation of exploration holes as well as water bores and service holes used for the project.

As outlined in the M21 Mineral Exploration Guidelines for backfilling drill holes, cement grouting (Government of South Australia, Department of State Development, 2012):

"*Cement used to plug, backfill or secure the casing in a drillhole must be fresh, of good quality and mixed as a neat slurry with not more than 30 litres of fresh water per 40 kilogram sack of cement, and be positively placed to reach the required position without contamination or dilution….*

…Grouting is achieved by pumping slurry of approved mix ratio and quality, through drill pipe or tremie line to the depth at which it is to be set. The equipment for mixing and placing grout must be adequate for the operation. The tremie line or grout pipe needs to be at the appropriate depth (i.e. at the bottom of the zone to be sealed) and drilling fluid or water pumped through it to ensure against any blockage, prior to the grout being pumped. It may be necessary to place a bridge plug or formation packer ahead of the grout to provide a seat for the plug.

This can save large amounts of grout being lost to the formation. The chemical reactions that cause grout to set begin as soon as the slurry is prepared, so it is essential that the grout is emplaced while it is still fluid"

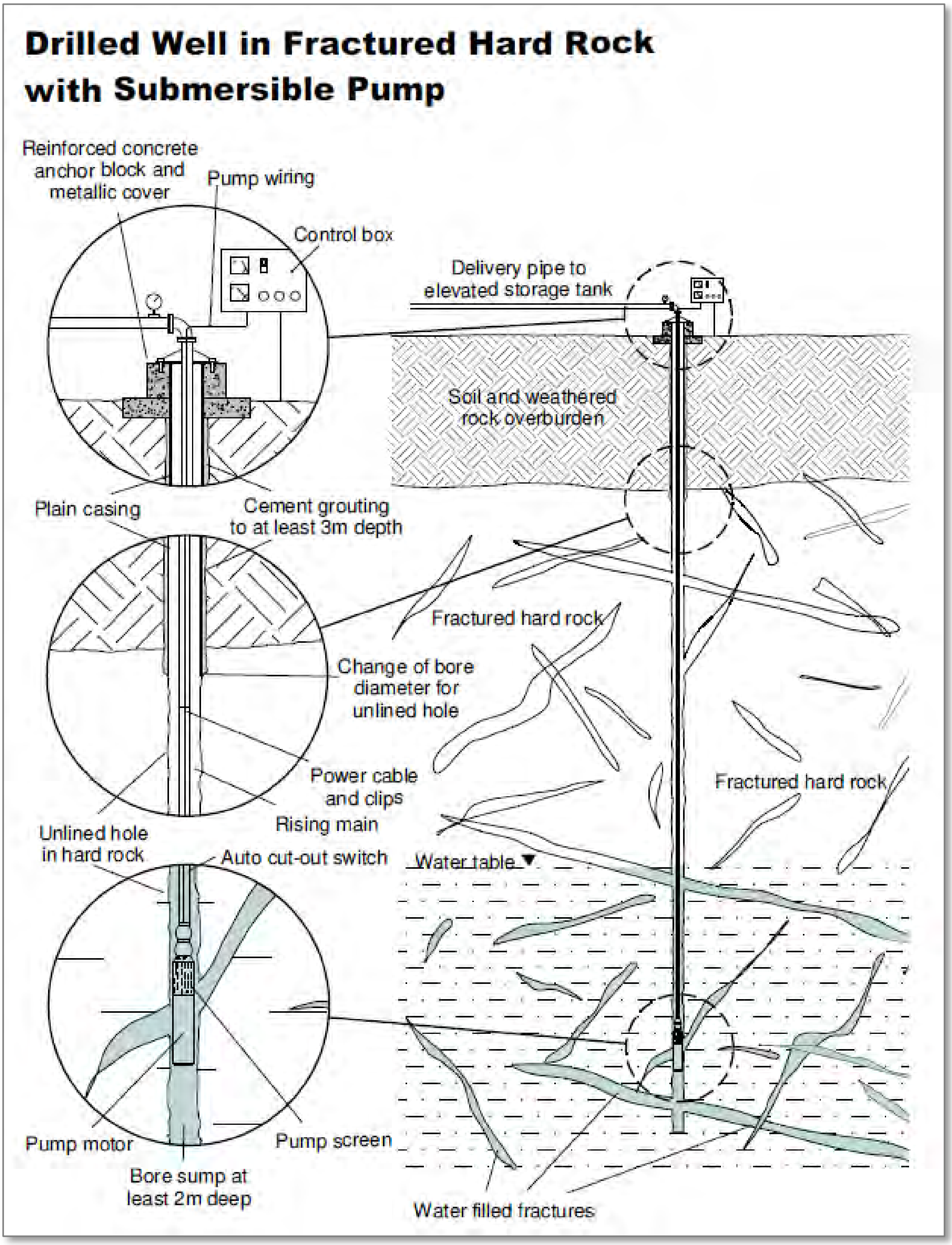


FIGURE 3-66 | EXAMPLE OF GROUT US IN WELL CASING (UNHCR, 2017)

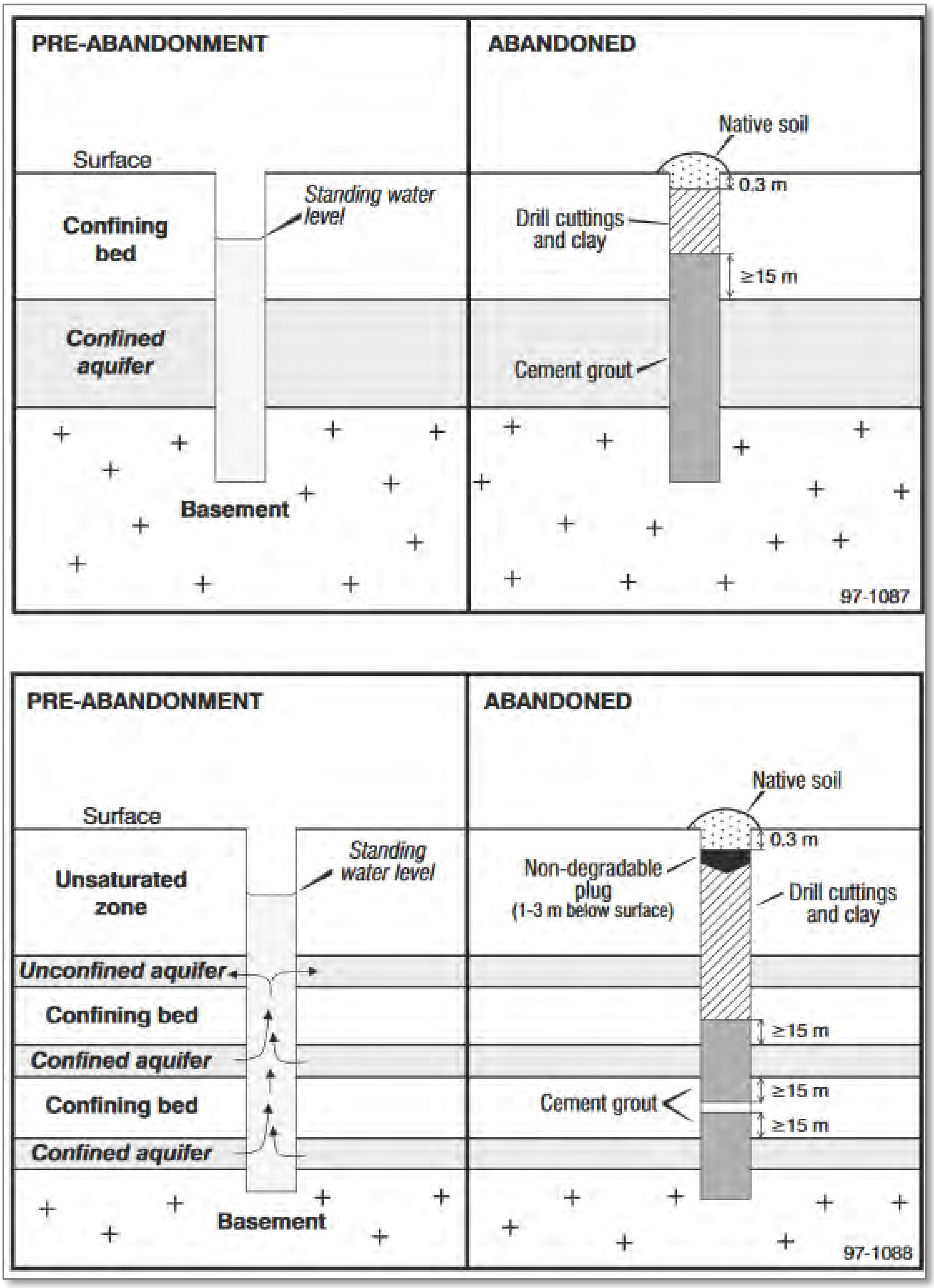


FIGURE 3-67 | GENERAL SPECIFICATIONS FOR CONSTRUCTION AND BACKFILLING OF EXPLORATION DRILL HOLES IN SOUTH AUSTRALIA REQUIRE THE USE OF GROUT (GOVERNMENT OF SOUTH AUSTRALIA, DEPARTMENT OF STATE DEVELOPMENT, 2012)

The casing and decommissioning of water bores will conform with the *Minimum construction requirements of water bores in Australia* (Australian Government, National Uniform Drillers Licencing Committee, 2012) that states:

"To decommission a water bore, several requirements must be met. These include:

- *preventing groundwater contamination*
- *conserving yield and maintaining hydrostatic head of aquifers*
- *preventing waters intermixing.*

Decommissioning by fully grouting from the top to the bottom is the preferred method for all bores."

3.4.3 Material Movements

3.4.3.1 LOM

The expected life of the mine is 5 years from the commencement of the decline, with ore production commencing in month 14 (Year 2).

There are exploration activities planned for down dip of the known ore body (below 450m below surface), as well as for the nearby reefs of Bird Extended, Ridge Mine, Brind Mine etc. Further details are discussed in Section 3.3 on proposed exploration activities.

Figure 3-68 to Figure 3-73 shows the annual progress for the underground mine and activities are summarised in Table 3-30.

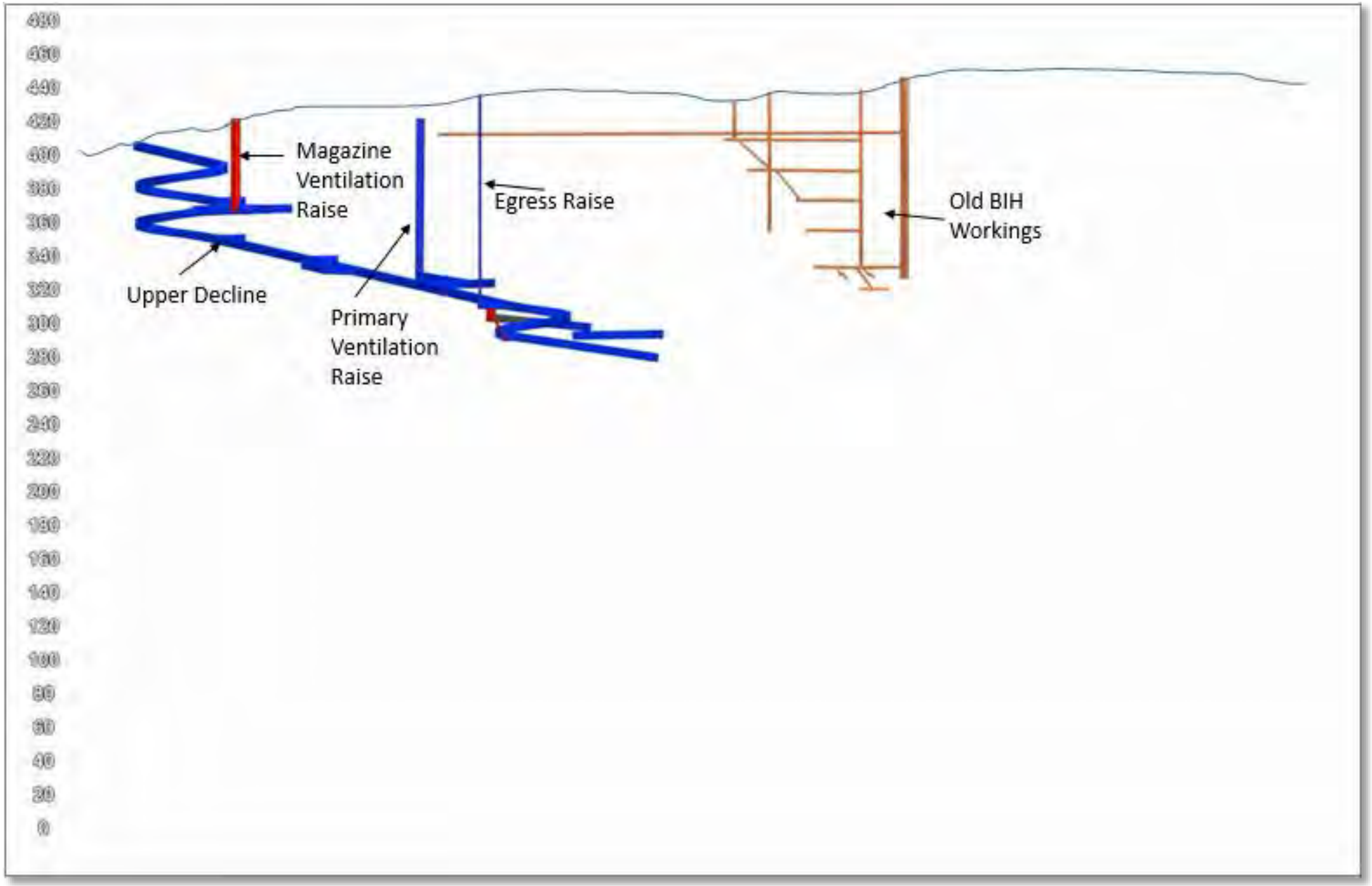


FIGURE 3-68 | UNDERGROUND MINE PROGRESS AS AT END OF YEAR 1

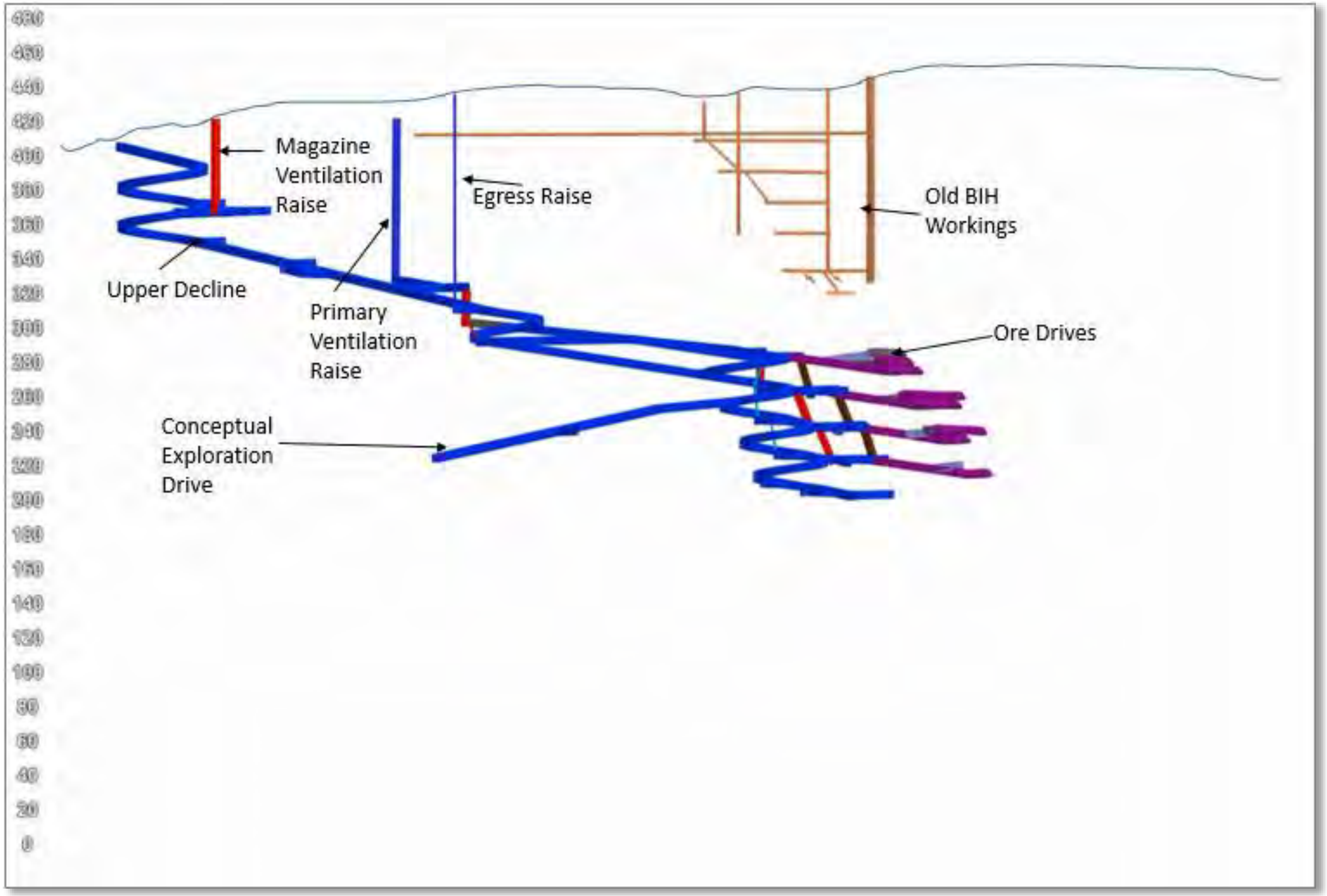


FIGURE 3-69 | UNDERGROUND MINE PROGRESS AS AT END OF YEAR 2

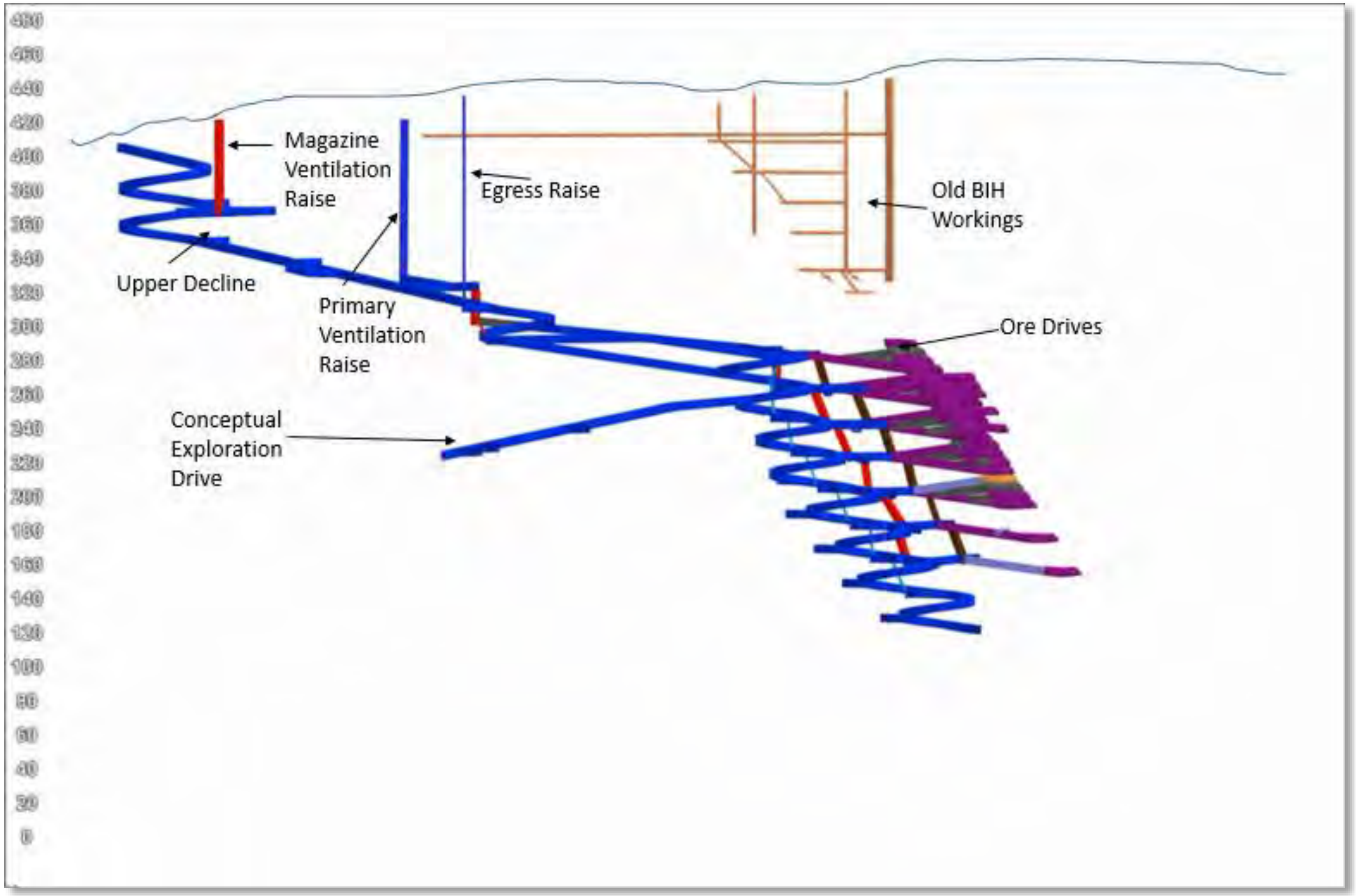


FIGURE 3-70 | UNDERGROUND MINE PROGRESS AS AT END OF YEAR 3

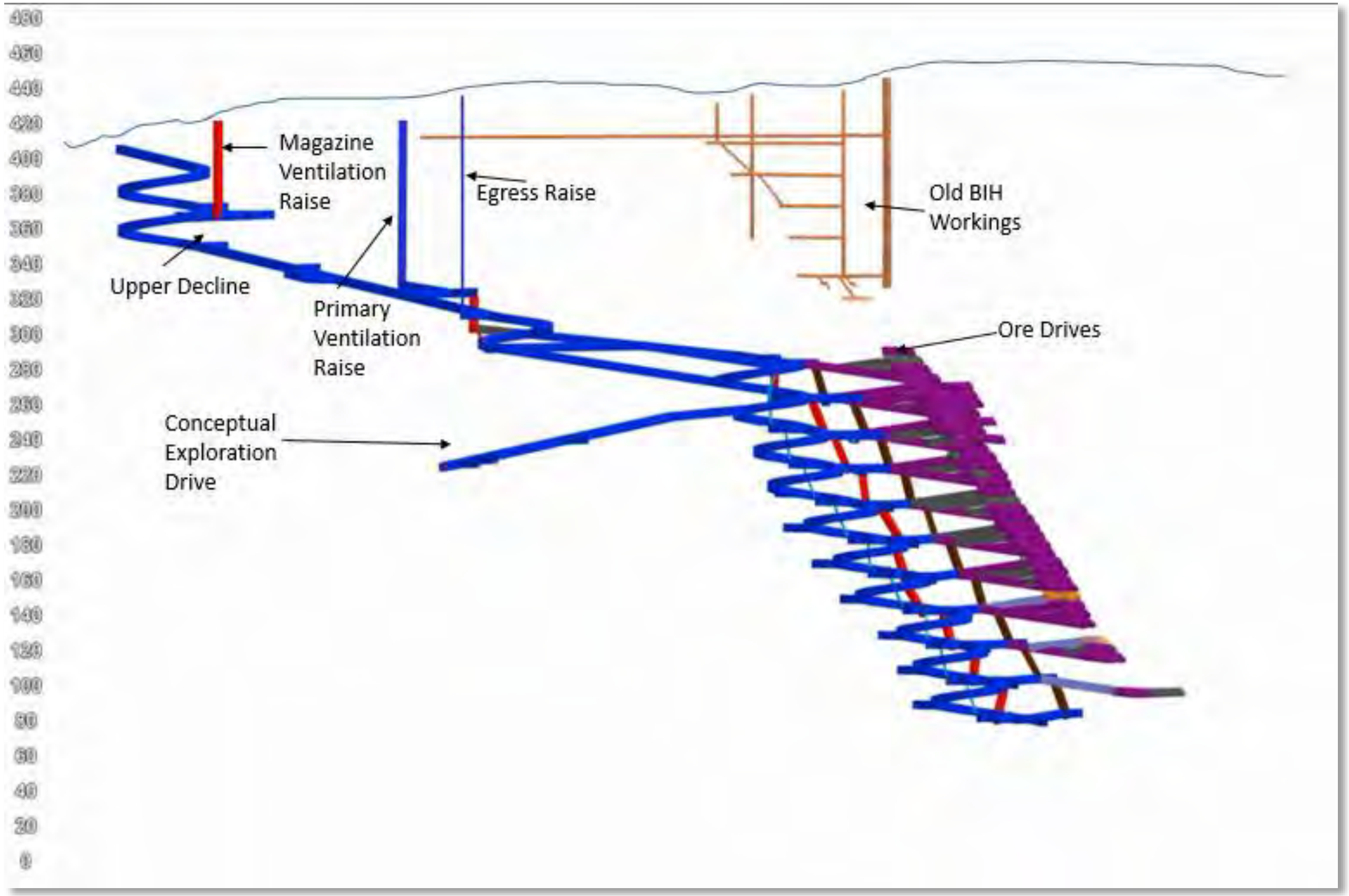


FIGURE 3-71 | UNDERGROUND MINE PROGRESS AS AT END OF YEAR 4

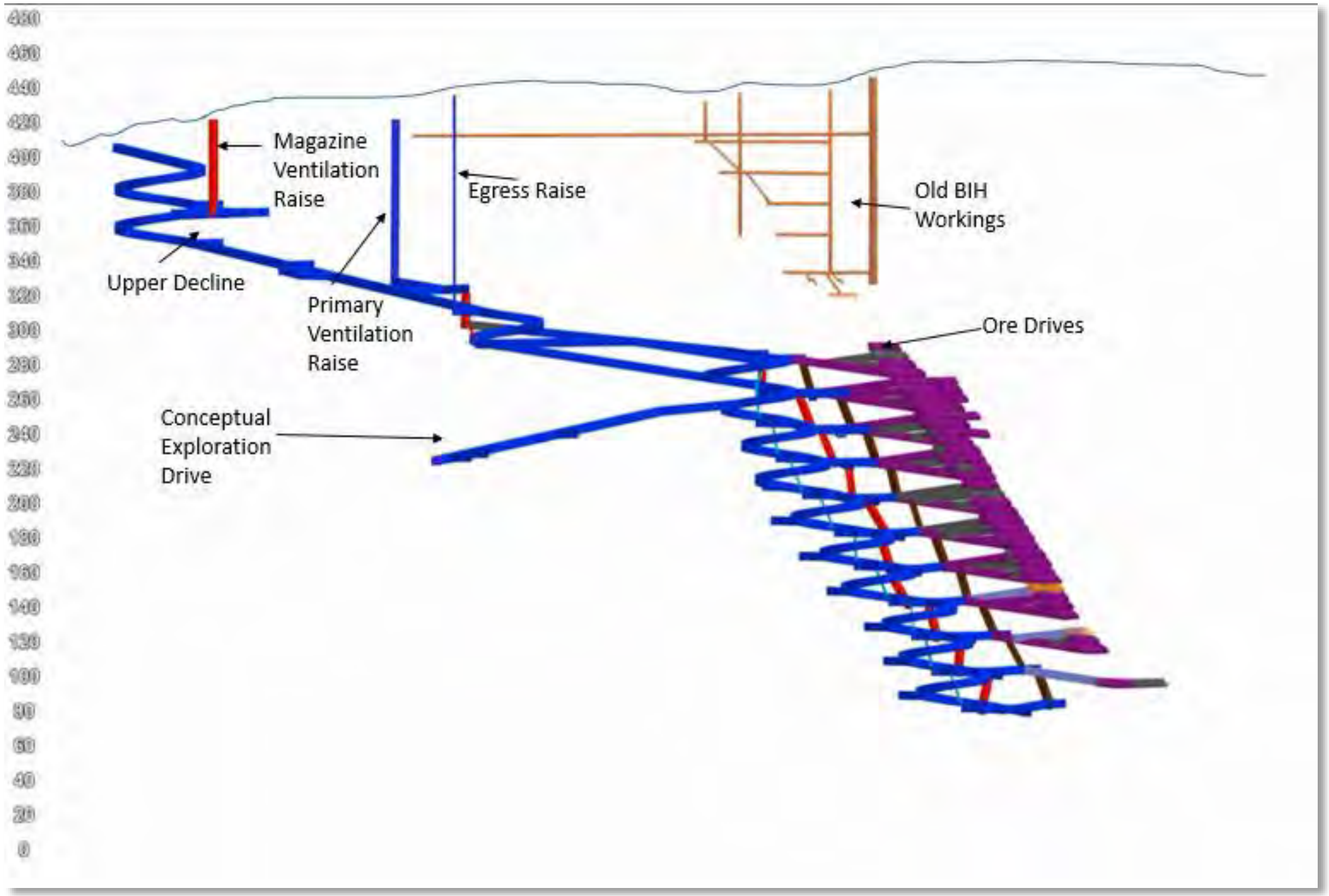


FIGURE 3-72 | UNDERGROUND MINE PROGRESS AS AT END OF YEAR 5

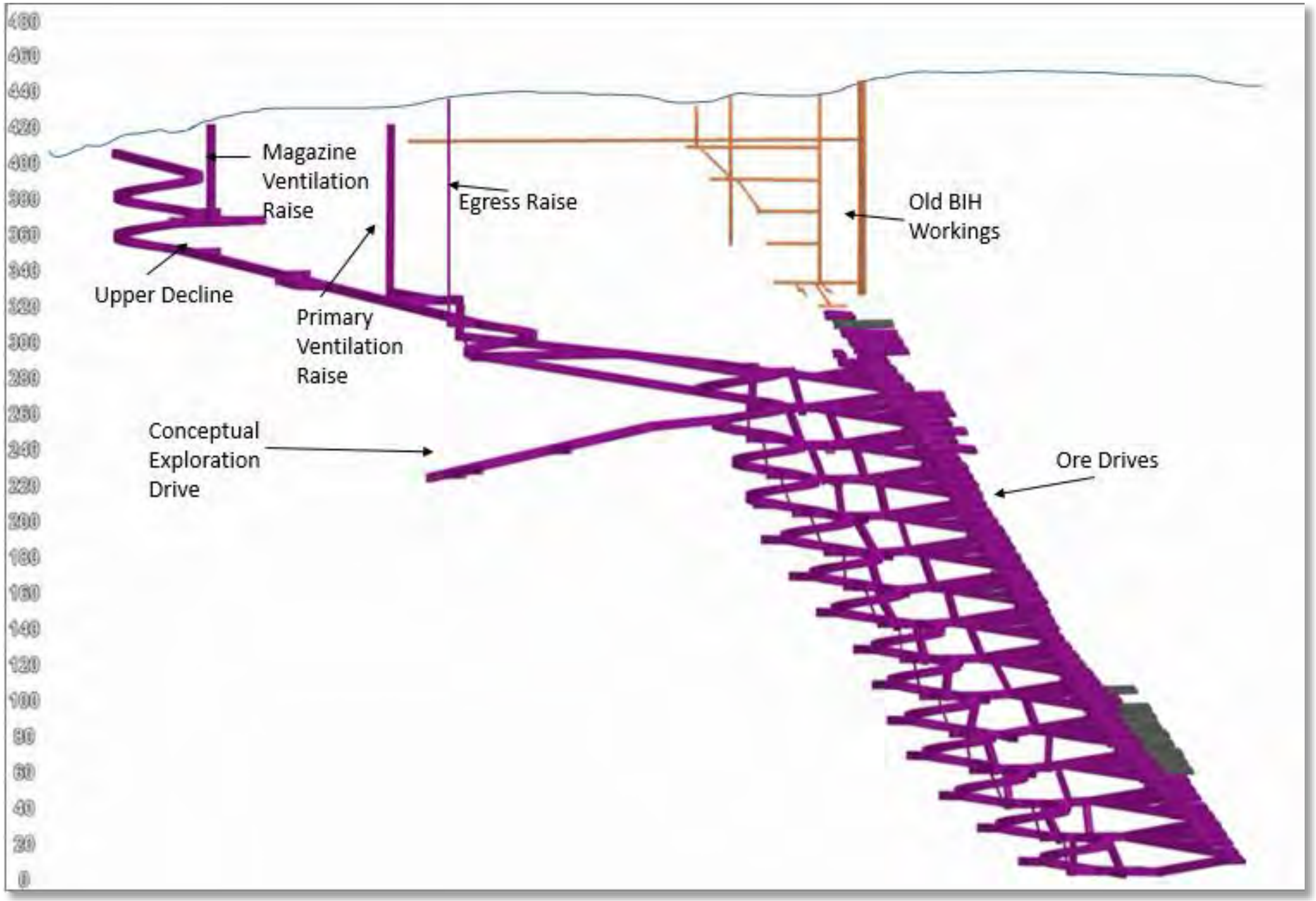


FIGURE 3-73 | UNDERGROUND MINE PROGRESS AT THE END OF MINING (BACKFILL)

TABLE 3-16 | ANNUAL MINE PRODUCTION RATES FOR ORE AND MULLOCK MATERIAL TO NEAREST KT (2018 SCOPING STUDY)

	Year 1	Year 2	Year 3	Year 4	Year 5	Total
Ore (t)	-	143,000	176,000	169,000	106,000	595,000
Mullock (t)	195,000	196,000	146,000	105,000	48,000	690,000

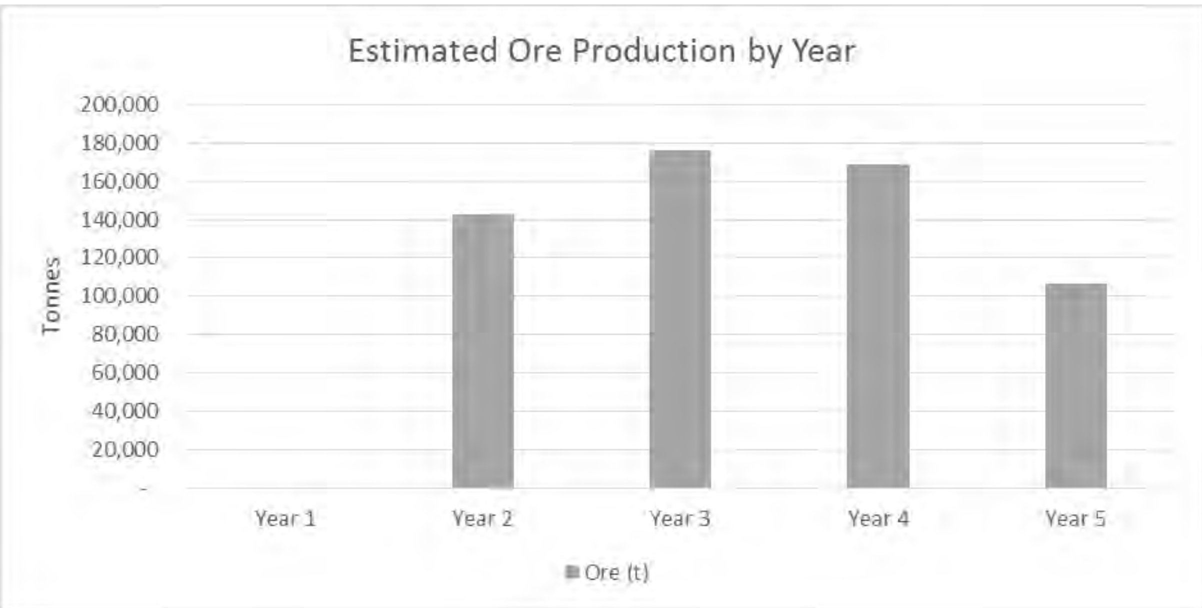


FIGURE 3-74 | ESTIMATED ORE PRODUCTION BY YEAR, TO BE DELIVERED TO THE ROM SILO

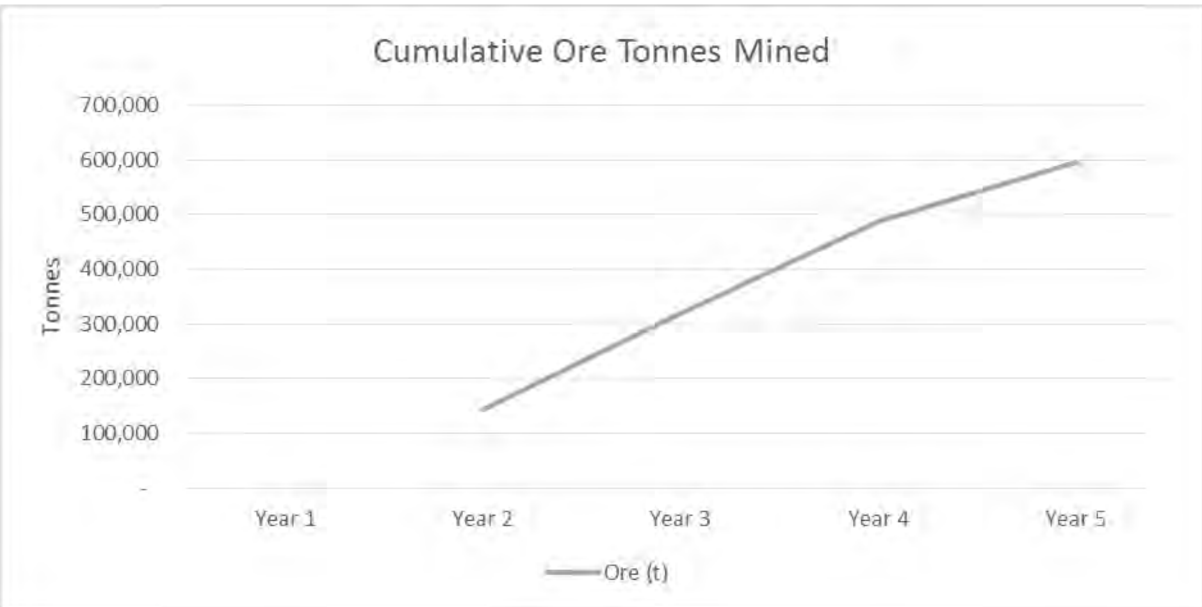


FIGURE 3-75 | CUMULATIVE ORE TONNES MINED

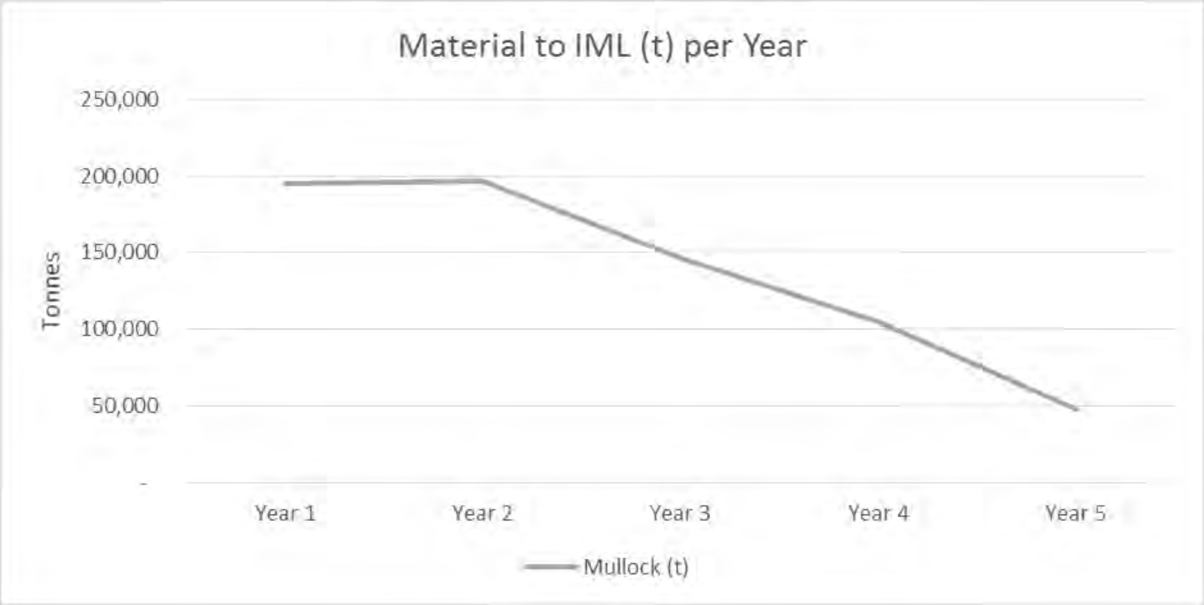


FIGURE 3-76 | ANNUAL MULLOCK MINED, ASSUMPTION THAT ALL WILL ALL BE STORED ON THE IML UNTIL USED FOR BACKFILL

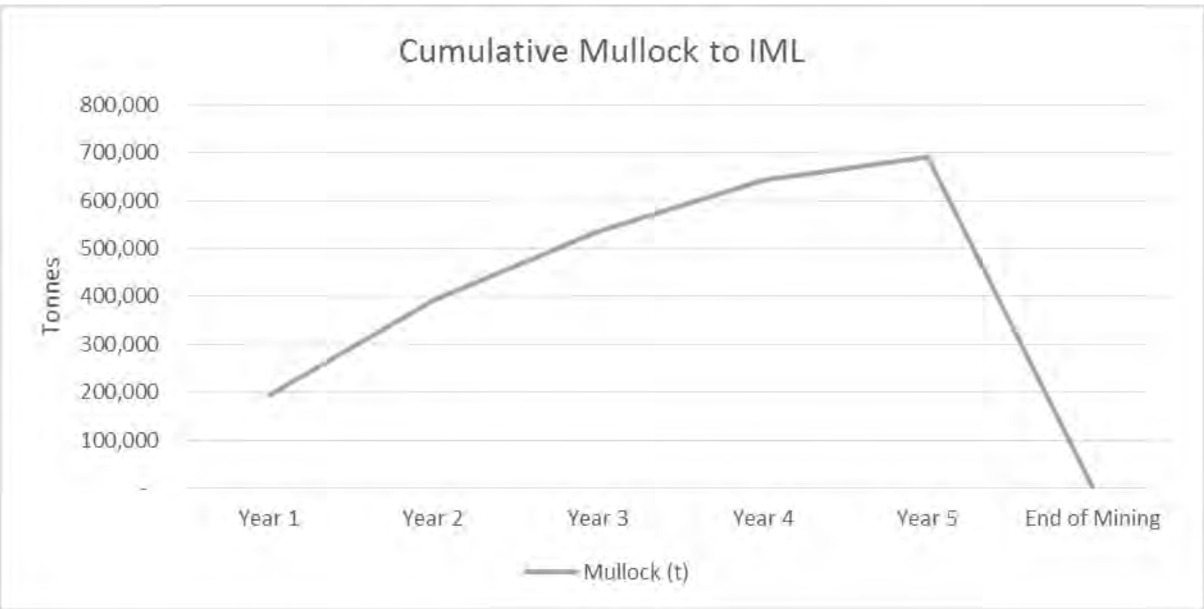


FIGURE 3-77 | CUMULATIVE MULLOCK MINED

3.4.4 USE OF EXPLOSIVES

3.4.4.1 USE OF EXPLOSIVES

Blasting activities are required to facilitate the excavation of rock in areas where this cannot be achieved by mechanical methods alone. Alternatives using road headers were originally investigated, but deemed unsuitable due to the properties of the rock expected to be encountered, potential delays due to poor equipment availability, and expected delays due to management of associated dust ventilation systems.

The two phases of the mining operation which require the utilisation of drill and blast practices include:

- Development of the Decline / Access Drives
- Production of the Ore Body

With the proposed cut and fill method of mining, the blasting practices will be consistent across both phases of the development and production activities.

Explosives will also be the key control of rock sizing, with blasts designed to give optimal rock fragmentation, reducing the need for continual comminution strategies such as crushing and screening prior to haulage to APF can occur.

Explosives detonation provides both:

- shock, which fractures (or breaks) the rock and
- force (in the form of gas products) which heaves and displaces the fractured rock.

An illustration on how rock is fragmented around a blast hole is shown in Figure 3-78. All explosives are mixtures that include carbon, nitrogen, hydrogen and oxygen along with other additives that affect or provide special properties (for example density, viscosity and water resistance).

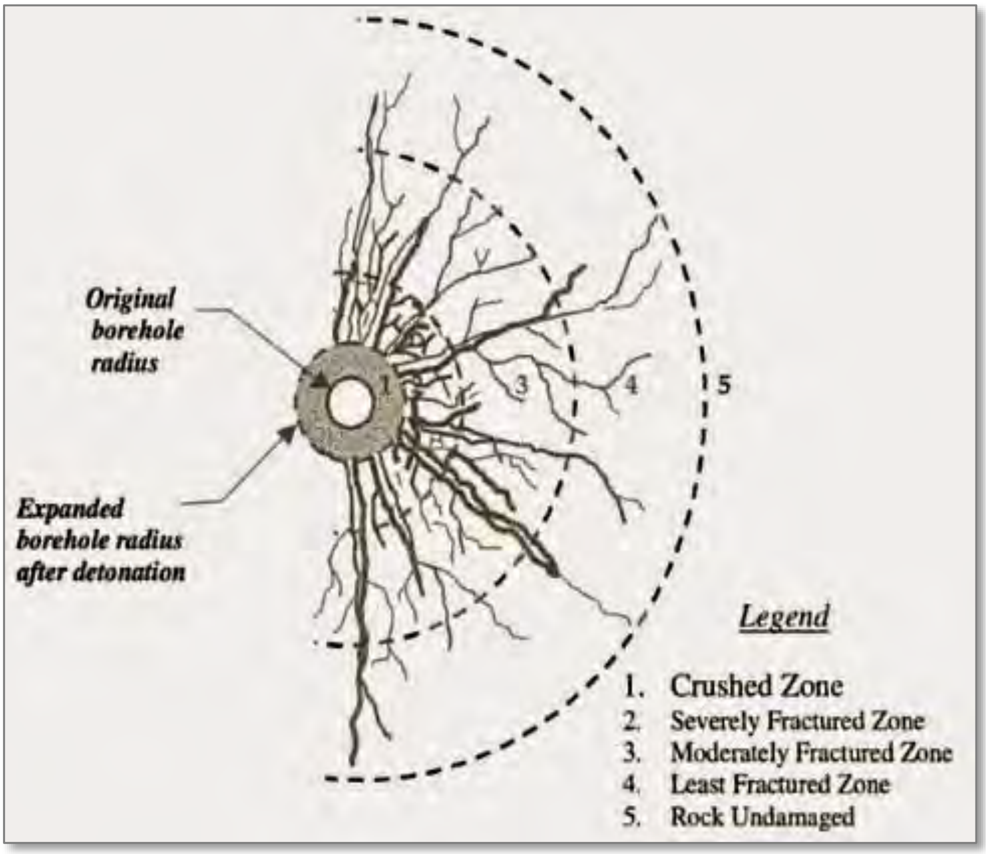


FIGURE 3-78 | EXAMPLE OF HOW EXPLOSIVES WORK TO BREAK ROCK, SHOWING THE FRACTURED ZONES CREATED AROUND THE BLAST HOLE

The impact of overpressure and vibration due to blasting was modelled by expert consultants Saros Pty Ltd (Saros) and the findings are discussed in their Blasting Impact Assessment Report – Appendix P1. Further discussion is also included in Chapter 17.

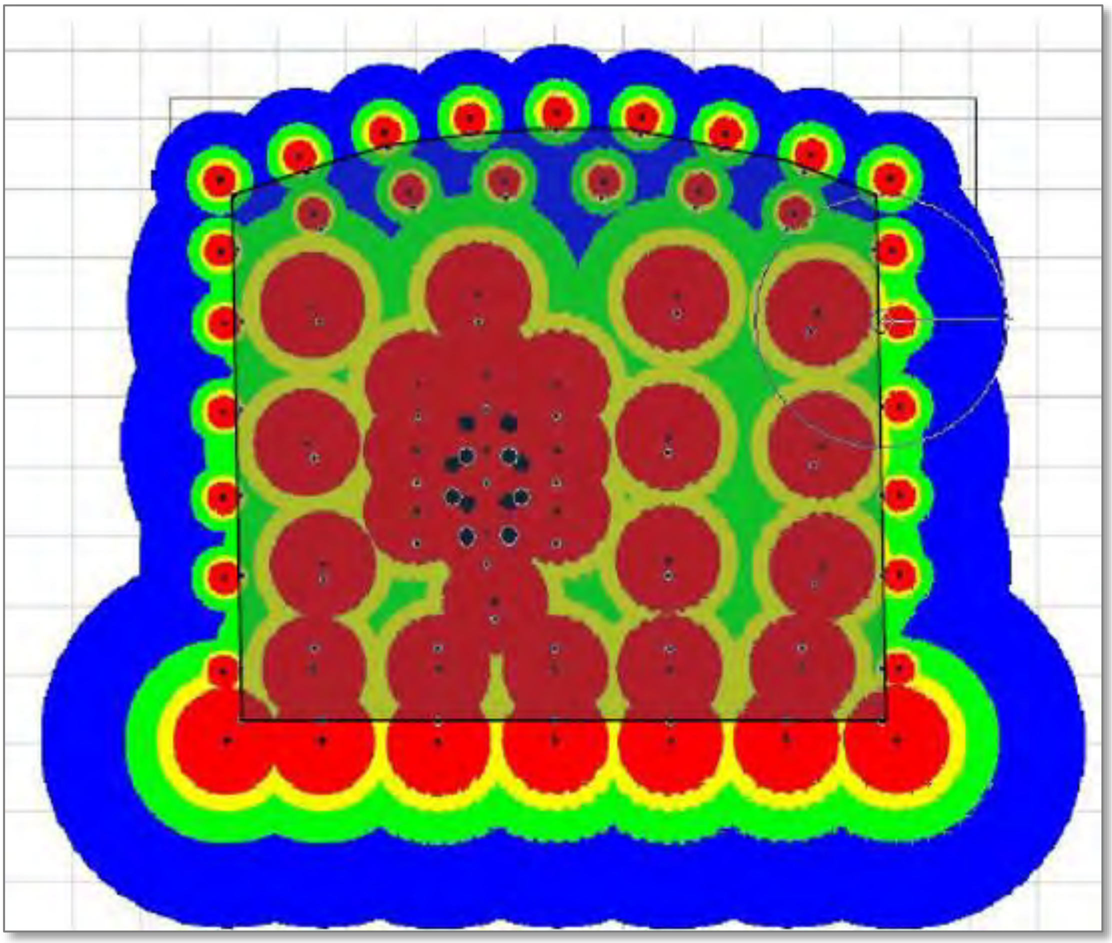


FIGURE 3-79 | EXAMPLE OF MODELLING A DEVELOPMENT HEADING BLAST AND THE ZONE OF IMPACT AROUND THE DRIVE PERIMETER. (SAROS, 2017)

With respect to blasting activities and the vibration and overpressure impacts, the typical compliance limits, based on Australian Standards, that the Bird in Hand Mine would be required to comply with are as follows:

- Ground Vibration – Not to exceed 5mm/s for 95% of occasions, with an upper limit of 10mm/s
- Air Overpressure – Not to exceed 115dBL for 95% of occasions, with an upper limit of 120dBL

Part of the mitigation of these impacts include correct explosive selection.

3.4.4.2 EXPLOSIVE SELECTION

Before selecting the explosive product to be used, there are a number of site specific details that must be taken into consideration to ensure the blast design is suitable. The blast design and hence the explosive selection will be based on:

- Fragmentation desired – the fragmentation must be suitable for the equipment handling the broken rock, including where secondary breakage is available (crushing and screening);

- Rock quality/character – the types and properties of the rock to be encountered in the excavation of the mine design will vary, including hardness, joints and fractures, ground water present etc.;
- Site limitations – Selection will be dependent on the proximity to nearby structures and other sensitive receivers;
- Safety limitations – fly rock protection, ventilation requirements, traffic management;
- Equipment/materials limitations – what equipment is drilling the charge holes, how accurate are they, product sources, what methods are available to charge holes etc.

Typical types of explosive products used will include:

- Bulk product (i.e. ANFO);
- Packaged explosives i.e. Orica's Sentinel™;
- Detonators – Nonel and Electronic;
- Primers and Pre-cast boosters;
- Packaged explosives – gel and emulsion;
- Detonating cord.

The explosives selected for the BIH operation are ANFO and pre-packaged Emulsion type products based on the potentially wet conditions expected to be encountered.

3.4.4.3 TIMING AND FREQUENCY OF BLASTING

The initial blasts occurring at BIH will be close to the surface, so these will be limited to daytime hours as needed in order to comply with noise limits on site.

Once the mining progresses further underground, and the risk of disturbance due to noise and overpressure to receptors is reduced, development firings will be undertaken over a 24-hour period, generally at the end of each shift, subject to safety and operational considerations at the time. Any larger firings, such as ventilation rises, ore passes or other required mining voids would be fired during daytime hours.

FIGURE 3-80 | TYPICAL UNDERGROUND DEVELOPMENT FACE DRILLED OUT AND CHARGED, READY FOR FIRING (ANGAS ZINC MINE, TERRAMIN)

3.4.4.4 SIZE OF BLASTS

A summary of the expected blast sizes is shown in Table 3-17. The impact of these blasts have been modelled as part of the Blasting Impact Assessment undertaken by Saros (Appendix P1). The majority of blasts at BIH will generally be development type blasts due to the nature of the mining method selected (cut and fill). These blasts are expected to require ~250kg equivalent of ANFO explosives per face.

Larger blasts may be required during the mining of capital infrastructure such as internal ore passes and ventilation raises. These are likely to use larger holes (76mm-102mm) and larger blasts (~600kg based on quantities used at AZM for one firing of ventilation rises).

The quantities of explosives will be determined with blast modelling as designs and ground conditions are further refined, and firings will be adjusted to minimise vibration and overpressure impacts to identified receptors. Modelling undertaken to date, indicates that a standard development firing will not exceed regulated vibration limits at these points (Appendix P1)

TABLE 3-17 | TYPICAL BLAST DESIGN DETAILS (BASED ON 100% ANFO USAGE)

	Units	Development face	4 x 4m raise
Hole size	mm	45	89
Hole charge depth	m	3	5
Charge density	kg/m^3	0.9	1.2
Weight/hole	kg	4.3	37.3
Charge holes/face	holes	64	16
Weight/face	kg	270	600

3.4.4.5 EXPLOSIVES MAGAZINE COMPOUND

The design of the explosive storage facility is directed by:

- Discussions with potential suppliers and operator of explosive facilities
- Discussions held with the Dangerous Substances Team (SafeWork SA), advised using QLD and WA regulations as guidelines for the Project's design.

The facility will comply with the *South Australian Explosives Act 1936*, *Explosives Regulation 1996* and Australian Standard *AS 2187.2-2006: Explosives – Storage and Use – Use of Explosives* (AS 2187)

Licenced storage facilities, transport vehicles and handlers, as well as licences to purchase will be required for the explosives products to be used at BIH. Due to the proximity of the site to nearby public roads, businesses and local residences, the maximum quantity allowed to be stored on surface will be limited to less than efficient quantities (*South Australian Explosives Regulations 201*1, v1.7.2016, Schedule T). Hence alternative storage facilities are required. The plan is to incorporate the existing AZM licenced magazines at Strathalbyn and an underground magazine located at the BIH site.

The magazine will be located an acceptable distance from major service installations so the possible effects of an explosion will not adversely impact upon, electrical substations, pump stations, ventilation equipment or other important infrastructure (AS 2187.1). It will also be located as close to the surface as possible to allow installation as soon as possible and remove the need for transporting explosives products between sites. Risk acceptability will be evaluated based on the quantity of explosives stored in the magazine and the direct distance through rock and along openings. (Lovitt, 2014).

3.4.4.5.1 AZM MAGAZINES

Currently there are still 3 licenced magazine buildings within the compound located at the Strathalbyn site (Figure 3-81).

Daily quantities of explosives required at the BIH will be transported via road vehicles to the BIH on a "just in time" basis, following the same route as the ore haulage trucks.

All facilities, vehicles, users, purchasers will be subject to the legislated requirements for licencing and operation of such activities (SafeWork SA, etc.).

FIGURE 3-81 | VIEW OF THE EXISTING LICENCED MAGAZINE COMPOUNDS AT AZM

3.4.4.6 BLASTING LOCATIONS AT BIH

3.4.4.6.1 SURFACE

Mechanical excavation methods are expected to be sufficient for the proposed earthworks and excavations on the surface, however should harder material be encountered, surface blasting may be required (i.e. boxcut excavation – Figure 3-82). Further geotechnical investigations are required to determine exact properties of material to be mined.

FIGURE 3-82 | FIRING OF INITIAL DECLINE CUT IN A BOXCUT (AMPT SERVICES, 2017)

3.4.4.6.2 UNDERGROUND

It is expected that all development will be undertaken with drill and blasting activities. The type and quantity of explosive used in each case will be selected based on the requirements:

- Decline;
- Drives;
- Chambers;
- Internal ventilation raises;
- Internal Ore passes;
- Stripping (backs, walls, sumps, etc.); and
- Secondary rock breakage – in cases where mechanical methods are not possible.

Exceptions where blasting will not occur will include:

- Raise bored rises – proposed to be used for the internal egress system as they resultant surface is much smoother for the installation of ladder ways, and retains better ground conditions for personnel using the ladder way; and
- Service holes – will be installed using drill rigs and possibly raise bore drilling depending on sizing required.

3.4.5 TYPE OF MINING EQUIPMENT

The vehicle and equipment fleet of the mine operator and associated contractors (where applicable) will vary during the life of the project, and will be subject to technological advances, industry practices and project requirements, however an indicative mobile equipment list is provided in Table 3-18.

3.4.5.1 MOBILE

Table 3-18 summarises the types and numbers of typical mobile fleet proposed for the Project at the different stages.

TABLE 3-18 | INDICATIVE MOBILE FLEET

Equipment Description	Number of units – Construction	Number of units – Production	Number of units – Closure/Rehab
Tracked excavator (20t)	1		1
Tracked excavator/backhoe (small – trenches etc.)	1		1
Surface Haul trucks (30/40t)	2		1
Dozer	1		1
Crane	1	**	1
Diesel Generators	2	1	2
Surface drill rig (service holes)	1		
Roller	1		1
Development Drill rig (Sandvik DD421)	1	2	
Grader (Cat 12H)	1	1	1
Surface Loader (Cat 966H)	1	1	1
Light vehicle (Toyota Hilux)	3	7	4
Telehandler (Faresin 17-40)	1	1	1
Water Truck (7000L)	1	1	1
Cable bolting/grouting drill (Atlas Copco Cabletec LC)		1	
Underground Loader (Cat R1700G)	-	2	
Underground 30t Ejector Truck (Cat AD30)	-	2	
Integrated tool carrier (Volvo L120c)		1	
Shotcreter (Normet Spraymec 6050 WP)		1	
Explosive Charging vehicle (Normet Charmec 6605B)		1	

** Note: the final number of vehicles will vary dependent on operational requirements, and further defined through Feasibility Studies.

3.4.5.2 FIXED

3.4.5.2.1 ORE HANDLING

The proposed ore handling infrastructure is illustrated in Figure 3-83 and will be located on the surface close to the portal. Further details can be found in section 3.5.3 Conveyors and pipelines and 3.5.4 Stockpiles, however the basic list of the components include:

- ROM pass;
- ROM conveyor;
- ROM Silo;
- Ore Hopper;
- Ore conveyor; and
- Weightometer.

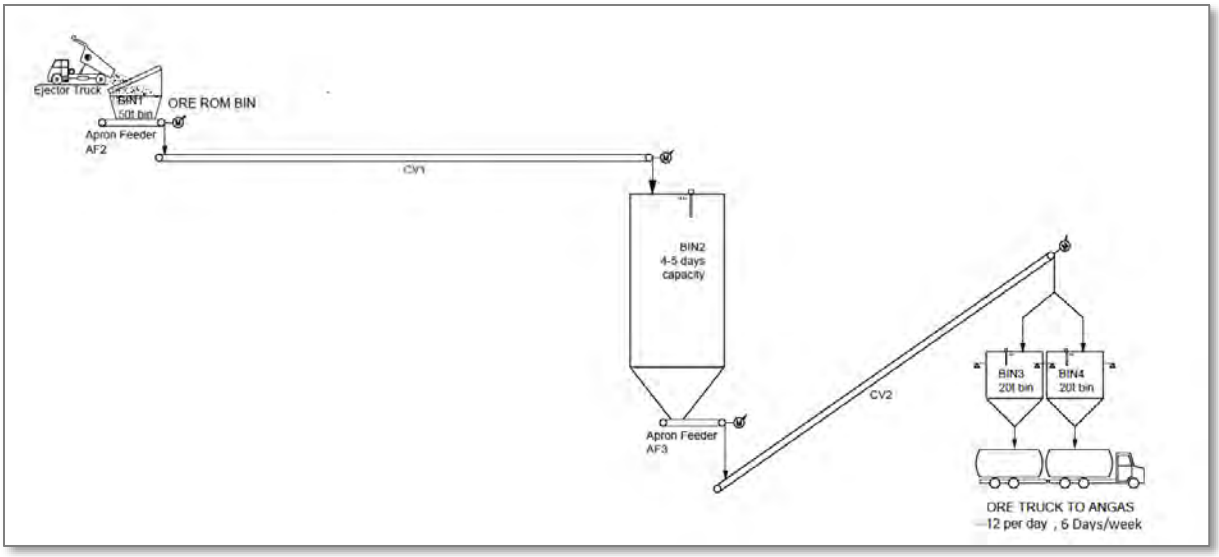


FIGURE 3-83 | PLANNED CONVEYOR SYSTEMS FOR THE BIH GOLD PROJECT ROM (AMMJOHN PTY LTD, 2016)

3.4.5.2.2 WATER TREATMENT FACILITY

Details regarding the proposed water treatment plant for the site are discussed in Section 3.7.9.5 and in Appendix J1.

The following is a list of the typical types of fixed infrastructure that is required for the process:

- Dams;
- Pumps;
- Clarifiers;
- Tanks;
- Ion exchange unit;
- Bio-Filter units; and
- Storage and handling facilities for chemicals etc. used in the process.

3.4.5.2.3 BATCHING PLANT

Conceptual design specifications and sizing of the of the batching pant has been based on estimations for all cement production required during the life of the mine, including but not limited to CRF sill pillars, fibrecrete, concrete blocks and tip blocks. The batching plant design has not taken into account it being used to produce concrete for surface civil works such as footings or pre-fabricated concrete panels.

The required materials will be formulated according to purpose, the ingredients combined into agitator trucks for delivery to the application location underground.

All runoff from the concrete batching plant will be directed to the storage dam and not be allowed to discharge to the stormwater management system.

Options considered for the batching plant included:

Extremal Batching: This would require up to 11 agitator loads per day delivered to site, from local suppliers (i.e. Direct Mix at Littlehampton), at all times throughout the 24 hour period. Although this provides the most cost effective option for the Project, impacts on local receptors, through noise, traffic movements etc. were the main reason for not considering this option further.

Wet Batching: The use of a full wet batching facility is available. However, the plant would be extremely under-utilised. The smallest plants currently available are capable of mixing 40m^3/hr. Current schedule estimates for the Project requires up to 45m^3/day. This type of facility is also the most capital intensive option.

Dry Batching: Local suppliers are capable of dispatching a dry mix for both CRF and shotcrete from their plant into agitators, with cement added on site prior to its use. Large agitators can hold approximately 7.5m^3 of material, delivering approximately 16t of aggregate per load. Based on 1-4 headings per day this equates to 1 aggregate deliver approximately every 1-3 days. Alternatives are to stockpile aggregate at Angas Zinc Mine and backload ore trucks to decrease traffic inputs to site.

Mixed Method: A combined approach would involve setting up a simple batching facility for CRF production on site. This would involve a cement silo with a weigh hopper and water dosage device. The shotcrete production would be undertaken by local suppliers at Littlehampton. This option reduces the trucks required on the roads whilst minimising the infrastructure required onsite.

At this stage the site has been designed using the Dry Batching option, and typical plant is illustrated in Figure 3-84. With the noise modelling that was undertaken for the project, it was recommended that the noisier aspects of the batching plant (conveyor/feeders/hoppers etc.) be constructed with noise screening or possibly placing the plant under cover to reduce noise emissions. This will be factored into the final design of the plant prior to PEPR submission.

FIGURE 3-84 | BACKFILL BATCHING PLANT SHOWING A SIMILAR SET UP TO THE CONCEPT BEING DEVELOPED FOR BIH (UTRANAZZ, 2016)

- Horizontal cement silo;
- Aggregate hoppers with screw feeders; and
- Wash down facilities for agitator vehicles.

3.4.5.2.4 RE-FUELLING STATION AND WASH BAY

Re-fuelling facilities will be made available for plant and vehicles on site, including both heavy vehicles and light vehicles. Wash down facilities will also be constructed for cleaning equipment and vehicles. These areas will be located close to the workshop and go line areas and will consist of the following:

- Fuel storage tank; and
- Pressure washer.

3.4.5.2.5 WORKSHOP

The requirements for a maintenance workshop are not significant due to the size of the fleet and operation proposed at BIH. It is proposed that a shed will be constructed similar style to the existing sheds in the area Figure 3-85. The workshop will be sized and positioned appropriately for the underground operations and will provide facilities for maintenance of the mobile fleet, capacity for fixed plant maintenance, boilermaker and electrical maintenance. At least one of the bays will allow for drive through access to the workshop and all accesses will have doors to aid in noise mitigation, particularly at night. Where economic and possible to do so, elements of the surface workshop at Angas, such as the overhead 25t crane will be relocated to the Bird-in-Hand site. The surface workshop components at BIH will include:

- Overhead crane;
- Air compressor;
- Electricians bay;
- Hot Work area; and
- Bit sharpening facility.

FIGURE 3-85 | TYPICAL WORKSHOP PROPOSED FOR THE BIH SITE (TERRAMIN, 2017)

3.4.5.2.6 EMERGENCY EGRESS SYSTEM

The emergency egress system will include:

- Ladder way from underground levels (Figure 3-46);
- Communications (phone, radio etc.);
- Independent ventilation fan (located underground); and
- Refuge chamber(s) (Figure 3-47) as and where access to egress is limited.

3.4.5.2.7 MINE DEWATERING

The mine dewatering system is described further in 3.4.6 Mine Dewatering. However, basic equipment includes:

- Pumps – various depending on requirements; and
- Tanks.

3.4.5.2.8 VENTILATION

Except for the initial stages of the decline development, ventilation equipment will be located underground. Further detail is included in section 3.4.2.4 Ventilation. Main items include:

- Primary fans – 2 x 200kW fans located ~120m underground in a dedicated ventilation return drive, access from the main decline; and
- Secondary fans – 110kW, 55kW etc.

3.4.5.2.9 ELECTRICAL

Various pieces of fixed infrastructure (Figure 3-86) will be required for the electrical reticulation system and further details on the planned infrastructure are discussed in Section 3.7.4.4 and Section 3.11.2, but in brief will include:

- Substations;
- Distribution boxes;
- Control Panels;
- Communications (leaky feeder, telephones, PLC (Programmable Logic Controller) systems), and;
- Starter boxes ("Jumbo boxes") (Figure 3-87)

FIGURE 3-86 | EXAMPLE OF TYPICAL UNDERGROUND ELECTRICAL INFRASTRUCTURE FOR ELECTRICITY RETICULATION.

FIGURE 3-87 | EXAMPLE OF A JUMBO STARTER AND PUMP STARTER BOX USED UNDERGROUND

3.4.5.3 NOISE OUTPUTS

Typical noise levels are listed in the Bird-in-Hand Gold Mine – Noise Impact Assessment Report (Appendix O3) and are summarised in Table 3-19 and Table 3-20.

The equipment selections listed below are indicative only and therefore may not be the exact model used on site. Where equipment selections have not been listed, generic sound power levels have been provided.

TABLE 3-19 | NOISE SOURCE SOUND POWER LEVELS – SURFACE CONSTRUCTION PHASE (APPENDIX O3)

Equipment	Number	Sound Power Level (each)	Notes
Surface trucks	2	108	Trucks located along the site access road
Excavators	2	110	Located at the box cut and dam
Franna	2	98	Located at office/workshop and WTP
Scraper	1	110	Located on the mounds
Grader	1	113	Located on the site roads
Cement trucks	2	109	Located at office/workshop and box cut
Road paver	1	114	Located on the site access road
Water trucks	1	107	Located on the site roads
Rollers	1	109	Located on the site roads

TABLE 3-20 | NOISE SOURCE SOUND POWER LEVELS – UNDERGROUND DEVELOPMENT AND ORE PRODUCTION PHASES (APPENDIX O3)

Item	Sound Power Level (dB) at Octave Band Centre Frequency (Hz)								
	63	125	250	500	1k	2k	4k	8k	Overall (dB)(A))
Magazine fan (Outlet)[1]	87	89	85	88	83	83	78	93	88
Road Truck (B-double)[2]	113	110	104	105	110	107	101		113
Road Truck Idling	96	88	84	90	89	85	80		93
Delivery Truck	110	107	101	102	107	104	98		110
Delivery Truck Idling	93	85	81	87	86	82	77		90
Front end Loader (CAT 966K with low noise package)	115	114	110	105	102	100	94		108
ADT (Volvo A40E)	107	107	105	98	100	99	93		112
IT Carrier (Volvo L120)	108	109	105	102	99	97	92		112
Forklift	82	88	91	95	99	97	92		103
Water Truck	101	102	96	100	94	95	91		101
Cement Mixer Truck	108	101	99	100	99	101	93	87	105
Cement Mixer Truck Idling	101	91	86	93	93	88	83		96
Toyota (Light Vehicle)				103					100
Conveyer Drive		83	86	87	88	89			93
Conveyer Line Source (per metre)	56	60	63	73	68	65	56		73
Dump into ROM BIN	110	110	107	104	102	99	95	86	107
Air Compressor[3]				79					76
Workshop (SPL)[4]	67	79	69	72	74	69	69	67	78
Batching Plant	104	109	112	107	104	102	96		110
1 x Pump (50kW)[5]	81	83	85	84	88	85	81		91
1 x Pump (50kW)[6]	84	86	88	87	91	88	84		94
Drill Rig (surface / services / longhole)[7]	102	103	100	100	101	102	102		108
Raise Borer[8]	110	111	109	108	110	111	111		117

1 Fantech AP16010DP9/25
2 It is intended to use a smaller 32 tonne truck and trailer combination, modelling has been undertaken with the larger B-double as a worst case noise modelling scenario
3 compare L160
4 Internal reverberant Sound Pressure Level
5 Used for raw water pump and water treatment plant
6 Used for was-down pad pump
7 Ditch Witch JT60 Directional drill
8 Atlas Copco L9 Jumbo drill. Based on advice by Terramin, these units are typically louder than a raise borer and therefor this is a conservative modelling approach

3.4.5.4 EXHAUST OUTPUTS

A summary of the emission outputs for the proposed equipment types are summarised in Table 3-21. These are the values used in the Air Quality Impact Assessment modelling included in Appendix N3

TABLE 3-21 | SUMMARY OF EMISSION RATES BY ACTIVITY (APPENDIX N3)

Activity	Emission rate (g/s)		
	TSP	PM_{10}	$PM_{2.5}$
Construction			
Drilling	0.03	0.016	0.002
Blasting	0.002	0.001	0.0001
Scraper	0.03	0.01	0.001
Excavate and load trucks with excavator	0.002	0.001	0.000
Move mullock around with trucks - loaded	0.12	0.03	0.003
Trucks move around - unloaded	0.08	0.02	0.002
Trucks dumping material on IML	0.22	0.08	0.01
Dozer on IML	0.21	0.04	0.01
Concrete batching	0.013	0.0037	0.0006
Wind erosion	0.13	0.07	0.01
Operation			
Primary vent shaft	0.25	0.12	0.06
Underground Magazine vent shaft	0.03	0.02	0.01
Trucks haul ROM ore to ROM bin (surface component only)	0.023	0.007	0.001
Trucks dump ore into ROM bin	0.017	0.006	0.001
Transfer points in ROM bin	0.004	0.002	0.0003
Trucks haul mullock to IML (surface component only)	0.409	0.121	0.012
Trucks dump mullock onto IML	0.09	0.03	0.005
Concrete batching	0.013	0.0037	0.0006
Wind erosion	0.21	0.11	0.02
Grader	0.09	0.04	0.01
Dozer on IML	0.21	0.04	0.007

3.4.5.5 VIBRATION

Work undertaken by Saros for the Blasting Impact Assessment (Appendix P1) states the impact from the proposed mining equipment to be relatively small or negligible due to the size of the proposed fleet and the distances to sensitive receptors. Thus they were not included in the modelling.

3.4.5.6 FIRE IGNITION SOURCES

As stated by Grant, (Grant, 2011) fires on diesel-powered mining equipment typically arise from leaking high-pressure hydraulic lines which can spray a heated mist of highly combustible liquid onto an ignition source, such as a hot exhaust manifold or turbocharger.

Much of the mobile equipment used in underground mines contains not only fuel sources (e.g., diesel fuel and hydraulics) but they also contain ignition sources (e.g., diesel engines and electrical equipment). Thus, this equipment presents an appreciable risk for fires.

Fire ignition sources for mobile equipment includes, but is not limited to:

- Overheating engines;
- Oil/Fuel spills/leaks on hot machinery components;
- Overheated tyres;
- Collision with other vehicles;
- Collision/contact with power cables; and
- Rubbish build up on or near hot machinery components.

These hazards will be managed through the use of well maintained, fit for purpose vehicles, fitted with the appropriate fire suppression systems, as well as trained competent operators. The site will have policies and procedures for maintaining vehicle condition, vehicle operation as well as for the handling of incidents in the case of fire occurring.

Similar management principles will be applied with the fixed plant and equipment used within the operation.

3.4.5.7 FUEL BURN ESTIMATES

Estimated annual fuel estimates for the fleet are summarised in Table 3-22.

TABLE 3-22 ESTIMATED ANNUAL FUEL CONSUMPTION DURING EACH PROJECT PHASE FOR MOBILE FLEET

Equipment Description	Estimated Annual Construction fuel consumption (kL)	Estimated Annual Production fuel consumption (kL)	Estimated Annual Closure/Rehab fuel consumption (kL)
Tracked excavator (20t)	75	75	75
Tracked excavator/backhoe (small – trenches etc.)	51	-	51
Surface Haul trucks (30t)	336	-	168
Dozer (Wheeled) (8-10.6m2 blade)	268	-	268
Crane – 200t	99	-	99
Crane – 20t	140	-	140
Diesel Generators	123	61	123
Surface drill rig (service holes)	75	-	-
Roller	171	-	171
Development Drill rig (Sandvik DD421)	75	150	-

Grader (Cat 12H)	84	84	84
Surface Loader (Cat 966H)	145	145	145
Light vehicle (Toyota Hilux)	225	526	301
Telehandler (Faresin 17-40)	64	64	64
Water Truck (7000L)	75	75	75
Cable bolting/grouting drill (Atlas Copco Cabletec LC)	-	82	-
Underground Loader (Cat R1700G)	-	359	-
Underground 30t Ejector Truck (Cat AD30)	-	417	-
Integrated tool carrier (Volvo L120c)	-	102	-
Shotcreter (Normet Spraymec 6050 WP)	-	66	-
Explosive Charging vehicle (Normet Charmec 6605B)	-	66	-
Totals	2,007	2,272	1,764

3.4.6 Mine Dewatering

Mine de-watering is the removal of any water within the mine excavation from any source. This includes but is not limited to:

- Groundwater inflows
- Equipment supply (heat, wash down etc.)
- Environmental management processes (dust, heat etc.)

The values use for the modelling and design of the mine dewatering system are based on the work undertaken by.

- AGT – Groundwater Modelling – Appendix H1
- Golder – MAR Investigation – Appendix H9
- Multigrout – expected effectiveness of grouting – Appendix H4
- Mining One – Geotechnical – Appendix M1

Control measures proposed to manage, limit or remedy groundwater impact events must be peer reviewed by a suitably qualified independent expert as required by the Ministerial Determination. Terramin have undertaken peer reviews on the grouting, the groundwater assessment, the managed aquifer recharge strategy and the site water balance. Peer reviewers were chosen for their qualifications and experience in the requisite areas. All peer reviewers qualifications are included in their respective reports.

In regards to the groundwater model, the final independent peer review report must include; an assessment of whether the model is fit for purpose, verification of model inputs, the results of the review of the model against Tables 9-1 and 9-2 of the Australian groundwater modelling guidelines (National Water Commission Waterlines Report Series No. 82, June 2012), the scope of the review and details of any actions undertaken as a consequence of the findings of the review. This has been completed by Innovative Groundwater Solutions during 2017, and again in 2019 with the updated groundwater model.

Peer reviews undertaken have been included in Table 3-23.

TABLE 3-23 | PEER REVIEWS UNDERTAKEN

Water Management Strategy	Report/Assessment	Peer Review
Grouting	Bird in Hand Gold Project – Grouting for Groundwater Control, Multigrout (Appendix H4)	Bird in Hand Gold Project – External Review – Proposed Grouting Programme, Golder Associates (Appendix H5)
Groundwater Modelling and Impact Assessment (including MAR modelling)	Groundwater Impact Assessment for the Bird in Hand Project, AGT (Appendix H1)	Outcomes of Peer Review of Bird in Hand Gold Project Groundwater Assessment Report, Innovative Groundwater Solutions (Appendix H2 and H3)
Site water balance	Water Balance, Terramin (Appendix K1)	Review of Mine Water Balance Model for BIH Project, Golder Associates (Appendix K2)
Managed Aquifer Recharge System	Bird in Hand Gold Project – Investigation into Managed Aquifer Recharge, Golder Associates (Appendix H9)	Independent peer review of updated modelling for the Bird-in-Hand Gold Project, Innovative Groundwater Solutions (Appendix H10)
Water Treatment Proposal	Water Treatment Options Study Report and Addendum to Water Treatment Options Study Report, GPA Engineering (Appendix J1)	Peer Review Of Water Treatment Options Study, Golder Associates (Appendix J2)

3.4.6.1 MINE WATER BALANCE

A water balance has been developed to illustrate the flow of water throughout the planned operation of the BIH Gold Project. Figure 3-88 shows a conceptual flowsheet, a detailed water balance summary is included in Appendix K1. It is modelled such that various inputs can be adjusted in order to model numerous scenarios including:

- Groundwater inflows;
- Precipitation and evaporation rates;
- Surface areas directed to either water treatment pathways or clean storm water pathways;
- Annual production rates (Ore/mullock moisture content);
- Underground mine usage; and

- MAR quantities.

The logic of the water balance was peer reviewed independently by Golder Associates and was considered as fit for purpose. Details of this review can be found in Appendix K2.

Figure 3-88 illustrates the proposed flow for the Mine Water System, divided into inputs, process and outputs, while Figure 3-89 illustrates the Mine Dewatering System, showing the paths between surface and underground.

Water balance tables for the 70% (Table 3-24) and 90% (Table 3-25) grout effecting groundwater inflow scenarios are listed below showing estimated inflows and outflows.

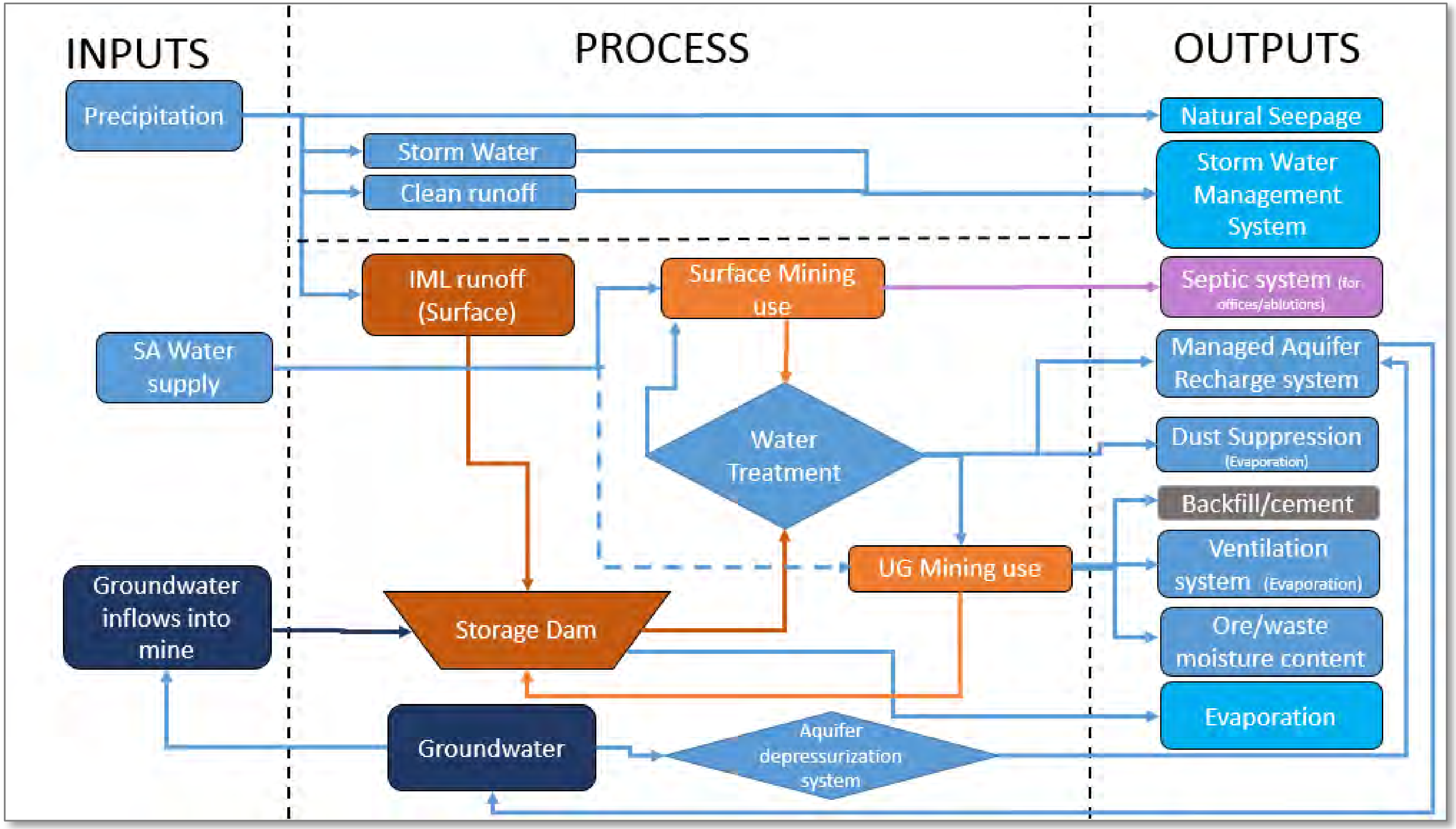


FIGURE 3-88 | CONCEPTUAL SITE WATER FLOWSHEET FOR THE PROJECT ILLUSTRATING THE INPUTS AND OUTPUTS TO THE SYSTEM

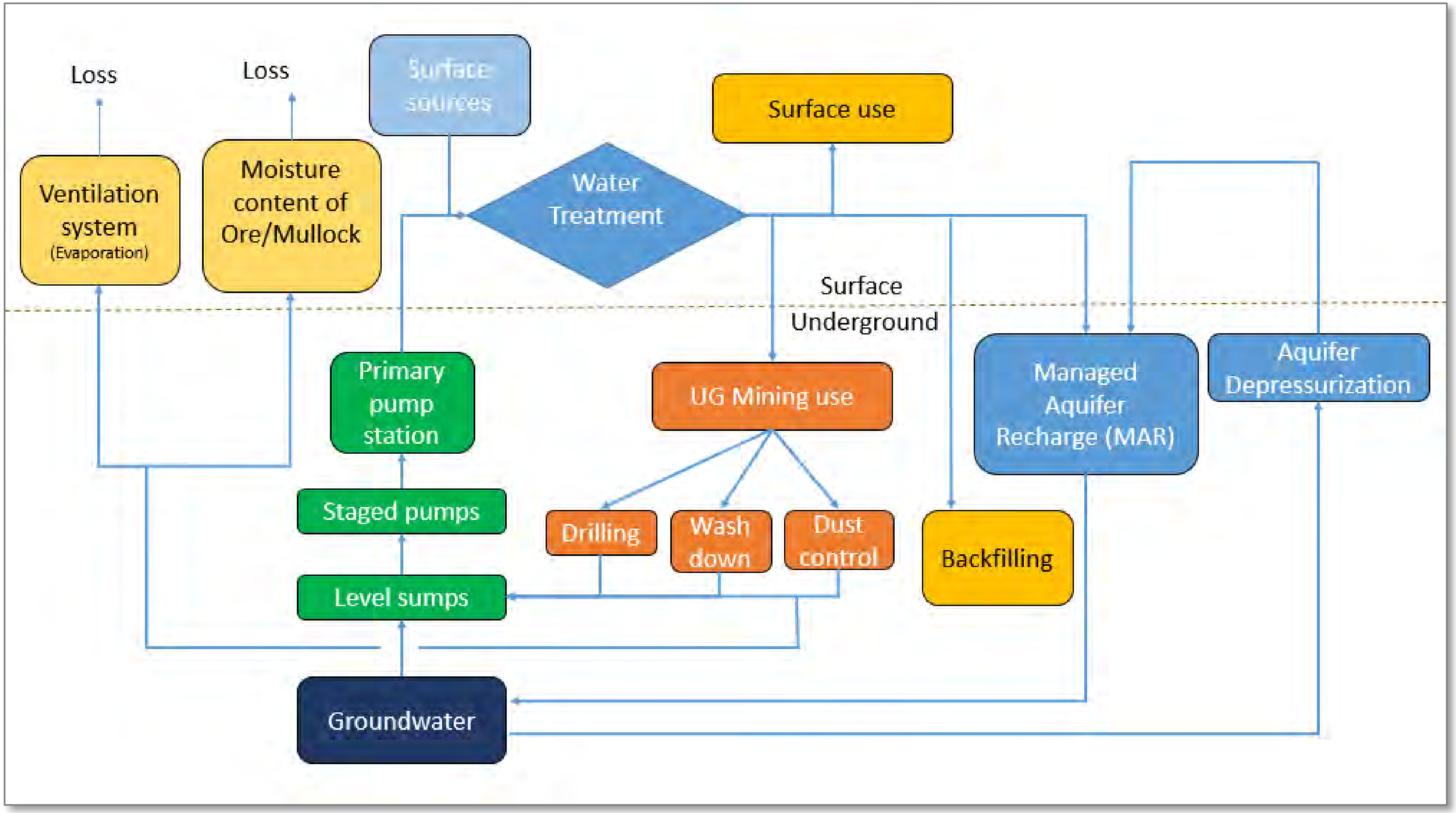


FIGURE 3-89 | CONCEPTUAL FLOWSHEET FOR UNDERGROUND MINE DEWATERING SYSTEM

TABLE 3-24 | YEARLY SUMMARY OF SITE WATER INFLOWS AND OUTFLOWS (90% GROUT EFFICIENCY SCENARIO)

90% with MAR	Year 0 ML/year Inflows	Year 0 ML/year Outflows	Year 1 ML/year Inflows	Year 1 ML/year Outflows	Year 2 ML/year Inflows	Year 2 ML/year Outflows	Year 3 ML/year Inflows	Year 3 ML/year Outflows	Year 4 ML/year Inflows	Year 4 ML/year Outflows	Year 5 ML/year Inflows	Year 5 ML/year Outflows
Precipitation	57		57		57		57		57		57	
UG inflows	-		44		81		113		141		141	
SA Water/rainwater	11		23		33		33		33		36	
Goldwyn bore	15		15		15		15		15		15	
Sewage		11		11		11		11		11		11
Ventilation		23		23		23		23		23		23
Rock moisture		24		24		24		24		24		24
Evaporation (dams)		2		2		2		2		2		2
Seepage (stormwater)		-		0		0		1		1		1
Stormwater Discharge		-		12		20		19		19		21
Backfill (cement)		-		0		1		1		1		2
Waste water from WTP		-		0		1		1		1		1
Site use (dust, wheelwash etc)		24		24		24		24		24		24
MAR		-		44		81		113		141		141
Balance	83	83	139	111	185	199	218	263	246	326	248	360

TABLE 3-25 | YEARLY SUMMARY OF SITE WATER INFLOWS AND OUTFLOWS (70% GROUT EFFICIENCY SCENARIO)

70% with MAR	Year 0 ML/year Inflows	Year 0 ML/year Outflows	Year 1 ML/year Inflows	Year 1 ML/year Outflows	Year 2 ML/year Inflows	Year 2 ML/year Outflows	Year 3 ML/year Inflows	Year 3 ML/year Outflows	Year 4 ML/year Inflows	Year 4 ML/year Outflows	Year 5 ML/year Inflows	Year 5 ML/year Outflows
Precipitation	57		57		57		57		57		57	
UG inflows	-		131		242		339		423		422	
SA Water/rainwater	11		25		36		37		38		42	
Goldwyn bore	15		15		15		15		15		15	
Sewage		11		11		11		11		11		11
Ventilation		23		23		23		23		23		23
Rock moisture		24		24		24		24		24		24
Evaporation (dams)		2		2		2		2		2		2
Seepage (stormwater)		-		1		1		1		2		2
Stormwater Discharge		-		12		20		19		19		21
Backfill (cement)		-		1		2		3		4		5
Waste water from WTP		-		1		2		3		4		4
Site use (dust, wheelwash etc)		24		24		24		24		24		24
MAR		-		131		242		339		423		422
Balance	83	83	228	228	349	350	448	449	533	534	536	537

3.4.6.2 ESTIMATED GROUNDWATER INFLOWS

All technical inflow information is provided in the Groundwater Impact Assessment in Appendix H1 completed by Australian Groundwater Technologies Pty Ltd (AGT), and then updated in 2019 by Golder Associates and included in Appendix H9. This modelling of the groundwater has been peer reviewed by Innovative Groundwater Solutions (IGS) in 2017 and 2019 and their findings are included in Appendices H2, H3 and H10.

The layout of the proposed mine has been designed to avoid the main water bearing structures to minimise groundwater inflows and groundwater impacts. The groundwater model takes this structural feature into account. Particular attention was placed to replicate the separation distance between the hanging wall fracture and Marble which contains the gold reef deposit. Where development occurs near the water bearing structures, probe drilling and grouting ahead of development will be undertaken to control groundwater inflow.

Groundwater that seeps into the mine during operations drilling will be pumped to surface along with water used for mining activities (i.e. drilling), treated to meet the EPA water quality and the DEW well drainage permit requirements and reinjected back into the fractured rock aquifer (FRA) via injection wells in a radial pattern around the mine. Groundwater inflows into the mine come from the Tapley Hill Formation, Marble and the overlying Tarcowie Siltstone.

Several scenarios for grouting effectiveness were modelled as part of the groundwater modelling to determine likely inflows and are summarised in Table 3-27. Expected groundwater inflow calculations are with the assumptions of a MAR system which can received inflows from 90% grouting effectiveness of underground workings. This approach is proposed by Multigrout (Appendix H4), and supported by the peer review by Golder Associates (Appendix H5).

For representation of the underground mine grouting scenarios (90% and 70% grouting effectiveness, as outlined in the grouting proposal (Appendix H4)), drain conductance values in the model were reduced from large values until the desired percentage reduction in total mine inflows was achieved (i.e. as dictated by the grouting scenario). It is important to note that the reduction of drain conductance in the AGT model to meet the MultiGrout grouting effectiveness target (5.5 L/s) resulted in slightly higher modelled inflows of 7.5L/s by the end of mining, however on average the inflows were less on average at 4.5L/s.

Model predictions of groundwater inflow rates (annual average) with pre excavation grouting (90% and 70%) effectiveness are presented on Figure 3-91.

A summary of modelled results for estimated groundwater inflows over the life of the mine with pre excavation grouting (90% and 70% with MAR) from the groundwater modelling work undertaken by AGT (Appendix H1) and updated in 2019 by Golder Associates (Appendix H9) are illustrated in Figure 3-91.

Maximum average estimated inflows which occur approximately 3.5-4.5 years after mining commences:

TABLE 3-26 | PREDICTED ANNUAL AVERAGE GROUNDWATER INFLOWS AND VOLUMES

Year	90% Grout with MAR			70% Grout with MAR		
	ML/y	ML/d	L/s	ML/y	ML/d	L/s
1	44	0.1	1.4	131	0.4	4.1

2	81	0.2	2.6	242	0.7	7.7
3	113	0.3	3.6	339	0.9	10.8
4	141	0.4	4.5	423	1.2	13.4
5	141	0.4	4.5	422	1.2	13.4

TABLE 3-27 | SUMMARY OF GROUTING SCENARIOS USED IN THE GROUNDWATER MODELLING FOR DETERMINING EXPECTED INFLOWS INTO THE MINE (APPENDIX H1 AND H9).

Mining Scenario	Decline – Grouting effectiveness (%)	Active drives – grouting effectiveness (%)	Backfilled drives – grouting effectiveness (%)
No mitigation	0	0	0
No mitigation with 100% backfilled drives	0	0	100 (post mining)
Grouting of decline and drives	70	70	70
Grouting of decline and drives	90	90	90

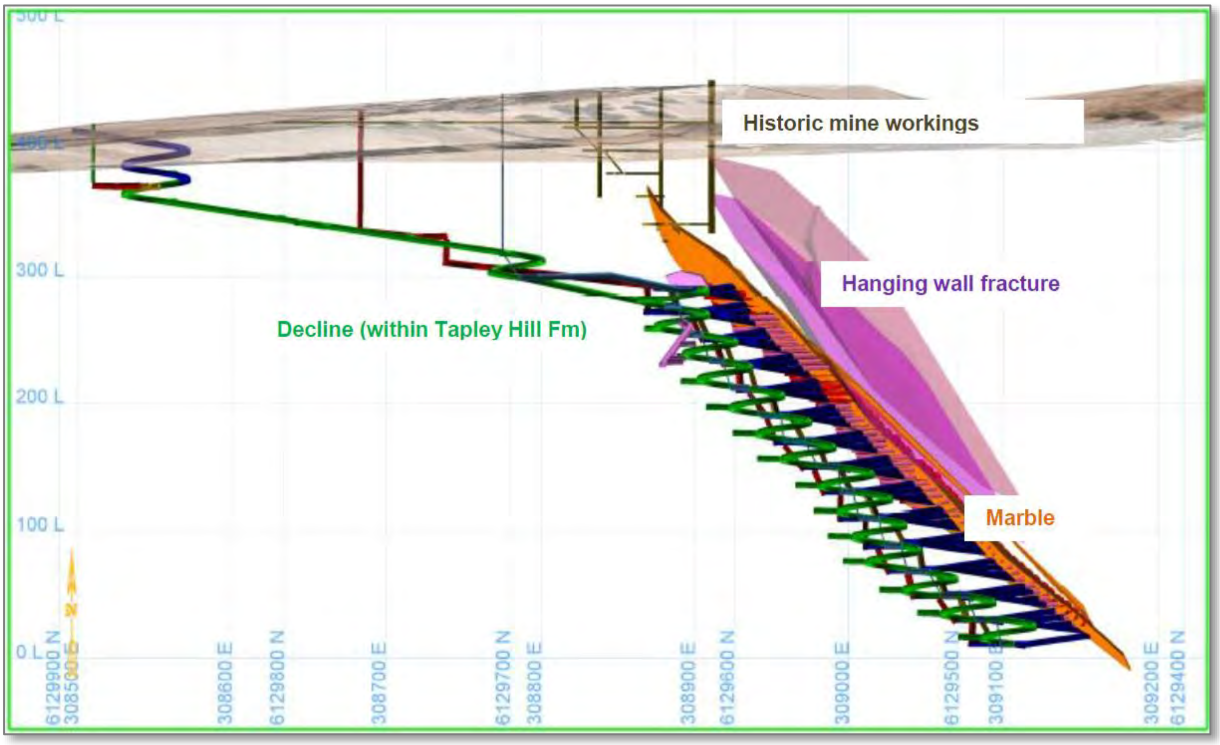


FIGURE 3-90 | UNDERGROUND MINE PLAN SHOWING THE LOCATION OF IDENTIFIED FORMATIONS CONTAINING GROUNDWATER (APPENDIX H1)

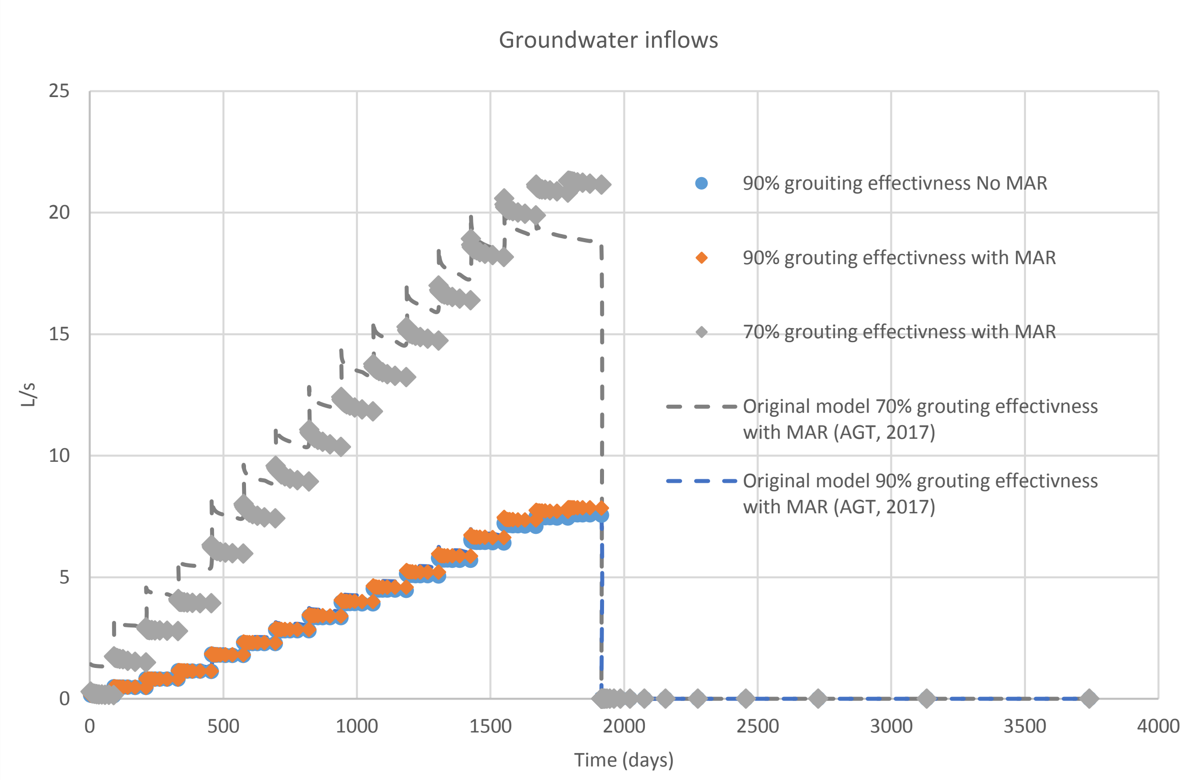


FIGURE 3-91 | SIMULATED GROUNDWATER INFLOWS WITH PRE EXCAVATION GROUTING TO 70% AND 90% GROUTING EFFECTIVENESS (APPENDIX H1)

3.4.6.2.1 SENSITIVITY ANALYSIS

Contingencies are required to manage any unexpected water inrushes effectively from both an environmental and safety aspect. If the hanging wall fault/fracture was intercepted unexpectedly, Terramin would expect to have the situation rectified significantly within the 2 week period to ensure no impact to identified sensitive receptors (existing groundwater users), otherwise operations would need to be suspended until a further solution was identified and approved by the mining regulator. This would be utilising a system such as Sovereign Hydroseal, who specialise in in mine grouting with the sealing of water with high flow rates - leak rates of 10,000 litres per minute have been successfully sealed in underground mines by Sovereign (www.sovereignhydro.com). Terramin expect to continue discussions with Sovereign regarding formalising contingency management plans.

For these reasons, the groundwater management system designed for the BIH Gold Project must meet the following criteria:

- Flexible and expandable to meet potential capacity over the life of the mine;
- Adaptable to be expanded at short notice should unexpected inflows be encountered;
- Provide access for post excavation grouting processes to occur to stem the flows;
- Provide sufficient storage capacity prior to treatment and/or re-injection; and
- Provide for sufficient measuring and monitoring points to identify any leading indicator criteria for both groundwater quality and quantity.

Detailed management of emergency inflows is outlined in Chapter 3: section 3.4.6.7.

Figure 3-92 displays the results of sensitivity analysis targeting the hanging wall fracture, showing the simulated inflows from a 10 m local (non-grouted) area within the hanging wall fracture zone at two representative mining depths: 130 m and 300 m bgl. The simulated inflows indicate that the hanging wall fracture may produce large amounts of water on the order of 50 L/s to 160 L/s, if exposed.

- 50L/s at the upper production level at 130m below ground level (m bgl) or approximately 1.5 years after excavation commences;
- 160L/s at 300m bgl or approximately 3.5 years after underground excavation commences.

These inflows are predicted to be a short term peak if the hanging wall was to be breached. This should not be compared to the "no mitigation" scenario, as the underground mine plan purposely avoids the hanging wall fracture. This scenario would only occur if the underground mine plan was not followed.

The resulting drawdown at 2 weeks following a simulated interception of hanging wall fracture is presented in Figure 3-93 which shows no additional drawdown to any of the identified sensitive receptors (existing groundwater users). This scenario includes the continued operation of the MAR system. Further discussion can be found in Appendix F of the Groundwater Assessment (Appendix H1).

Detailed information regarding groundwater inflows, and how flow rates and volumes were derived, as well as detailed groundwater management and potential groundwater impacts are located in Chapter 10: Groundwater.

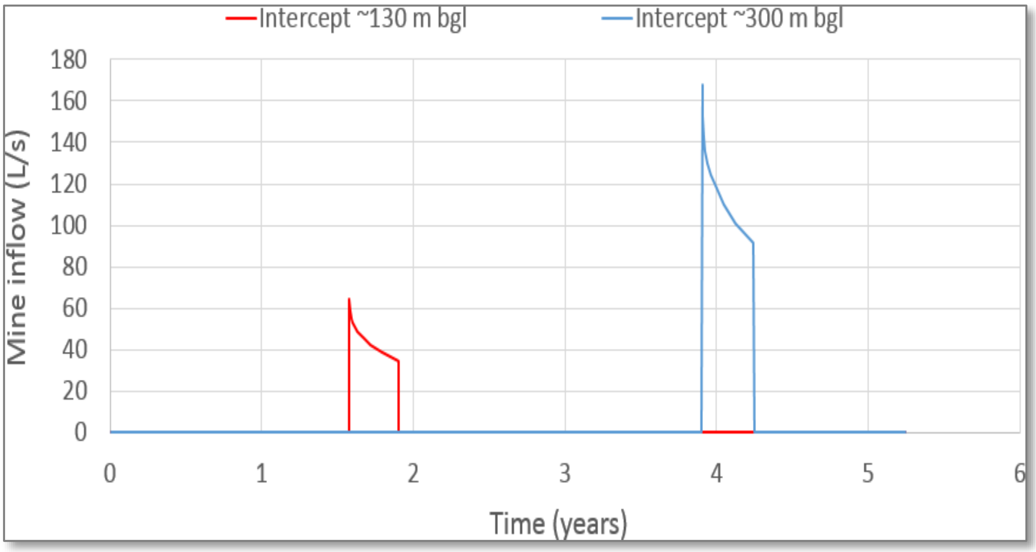


FIGURE 3-92 | GROUNDWATER INFLOWS DUE TO MINING IN THE HANGING WALL FRACTURE WITHOUT GROUTING

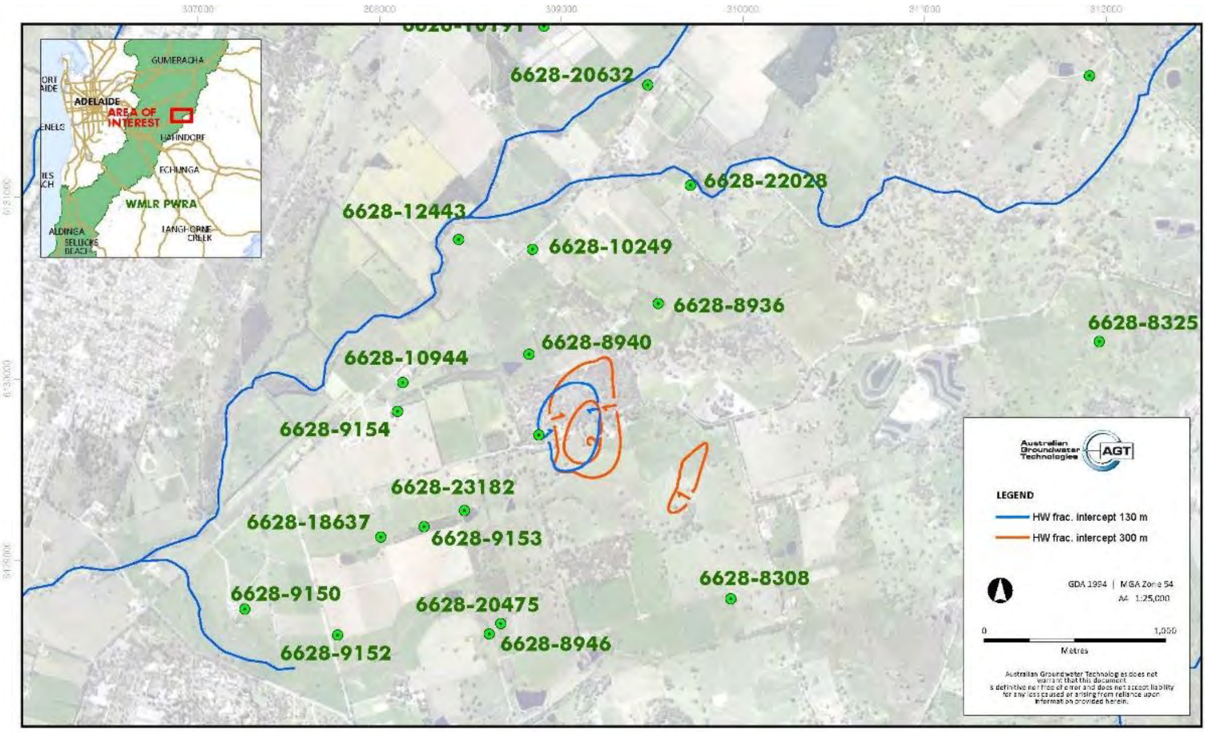


FIGURE 3-93 | DRAWDOWN DIFFERENCE (M) AT 2 WEEKS FOLLOWING SIMULATED INTERCEPTION OF HANGING WALL FRACTURE AT 130 M (BLUE) AND 300 M (ORANGE). (TAPLEY HILL FORMATION; 70% EFFECTIVE GROUT INCL. MAR SCENARIO.)

3.4.6.3 UNDERGROUND DE-WATERING SYSTEM.

As well as the potential for groundwater to enter the underground workings, water use is a requirement of the mining cycle to manage dust and heat from various sources (mobile equipment, blasting, drilling etc.) Drill rigs require a volume of water to cool drill bits and to prevent dust and fired headings required watering down to manage dust during the removal process of the fired rock. A system is required to collect this water, along with any groundwater leakage beyond design and grouting strategies, and pump it to the surface for treatment and recycling.

3.4.6.4 ESTIMATIONS FOR WATER USAGE UNDERGROUND

Estimations for the water demand for underground were broken down according to each type of equipment, with factors applied for water utilisation factor (what % of the time the activity occurs requires water) as well as activity utilisation (i.e. % of the time the activity is occurring). A summary of the equipment considered, the water requirements and the relative factors applied is included below in Table 3-28 to give a total L/s supply requirement.

TABLE 3-28 | WATER USAGE ESTIMATIONS FOR THE UNDERGROUND MINING FLEET AS USED IN THE WATER BALANCE CALCULATIONS

Equipment type	No. of units	Eq. specs (L/m)	Water utilisation factor	Activity utilisation factor	Total L/s	Total ML/yr
Jumbo	2	200	0.4	0.4	2.5	80
Raise bore	1	450	0.2	0.1	0.2	5
Cable-bolter/Longhole rig	1	100	0.3	0.2	0.1	3
Watering down	2	100	0.2	0.1	0.1	2
Leakage		5%			0.1	4
Total					3.0	94

3.4.6.5 STORM WATER ENTERING THE UNDERGROUND MINE

A value for storm water entering the mine has not been included as the catchment area of the portal is significantly small once the boxcut is backfilled and the pre-fabricated tunnel is installed. The gradient of the access will be such that it will direct water away from the portal and into the surface catchment system where it will be directed to the stormwater management system. Onsite catchments have been outlined in 3.7.8 for surface stormwater control.

Other potential entry points, such as ventilation raises, escape way raise and service holes will be designed to have storm water directed away from the shafts/holes.

Natural seepage of storm water into the underground workings is assumed to be included in the estimates for groundwater inflows.

3.4.6.6 UNDERGROUND MINE DEWATERING INFRASTRUCTURE

From the 2017 Groundwater Impact Assessment (Appendix H1) and using the scenario of a 70% effective grouting regime, resulted in a maximum peak inflow of 24l/s, the underground dewatering system has been designed on this plus an additional 14l/s. The additional 14l/s came from doubling of aquifer transmissivity of the Tapley Hill Formation (additional 7 l/s) and doubling of the vertical and horizontal conductivity of the hanging wall fracture zone (additional 7 l/s) was modelled (as part of modelling sensitivity analysis) to provide a worst case scenario to design to. This equated to a total inflow of 38l/s, rounded to 40l/s for ease of design.

This 2019 groundwater model recalibration after the MAR trial resulted in a reduction of these values for annual peak average, however the system will continue to be designed as per above.

Each production level for the BIH Gold Project has been designed with a sump and pump system to be installed (Figure 3-94). The decline will also have sumps included at regular intervals. Drain holes will be drilled between levels (~20-30m in length) to direct the water down to staged pumping levels which will then pump the water up to the final pump level (~100mRL) prior to being pumped to surface. This re-direction of water limits the volume running down the decline and potentially becoming contaminated further with silts etc. from traffic movement in the ramp. It also assists in maintaining road conditions and safety for underground personnel and equipment. For conservatism, the sizing of these pumps have been designed at this stage with the assumption of groundwater inflows equal to that of the inflows with no grouting in place.

From the main pump level (~100mRL), water will be pumped to surface and stored in the surface water dam until it undergoes treatment. Figure 3-95 is a simple conceptual flow diagram showing the interactions between the surface and underground areas.

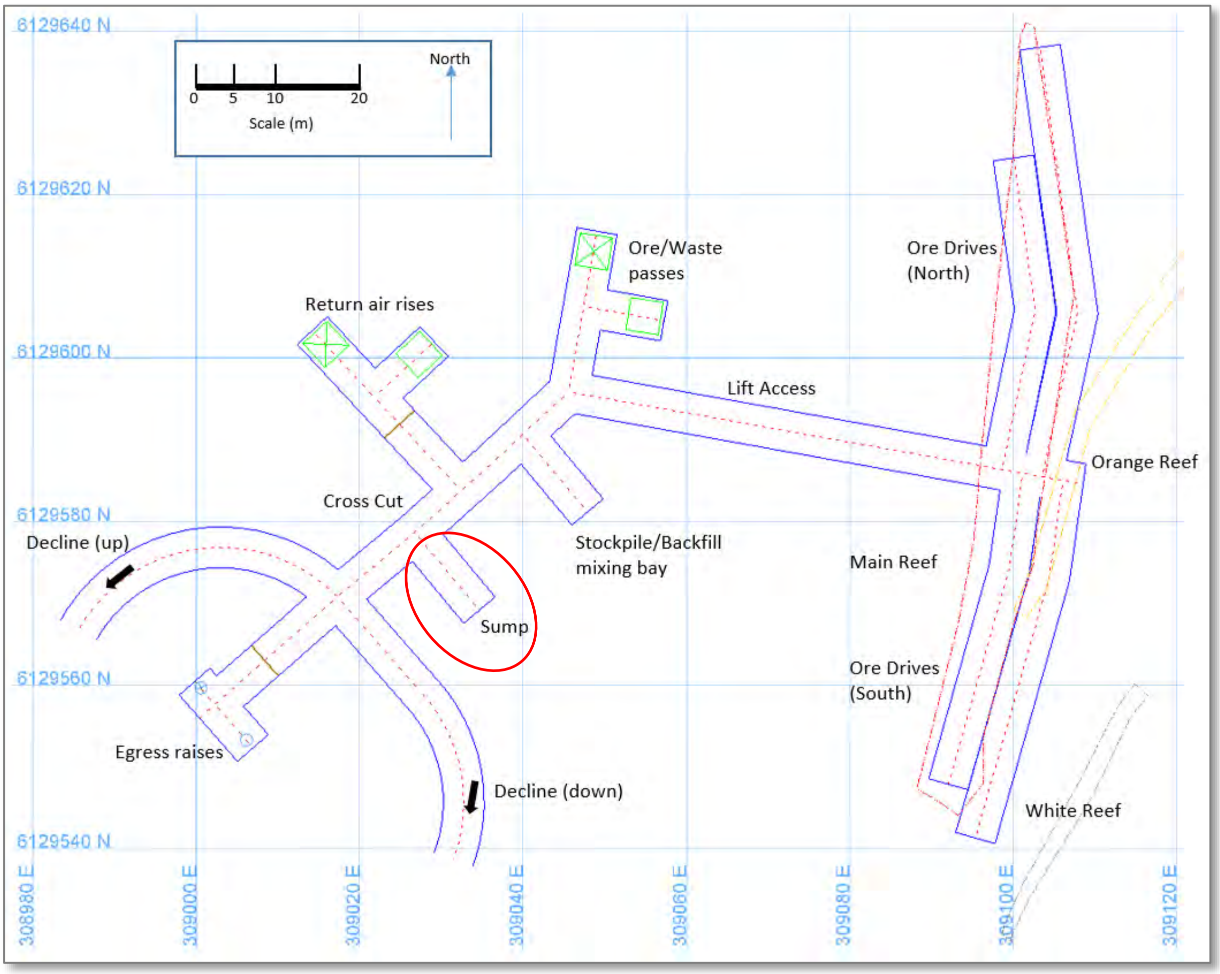


FIGURE 3-94 | TYPICAL CONCEPTUAL LEVEL LAYOUT SHOWING A POSSIBLE LOCATION OF THE SUMP (CIRCLED IN RED) ON A PRODUCTION LEVEL.

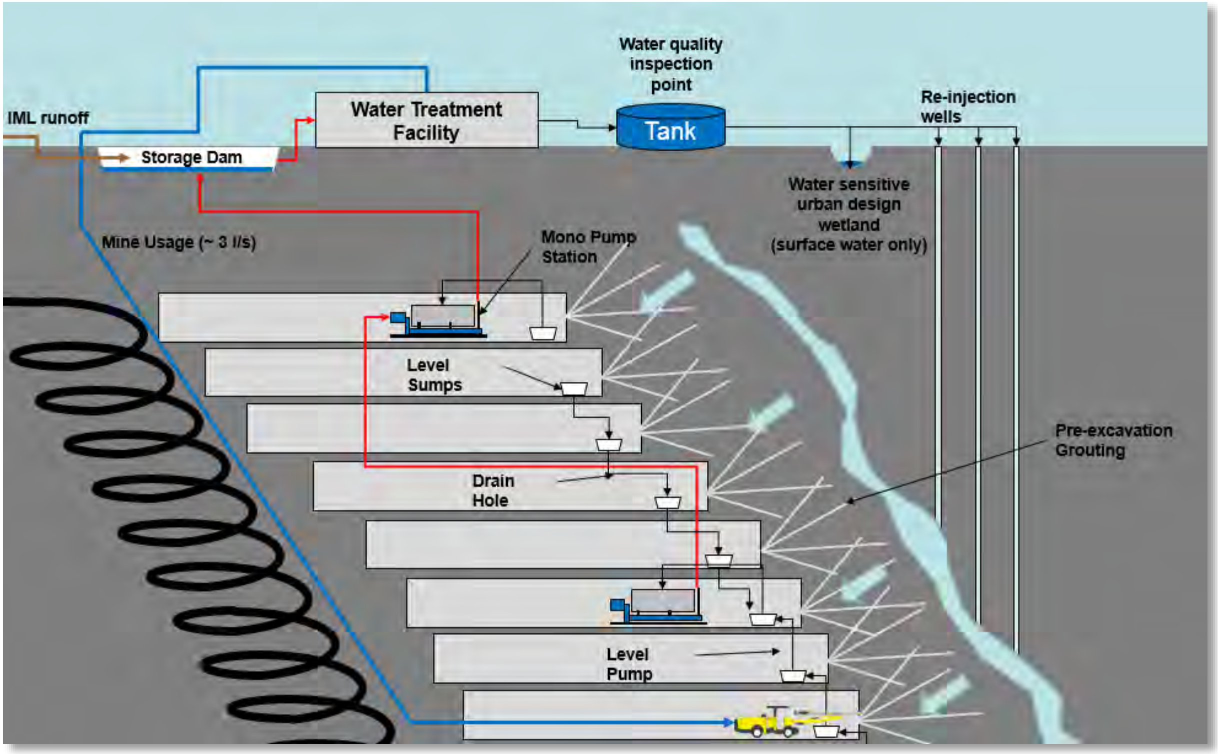


FIGURE 3-95 | CONCEPTUAL FLOW DIAGRAM SHOWING WATER FLOW INTERACTIONS BETWEEN UNDERGROUND AND SURFACE AREAS

3.4.6.6.1 PUMPS

Pumping stations (Figure 3-96) will be constructed at approximately 120m intervals as the mine continues at depth using pump types similar to E103 Mono pumps. Flyght pumps (Figure 3-97) will be used to move water from level sumps below the pumping station up to the pumping station level. Levels above move water down to the pumping station level through a series of drain holes between sumps. Within production levels pumps will be required to move water from the bottom of the access ramp to the sump.

TABLE 3-29 | ESTIMATED PUMP FLEET REQUIREMENTS AT PEAK MINING OPERATION (ASSUMPTION OF 40L/S INFLOW)

Pumps	5.2kW Flyght	8kW Flyght	20kW Flyght	37kW Flyght	E103 Mono	Jumbo Face Pump
Number Required (peak operation)	3	3	6	1	6	2
Contingency	1					2

FIGURE 3-96 | TYPICAL MONO TYPE PUMP SET UP FOR UNDERGROUND GROUNDWATER MANAGEMENT. (COMPLIANCE ELECTRICAL, 2017)

FIGURE 3-97 | TYPICAL SUMP PUMP SET UP IN AN UNDERGROUND MINE (GETTI IMAGES, 2017)

3.4.6.6.2 JUMBO FACE PUMP

Options exist to use a mounted face pump on the Jumbo. Pumping of water from the face is done through a bull hose and strainer basket. Suction location can easily be moved to reduce standing water levels at the face. However this option reduces flexibility as pumping ceases once the jumbo has left. Alternatively a 5.2kW Flyght pump can be used and placed at the face using the Jumbo to position it. The addition of a jumbo-mounted face pump may be an option to increase pumping capacity from 10 L/s up to 20 L/s if required.

3.4.6.6.3 PIPELINES

Dewatering pipe lines are required to be of a sufficient size to ensure head loss through pipe friction is minimised. To minimise the pressure head loss, the required flow rate for a 40L/s inflow can be handled through twin 125mm lines and achieve a head loss of 5m head/100m pipe (Vinidex, 2016).This product is available in 100m rolls and can be easily stretched out and dragged into position. Lengths of poly can be joined using either mechanical compression joints or electro fusion joining. Multiple lines, that can be installed as the mine development progresses, also allows for the system to be scaled up or down as pumping requirements may vary throughout the mining operation.

Maximum pumping head in the system occurs on the mono pump lifts. Taking into account pressure head loss, total pumping head for these legs are approximately 135m (13.2bar).

Specialised hangers can be used to maintain underground poly lines, similarly chains and straps can also be used, especially if quick installation is required. Hangers allow for leaks to be easily identified and fixed and allow for lines to be easily traced back to the source (Figure 3-98).

FIGURE 3-98 | POLY CLIPS FOR HOUSEKEEPING OF UNDERGROUND POLY LINES (SSORRICH, 2016).

3.4.6.6.4 SERVICE HOLES

Service holes are required to deliver mine water, mine air and dewatering capabilities to the underground operations. Options exist to run services down the return air system or decline. However, this can expose the system to damage from decline traffic, or prevent access for maintenance if in a shaft.

Additional drain lines may be required, due to the configuration and sequencing of the cut and fill drives creating static bodies of water, and may require monitoring and/or draining prior to the extraction of the last lift of the level.

Drain holes will be drilled using either a longhole drill rig or cable bolter depending on final equipment selections. Service holes are typically reamed out to 152mm to allow for installation of the 125mm dewatering line.

Once mono pumps are installed in a level, drain holes are required to drain water into subsequent levels. If drain holes are unable to be drilled, water may be required to be pumped between levels via pump lines in the decline or ventilation raises.

3.4.6.7 CONTINGENCY MEASURES

Contingencies are required to manage any unexpected water inrushes effectively from both an environmental and safety aspect. The water management system will require enough capacity to prevent workings becoming flooded and allow for post excavation grouting or other satisfactory mitigation measures to occur. It is important to have systems in place for contingency, as any mine does. An inrush at 40L/s, with no de-watering in place, prevents access to a typical 25m^2 face within 1 hour and completely covers the face in 3 hours. Sufficient pumping capacity for de-watering is required to allow access to the decline face to enable post-excavation grouting. Alternatively, pumping capacity should be sufficient to allow time for grout to be applied from a higher level to stem the flow of water, if access is available. For these reason, several contingencies have been built into the design of the groundwater management system for BIH:

- Pre-excavation grouting, inflow to be pumped to surface and managed aquifer recharge (MAR);
- Emergency de-watering pump(s);
- Design of a scalable underground pumping systems;
- Capacity and scalability of water treatment infrastructure to manage unexpected high inflows;
- Regular monitoring and testing processes (i.e. probing, flow meters, level indicators and alarms in sumps and tanks etc.) and continuous improvement system for risk management.

3.4.6.7.1 EMERGENCY DEWATERING PUMP

One 37kW submersible Flyght (or similar) pump is required to provide emergency dewatering requirements to handle unexpected inflows or to provide additional pumping capacity in required areas. The pump is ~250kg and may require the construction of a small frame with quick-hitch for manoeuvring with a wheeled loader or it can be transported using lifting chains and the IT forks.

3.4.6.7.2 DESIGN OF PUMPING INFRASTRUCTURE

The underground pumping infrastructure has been selected on the assumption of a 40L/s inflow into the mine. This provides a factor of safety >1.5 on the maximum inflows with an assumed 70% grouting effectiveness (~25L/s).

Spare, easily mobilised pumps will be on standby should inflows reach levels above the capability of installed pumps, or if pumps were to malfunction.

3.4.6.7.3 DESIGN OF MINE WATER STORAGE CAPACITY

The mine water storage dam has been designed to hold a potential 15ML of water sourced from operational areas of the mine, including mine groundwater, surface storm water runoff and the IML. Estimations of the expected water inflows over a 24hr period are that this equates to a FOS of 5.5 (550%) to fill to minimum freeboard, for the case of a maximum rainfall event (49mm/hr for 24hrs); groundwater inflows of 48l/s (twice the credible worst case inflow scenario modelled), and the proposed water treatment plant operating at 25l/s. Hence, under this scenario it would take just over 5 days to fill the dam to freeboard.

Details covering the design of the surface water dam are discussed in section 3.7.9.4.1.

3.4.6.7.4 DESIGN OF WATER TREATMENT AND MAR SYSTEM

These systems will be designed as a continuous process and such that the groundwater levels and quality are maintained, should additional water be required to be pumped from the underground mine. They have also been designed with backup capabilities, such as the modular design of the water treatment plant and backup injection bores for the MAR system, and its ability to be scaled up or down according to the through put required. The water treatment will consist of filtering to remove sediments and treatment to remove any hydrocarbons and nutrients, predominately nitrate explosive residue.

The MAR system is expected to consist of up to eight reinjection bores placed in a radial pattern around the mine void and will ensure the sensitive receptors of the Native Vegetation Heritage Agreement area, the Inverbrackie Creek springs and the regional licensed groundwater users are unaffected in terms of water quality and access to groundwater.

Further details on the proposed MAR system are discussed in Section 3.7.9.6 as well and in Chapter 10.

3.4.6.7.5 DEPRESSURISATION OF THE AQUIFER AND MANAGED AQUIFER RECHARGE (MAR)

Water can be pumped from the underground aquifers directly above the underground workings and immediately reinjected back into the aquifer in the event of an emergency.

This strategy aims to:

- Prevent the water from entering the mine workings and coming into contact with any possible contaminants (sediments, hydrocarbons);

- Reduce the pressure head forcing water into the open voids, and hence to volume of water requiring pumping to surface;
- Increases the safety for personnel and infrastructure underground as water is under less pressure and less volume; and
- Prevent impacts to groundwater users and water dependent ecosystems.

3.4.7 SEQUENCE OF MINING AND REHABILITATION OPERATIONS

Table 3-30 gives a summary of the sequence of activities over the life of the mine, from construction through to mine closure. Further details on the Mine Closure process as discussed in section 3.10.

TABLE 3-30 | YEAR BY YEAR SUMMARY OF MINING ACTIVITIES AT SITE

	Year 0	Year 1	Year 2	Year 3	Year 4	Year 5	Year 6	Year 7
Surface	Site preparation	ROM system	Addition/removal of mullock from IML for backfill (net loss)	Addition/removal of mullock from IML for backfill (net loss)	Addition/removal of mullock from IML for backfill (net loss)	Addition/removal of mullock from IML for backfill (net loss)	Removal of mullock from IML for backfill	Finalise decommissioning of surface infrastructure not required for post mining land use
	car park and creek crossing	Laydown yard	Surface re-vegetation of disturbed areas and infilling of re-vegetation zones	Surface re-vegetation of disturbed areas and infilling of re-vegetation zones	Surface re-vegetation of disturbed areas and infilling of re-vegetation zones	Surface re-vegetation of disturbed areas and infilling of re-vegetation zones	Surface re-vegetation of disturbed areas and infilling of re-vegetation zones	Undertake surface earthwork to form long term landform
	Access road construction	Ventilation raises					Commence decommissioning of ROM	Distribute stockpiled top soil over final surfaces
	Offices and Workshop installed	Progressive expansion of IML as storage of mullock is needed					Last ore trucked to APF	Surface re-vegetation of disturbed areas and infilling of re-vegetation zones
	Dams and stormwater systems installed	Surface re-vegetation of disturbed areas and infilling of re-vegetation zones						
	Commissioning of MAR bores	First ore trucked to APF						
	IML excavation and construction							
	Amenity bunding construction							
	Batching Plant installation							
	Services installations (power, air, water, fuel etc.)							
	Water treatment facility installation							
	Boxcut excavation and infill							
	Surface revegetation of disturbed areas							
Underground	Portal development	Decline development	230-290 Levels Production	170-270 Levels Production	110-190 Levels Production	010-130 Levels Production	Ore production ceases 030-090 Levels and 290-330 Levels	Backfilling of underground voids of capital infrastructure as areas are no longer in use as per Mine Closure plan
		UG magazine	Backfill of production levels continues	Backfill of production levels continues	Backfill of production levels continues	Backfill of production levels continues	Final backfill of production levels	Plugging and backfilling raises and decline
		UG ventilation raises	Decline development	Decline development	Decline development	Decline development	Commence removal of UG infrastructure	
		Egress raise installation	UG geological exploration				Backfilling of underground voids of capital infrastructure as areas are no longer in use as per Mine Closure plan	
		UG pumping station						
		First ore production (230 Level)						
		First backfilling						
		UG geological exploration						

3.4.8 Rehabilitation Strategies and Timing

Owing to the size of the site, opportunities for progressive rehabilitation are limited. The landscaped amenity bunds created during construction will be vegetated as soon as is practical, as will disturbed areas not required for mining. This vegetation will remain throughout operations and closure.

Rehabilitation of exploration sites has been detailed above in section 3.3.7.

The following sections outline specific activities which will be undertaken once closure is announced.

3.4.8.1 STOCKPILES

Details regarding the rehabilitation strategies and timings for the surface ore, mine mullock handling and stockpile is dicussed in section 3.10.

3.4.8.2 MINING EQUIPMENT

Once production ceases and final closure is in progress, mining equipment will be taken out of service and will either be re-conditioned and used for other projects, or potentially sold off if still serviceable. This process may commence earlier in the life of the operation, depending on the resources required to meet production demands. For anything no longer serviceable, it will be disposed of as per the site's waste management plan through licenced facilities/receivers.

3.4.8.3 MINE DEWATERING INFRASTRUCTURE

Sections of the mine that are completed prior to the end of mine line will be backfill, rehabilitated and infrastructure removed as this occurs as it will likely be relocated closer to the active areas of the mine during operation.

Once production ceases and final backfill and closure is in progress, infrastructure such as pumps and pump lines located underground will be disconnected and removed as the mine is backfilled/rehabilitated in a retreat fashion. This equipment will either be re-conditioned and used for other projects, or potentially sold off if still serviceable. For anything no longer serviceable, it will be disposed of as per the site's waste management plan through licenced facilities/receivers.

Service droppers (bore holes) from the surface to UG will be sealed and capped as per guidelines for bore holes.

All bores and pipelines for the proposed MAR system will be removed, and the bores sealed and capped.

3.4.8.4 LAND DISTURBANCE

Any disturbed areas of the surface that is not proposed to remain after closure will be rehabilitated and revegetated according to the Mine Close Plan that will be developed as part of the PEPR. For further details on the closure work planned, please refer to Section 3.10.

3.4.8.5 MINE VOID BACKFILLING

A Geotechnical assessment of the mine, it's voids and backfill material placed throughout the operation will be undertaken as part of the detailed planning for Mine Closure through the development stage to ensure that the required zones of the mine (and their potential impacts on the surface) will not damage any third party infrastructure nor cause injuries/ deaths resulting from collapse of the underground workings.

Existing mine voids of the original mine workings, will be left unchanged, and there is no intention at this stage to excavate into these areas.

3.4.8.6 SEALING OF PORTAL AND VENTILATION SHAFTS

It is proposed that the decline portal and the shafts will be made secure by sealing with backfill material and capping the surface. Basing the initial conceptual plans on the approved closure plans for the Angas Zinc Mine the following will likely occur at the BIH site:

- All shafts (ventilation and escape way) will be filled, plugged and sealed (Figure 3-99)
- The mine portal will be plugged and sealed (Figure 3-100)
- Ore drives and underground excavations will be backfilled as required to manage all possibilities of subsidence (and other potential impacts) occurring to receptors.

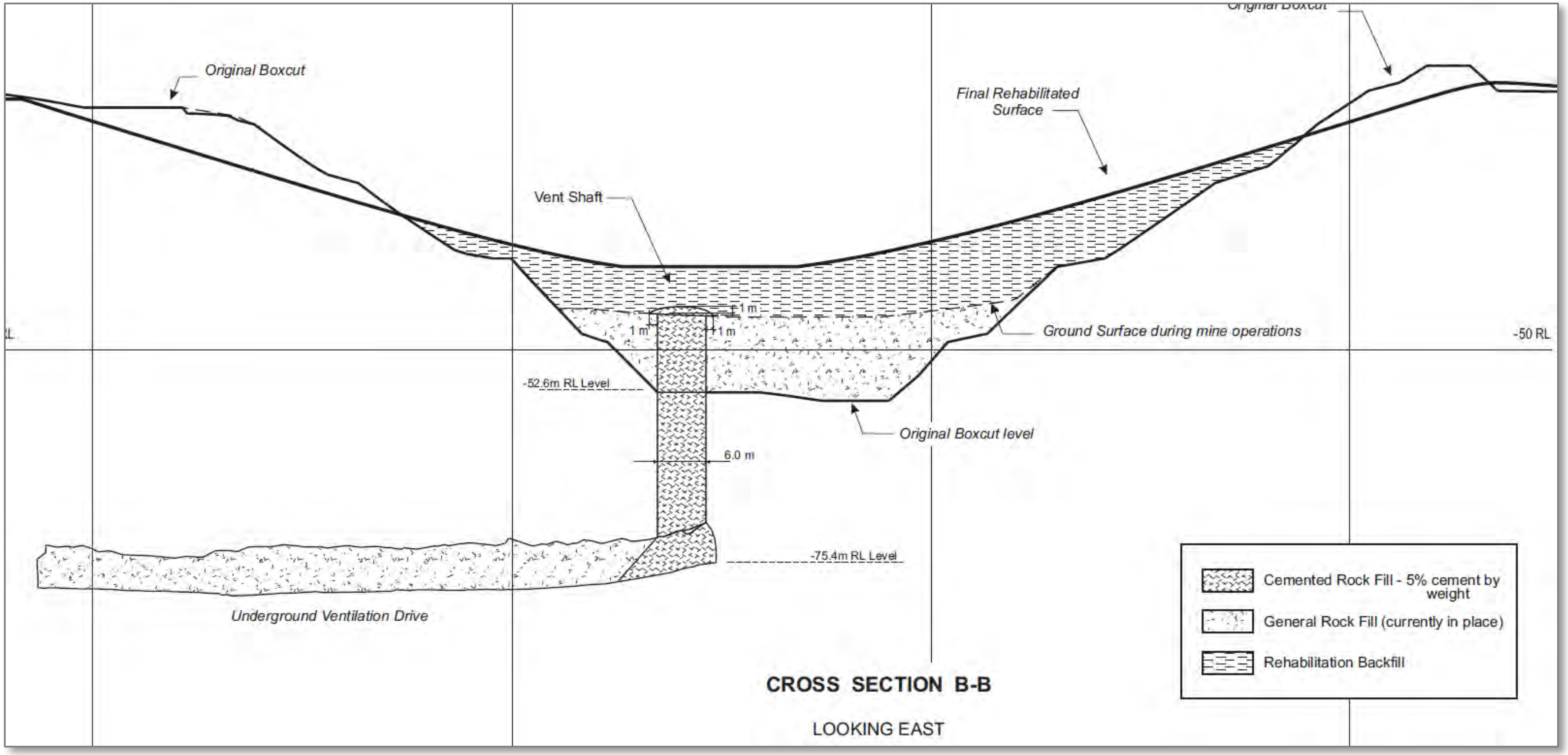


FIGURE 3-99 | A SIMILAR SYSTEM TO THAT APPROVED AS PART OF THE CLOSURE PLAN STRATEGY FOR THE ANGAS ZINC MINE FOR BACKFILLING OF THE VENTILATION RAISE WILL BE USED AT BIH FOR THE RAISES AT THAT SITE. (ROACHE, 2014)

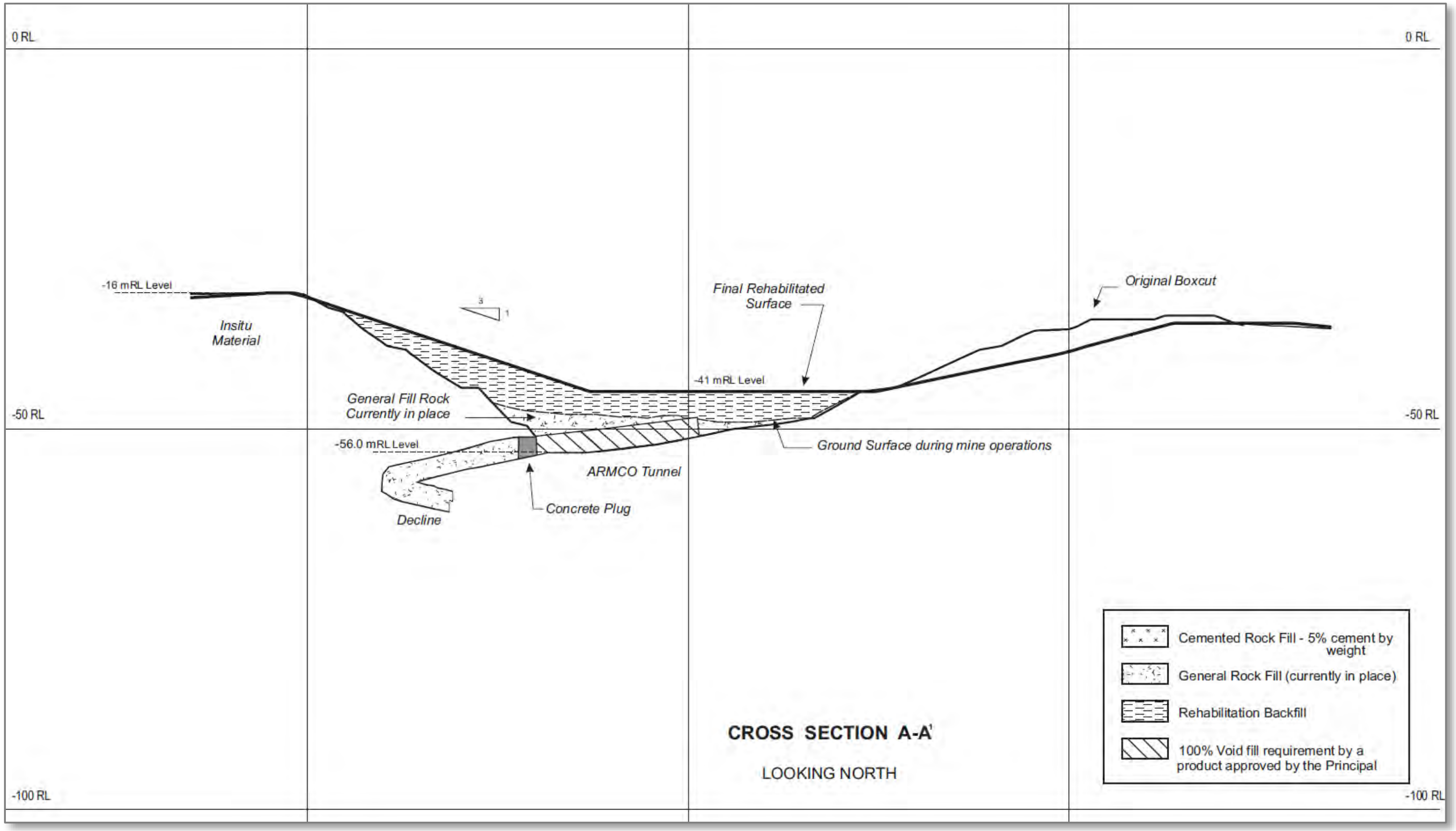
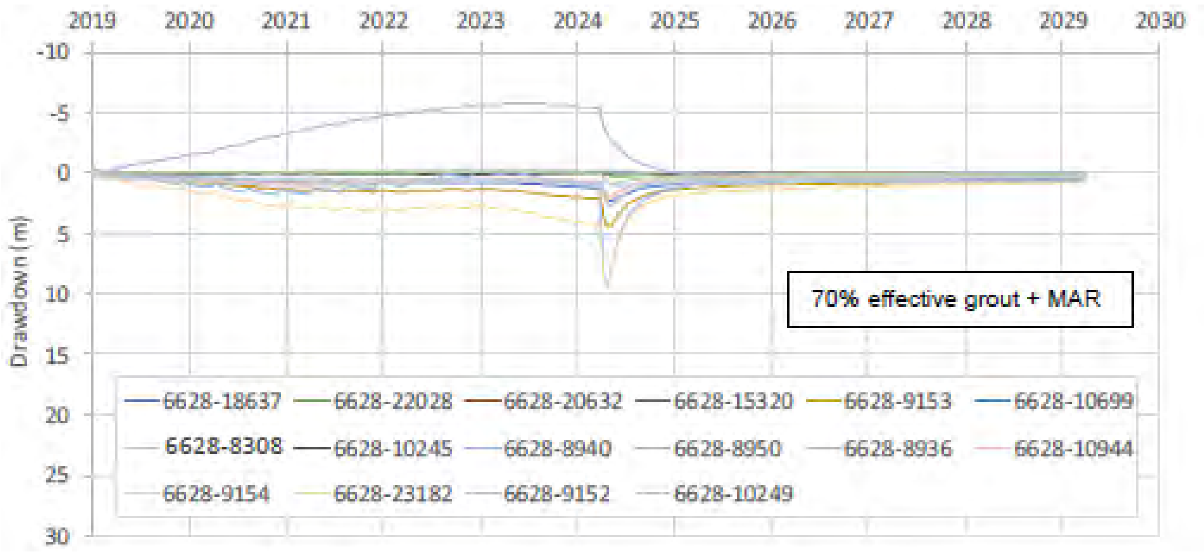


FIGURE 3-100 | A SIMILAR SYSTEM TO THAT PROPOSED AND APPROVED IN THE CLOSURE PLAN FOR THE BACKFILLING OF THE ANGAS ZINC MINE PORTAL AND UPPER DECLINE WILL BE USED AT BIH MINE (ROACHE, 2014)



3.4.8.7 SOIL MANAGEMENT

For further detail on the battering of mining faces and other earth works, abandonment bunds, soil management, revegetation, please refer to section 3.10on the Mine Closure.

3.4.8.8 EXPECTED WATER INFLOW RATES FOR CLOSURE

This section is replicated in section 3.10.9 and details are contained in Appendix H1.

With the proposed system of ground water management, it will be a relatively short timeframe for the groundwater levels to return to their pre-mining state. Even if operations only achieve 70% effective sealing of inflow with grouting regime with MAR, modelling predicts that levels will return to within 2m of original, in the first 12 months after mining ceases.

A comparison of the residual groundwater drawdowns, with and without MAR at five years post mining are presented for the Tapley Hill Formation and the Tarcowie Siltstone (Figure 3-101). Groundwater modelling 5 years post mining shows that without MAR, there is a small residual drawdown of 1 to 4 m across the main irrigation area, and no residual drawdown with MAR.

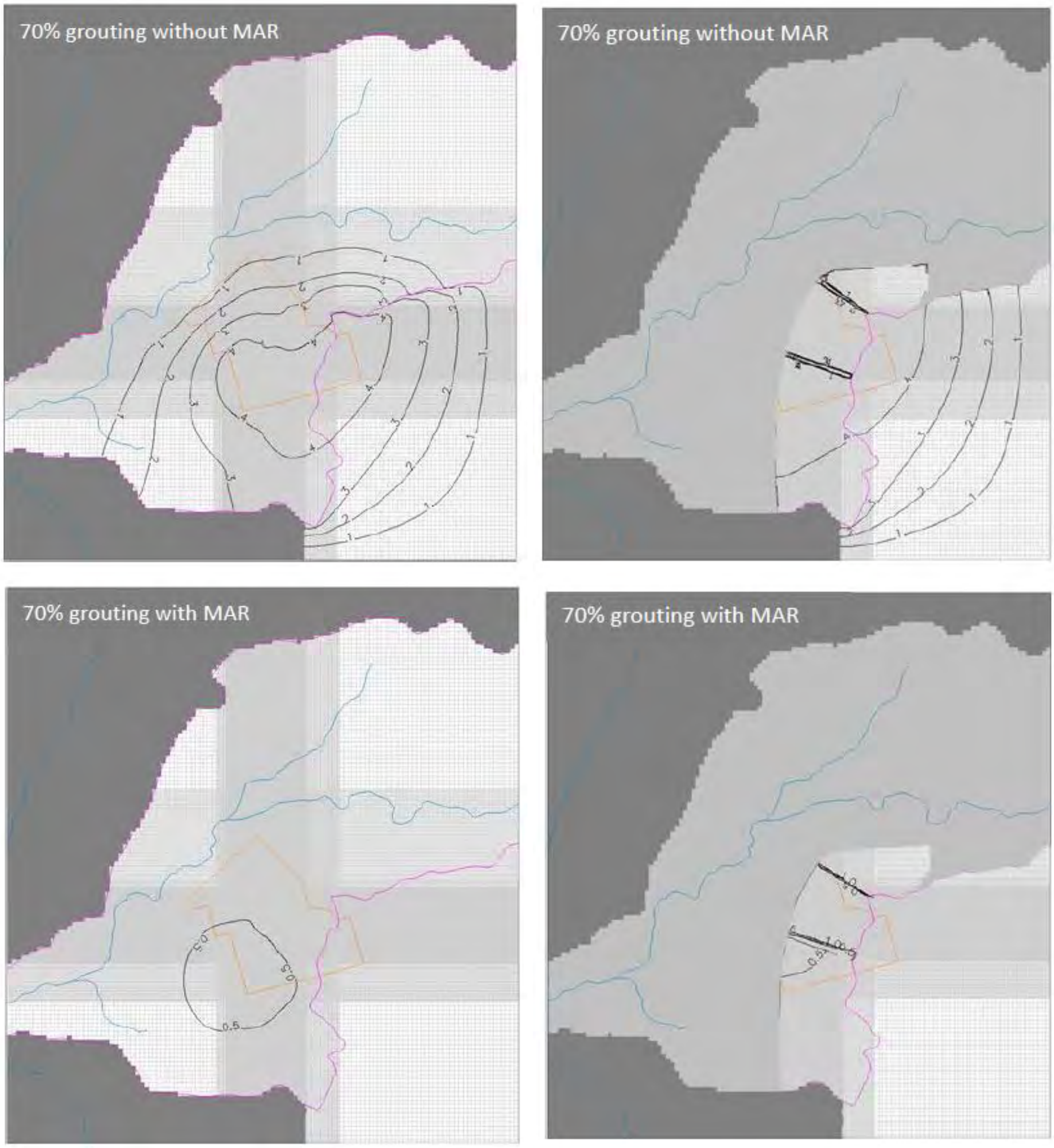


FIGURE 3-101 | RESIDUAL DRAWDOWNS FIVE YEARS POST CLOSURE TAPLEY HILL FORMATION (LEFT), TARCOWIE SILTSTONE (RIGHT)

The AMD assessment (Appendix M2) undertaken identified a discrete supergene sulphide zone which is held within healed fractures, or have formed as growths locked up in a clay aquitard. If this zone were to dry out it would oxidise, potentially degrading the native groundwater quality post mining.

To avoid the supergrene zone, the decline and lower decline spiral will be developed within less weathered rock units to keep excavations within comptetent ground conditions. Numerical modelling of groundwater levels above the weathered zone show that the aquitard containing the supergene layer will not dry (oxidise) over the relatively short mine life (5 years).

3.5 SURFACE ORE, MINE WASTE HANDLING, STOCKPILING AND TRANSPORT

Standard mine/quarry/construction type equipment is proposed to be used on surface at the BIH site including

- Ore handling – conveyor and ROM silo, with loading hopper
- Mine Waste handling/stockpiling – mine trucks and surface/underground loaders
- Transport – General access vehicles

This section addresses the details such as fleet types and vehicle numbers, noise and exhaust outputs and potential fire ignition sources for these processes.

3.5.1 TYPE OF MOBILE EQUIPMENT

Table 3-31 lists the expected types and numbers of equipment in the proposed fleet. These will vary over the life of the project depending on the requirements at the time, but will comprise general mining/quarry/construction type vehicles (Figure 3-102).

FIGURE 3-102 | TYPICAL EQUIPMENT ON SITE FOR IML, BACKFILL LOADING (GALLAGHER, 2017)

TABLE 3-31 | ESTIMATED TYPES AND NUMBERS OF MOBILE EQUIPMENT FOR THE THREE STAGES OF THE PROJECT: CONSTRUCTION, OPERATION AND CLOSURE

Equipment Description	Number of units - Construction	Number of units - Production	Number of units - Closure/Rehab
Tracked excavator (20t)	1		1
Tracked excavator/backhoe (small - trenches etc.)	1		1
Surface Haul trucks (30/40t)	2		1
Dozer	1		1
Crane	1	**	1
Diesel Generators	2	1	2
Surface drill rig (service holes)	1		
Roller	1		1
Development Drill rig (i.e. Sandvik DD421)	1	2	
Grader (i.e. Cat 12H)	1	1	1

Surface Loader (Cat 966H)	1	1	1
Light vehicle (Toyota Hilux)	3	7	4
Telehandler (Faresin 17-40)	1	1	1
Water Truck (7000L)	1	1	1

** Numbers will be subject to operational needs.

3.5.1.1 NOISE OUTPUTS

Noise modelling for the project was undertaken by AECOM's acoustic consultants and included proposed equipment types and numbers. The equipment selections listed in Table 3-19 and Table 3-20 are indicative only and therefore may not be the exact model used on site. Where equipment selections have not been listed, generic sound power levels have been provided.

Details on how these outputs were included in the Noise modelling for the Project are covered in the Noise Impact Assessment - Appendix 03.

Further details regarding noise are discussed in Charter 15.

3.5.1.2 EXHAUST OUTPUTS

A summary of the emission outputs for the proposed equipment types are summarised in Table 3-21.

These are the values used in the Air Quality Impact Assessment modelling, undertaken by AECOM's Air Quality Consultants, included in Appendix N3.

Further details regarding Air Quality are discussed in Chapter 15.

3.5.1.3 FIRE IGNITION SOURCES

Fires in any business present a hazard to people and property. The approach to managing and controlling the risk associated with fire is undertaken as a Primary Duty of care as per Division 2 of the *Work Health and Safety Act 2012* (SA). It is the responsibility of all businesses operating in South Australia. The identification of possible fire ignition sources is undertaken as prescribed by Chapter 10, Part 2 of the Work Health and Safety Regulations 2012 (SA) to ensure that hazards are managed to control the risk to health and safety. Uncontrolled fires are classified as a Dangerous Incident and 'notifiable incidents' under Australia's Work Health and Safety (WHS) legislation. As a result, a Hazard Management Plan covering fire will be implemented for the Project. This includes procedures around the management of any potential works that presents a fire hazard and the emergency procedures to manage a fire event. This includes the authorisation of any Hot Works through a risk assessment process. Ignition sources include hot surfaces, electricity, static electricity, flames, sparks or smoke.

Undertaking any business that utilises machinery, moving parts or people has the potential to ignite a fire. A common source for ignition comes from fuel powered equipment and is common for harvesting equipment, in particular, to cause fires. In recognition of this fact, a review of possible ignition sources from equipment was undertaken. As stated by Grant (Grant, 2011) fires on diesel-powered equipment typically arise from leaking high-pressure hydraulic lines which can spray a heated mist of highly combustible liquid onto an ignition source, such as a hot exhaust manifold or turbocharger.

Much of the mobile equipment used in underground mines contains not only fuel sources (e.g., diesel fuel and hydraulics) but they also contain ignition sources (e.g. diesel engines and electrical equipment).

Fire ignition sources for mobile equipment includes, but is not limited to:

- Overheating engines;
- Oil/Fuel spills/leaks on hot machinery components;
- Overheated tyres;
- Collision with other vehicles;
- Collision/contact with power cables; and
- Rubbish build up on or near hot machinery components.

It has been shown that the likelihood of equipment starting fires is significantly reduced by the implementation of regular inspections and preventative maintenance. Hazards are managed through the use of well maintained, fit for purpose vehicles, fitted with the appropriate fire suppression systems, as well as trained competent operators that inspect vehicles prior to use. The site will have policies and procedures for maintaining vehicle condition, vehicle operation as well as for the handling of incidents in the case of fire occurring.

3.5.2 Product Transport

As there will be no processing of ore at the BIH site, this section only addresses the transport of material from BIH to the Angas Processing Facility. Details regarding the transport of final product from Angas is addressed in the associated Miscellaneous Purposes Licence Proposal (2019/0826).

It is proposed that the material mined at BIH will be trucked via road to the processing facilities at AZM. A Transport Assessment (Appendix F1) was undertaken by Tonkin to determine the existing traffic and road conditions between the two sites as well as identifying suitable vehicles to use and possible routes for ore haulage. Aspects of this assessment are summarised below.

Further details are also discussed in Chapter 8

Haulage will be undertaken using general access heavy vehicles (GAV) in the form of ridged tipper trucks with a Dog trailer less than 19m in length, equipped with standard covers for material haulage. These vehicles are specified to haul bulk loads on all roads and present a cost effective option for haulage.

A rail network does exist across the region, owned by the Australian Rail Track Corporation (ARTC), however there is no existing bulk loading siding or spur line suitable for use or unloading facilities proximal to the processing facility. Rail haulage is considered not to be feasible due to the upgrades and capital construction for infrastructure required for the relatively short mine life.

3.5.2.1 PROPOSED HAULAGE ROUTE

From initial analysis of the road network between the two sites, three possible routes were identified for further consideration.

These are described in detail in the Transport Assessment (Appendix F1) and in Chapter 8.

Selection of the ideal route included assessment of:

- Existing road conditions – including surface, lines of site, traffic volumes and types;
- Existing Restricted Vehicle Access Networks – not all roads are gazetted for vehicles outside the General Vehicle classification – such as B-Doubles etc.;
- Proximity to townships, residential and public areas, school bus routes;
- Identification of routes used by traffic similar to that proposed for BIH;
- Crash data associated with the roads considered; and
- Planned development in the area – i.e. the Adelaide Polo Club.

Discussions were held with the Department of Planning, Transport and Infrastructure (DPTI) and the three local councils across which the routes would travel to gain their input, including the Adelaide Hills Council, Alexandrina Council and the Mount Barker District Council. A traffic Focus Group involving community representatives (industry, police, schools, residents, businesses etc.), along with other stakeholder engagement sessions (open days, personal discussions etc.) were used to guide the selection of the preferred route. Three routes were proposed for discussion including using the Nairne Road, the Old Princess Highway and the new Princess Highway (South Eastern Freeway). From the Callington Road Freeway interchange, the proposed route is the same as the route used for product transport from AZM during operations. DPTI have indicated that further discussions will be held once the MLA has been submitted.

3.5.2.2 PREFERRED HAULAGE ROUTE

The preferred route selected initiates at the mine site access point, travels along Pfeiffer Road, the Nairne Road into the Nairne Township, then onto the South Eastern Freeway via Bald Hills Road and the recently constructed Bald Hill interchange. The South Eastern Freeway is currently gazetted for B-Double and Rigid Truck and Dog access. Trucks will leave the South Eastern Freeway at the Callington Road exit and continue to the Angas Processing Facility (APF). The route from the freeway to APF is the same route that was used for the transport of concentrate from the AZM. (Figure 3-104 | Preferred Haulage route between Bird-in-Hand Mine site and the Angas Processing Facility (appendix F1).Figure 3-104.)

It is proposed that an access to the site is constructed to provide for vehicles from the site merging with existing traffic and to provide for vehicles entering the site not to cause congestion. The access will be off of Pfeiffer Road as indicated in Figure 3-103.

FIGURE 3-103 | CONCEPTUAL SITE PLAN SHOWING THE NEW SITE ENTRY AT LOCATION 1 (HIGHLIGHTED YELLOW) (APPENDIX G1)

The estimated one-way travel time between the sites for the haulage vehicles is 40 minutes.

As part of the route assessment, it was identified that some of the intersections did not suit existing traffic requirements. In order to suitably accommodate the proposed mine traffic it is recommended that upgrades would provide a benefit to both the haulage vehicles and the existing traffic currently using these roads. Issues identified include:

Terramin are concerned that the Pfeiffer Road/Nairne Road intersection is currently not fit for purpose, even for General Access Vehicles (GAVs), and along with the community, would like to see it upgraded in a collaborative approach from DPTI, Adelaide Hills Council and Terramin, as well as other large users of the intersection. Terramin will continue discussions with all stakeholders (including DPTI, Adelaide Hills Council and other large commercial users, and the developers of a large residential property development on the existing Detention Centre site) through the assessment of the ML and PEPR in order to come to an acceptable result for all stakeholders.

This route has been selected based upon engineering considerations, namely the current route rating, suitability of proposed vehicles and, efficiency and functionality of the route. The route selection has been presented to community and key stakeholders, namely the Department of Planning, Transport and Infrastructure (DPTI), the Adelaide Hills Council (AHC), District Council of Mount Barker (DCMB) and Alexandrina Council (DCA).

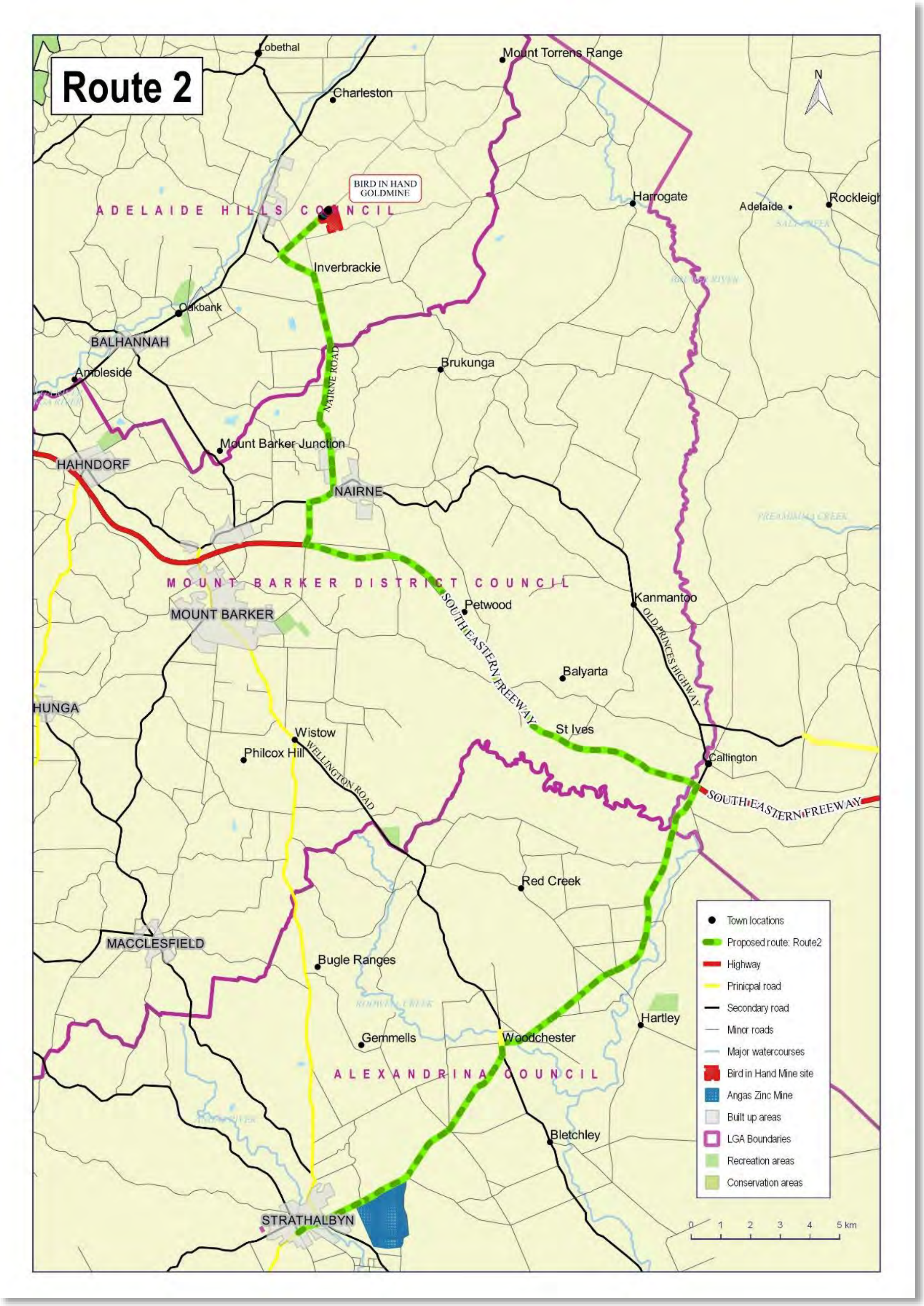


FIGURE 3-104 | PREFERRED HAULAGE ROUTE BETWEEN BIRD-IN-HAND MINE SITE AND THE ANGAS PROCESSING FACILITY (APPENDIX F1).

3.5.2.2.1 PFIEFFER RD/NAIRNE RD INTERSECTION

The Pfeiffer Road/Nairne Road intersection is General Access Vehicle approved.

To improve the intersection, the following is recommended:

- Junction widening on both shoulders of the eastern Pfeiffer Road leg approach;
- Land acquisition;
- Relocation of an existing stobie pole on the south shoulder of the Pfeiffer Road leg;
- Relocation of two Telstra pits on both shoulders of the Pfeiffer Road leg; and
- Relocation or extension of a culvert crossing Pfeiffer Road.

Further discussion with both the Department for Planning, Transport and Infrastructure and the Adelaide Hills Council will continue with the submission of the MLA regarding the process forward to achieve an outcome which is in the interest of the community and all other stakeholders.

FIGURE 3-105 | PFEIFFER ROAD/NAIRNE ROAD INTERSECTION LOOKING WEST FROM PFEIFFER RD (APPENDIX F1)

3.5.2.2.2 NAIRNE ROAD RAILWAY CROSSING

The Nairne Road rail crossing shown in Figure 3-106 is narrow considering the existing traffic. Government records show that 250 heavy vehicles use the crossing each day. The intersection is controlled by signs and signalling equipment along with the general speed of traffic, being a 50km zone and proximity to the Princess Highway intersection. A review of traffic records and crash data indicate that the section of Nairne Road between North Road and The Princess Highway has a high occurrence of accidents. It is not indicated if these accidents occur at the crossing. The section of road is currently rated for Rigid Truck and Dog access over the freight line crossing.

FIGURE 3-106 | UPGRADES TO THE RAIL CROSSING AT NAIRNE ARE RECOMMENDED TO IMPROVE SAFETY FOR ALL USERS. (IMAGE LOOKING NORTH, APPENDIX F1)

3.5.2.2.3 NAIRNE ROAD – BETWEEN NORTH ROAD AND OLD PRINCES HIGHWAY

The section of Nairne Road between North Road and the Old Princes Highway is currently classified for GAV's as proposed for use by the Project. It has been identified that Nairne Road begins to narrow in this section, and in conjunction with a crest, multiple local road access points to Nairne Road and an increase of residential density, an increase in hazards for haulage vehicles exists. As a general assessment, the condition of this road requires upgrading. Road widening is recommended throughout this section to provide the necessary travel lane widths for trucks and to improve safety to other motorists. Initial discussions and consultation with the District Council of Mount Barker and DPTI have been held regarding plans for this work. Given that there has been 15 crashes with eight injuries and one fatality along this section in the last five years, the zone could be considered for Black Spot funding. It is proposed that Project vehicles restrict their use of this section of road to outside of the congested times and adopt appropriate mitigation measures. This intersection has been identified by the current Government to be upgraded during the current election cycle.

3.5.2.2.4 SITE ACCESS

An upgrade will be required on Pfeiffer road to allow safe access into the BIH site. Recommendations from Tonkin Consulting include the upgrade of this section of the road to a right-turn treatment (BAR) to comply with to Austroads Guidelines. A BAR treatment features a widened shoulder on a major road which assists turning vehicles to move further off the through carriageway making it easier for through vehicles to pass. Figure 3-107 shows a typical BAR treatment layout for a two-lane rural road.

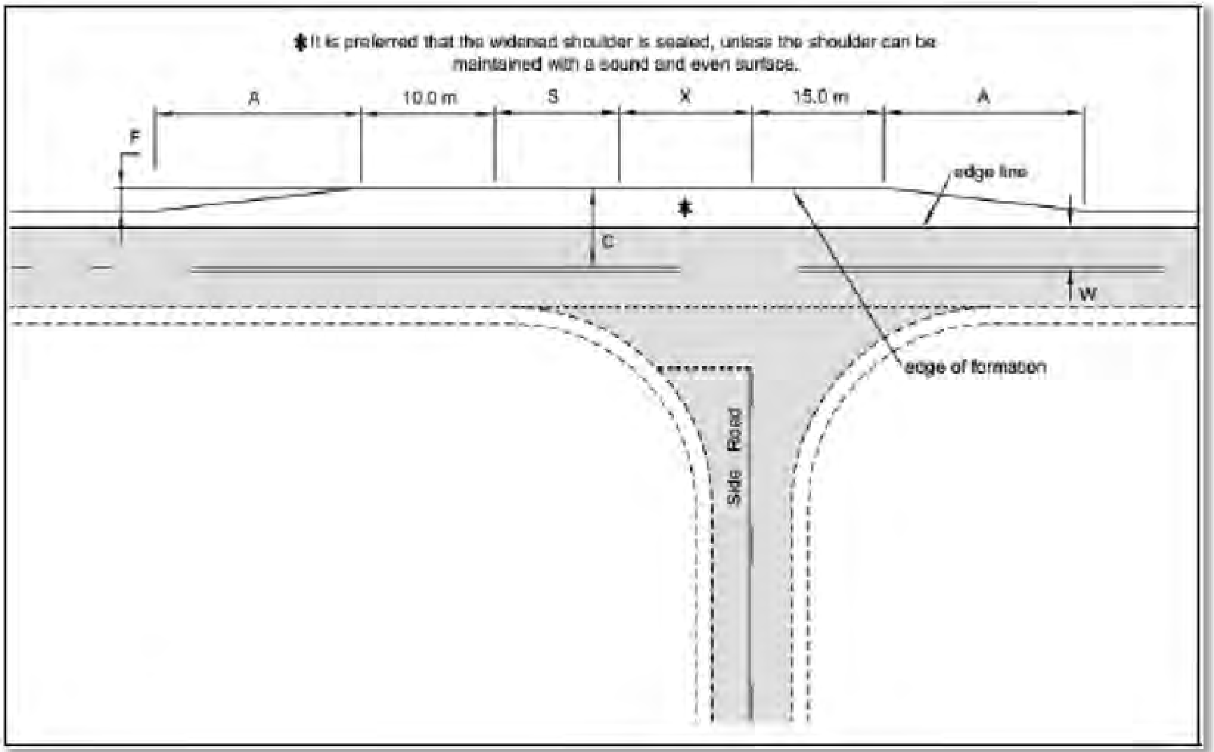


FIGURE 3-107 | BASIC RIGHT (BAR) TURN TREATMENT ON A TWO-LANE RURAL ROAD (AUSTROADS PART 4A, FIGURE 7.5 AS SHOWN IN APPENDIX F1)

Potential widening of Pfeiffer Road to accommodate a BAR treatment was considered, and whether Pfeiffer Road should be widened on either the north or south side. Widening of Pfeiffer Road on the north and south sides is somewhat restricted due to roadside vegetation and battered slopes.

The minimum length from the edge of the BAR treatment to the centreline of the side road as required by Austroads Guidelines for an 80km/h road and with shoulder widening of 1-2m, is approximately 60m to 75m. This location takes into account and has no impact on operation of the Polo Club access point.

3.5.2.3 HAUL VEHICLE SELECTION

The section of the preferred haulage vehicles for ore between the two sites was based on

- The number of vehicles required to transport the ore each day (noting that some larger vehicles can carry more load with less trips);
- The ability of the road geometry to cater for the proposed vehicle type; and

- Vehicle operating costs.

The types of ore haulage vehicles considered are listed in Table 3-32.

TABLE 3-32 | GCM AND PAYLOAD OF HAULAGE VEHICLES (APPENDIX F1)

Vehicle Type	GCM (t)	Payload (t)
19m Semi Trailer	42.5	24.13
19m ridgid truck and dog	50	34.19
26m B-double	62.5	40.5

Since the 26m B-Double is not rated as a GAV, it would require the most upgrades to the proposed haulage route to accommodate its large turning circle. For this reason it was excluded from the selection.

As the 19m rigid truck and dog combination has a 40% higher payload, and also a lower operating cost than the 19m semitrailer (Appendix F1), it is proposed as the preferred haulage vehicle for BIHGP.

Haul vehicles and trailers will have covered loads to minimise dust impacting receptors along the route between the sites (Figure 3-108).

FIGURE 3-108 | ORE HAULAGE VEHICLE PROPOSED - 19M RIGID TRUCK AND DOG COMBINATION WITH COVERED LOAD

3.5.2.4 ESTIMATED VEHICLE MOVEMENTS

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

The increase in commercial vehicles generated from the mine operation on the surrounding road network is estimated to be around 18.2% on Pfeiffer Rd and between 1 and 10% on Narine, Bald Hills Road and South Eastern Freeway.

3.5.2.4.1 ORE HAULAGE

Using the estimated ore production volumes, and trucking 7 days per week, a comparison was undertaken for three different vehicle combinations for ore haulage. The average daily truck movements for each vehicle type were estimated, as shown in Table 3-33.

TABLE 3-33 | SUMMARY OF THE NUMBER OF VEHICLE MOVEMENTS PER TYPE OF VEHICLE (APPENDIX F1)

Vehicle Type	Truck movements / day	Truck frequency (assuming 7am - 5pm mine operation)
19m Semi Trailer	16 x 2 = 32	1 truck every 19 minutes
19m rigid truck and dog	12 x 2 = 24	1 truck every 25 minutes
26m B-double	10 x 2 = 20	1 truck every 30 minutes

For the selected 19m rigid truck and dog combination, on average, an additional 24 Truck and Dog movements (12 return loads), and an estimated 4 heavy vehicle delivery movements (2 deliveries) per day. This is based on the current production estimated (Scoping Study, 2018). In the event of an increase in ore or mullock as a result of design updates through Feasibility Studies, the constraints proposed regarding IML height and visibility, and Ore Silo will continue to be implemented and options to store mullock from decline development at APF will be investigated. Any additional ore or mullock offsite will be controlled by the proposed haulage control measures and not increase daily average truck movements of 12 trips over the life of the project.

Management measures proposed for the ore haulage trucks includes limiting operating hours to outside of commuter and school drop off time (6am – 9am) and school pick up and school bus time (3pm – 4.30pm), as well as no overnight haulage to Strathalbyn (between 10pm – 6am). The haulage numbers are based on averages to provide for allowance to limit ore haulage during weather events, i.e. when bitumen damage is more likely, in extremely hot or storm weather, and to accommodate occasions when community events are planned i.e. Easter long weekend.

3.5.2.4.2 OTHER VEHICLES

Other vehicle movements have been estimated through combined advice from Terramin regarding estimated mine employee numbers and from experience with traffic movements at other mine sites:

- Other trucks (e.g. supply trucks) – 4 trips per day.
- Company light vehicles – 10 trips per day.
- Visitors – 6 trips per day.

In addition, there will be employee vehicle movements similar to local business in the area, based on the following employee profile:

- Dayshift – 52
- Nightshift – 15
- Weekend shifts - 15

3.5.2.5 TRAFFIC DISTRIBUTION

Local workers (operational and construction) and other service vehicles will be distributed evenly on the road network throughout the Adelaide Hills and towards Adelaide.

3.5.3 CONVEYORS AND PIPELINES

3.5.3.1 CONVEYORS

Conveyors will be used to transport ore on site from the tip point near the mine portal up into the ROM storage silo (CV1 in Figure 3-83) The tip point for the mine trucks is into a hopper sized to take approximately two truck loads. This tip point will be sheilded with a noise barrier and covered by a screen (grizzly) to capture any oversize, This provides a bed of material to remain on the base of the hopper to prevent damage by the next load and assists with noise reduction. The level of material in the hopper is controled using apron feeders.

A secondary conveyor system (CV2, Figure 3-83) will be used to transfer ore from the ROM silo, into hoppers ready for loading the road trucks for haulage to APF.

Ore is loaded into the road trucks via two bins mounted along the road centreline, each bin is mounted on weigh cells to control the weight loading of the road trucks. These bins are refilled from the ROM silo via an apron feeder and conveyor at a slow rate after to reduce noise and dust emissions. Ore loading in this manner reduces the need for a ROM pad, a wheeled loader and the road trucks leaving a sealled road. The ROM silo and conveyor system provides environmental benefits in relation to reduced potential dust, reduction in noise, reduction in carry out and reduces carbon emmissions by removing the need for a wheeled loader.

The conveyors are designed in trenches constructed with vertical retaining walls, in preference to tunnels. The preliminary width of the trenched area is 2.8m, based on a 1.2m conveyor/idler frame and 800mm on both sides for maintenance access. Positioning these conveyors below surface helps contain noise and removes the structures from view.

The layout of the ROM system, from the tip point, the conveyors, to the storage bin has been planned in order to minismise the visual impact from all surrounding view points. The design also reduces impacts from noise and provides for management of potential dust by using covered transfer points.

Conveyor systems used at AZM already exist as part of the processing facility used previously. Specifics will be addressed in the Angas Processing Facility Miscellaneous Purposes License Proposal.

3.5.3.1.1 NOISE SOURCES

The conveyor systems will be run using electric motors driven by mains power. According to Brown (Brown, 2004) Conveyor Noise generation mechanisms thought to be of acoustical significance can be summarised as follows:

- Idler Roll Bearing Noise;
- Idler Roll Shell Noise;
- Belt Idler Interaction;
- Air Pumping, Belt/Idler Roll; and
- Structure-borne Noise – conveyor support structure.

Measured Sound Power Levels of conventional belt conveyors range from 113 dB(A) to 119 dB(A) per 100 m for typical 10,000 TPH 5 m/s coal conveyors. Standard and alternative idler roll designs, referred to as “low noise” and “super low noise” conveyors produce sound power levels of 107 dB(A) and 101 dB(A) per 100 m respectively. The system designed for the BIH site is designed to manage 10,000 tonnes per month and will be 25m long. The noise generated will be significantly less than the conveyors used in the modelling. The conveyor operation will be restricted to the noise limitations for the site. The conveyor system was included in the noise modelling undertaken for the Noise Impact Assessment (Appendix O3).

3.5.3.1.2 DUST CONTROL

There are three primary root causes for fugitive dust emissions associated with conveyor belts: spillage, carry-back, and airborne dust (Figure 3-109). Control of all three primary dust sources is necessary to eliminate fugitive dust emissions.

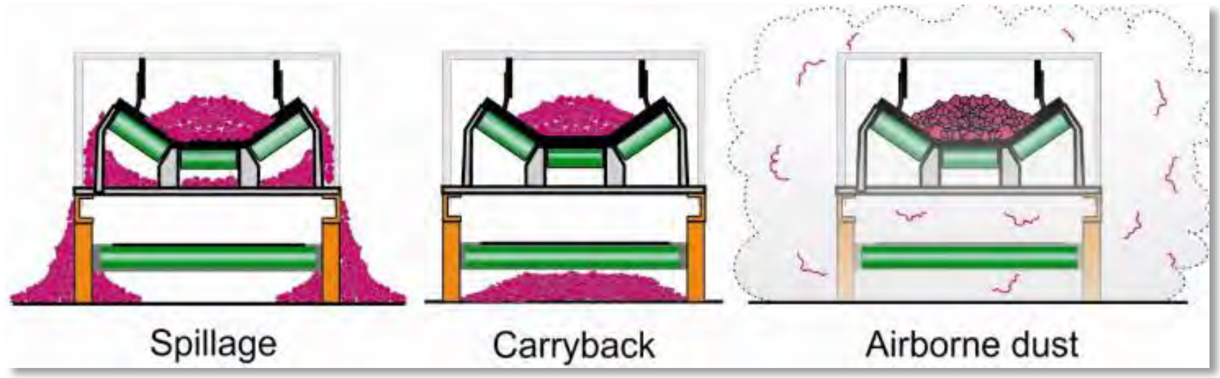


FIGURE 3-109 | TYPES OF FUGITIVE DUST EMISSIONS FROM CONVEYOR BELTS (CECALA, ET AL., 2012)

Spillage

Material spillage from a conveyor belt is caused by a lack of material control, either at a transfer point or along the transfer route. The most prevalent location for material spillage is at transfer points. Material may be deposited virtually anywhere along a conveyor, but always leaves the conveyor at the head pulley. In order to effectively control material at transfer points, the following four steps are used.

- Feeding material onto the belt in the direction of travel and at the same speed as the receiving conveyor.
- Keeping the feed material centred on the conveyor belt.
- Minimising the transfer distance which, in turn, minimises material impact on the belt and air entrainment within the material.
- Using skirt board ("skirting") to manage the loaded material as it travels on the belt.

Carry-back

Material that sticks or clings to a conveyor belt after passing over the head pulley is called carry-back. Carry-back tends to fall from the belt as it passes over return idlers. This creates piles of material that require clean-up, which can increase dust sources. The goal is to remove carry-back before it is released into the air and becomes a source of contamination to the environment or creates piles of material that require clean-up.

The primary means of controlling carry-back is to clean the belt as it passes over or past the head pulley (i.e. shortly after material is discharged from the belt). The two most common means of cleaning a conveyor belt of carry-back are to mechanically "scrape" the belt via scrapers or brushes or to wash the belt. Due to the size and nature of the material expected at the BIH site, a scraper is an appropriate method of control.

Further details on the dust mitigation methods will be included in the PEPR.

Air-borne dust

With any movement and transfer of material, there is the potential to generate airborne dust. With the ROM system being covered at the tipping points to meet noise limits for the site, the dust generating points would already be contained and dust control systems can be installed. The details for the design of these systems will be completed with the design of the ROM system, however typical methods include:

- dust suppression water sprays - When properly designed and installed, water sprays are a cost-effective method of controlling dust from conveyors; or
- dust extraction system - whether simple or complex, have in common the use of hoods, ductwork, and an air cleaning and collection device that leads to the exhaust fan such as shown in Figure 3-110.

Further details on general site dust control (Air Quality) are discussed in Chapter 15 and Appendix N3.

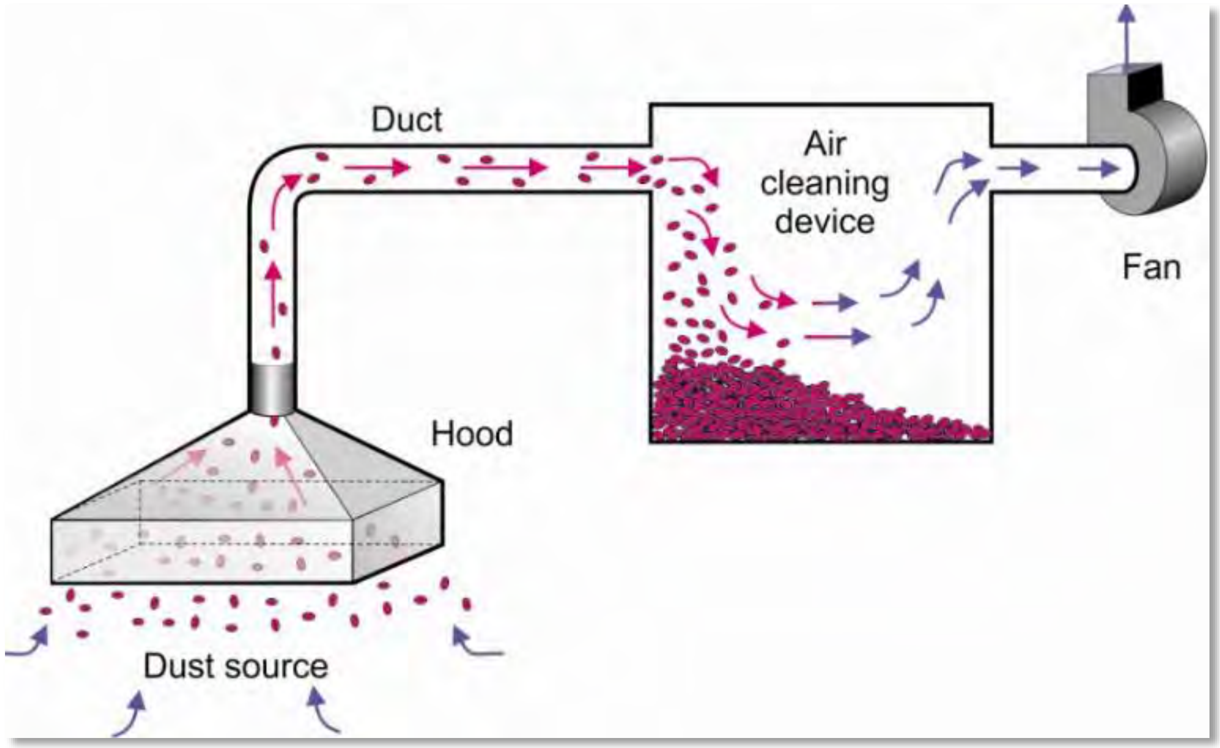


FIGURE 3-110 | A BASIC DEPICTION OF A SIMPLE EXHAUST SYSTEM WITH THE MAJOR COMPONENTS BEING THE HOOD, DUCT, AIR CLEANING DEVICE AND FAN (CECALA, ET AL., 2012)

3.5.3.1.3 FIRE IGNITION SOURCES

The following non-exhaustive list (Manojkumar & ShiyamPresanna, 2014) summarises causes for conveyor belt fires without any classification:

- Friction of belts;
- Collapsed idler bearing;
- Fires of flammable liquids;
- Slide of a belt in a drive;
- Jammed rollers;

- Friction from brake;
- Excessive temperature of the drive;
- Seizing of bearings;
- Seizing of gears;
- Collapsed pulley bearing;
- Sparks, electrical causes; and
- Hot surfaces.

The design of the conveyor system, including maintenance programs and fire suppression systems will ensure it is fit for purpose.

3.5.3.2 PIPELINES

3.5.3.2.1 SITE SERVICES

Site services requiring pipework include:

- Water supply (Mains);
- Water reticulation (MAR, Underground supply, underground pump returns, storm water etc.);
- Sewage system;
- Compressed Air; and
- Electrical conduits.

3.5.3.2.2 MANAGED AQUIFER RECHARGE (MAR)

The proposed managed aquifer recharge system (MAR) will require a network of 50mm-110mm diameter pipelines to carry water from the water treatment Plant to the re-injection bores to the reinjection bores for the water that will not require treatment (Figure 3-112). Where possible, the pipelines will follow fence lines and will be located within easements on properties within the lease. Access and waiver agreements will be required with the landholders on whose land the bores and pipelines are located. There will be a need to pass the pipelines under the Bird-in-Hand Road – directional drilling is proposed for this to occur to prevent damage and excavation of the existing road surface.

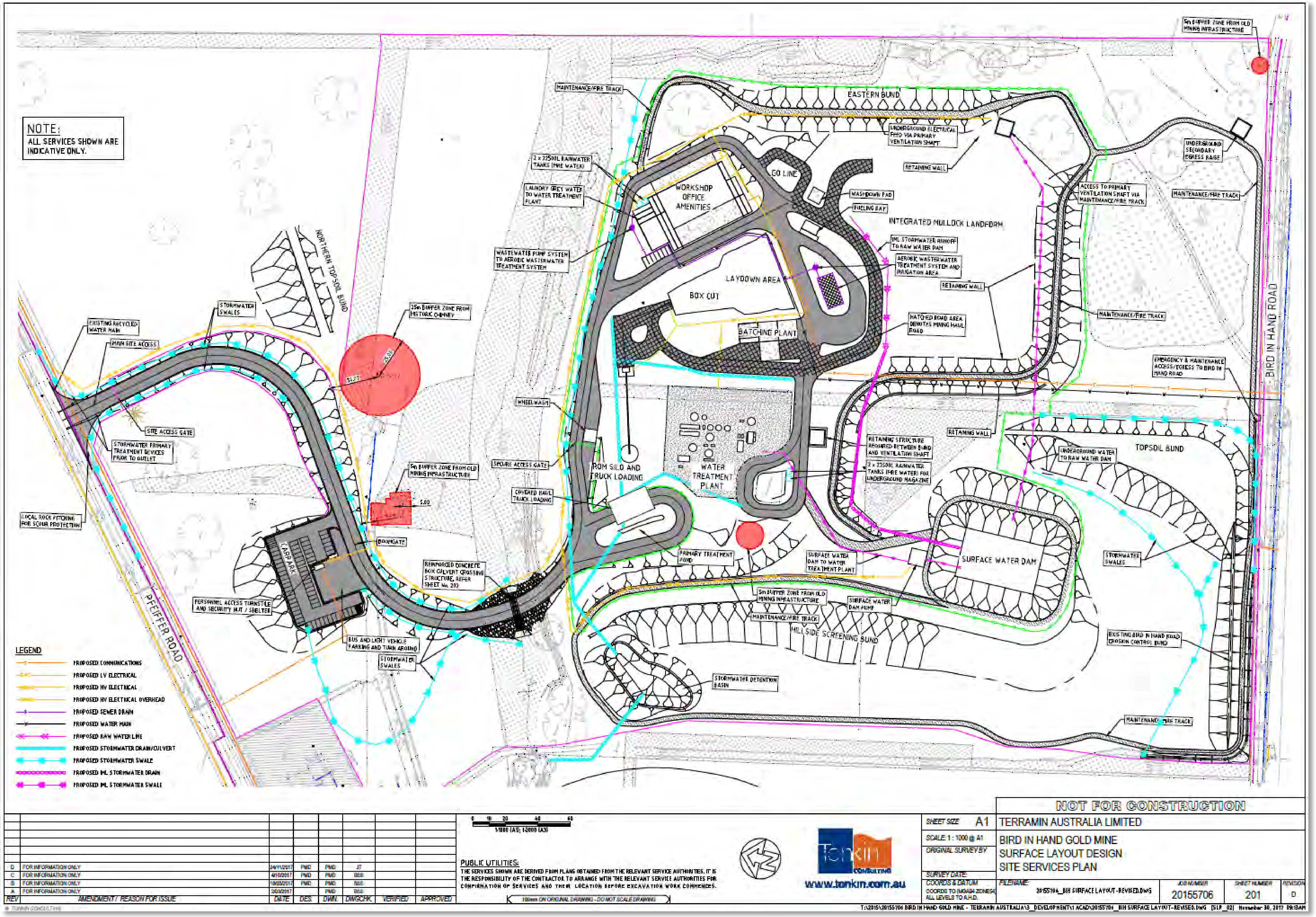


Figure 3-111 | Site layout showing services pathways (Appendix B1)

FIGURE 3-112 | PROPOSED MAR BORE LOCATIONS AND ASSOCIATED PIPELINES

3.5.3.2.3 UNDERGROUND SERVICES

The supply of compressed air, water and electricity for the underground component of the Project will be initiated from surface and require the laying of pipework and/or conduit from the source (air compressor, water treatment plant, transformer/substation etc.) to the dropper supply point underground. Proposed pipelines are shown in Figure 3-111.

3.5.4 STOCKPILES

3.5.4.1 UNDERGROUND ORE STOCKPILE

A series of underground ore passes will connect each of the levels to allow temporary storage of ore and mullock, placed by either underground loaders or ejector trucks, depending on requirements.

Ore pass dimensions are proposed to be 4m x 4m in cross section and approximately 20m in height. Storage capacity = approximately 850 tonnes (Figure 3-113).

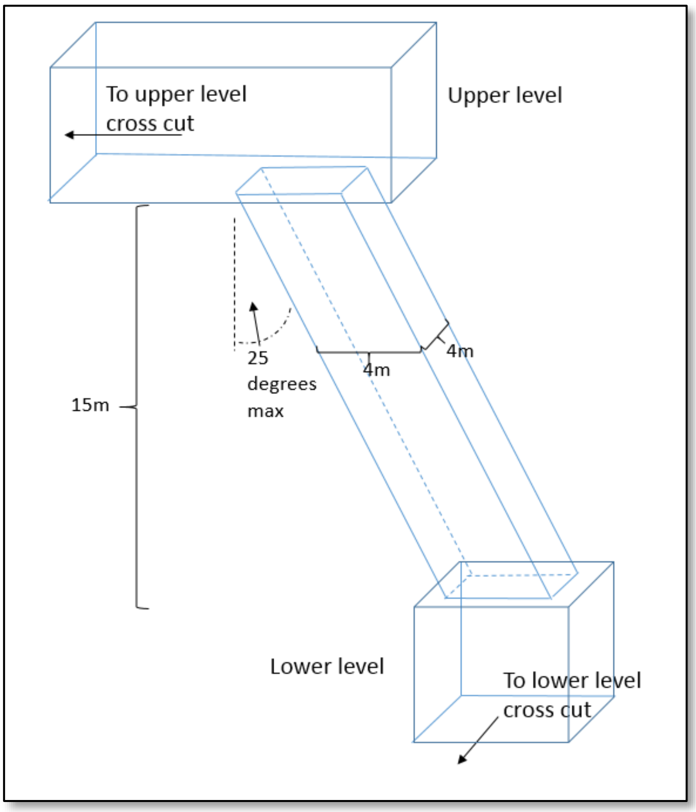


FIGURE 3-113 | ISOMETRIC VIEW SHOWING CONCEPTUAL ORE PASS DESIGN BETWEEN TWO CONSECUTIVE LEVELS

FIGURE 3-114 | UNDERGROUND LOADER TIPPING MATERIAL INTO AN UNDERGROUND ORE/WASTE PASS (INDUSTRY QUEENSLAND, 2016)

Broken material will also be stockpiled in available underground stockpiles (dedicated drives for the storage of material), again with a capacity of approximately 400 tonnes.

Water moving through underground stockpiles will be directed to the nearest sump and will be pumped to the surface for treatment. Material will not be stored long term within the passes, to prevent compaction and possible pooling/build-up of water.

3.5.4.2 *Surface ore stockpile*

It is proposed that ore will be stockpiled on surface in a specifically designed silo rather than a conventional pile. Once trucked to the surface, ore will be tipped directly into a hopper with a screen (aka. "grizzly") (Figure 3-83), and loaded via conveyor into the ore storage silo (ROM silo). Oversize ore (material that does not pass through the grizzly) will be stockpiled within a suitable storage area, and loaded into trucks using a surface loader periodically as required, or taken back underground for further breakage. By storing the ore in a closed structure (silo), the impacts from dust and noise are minimised, as well as providing a smaller footprint and improved stormwater management.

3.5.4.2.1 ROM STOCKPILE DESIGN

The ore storage silo will be sized to hold a capacity of ~1,500-2,000t (4-5 days production) and uses conveyors and weigh hoppers to transfer ore from the mine and loading into road trucks for haulage to APF for processing. Figure 3-115 shows the location of the ROM facility on the surface layout. The ROM stocks at BIH will be minimised with the preference for ore to be stockpiled at the APF site prior to processing.

FIGURE 3-115 | PROPOSED SITE PLAN SHOWING CONCEPTUAL LOCATION OF THE ROM SYSTEM (NUMBER 22, HIGHLIGHTED YELLOW) (APPENDIX G1)

3.5.4.2.2 METHOD OF STABILISATION AND EROSION CONTROL

As ore will be stored within an enclosed silo, no method of stabilisation or erosion control is required. Regular clean-ups around the conveyor and loading areas will manage any spillage from tipping and conveying.

Should the system be out of order for a period of time, short term temporary ore storage may be utilised underground or in a designated location on the IML, where the same stabilisation methods would be used as those for mullock stockpiles (3.5.4.3).

3.5.4.2.3 WATER MOVEMENT THROUGH STOCKPILES

All surface stockpiles of ore will be contained within sealed silos to ensure no water infiltration through the ore. Any material stored outside of these areas (i.e. during periods when the ROM system is unavailable) will need to be stored temporarily on the IML.

Run off from oversized stock piles and any short term storage of ore in the IML will be directed to the Mine stormwater management system and will be treated to the required standard.

3.5.4.3 INTEGRATED MULLOCK LANDFORM (IML)

Mullock is the collective term for un-mineralised broken rock generated by the mining process. Mullock taken from the mine as part of the access tunnels will be stockpiled for later use as backfill. On surface an Integrated Mullock Landform (IML) has been conceptually designed to hold all of the mullock generated during the Project life, with the assumption that all mullock mined will need to be stored on surface until it is used for backfill. The IML location was selected in respect of community expectations and is located to the south of the portal. In order to reduce the height and visual impact of the IML the existing landscape will be cut by approximately 5m with the cut material used in planned earthworks. Allowance has been made in the IML footprint to manage and separate sulphidic materials should they be encountered. There is sufficient area within the IML to allow for possible rock screening, if required for backfill purposes (using a temporary crushing and/or screening plant). The IML will also be used for storage of solid wastes produced from the water treatment plant prior to use in backfill underground. As a result, the IML has a height constraint for visual amenity of 10m, which is reliant on the landscape amenity bund design.

All designs use the assumption that all mullock material is brought to the surface rather than stockpiled underground where possible. Terramin will utilise stockpile drives, ore/waste passes and cross cuts to store mullock underground where possible, as it is more economical and efficient for backfilling, however, the IML area has been designed to hold the maximum amount of mullock generated for stockpiling at less than the height of the landscape amenity bunds, to minimise the visual impact. The IML area will be effectively screened from view behind existing established vegetation zones along with the construction of earthen landscape amenity bunding and new vegetation. In addition to reducing the visual impact, the vegetation assists in dust management.

The shape of the IML has been configured with broad radius curves (50m) to minimise the impact of erosion caused by water runoff. The IML is expected to be no greater than 10m high, i.e. above the height of the cut down IML floor. Currently the expected maximum IML capacity available is ~108,000m^3, a design factor of 1.7 has been applied in case additional space should be required. A rate of 2.7t/m^3 S.G. has been derived from geological testing of core to date and an industry standard swell factor of 0.3.

Volumes and designs will be continually refined, as the project completes both Feasibility Studies and the PEPR.

TABLE 3-34 | MULLOCK TONNES BY YEAR TO NEAREST KT/KLCM (2018 SCOPING STUDY)

	Year 1	Year 2	Year 3	Year 4	Year 5
Mullock (t)	195,000	196,000	146,000	105,000	48,000
Mullock (LCM)	94,000	94,000	73,000	50,000	23,000

3.5.4.3.1 LOCATION, SIZE, SHAPE AND HEIGHT

The location of the IML is shown in Figure 3-116 in red. The peak footprint used by the IML is 14,300m^2 area allocated to the IML. The mullock can be stored in the footprint of this area and stockpiled up to 10m high. Figure 3-116 to Figure 3-126 shows the estimated IML dimensions by year. The area will be cut down 5m into the existing surface. The cut material will be used to construct a surrounding 5m high visual bund above the existing landform to minimise the visual impact of the IML. This area will be effectively screened using earthen landscape amenity bunding and vegetation to reduce visual impact as well as assist in noise and dust management.

The plan view, Figure 3-116, of the IML illustrates the footprint taken up by the mullock in the planned area. The series of figures, Figure 3-117 to Figure 3-126 show the section views and isometric views of the IML at the end of each year of mining with the constructed surface in green and the IML in grey. Again, designs will be continually refined, as the project completes both Feasibility Studies and the PEPR. In the event of an increase in mullock as a result of design updates through feasibility, the constraints proposed regarding IML height and visibility will continue to be implemented and options to store mullock from decline development at APF will be investigated. Any mullock offsite will be controlled by the proposed haulage control measures and not increase daily average truck movements of 12 trips over the life of the project.

FIGURE 3-116 | PLAN VIEW OF SITE SHOWING CONCEPTUAL IML FOOTPRINT AT YEAR 1

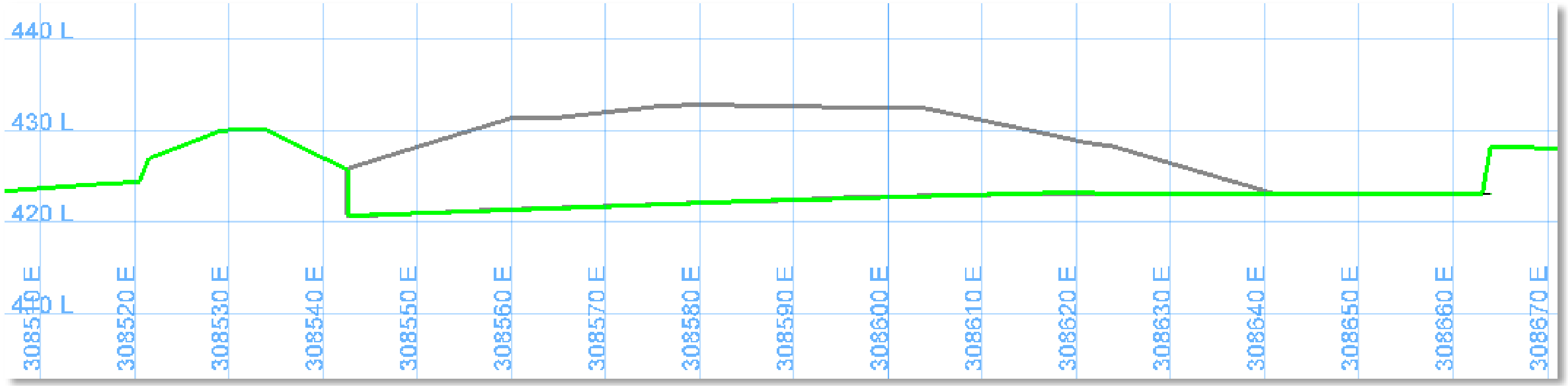


FIGURE 3-117 | CONCEPTUAL IML SECTION AA' YEAR 1, LOOKING NORTH.

FIGURE 3-118 | PLAN VIEW OF SITE SHOWING CONCEPTUAL IML FOOTPRINT AT YEAR 2

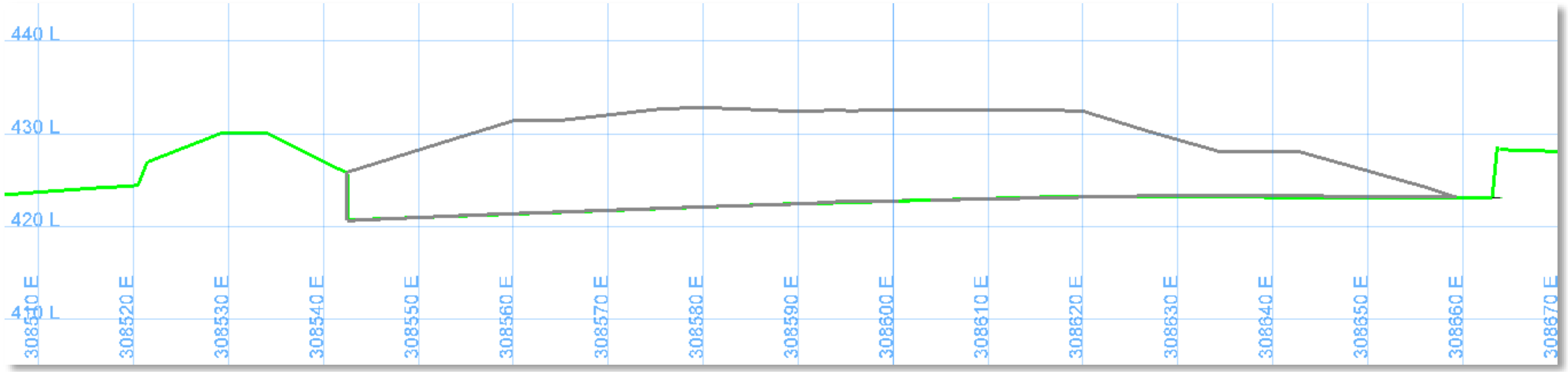


FIGURE 3-119 | CONCEPTUAL IML SECTION AA' YEAR 2, LOOKING NORTH.

FIGURE 3-120 | PLAN VIEW OF SITE SHOWING CONCEPTUAL IML FOOTPRINT AT YEAR 3

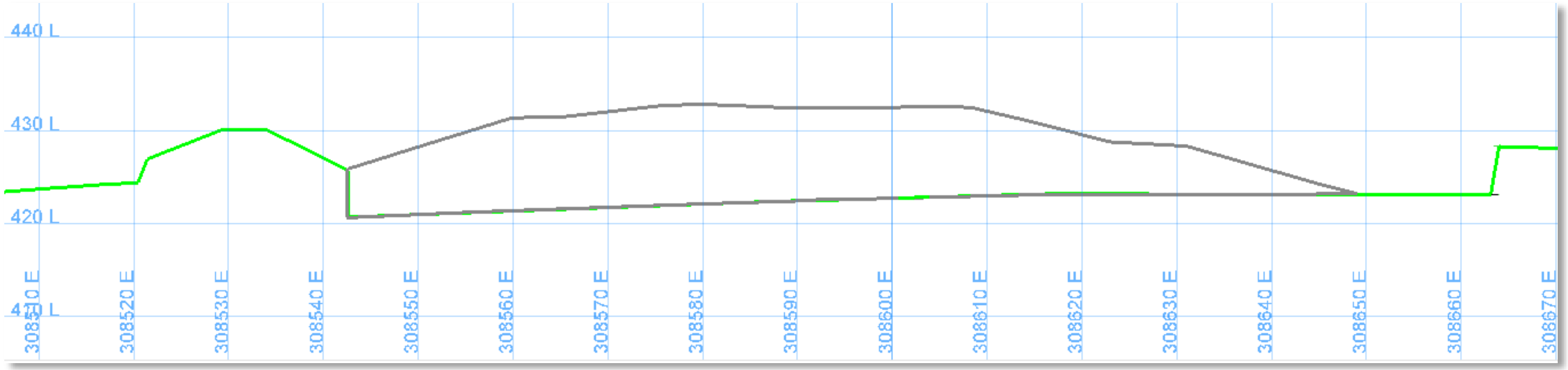


FIGURE 3-121 | CONCEPTUAL IML SECTION AA' YEAR 3, LOOKING NORTH.

FIGURE 3-122 | PLAN VIEW OF SITE SHOWING CONCEPTUAL IML FOOTPRINT AT YEAR 4

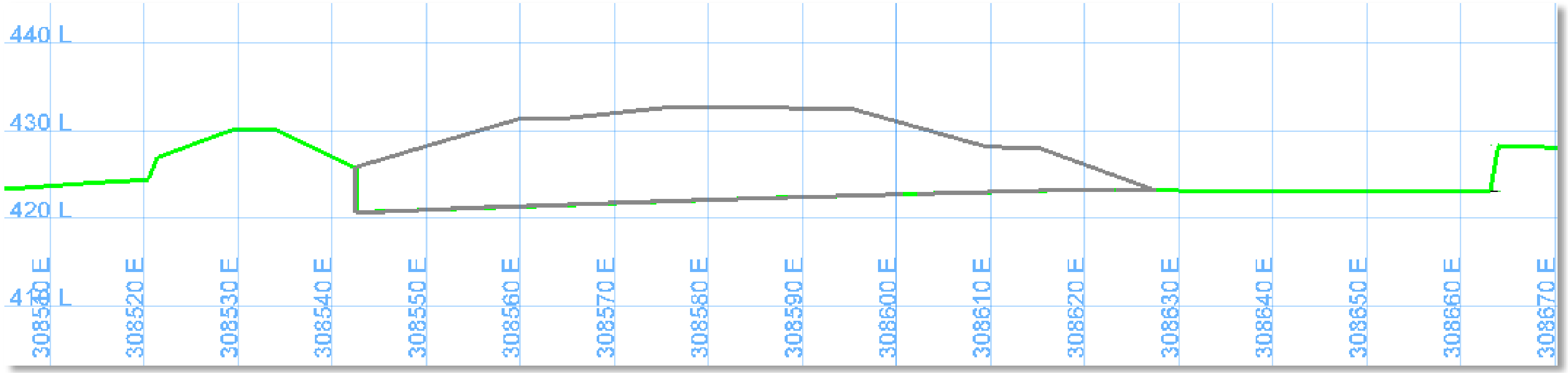


FIGURE 3-123 | CONCEPTUAL IML SECTION AA' YEAR 4, LOOKING NORTH.

FIGURE 3-124 | PLAN VIEW OF SITE SHOWING CONCEPTUAL IML FOOTPRINT AT YEAR 5

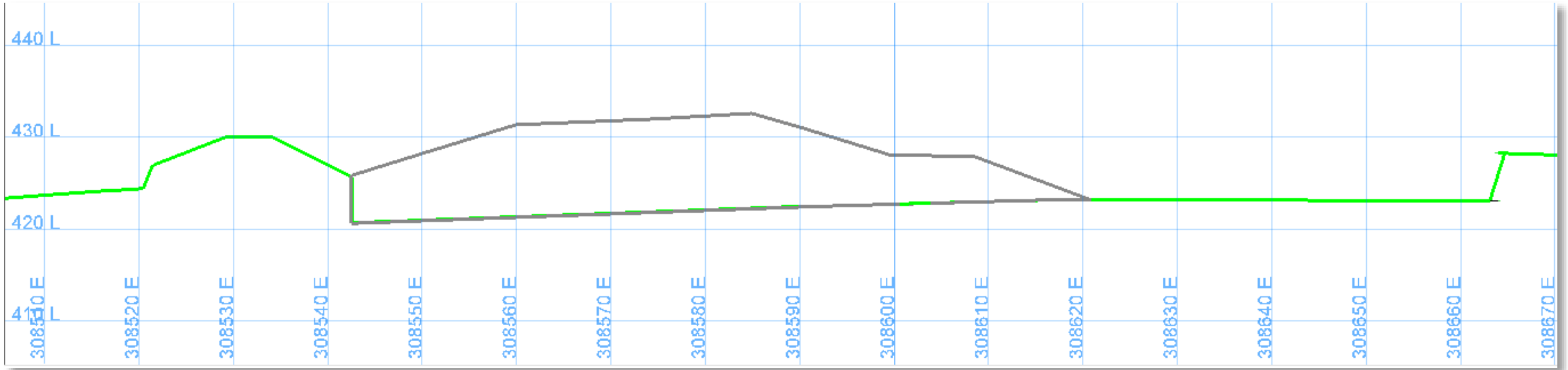


FIGURE 3-125 | CONCEPTUAL IML SECTION AA' YEAR 5, LOOKING NORTH.

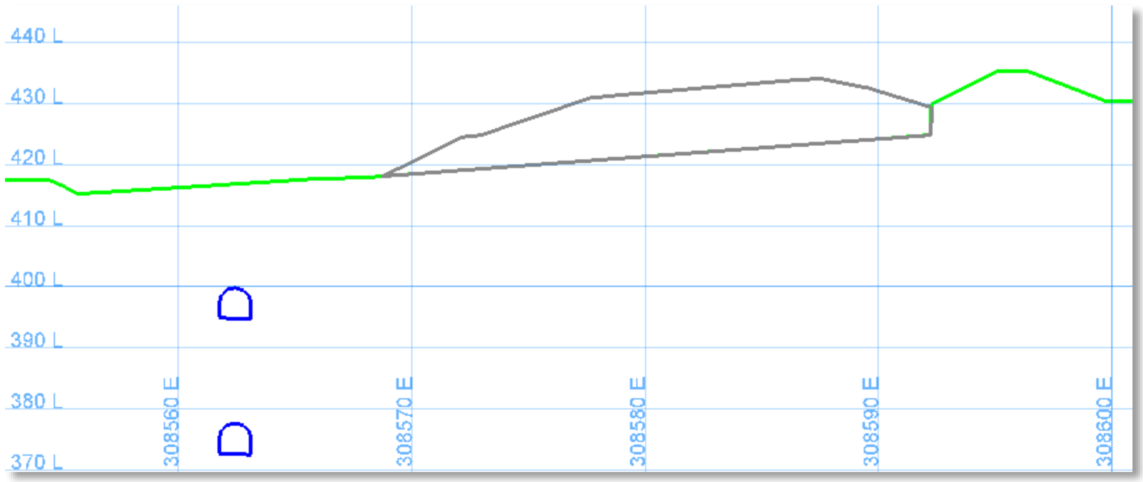


FIGURE 3-126 | CONCEPTUAL ML SECTION BB' FOR ALL YEARS LOOKING EAST

3.5.4.3.2 POTENTIALLY ACID FORMING MATERIAL (PAF)

An acid and metalliferous drainage (AMD) assessment was undertaken by Tonkin (2017) by examining the geochemical characteristics of 58 representative samples of selected country rock drill-core that represent the proposed mine geology (Appendix M2).

A very distinct zone of potentially acid forming material (PAF) has been identified in the supergene zone. The mine design was altered to ensure that the PAF is avoided where possible. (Figure 3-34). As a result there is a small amount of mullock that is expected to contain PAF material (the estimate is ~200-300t from the ventilation shaft). The PAF material identified is hosted within limestone/marble (carbonates) and other material that are classified as acid consuming (ACM) which has the effect of neutralising any potential acid formation resulting in an overall non-acid forming environment.

To minimise the likelihood of intersecting the identified PAF zone, the decline has been designed to pass below the supergene zone. In order to ensure that any unexpectedly encountered PAF material is managed, additional capacity has been allowed for PAF storage on the IML. All PAF material will be placed upon clay lining, and will be prioritised for storage underground and incorporated into the cemented backfill process as soon as possible. As described below, all drainage from the IML area will be pumped to the mine water storage dam via a silt and hydrocarbon trap, prior to undergoing treatment through the site's water treatment facility.

3.5.4.3.3 METHOD OF PLACEMENT

Mullock will be transported from the mine and placed on the IML by articulated ejector trucks. Once dumped the mullock will be shaped and compacted using a surface loader or excavator. The loader will be used to recover the mullock from the IML and loaded back into the mine trucks for use in backfilling.

Material used for backfilling may require screening to produce required size distributions for optimal strength, Figure 3-127. An area for screening has been anticipated in the space allocated for the IML. It is assumed that management of blasting techniques to manage fragmentation and screening will negate the requirement for waste crushing on surface. Screening of product could be done in short campaigns and required for only 2-4 weeks per year.

FIGURE 3-127 | SCREENING SYSTEM FOR MULLOCK ON THE IML IF REQUIRED. (ROCK, 2015)

3.5.4.3.4 METHOD OF STABILISATION AND EROSION CONTROL

Stabilisation and erosion control has been considered for both the shape of the excavated area to hold the IML as well as the shape of the IML as it progressively stores the mullock from mining operations. The IML excavation will be constructed with a batter angles as show in Table 3-35, modelled and confirmed as a stable landform by independent geotechnical consultants Mining One Consultants (Appendix M1) and the BIH Soil Erosion Assessment (Appendix L5). In cases where steeper angles are required, retaining walls will be installed.

Angles of the stored mullock will follow the guidelines outlined in Table 3-36, but will be reviewed depending on the properties of the mullock (size, rock types etc.).

TABLE 3-35 | PROVISIONAL CUT SLOPE DESIGN (<3M HEIGHT) (APPENDIX M1)

Soil Unit	Temporary (<3months)/ Permanent	Estimated Slope Angle (Max. Ht. 3m)	Slope (deg.)
In-situ Clay	Temporary	1H : 1V	45°
	Permanent	1H : 0.5V	26.6°
Extremely Weathered Rock	Temporary/Permanent	1H : 2.14V	65°

Notes:

1. Following excavation of cutting, recommended slope angles may have to be flattened (or retaining structures installed) due to localised groundwater inflows or poor ground conditions.

2. Stable slope angle may need to be revised subject to discontinuities and rockmass type / condition exposed by initial excavation.

Topical dust suppression techniques will be applied to the IML to minimise dust generation, delivered through either a sprinkler system or water truck. In areas where no disturbance is likely within 6 months, a topical treatment, or even temporary vegetation will be applied to minimise erosion, dust generation and water infiltration through the mullock.

A geotechnical review of the IML by Mining One (Appendix M1) shows that the peak production design for the IML stability indicate stable conditions with the Factor of Safety (FOS) in excess of 2.

During the construction phase of the IML infrastructure, it is proposed that a 5m vertical wall is designed as part of the stripping of the surface prior to the mullock being stockpiled. This 5m high vertical wall in clay/highly weathered material (Table 3-36). If this wall is to remain the batter will be reduced to 40° to 45° or retaining walls constructed on the inside of the IML. In order to prevent failure of this bank, mullock will be place onto the face to provide support and prevent failure. This will be further reviewed during further evaluation of the properties of the mullock (size, rock types etc.).

TABLE 3-36 | SUMMARY OF RESULTS FOR MODIFIED INFRASTRUCTURE DESIGN (APPENDIX M1)

Infrastructure	Phase	Wall	Water Conditions	Geometry	Factor of Safety (FOS)	Figure location in Appendix M1
Mine water storage dam	Peak production	East	Dry	18° batters, 11m high (2 batters)	3.95	D3
			Saturated		2.75	D4
		North	Dry	18° batter, 6m high	6.03	D5
			Saturated		4.89	D6
IML	Construction	West	Dry	5m vertical cut/wall	1.04	D9

	Peak production	West	Dry	21° batter, 6m high	1.97	D7
		North	Dry	21° batters, 13m high (2 batters)	1.96	D8

3.5.4.3.5 WATER MOVEMENT THROUGH STOCKPILES

Where possible, the size and shape of the IML will be managed such that water falling onto the IML will be directed around the landform and into the site's drainage system. The surface of the mullock will be managed to prevent water pooling and seeping down through the material. The design of the area will be:

> "*…constructed such that the base of the stockpile slopes in the direction of the later material reclaim and the head of the stockpile (the top surface of the stockpile) slopes in the opposite direction. Consequently, only little water flows or stands in the later reclaim area. The waste water should be collected and channelled into a settling basin for deposition of the suspended matter. The size of the basin depends on the stockpile area*" (Ziegelindustrie International Brick and Tile Industry International, 2011).

An example of a suitable stockpile layout showing the direction of flow for water run-off is provided in Figure 3-128.

A seepage assessment was undertaken as part of the water management and acid mine drainage (AMD) studies. The following is taken from the report: Geotechnical Assessment, erosion analysis (Appendix M1):

"*AMD assessment (Appendix M2) indicates that a quite small quantity of PAF material will be excavated, and the availability of large quantities of limestone waste means that neutralisation of that PAF material should not be difficult if co-disposed and/or encapsulated with limestone. Seepage from the IML may be mildly saline (due to neutralisation of PAF material), but – given that the base of the IML will be initially excavated below ground level – it is less likely that seepage from the IML will discharge onto the soil surface and enter the drain bordering the IML which reports to the mine water dam.*

Nonetheless, if saline seepage mixes with runoff from the IML, then it may increase sediment deposition in the mine water dam, and there is potential that that structure may need to be cleaned of sediment periodically if deposition rates are high. Regular monitoring of water quality in the mine water dam will be required.

Both compaction and surface sprays of a relatively viscous soil stabiliser/dust control product applied to the flat top of the IML could be used to minimise seepage if seepage quality is found to be undesirable."

The flow of water from the IML area will be directed to the surface water dam via a silt and hydrocarbon trap, prior to undergoing treatment through the site's water treatment facility.

Figure 3-128 | Example of a suitable stockpile layout showing direction of flow for water run-off. (Ziegelindustrie International Brick and Tile Industry International, 2011)

3.5.4.4 SUBSOIL STOCKPILE

There will be several stockpiles of soil, both sub soil and top soil, around the site created during the construction phase of the project. Earthworks for the operational area will cut into the existing surface and the resultant excavated material will be strategically placed around the site. Top soil will be stored separately for future use during rehabilitation of the site, and the majority of the subsoil will be used to create landscape amenity bunding to aid in the visual impact of the site, as well as provide benefits in noise and dust control.

3.5.4.4.1 LOCATION, SIZE, SHAPE AND HEIGHT

Figure 3-129, taken from the BIH Soil Erosion Assessment report (Appendix L5) shows the location of the bunds planned for the BIH site. Their size and shape will vary according to where they are located and the material that will be used to construct them.

FIGURE 3-129 | BIH SITE DESIGN WITH THE PROPOSED BUNDS WHICH HAVE THE POTENTIAL FOR EROSION (APPENDIX L5)

3.5.4.4.2 METHOD OF PLACEMENT

Top and sub soils will be removed using conventional earth moving methods (i.e. excavator, trucks, graders, rollers, dozers etc.) and will predominantly occur during the first 12 months of the operation as the site is prepared, allowing rehabilitation to occur as it happens

The first areas excavated after top soil removal will provide the materials to form the levelled area for the carpark as well as for the central bund and the screening bunds.

3.5.4.4.3 METHOD OF STABILISATION AND EROSION CONTROL

- Slope angles minimised to prevent run-off;
- Avoidance of sharp angles within the design
- Compaction where required; and
- Re-vegetation with grasses and shrubs/trees to assist with erosion control, dust management, noise and visual impact.

3.5.4.4.4 WATER MOVEMENT THROUGH STOCKPILES

The storm water management system designed by Tonkin, has been designed so that all water run-off from the IML will report to the mine water storage dam prior to undertaking water treatment. Refer to Stormwater Management Plan (Appendix I3) for how surface water flows are controlled onsite. The Water Treatment Plant is described in detail in section 3.7.9.5.

3.5.4.5 TOPSOIL STOCKPILE

3.5.4.5.1 LOCATION, SIZE, SHAPE AND HEIGHT

Current estimates of the required topsoil stockpile is approximately 72,000m^3. Based on the estimated operations area and an average topsoil thickness of 300mm. The topsoil stockpile is located on the eastern edge of the operations area in a bund. The bund is currently planned to be 3m high from the current ground surface and constructed with a batter angle no more than 30^o.

Based on the current layout the operational area where topsoil would be required to be removed is approximately 72,000 m^2. Therefore topsoil storage would be required for approximately 40,000 tonnes, based on an average thickness of 300mm as determined by soil sampling and geotechnical pits undertaken to date.

FIGURE 3-130 | STORMWATER MANAGEMENT PLAN SHOWING SURFACE RUN-OFF FROM THE IML BEING DIRECTED TO THE SURFACE WATER DAM (APPENDIX I3)

FIGURE 3-131 | SURFACE LAYOUT SHOWING THE TOPSOIL STOCKPILE SHADED IN YELLOW (APPENDIX G1)

3.5.4.5.2 METHOD OF PLACEMENT

The topsoil from the site will be removed using bulldozers and/or excavators prior to construction of the operations area. The soil will be transported and dumped using trucks and stacked and shaped using an excavator.

3.5.4.5.3 METHOD OF STABILISATION AND EROSION CONTROL

Stabilisation will primarily be through construction at a stable angle. Erosion control will be managed through spray seeding of the constructed surface. The vegetation creates a barrier preventing the high wind velocities from contacting the stockpile surface, thereby minimising entrainment of topsoil particles. Vegetation also minimises water runoff induced erosion of the topsoil from the stockpile. Figure 3-132 shows an example of cross section through a vegetated topsoil stockpile.

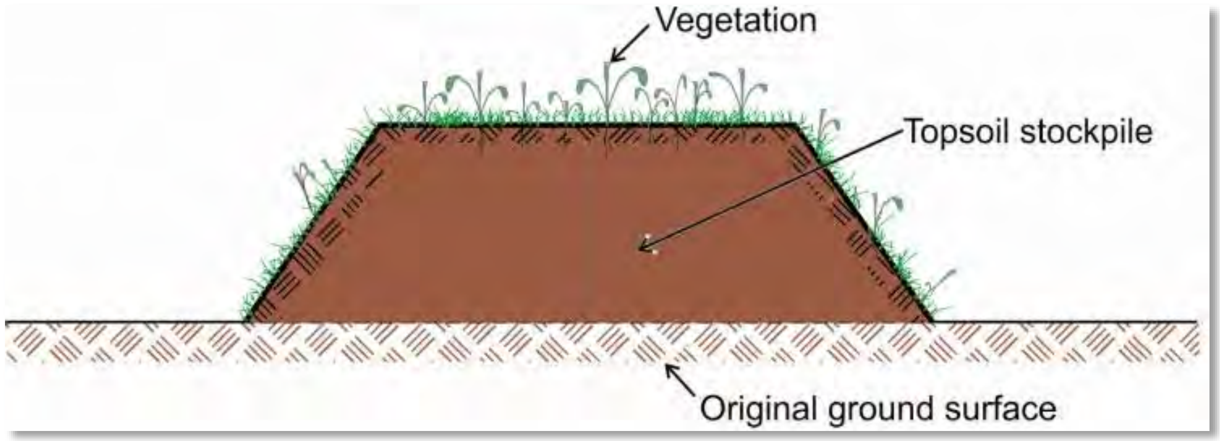


FIGURE 3-132 | EXAMPLE OF A VEGETATED TOPSOIL STOCKPILE (CECALA, ET AL., 2012)

3.5.5 REHABILITATION STRATEGIES AND TIMING

3.5.5.1 MOBILE EQUIPMENT

All mobile equipment will be removed from site once the mining operation finishes. The timing and sequence of the removal of the equipment will be dependent on the activities required during closure. It is likely that the equipment will be sold off at the end of the mine life, or used at any other operations the company deems necessary.

3.5.5.2 CONVEYORS, PIPELINES AND PRODUCT TRANSPORT

All pipelines except for those suppling services (power, water) to the offices and workshop area will be removed and recycled according to the site's waste management plan.

This includes the removal and rehabilitation of pipelines to MAR bores and lines to provide underground services used for the project

All conveyors and product transport infrastructure will be removed along with the rest of the ROM system infrastructure, and sold off for use by other parties, recycled or disposed of according to the site's waste management plan.

3.5.5.3 STOCKPILES

All material from the IML is planned to be used within the mine as backfill, with backfill continuing for a short period after ore production ceases.

All infrastructure for the ROM system will be removed from the site once ore production finishes. The area used for the conveyor system, the truck loading area etc. will be reformed and rehabilitated within the landscape as per the recommendations for the other stockpile and bunds on the site.

As part of the closure plan for the mine, and to ensure the turbidity of the existing surface water is not impacted, there is a need for erosion to be at or below the natural background 5 tonne/hectare/year level without any ongoing maintenance post mine closure. The bunds will remain and be built to remain stable post closure. For the bund surfaces which result in less than 5 tonne/hectare/year with a coverage of dense shrubs and/or native grasses, there is no further actions needed, as this reflects a regional trend and creates sustainable background erosion rates. For the remainder of the surfaces which are recommended to have annual hydromulching or permanent geospray, there are other management options to return the erosion level to natural levels. The northern topsoil bund will remain as a vegetated mound. The Eastern Screening Bund height will be reduced to 1.5m, with the same length and contour intervals applied at ~ every 3m with a slope of 2-5° along the slope length, with dense shrub vegetation coverage. Contour intervals established on bunds through construction will play an important role in preventing erosional potential. The remainder of the landscape amenity bunds and dams which will require ongoing maintenance after closure are designed to be in areas which are a commercial asset for prospective future owners. These include the carpark, dams and central track, which can all can be further managed by the future owners to prevent excess erosion as part of accepted basic land management practices.

TABLE 3-37 | RECOMMENDATION FOR CLOSURE PLANNING FOR EACH BIH LANDSCAPE AMENITY BUNDS (APPENDIX L5)

Bund (name)	Recommendations for Closure plans
Northern top soil bund	Remain as vegetated mound
Car park	Mulching and vegetation by new owners
Southern bund extention	Remain as vegetated mound
Water storage dam	Remain as vegetated mound and contoured slope. Minimal maintenance will be optional for new owners
Eastern screening bund	Height to be reduced to 1.5m, with same length, contouring and dense scub cover
Hillside screen bund	Remain as vegetated mound and contoured slope. Minimal maintenance will be optional for new owners
Stormwater bund	Mulching upkept by new owners
Central bund	Retaining walls and vegetations will remain

3.6 WASTES

3.6.1 Waste Rock Facilities

Information regarding the waste rock facilities – the IML – is discussed above in section 3.5.4.3

Fate of potential contaminant and their Source-Pathway-Receptor relationship has been addressed in their respective chapters:

- Groundwater –Chapter 10;
- Surface water – Chapter 11;
- Land and Soil Quality – Chapter 12;
- Geochemistry and geohazards – Chapter 13; and
- Site contamination – Chapter 14.

3.6.2 Other Processing Wastes

No processing of ore will be undertaken at the BIH site, with all ore to be hauled to the APF for processing. This section addresses wastes generated from the processing of site water, sources from the underground mine, or from stormwater run-off.

3.6.2.1 WATER TREATMENT WASTES

There are two main streams of waste produced from the water treatment system – waste solids and waste water.

The recovered sediment from the biofilter will have a concentration of 20-25% (% w/w) and will be sent to the IML for solids recovery as part of the mine backfilling, or will be transported to AZM for further processing, depending on the gold content. The filtrate from dewatering will be pumped to the wastewater tank and periodically removed from site to a suitable trade waste.

The suitability of this waste for site uses such as underground dust suppression should be investigated through the PEPR stage. If it is not suitable, it will be stored in the Brine Waste Tank and periodically removed from site to a suitable trade waste.

All surface water, groundwater and soil and land quality potential impacts and design measures and management strategies have been included in their respective chapters.

The following sections are taken from the Water Treatment Options Study undertaken by GPA Engineering (Appendix J1)

3.6.2.1.1 SOLIDS RECOVERY

The following options are recommended for the handling and recovery of solids that are removed by the water treatment plant (WTP) process, and also generated by rainfall runoff from the IML and other mine-affected areas;

- Sediment pumped from the clarifier is expected to have a concentration of 3 - 5% (% w/w). This sediment will be processed through a solids recovery unit, such as a belt filter press, with the aim of recovering about 90% (%w/w) of these solids. The recovered solids will have a concentration of 20-25% (% w/w) and will be sent to the IML for solids recovery as part of the mine backfilling, or will be transported to AZM for further processing, depending on the gold content. The filtrate from dewatering will be pumped to the wastewater tank.
- Water runoff from the IML area will contain solids as well as potentially soluble and insoluble metals. This runoff will be screened and collected in a sump system before being pumped back to the Storage Dam. Periodically, the sump will be pumped back to the WTP Feed Tank to remove metals and total suspended solids.

3.6.2.1.2 WASTEWATER

Wastewater generated from the WTP process will include;

- Backwash water from the Moving Bed Bio-filter:

  Backwash water flow (up to 1.8 litres per second) will contain up to 46 kg/day of suspended solids and biomass. It is proposed to direct this continuous flow back to the WTP Feed Tank to ensure less water is required for make-up in the site water balance. Sediment from this stream is also removed by the clarifier to minimise the impact of additional solids on the Storage Dam. Material from the moving bed biofilter will be periodically trucked offsite to a suitable approved waste facility.

- Brine waste from the Ion Exchange (IEX) system:

  Regeneration of the IEX resins will require the use of 1.5% to 3% (% w/w) sulphuric acid for the cation resin (co-current regeneration) and 10% (% w/w) brine for the anion resin (co-current regeneration). In each case, the regenerant will be passed at a controlled rate through the resin bed and then discharged as a waste stream into the Brine Waste Tank.

  The water required for each regeneration cycle will be sourced from the MAR tank as treated water. Preliminary estimates of the frequency of resin regeneration and the quantity of waste that will be produced for the Stage 1 IEX system are shown in Table 3-38.

  The size of the Brint Wate Tank will be defined through the Feasibility design stage of the project and detailed in the PEPR.

TABLE 3-38 | ESTIMATE OF REGENERATION WASTES (APPENDIX J1)

Type	No of beds	Frequency of regeneration (days)	Waste per regeneration (m^3)	Waste produced (m^3/day)
Cation	2	4	10	2.5
Lead Anion	2	4	10	5
Lag Anion	2	4	10	5
Waste produced per day				**12.5**

The combined regeneration waste is expected to have a total concentration of cations and anions of approximately 5% (% w/w). It was considered whether the volume of this brine waste could be reduced further. However, RO units would only reduce volume by 50%, are not cost effective hence, reducing brine volume was not considered further. The suitability of this waste for site uses such as underground dust suppression should be investigated. If it is not suitable, it will be stored in the Brine Waste Tank and periodically trucked offsite to a suitable trade waste disposal facility.

- Rinse water from IEX:

  On completion of each resin bed regeneration, rinsing of the resin beds with good quality water will be required to restore the resins to their duty condition. It has been calculated that each resin bed will be regenerated every 4 days. The cation beds will each require about 12 m^3 of rinse water while the anion beds will need about 7 m^3 of rinse water each time. The amount of rinse water produced every 4 days will total about 52 m^3. The rinsate will be sent to the Wastewater Tank. The suitability of this waste for site uses such as underground dust suppression should be investigated through the PEPR stage. If it is not suitable, it will be stored in the Brine Waste Tank and periodically trucked offsite to a suitable trade waste disposal facility.

3.6.3 Explosives

Explosives will be transported, stored and used in accordance with Australian Standard AS 2187. Packaging will be disposed of via an appropriate waste stream (cardboard/plastic). Any explosive materials unused, expired or spilled, will be managed according to the explosive handling regulations and standards, by licenced operators, and in consultation with the manufacture as required.

3.6.4 Industrial and Commercial Wastes

The Project will endeavour to avoid and reduce waste generation. It is proposed that a number of waste streams will be generated at the mine site for disposal as summarised in Table 3-39. Contamination of the site and surrounding environment is possible if these wastes are not stored, handled or disposed of in the correct manner. A site waste management plan has been developed for the site, and will be regularly updated as the activities and associated waste streams come online.

Table 3-39 | Potential Waste Streams and Preferred Disposal Methods

Waste Stream	Preferred method of disposal
Paper and Cardboard	Offsite licenced recycling facility

Recyclable food containers and packaging including plastic, bottles, cans, metal and glass	Offsite licenced recycling facility
Scrap metal	Offsite licenced recycling facility
Tyres and other rubber	Offsite licenced recycling facility
Electrical and electronic	Offsite licenced recycling facility
Solid hazardous waste	Licenced offsite facility
Waste oil	Offsite licenced recycling facility
Masonry	Offsite landfill
General waste - inseparable	Offsite landfill
Plastics	Offsite licenced recycling facility or licenced landfill if not recyclable
Organics and putrescible	Offsite green waste facility
Leather and textiles	Offsite green waste facility
Timber and Wood	Offsite green waste facility

Regular waste audits will be undertaken as part of the site waste management plan to monitor type and quantities of waste being stored on site, as well as checking the storage methods comply with regulations.

Where possible, storage of wastes will occur close to the site of use to minimise the spreading of possible contamination, while still maintaining required levels of isolation such as ignition sources and fume impacts. Disposal will be done on a regular basis to prevent lager stockpiles from accumulating on site.

No long term storage of waste is proposed on site, rather it is removed from site and disposed of in a licenced facility or recycled.

3.6.4.1 PUTRESCIBLE WASTE

Where possible, this waste stream will be separated and disposed of to a green waste disposal facility. Where these wastes cannot be separated out from general waste they will follow the general waste stream to be disposed of in a EPA licenced facility.

3.6.4.2 SEWAGE

Terramin's preference is for the site sewerage to be pumped off site, connected to the Bird in Hand Waste Water Treatment Plant, located on Bird in Hand Road. Upgraded in 2017, the new plant treats wastewater from several catchments including Lobethal, Woodside, Charleston and Inverbrackie and has capacity of up to 12.5ML/day to cater for growth in the Adelaide Hills over the proceeding decades. The location of the treatment plant is shown below in Figure 3-133.

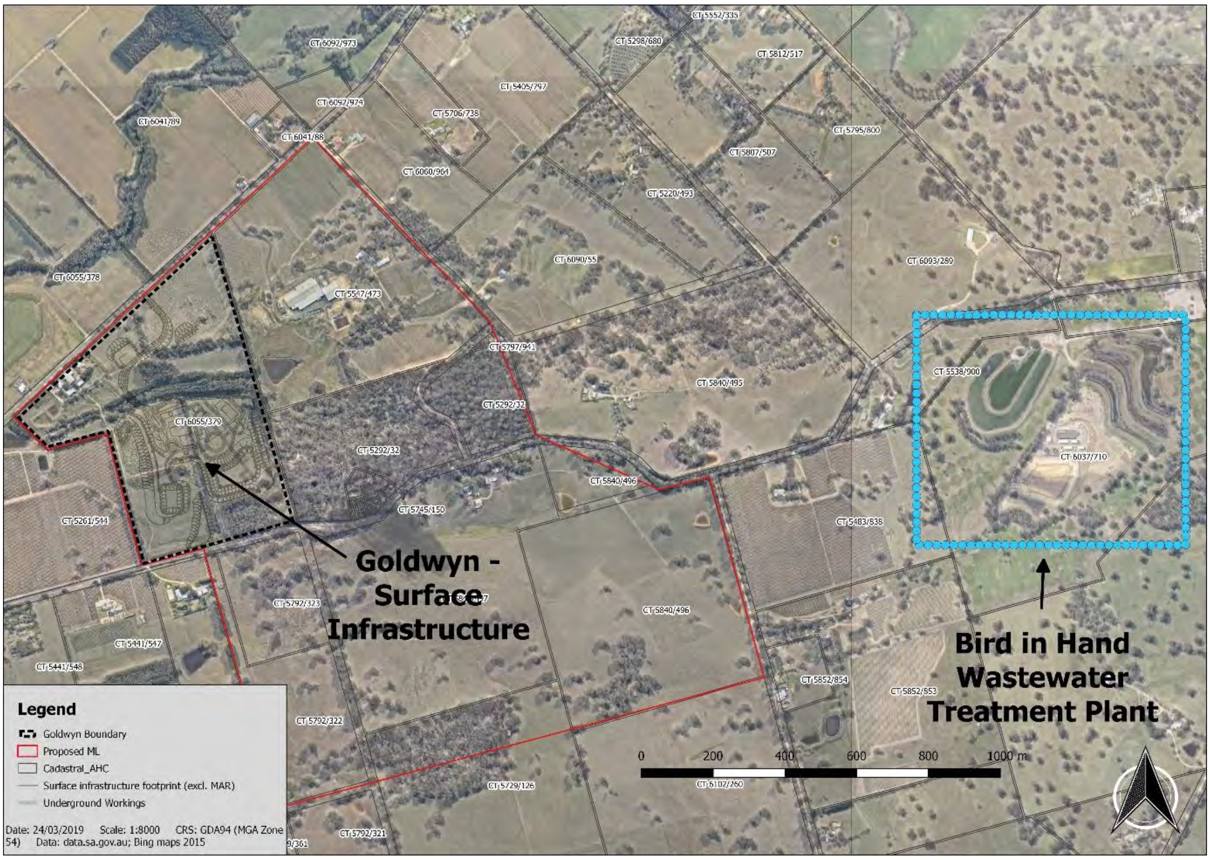


FIGURE 3-133 | SA WATER BIRD IN HAND WASTEWATER TREATMENT PLANT

In the event that this option is not feasible, Terramin have designed an onsite sewerage system, described below.

Sewage will be directed into an approved, on-site septic tank system. Effluent will be treated on site via an aerobic system or similar and discharged via an onsite land application system. A nominal irrigation area will be identified on the drawings; however, this is subject to outcomes of detailed design.

As part of a maintenance program, periodic pumping of the holding tank will be required to clean it. This will be done by a licenced operator and disposed of to a licenced facility. SA Water's Bird in Hand wastewater treatment plant is located a short distance from the site, and could possibly be a disposal method for this stream.

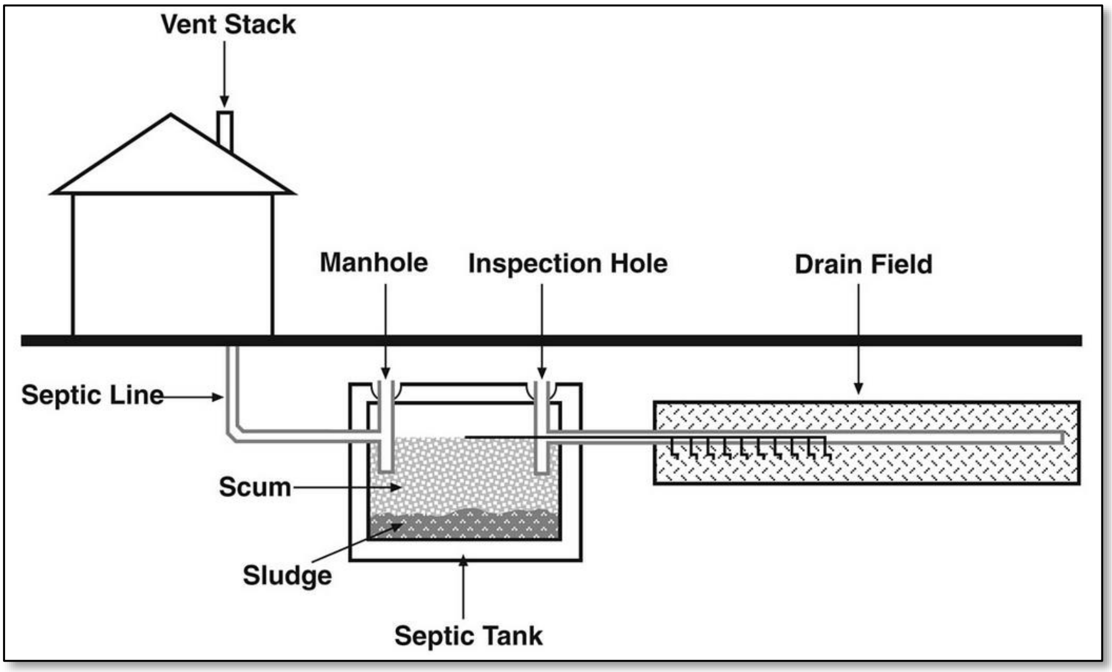


FIGURE 3-134 | CONCEPT OF PROPOSED SEPTIC SYSTEM FOR THE SITE

The mining offices septic treatment system outflows will be drip irrigated onto an area (commonly called a land application area) of at least 450m^2 and vegetation, such as reeds, grown to utilise the nutrients and water (Figure 3-134. The land application area is an area of land within the confines of the operational area in which the discharge from the septic tank is spread in such a manner that the water and its dissolved and suspended solids are absorbed into the soil profile for final treatment. The nutrients are absorbed by the vegetation or retained in the soil, the water drains slowly downwards and sideways under capillary flow and upwards to evaporate into the atmosphere.

The surface of the land application area must be protected from traffic (vehicle and people) as compaction when wet will impede the effective movement of water. The land application area will have diversion of run-on water away to other areas.

The septic system will be constructed and operated in accordance with SA Health Department requirements and will be inspected quarterly. Signage to ensure no personal access occurs will be installed.

3.6.4.3 TYRES

Commercial arrangements will be put in place, as is common in industry, for tyre supplier(s) will remove used tyres from the site for disposal through their approved, licenced systems.

3.6.4.4 OILS AND HYDROCARBONS

These wastes will be stored on site in approved, bunded containers, and disposed of through approved, licenced facilities.

3.6.5 REHABILITATION STRATEGIES AND TIMING

Details regarding the rehabilitation strategies and timings for the surface ore, mine waste handling and stockpile is dicussed in section 3.10.

3.7 SUPPORTING SURFACE INFRASTRUCTURE

A variety of supporting infrastructure will be required within the proposed Mining Lease boundary to support the proposed Mining Operation (Figure 3-135). These include:

- Access roadway into and around the operational area within the site;
- Landscaping;
- Fuel and chemical storage;
- Site security infrastructure; and
- Stormwater management and drainage infrastructure.

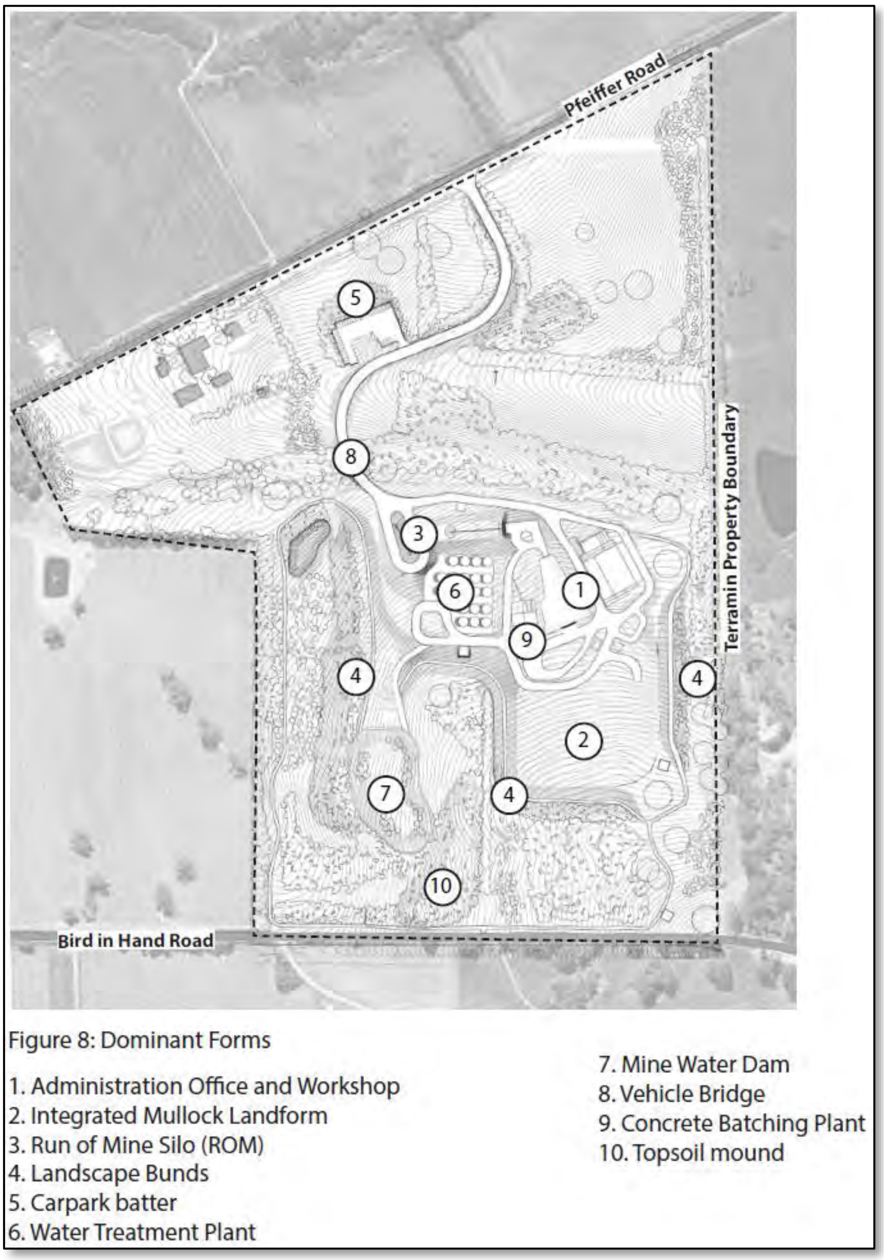


FIGURE 3-135 | MAIN AREAS WITHIN THE PROPOSED BIH MINE SITE (APPENDIX G1)

3.7.1 ACCESS

3.7.1.1 EXPLORATION SITE(S) AND MAR BORE ACCESS

Access to the Project's underground exploration sites will be from Pfeiffer Road and the access as per the mine site access as described in 3.7.1.2.

Other potential exploration sites as described in Section 3.3, will be from Bird in Hand Rd, with access off this road via the existing landholder's access driveways, as shown in Figure 3-136 utilising a combination of existing tracks, existing unformed tracks and any unformed tracks with landholder consent. Designated tracks will be constructed as required to the drill sites, minimising the disturbance to the area in accordance with the following:

- Ministerial Determination MD013 (Government of South Australia, 2015)
- Minerals Regulatory Guideline MG22: Guidelines for conducting mineral exploration in South Australia (MG22)
- Statement of environment objectives and environmental guidelines for mineral exploration activities in South Australia (M33) (Department of the Premier and Cabinet, 2004).

All tracks will be rehabilitated in accordance with landholder's requirements.

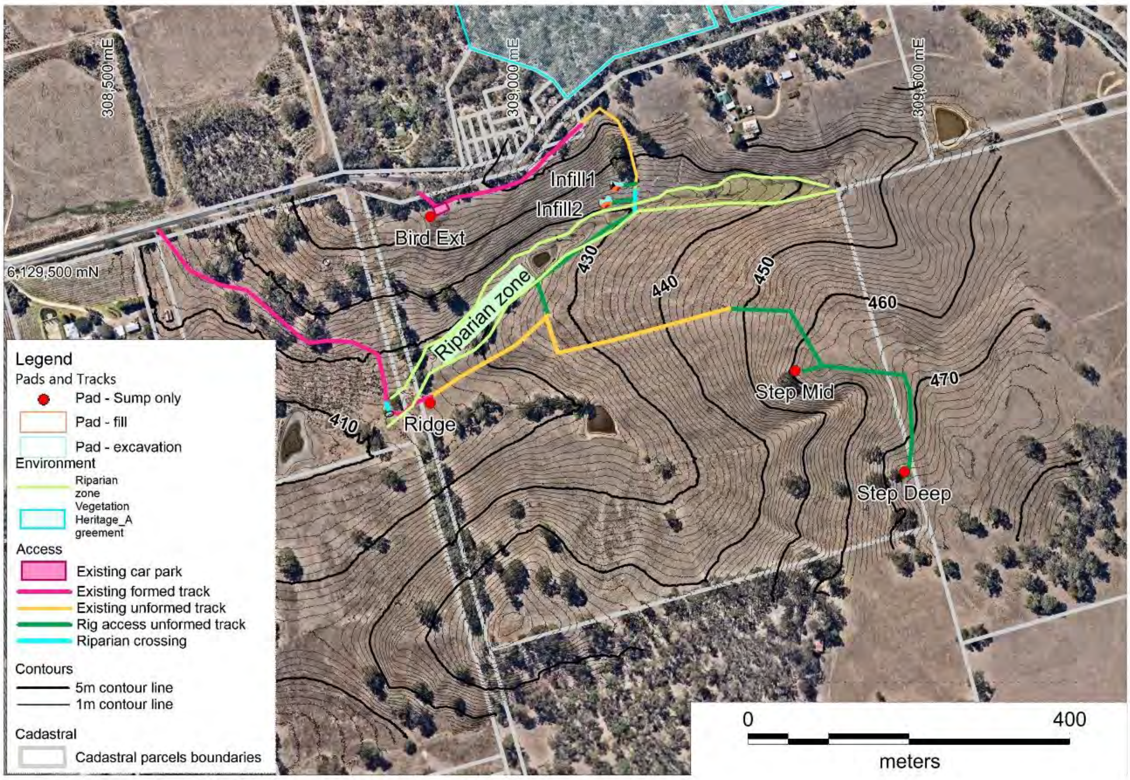


FIGURE 3-136 | CONCEPTUAL EXISTING ACCESS TO EXPLORATION SITES FROM BIRD IN HAND ROAD (TAKEN FROM SARIG, 2018)

3.7.1.2 MINE SITE ACCESS

Access to the Project site will be from Pfeiffer Road (Figure 3-137). A new access road into the site will be constructed on the Goldwyn property, suitable for planned vehicles entering the site. The proposed access road is shown in Figure 3-137 starting at the red Pfeiffer Road Entry. The site of the new access was selected at the point that provides the best line of sight in each direction. Consideration was given to existing and proposed third party accesses onto Pfeiffer Road to present the safest location for traffic using Pfeiffer Road along with entering/exiting vehicles.

It is proposed to construct an additional turn out lane to allow for the passing of turning vehicles into the site (Figure 3-138 and Figure 3-139). In recognition of the existing stormwater drainage and erosion issues along Pfeiffer Road, the access will incorporate drainage for the existing road and control the drainage from the access. The drainage can be seen in Figure 3-139 running under the access road.

The majority of vehicles, in particular heavy vehicles, will access the Project from the southwest from the Nairne Road. However occasions may occur where alternate routes are used depending on where the vehicles are travelling from/to and the conditions of the road network at the time.

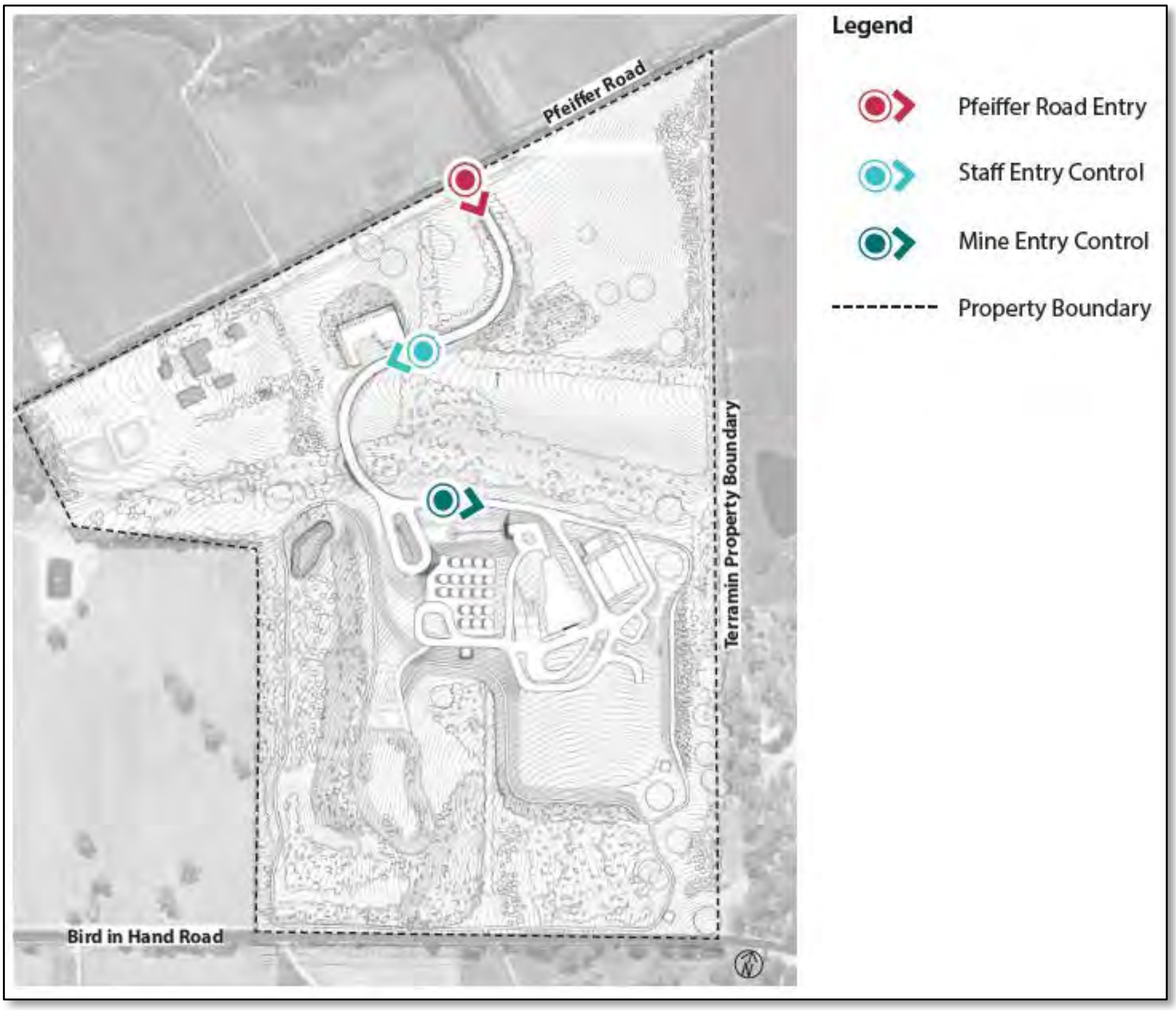


FIGURE 3-137 | PROPOSED SITE ACCESS AND SECURITY POINTS (APPENDIX G1)

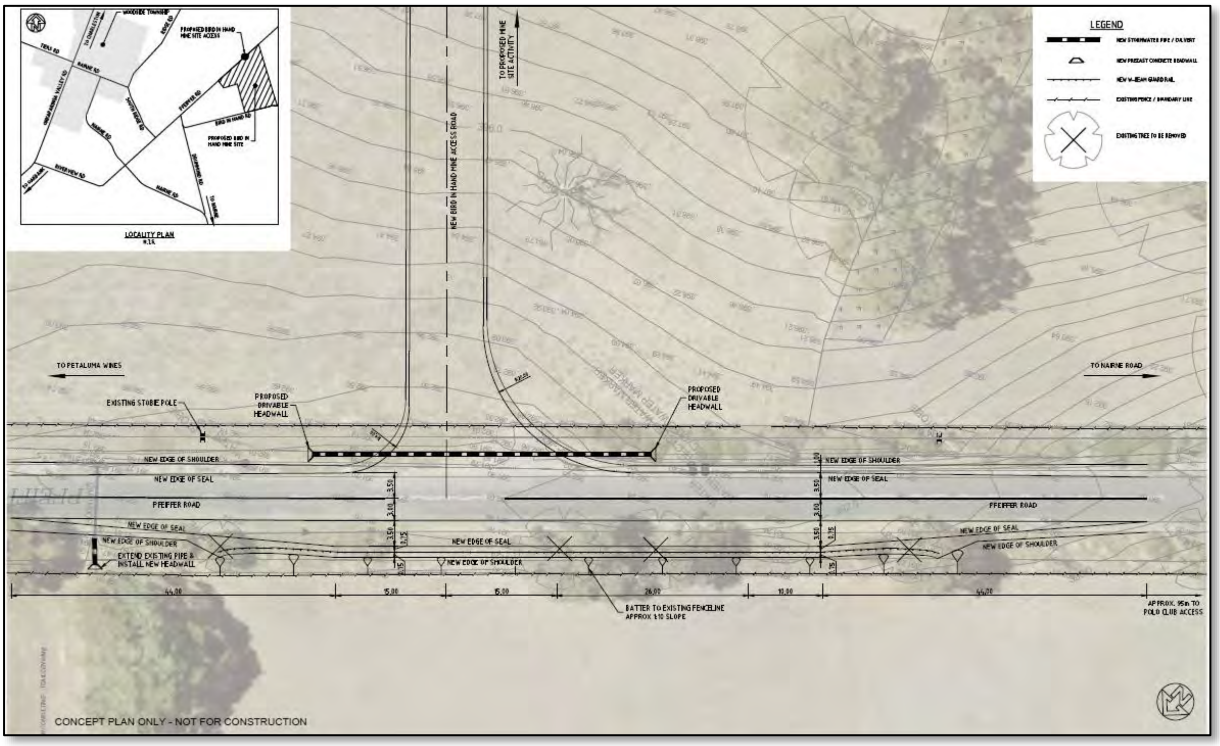


FIGURE 3-138 | PROPOSED SITE ACCESS AND ADDITIONAL PASSING LANE (APPENDIX F1)

FIGURE 3-139 | PROPOSED NEW SITE ACCESS FROM PFEIFFER RD (VIEW LOOKING WEST ALONG PFEIFFER RD) (APPENDIX X1)

3.7.1.3 ACCESS TO MAR BORES

Access to MAR bores will be utilising existing road networks along Pfeiffer, Reefton and Bird in Hand Roads.

MAR bores located within Goldwyn will be accessed utilising the proposed access roads proposed in the site design outlined in section 3.7.1.2. MAR bores located off Reefton Road will be accessed via

Reefton Road and the existing fire access track. MAR bores located on the southern side will be accessed utilising the same access as proposed exploration sites outlined in section 3.7.1.1.

3.7.1.4 NEW ROAD CONSTRUCTIONS AND UPGRADES

3.7.1.4.1 EXTERNAL AND PUBLIC ROADS

All roads considered for the proposed haulage of ore to the processing facility at AZM are existing and established, comprising a minimum of two-lane, two-way, undivided sealed roads. to the proposal is to make use of the South Eastern Freeway where possible as the high frequency corridor provides a two-way dual carriageway established for the efficient transport of bulk commodities and goods. The proposed haulage vehicle is a Tipper Truck and Dog trailer <19m length (Truck and Dog). This vehicle is rated as a General Access Vehicle (GAV). General Access Vehicles (GAV) 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 across South Australia unless the road is sign-posted otherwise. All of the roads proposed for use along the haulage route have a minimum classification for use with general access, up to a 19m semi-trailer.

The most efficient route uses the arterial road from Woodside to Nairne and onto the South Eastern Freeway at the Bald Hills intersection and to Strathalbyn via Callington Road.

Upgrades to Pfeiffer Rd will be required at the access point where traffic will turn into the new site access road, in order to allow other vehicles to pass as vehicles are turning into the site, see Figure 3-138. This is described in section 3.7.1.1.

Tonkin were commissioned to look at possible haulage options and suitable haulage vehicles. During the Traffic Impact Assessment (Appendix F1), Tonkin identified that if larger haulage vehicles, B-doubles and Truck Trailer combinations of >19m were used restrictions on haulage capacity on local roads limited access to the Project. The original assessment, looking at larger capacity trucks, was undertaken in recognition that community engagement had identified that adding haulage trucks was a concern for local residents. On reviewing the existing traffic movements and the impact of the small increase in traffic posed by the Project it was determined that the reduction in traffic benefit provided by the larger trucks was not material. The use of smaller GAV for haulage complied with the existing ratings along the proposed haulage route and presented a cost effective solution to haulage.

During the Traffic Impact Assessment it was recognised that the Pfeiffer Rd and Nairne Rd intersection is not currently fit for purpose and does not comply with requirements to meet General Access Vehicle (GAV) and Rigid Access Vehicle (RAV) requirements. This has been brought up in discussions between the DPTI and Adelaide Hills Council. There is an existing need to address this intersection. In the last five years of records there has been 13 crashes on this intersection resulting in 9 injuries. Considering the proposed development in the area, particularly with the planned housing development ("Crest @ Woodside" owned by Mill Hill Capital) planned for the Inverbrackie Army Base area, it would be advantageous to upgrade this intersection. The wheel marks from existing traffic pulling onto the Nairne Road can be seen in Figure 3-140.

FIGURE 3-140 | PFEIFFER ROAD/NAIRNE ROAD INTERSECTION SHOWN WHEEL MARKS FROM EXISTING TRAFFIC.

3.7.1.4.2 INTERNAL ROADS

Planned internal roads are illustrated in Figure 3-141. The access road into the site will be cut into the existing ground surface to ensure suitable grades for the nominated design vehicles and ease of access where possible. The admin site access will be via Pfeiffer Rd. Emergency access will be provided at the southern end of the site onto Bird in Hand Road. Other design bases used for the design of this access road are listed below.

- All significant trees will be avoided;
- The road will incorporate a flat grade section adjacent to the proposed entrance security check point i.e. potential vehicle standing zone;
- Designed speed limit for the haul road is 20km/h;
- The road has been designed to accommodate B-double vehicles. This is a design contingency if at anytime Pfeiffer Road is gazetted to allow for B-double vehicles;
- Road run-off and drainage to control stormwater flows;
- Road batters have been designed to avoid riparian zones; and
- The roadway configuration allows for separation between delivery access and operational vehicle movement requirements where possible. It is assumed that the operations area ring

road will be one-way around the workshop (clockwise) to cater for delivery and mining vehicles.

Longitudinal sections of the access road proposed is shown in Appendix F1.

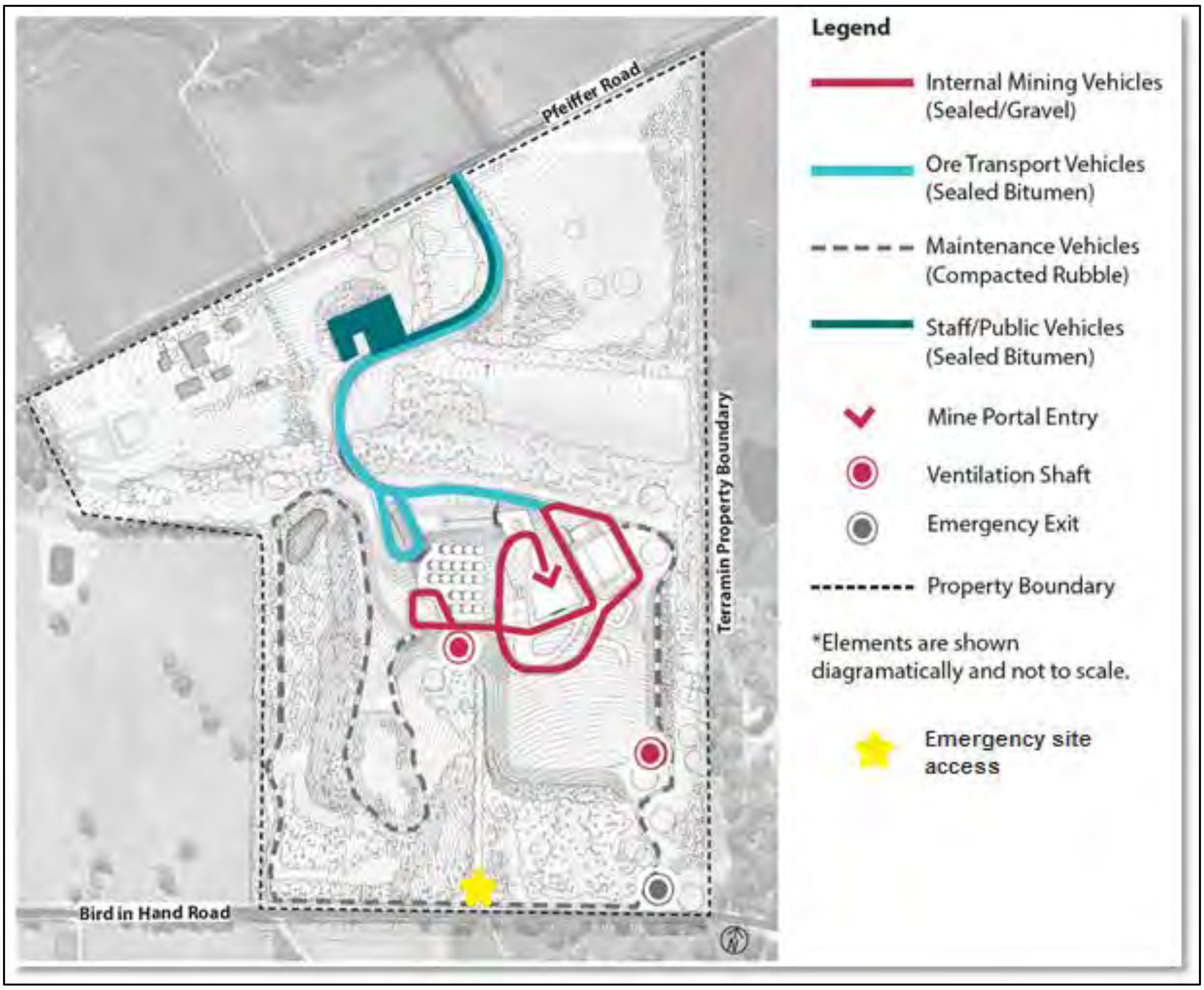


FIGURE 3-141 | PROPOSED INTERNAL ROAD TYPES AND ACCESS POINTS FOR THE BIH SITE (APPENDIX G1)

3.7.1.4.3 MAIN CARPARK

A new carpark will be constructed for site personnel and visitors, located just off the new access road. A 60 car and 5 motorbike parking area has been allowed for, in accordance to *AS2890.1:2004 (Parking facilities Part 1: Off-street car parking)*. Access into the site will be controlled by a gate adjacent to the car park. All persons entering the site will be required to pass through a security access point. The carpark design includes lighting that is consistent with 24 hour operation and in accordance with *AS1158 Road Lighting*, whilst minimising light spill.

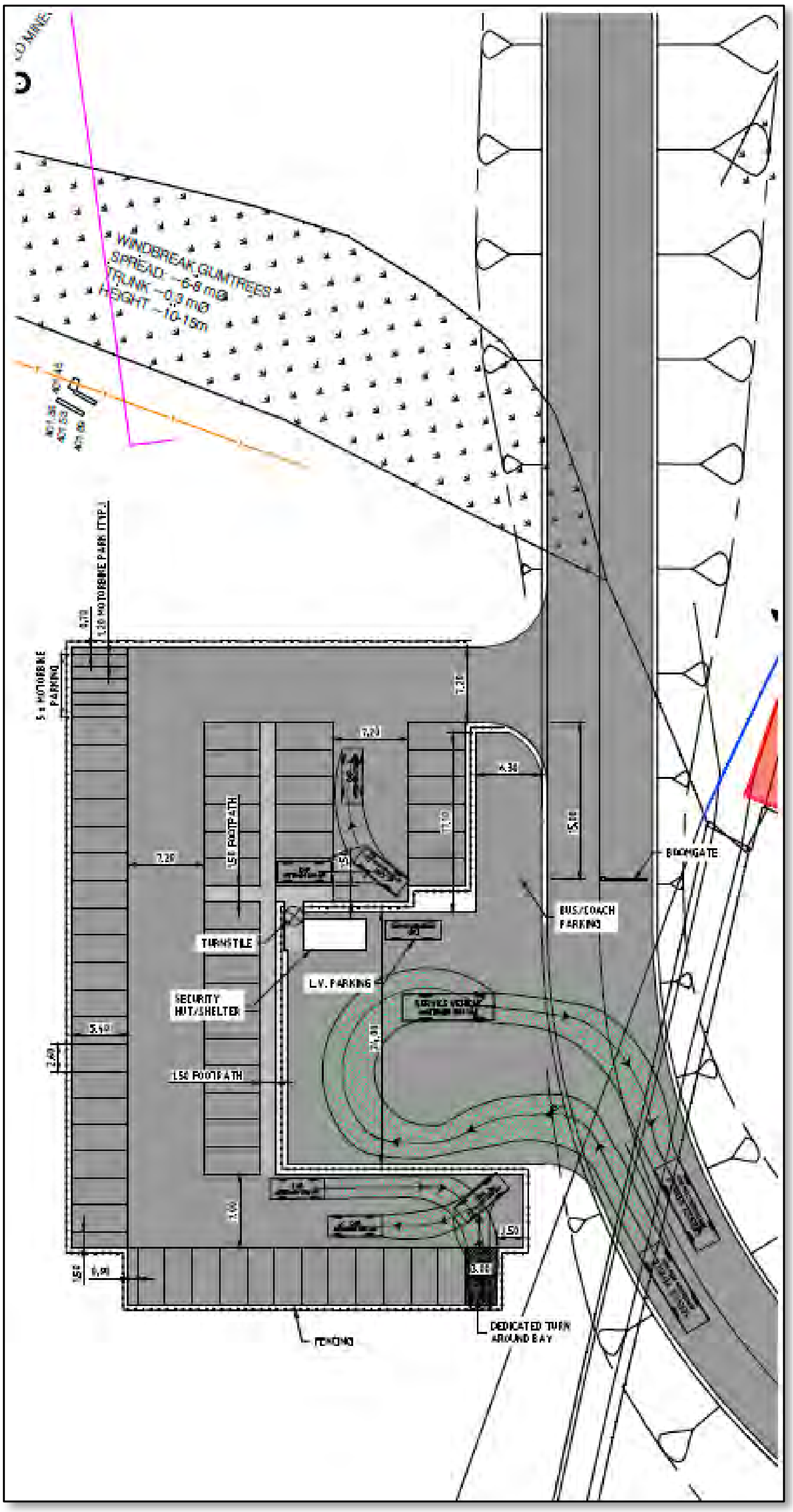


FIGURE 3-142 | EXCERPT FROM CONCEPTUAL SITE CARPARK AND SECURITY CHECKPOINT (TONKIN CONSULTING, 2017)

3.7.1.4.4 CREEK CROSSING

In order to access the operational area from Pfeiffer Rd, a creek crossing is required. The existing crossing consists an un-formalized crossing incorporating a culvert and loose fill. The existing crossing is not suitable for the planned vehicle types and volumes. A preliminary design for the creek crossing is shown in Figure 3-143. The crossing will involve the placement of culverts into the creek to maintain unrestricted flow, and designed fill to smooth the road gradients. The design included consideration of minimal disturbance of the riparian zone and suitable grade for vehicle movements. The shallower grade afforded in the proposed design provides loaded haulage vehicles a more sympathetic incline which reduces engine laboring and the potential noise generation when leaving site.

3.7.1.4.5 OPERATIONS AREA RING ROAD

A roadway has been designed around the operation site to facilitate deliveries to and from site. A ring route has been provided to assist with access and reduce the likelihood of reversing vehicles. The access has been designed to accommodate 26m B-double vehicles. These vehicles will only be accessing site under permitting requirements as they are not general access vehicles and the local road network is not gazetted for these vehicles.

3.7.1.4.6 TRANSPORT SYSTEMS

All material and personnel will be delivered to and from site via permitted and registered vehicles approved for use in South Australia. Road Haulage of ore will be transported from the site’s ROM loading facility in standard GAV, Truck and Dog <19m with covered loads.

The majority of supplies and consumables will be delivered to site in standard registered vehicles ranging from light vehicles (standard cars and utilities) up to Semi-trailer – depending on the load involved. As Pfeiffer road is limited to General Access Vehicles (GAV) vehicles travelling to and from site will be restricted to this class of vehicle.

Occasionally (such as during the construction phase and the mine closure phase) there will be some temporary need for oversize vehicles such as cranes to travel to and from site. These occurrences will be undertaken using the required traffic permitting process and restrictions for DPTI and the National Heavy Vehicle Regulator.

3.7.1.5 AIRPORTS/AIRSTRIPS

No airport/airstrips will be constructed for the Bird-in-Hand Gold Project however there is a private airstrip in the region that has been considered in the Project development and design.

3.7.1.6 EMERGENCY SITE ACCESS

An emergency site access has been allowed for in the site design from Bird-in Hand Road (Figure 3-144). It is proposed to maintain an existing gate access on Bird in Hand Road for limited, authorised access and emergencies. Emergency access will be used in cases where entry/exit via Pfeiffer road was not possible.

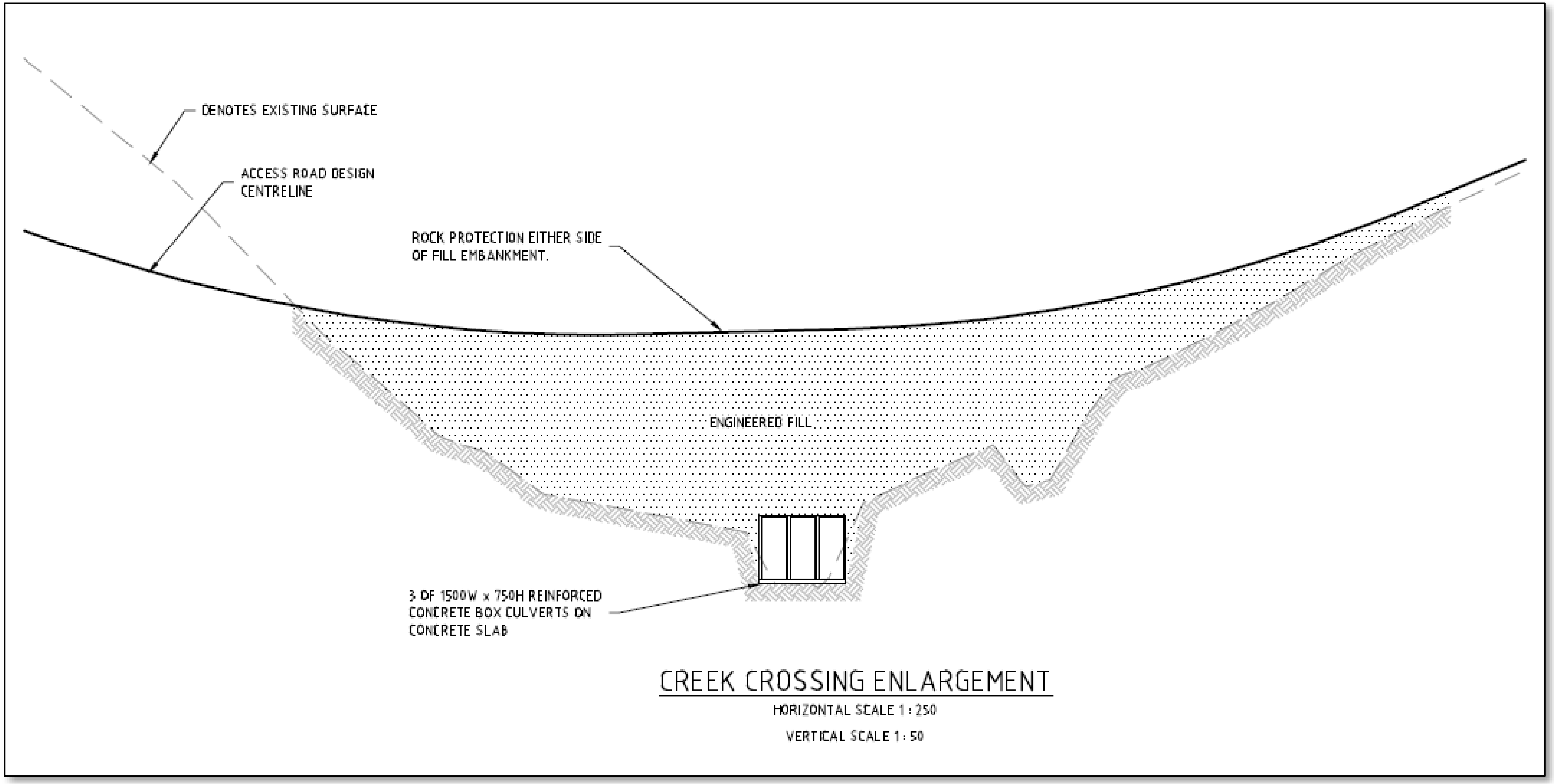


FIGURE 3-143 | DETAILS REGARDING THE PROPOSED CREEK CROSSING (APPENDIX B1) (EXAGGERATED VERTICAL SCALE)

FIGURE 3-144 | CONCEPTUAL SITE DESIGN SHOWING EMERGENCY ACCESS POINT FROM BIRD-IN-HAND ROAD (APPENDIX G1)

3.7.2 Accommodation and Offices

3.7.2.1 ACCOMMODATION

The Project is considered a residential operation, meaning that employees have their own accommodation in the region and travel to site each day. No on site accommodation facilities are planned for the site as it is expected that the majority of the workforce will be locally sourced. An exception to this will be in the case of particular expertise sourced from further afield on a temporary basis. In this case accommodation available in the surrounding Adelaide Hills region would be utilised.

There is an existing house located on Goldwyn, owned by Terramin. This is outside the operational area of the planned Project. There is a number of possibilities for this building and while it is not included in the Project there is potential for use as a training centre/meeting facility/visitors centre.

3.7.2.2 OFFICES

Office space has been included in the design for:

- Mine Manager;
- Technical Services – including geologist/geotechnical engineer, mining/production engineer and surveyor, mine technicians;
- Operations – Foreman and shift boss;
- Maintenance – Store person, Leading hand, Electrician;
- OHS – Mine training; and
- Admin – supporting admin.

The remaining supporting roles such as accountants, HR, IT support etc. will be located at either AZM or at Head Office in Adelaide.

The office block on site will be located adjacent to the Maintenance workshop. The style of building used will be modular in design for quick, easy assembly and dismantling (Figure 3-145), yet will be designed to integrate into the surrounding environment.

Facilities will also include:

- Crib room;
- Muster/Meeting room;
- First Aid office;
- Laundry Facilities;
- Ablutions;
- Store/Safety store/lamp room; and
- Vehicle parking for site light vehicles.

FIGURE 3-145 | TYPICAL MODULAR OFFICE LAYOUT PROPOSED FOR THE BIH SITE. (LOSBERGER DE BOER GROUP, 2017)

3.7.3 WORKSHOP

The requirements for a maintenance workshop are not significant due to the size of the fleet and operation proposed at BIH. It is proposed that a shed will be constructed similar style to the existing sheds in the area, see Figure 3-85. The workshop will be sized and positioned appropriately for the underground operations and will provide facilities for maintenance of the mobile fleet, capacity for fixed plant maintenance, boilermaker and electrical maintenance. All stored hazardous chemicals and fuel will be stored in bunding in line wkth EPA requirements and sized a minimum of 120% of the total volume stored. At least one of the bays will allow for drive through access to the workshop, and all accesses will have doors to aid in noise mitigation, particularly at night. Where economic and possible to do so, elements of the surface workshop at Angas will be relocated to the Bird-in-Hand site, including:

- Overhead crane;
- Air compressor;
- Electricians bay;
- Hot Work area; and
- Bit sharpening facility.

FIGURE 3-146 | TYPICAL WORKSHOP PROPOSED FOR THE BIH SITE (TERRAMIN, 2017)

3.7.4 PUBLIC SERVICES AND UTILITIES USED BY THE OPERATION

3.7.4.1 ROADS

Access via Pfeiffer Rd, with emergency access via Bird-in-Hand Rd.

Further detail on haulage between the BIH site and the APF are discussed in Section 3.5.2 and in Appendix F1.

3.7.4.2 WATER SUPPLY

There are a number of options available for supply of water for use in the Project. Water is required for human consumption, site ablutions, dust suppression, cooling and washing down. The Goldwyn property has a groundwater allocation that can be used. In addition the SA Water mains line runs along both bordering roads and the SA Water recycled water is available on Reefton Road.

3.7.4.2.1 SA WATER MAINS (POTABLE)

Potable water source will be via a water connection to SA Water see Figure 3-147. There will need to be an upgrade for the existing 50mm supply line to provide the required quantities. The water will be pumped to a 50kL header tank, to be located adjacent to the existing header tank for the site's bore, and reticulated along the new access road to the office block. This interim tank will provide sufficient pressure to the proposed office site.

3.7.4.2.2 SA WATER RECYCLED WATER

The site is located approximately 2 km from SA Water's Bird in the Hand Waste Water Treatment facility which services the townships of Lobethal, Woodside, Charleston and Inverbrackie. The existing supply line for re-cycled water (Figure 3-147) runs approximately 500m from the Project boundary. This water is considered as a potential source for water on site, however, it would have to undergo further treatment to remove nutrient and pathogenic contaminants prior to being safe to use around areas where human contact is possible. There would also have to be the construction of an intermediate storage pond on site to provide a buffer between supply and demand. The additional infrastructure and treatment required to allow use of this water constituted an increase in water supply cost that eliminated it as a consideration for the Project.

3.7.4.3 SEWAGE

Terramin's preference is for the site sewerage to be pumped off site, connected to the Bird in Hand Waste Water Treatment Plant, located on Bird in Hand Road.

In the event that this option is not feasible, Terramin have designed an onsite sewerage system.

More detail regarding sewage is outlined in section 3.6.4.2.

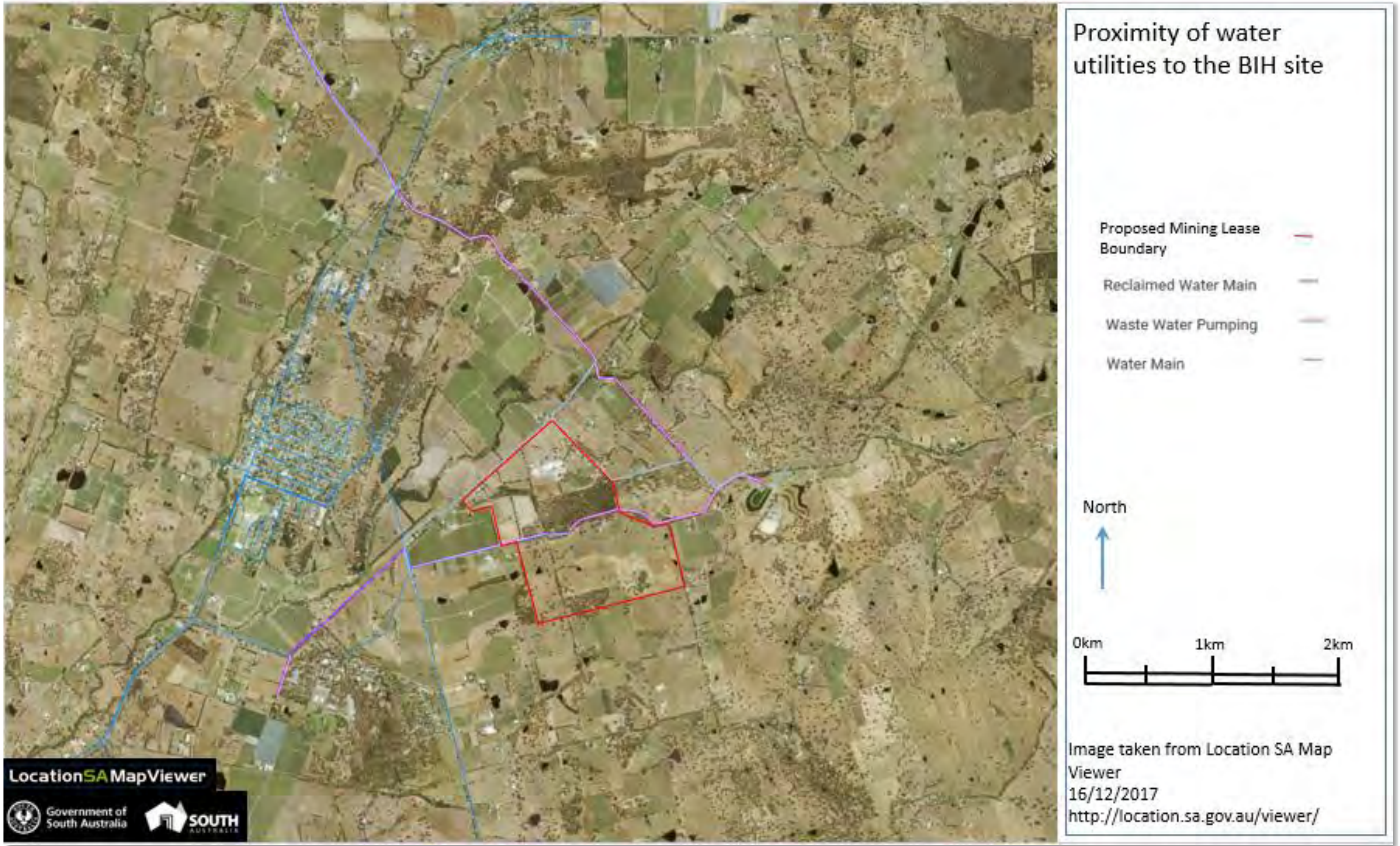


FIGURE 3-147 | PROXIMITY OF WATER UTILITIES TO THE PROPOSED MINING LEASE

3.7.4.4 ELECTRICAL SUPPLY

Cowell Electric Supply Pty Ltd, who have experience in mine power supply having worked with large operations such as BHP at Olympic Dam, were assigned to determine the options for power supply for the Project. They employed GPA Engineering (GPA) to undertake the engineering investigation into the most suitable option. The results of this investigation is included in Appendix B3.

The Project will be supplied with the required power demand via a high voltage grid connection to SA Power Networks (SAPN). Connection to the distribution network will be made at 11kV with the point of connection located across the road from the site access on Pfeiffer Road. The Pfeiffer Road 11kV overhead line forms part of the Inverbrackie Feeder which originates at the Woodside Substation located approximately 3.5km from mine site, see Figure 3-149.

It is intended the new grid connection will be completed prior to major construction activities occurring onsite. The majority of construction energy requirements can then be suppled via the grid connection. An emergency backup provision for supply of essential infrastructure will be provided by an installed diesel generator. (Figure 3-148)

FIGURE 3-148 | EXAMPLE OF A TYPICAL DIESEL POWERED, BACK-UP GENERATOR

Due to the anticipated Project's electrical demand during operation, the 11kV overhead line between Woodside-Nairne Road and the mine site will require upgrading prior to full mining operations commencing. Discussions regarding upgrade of the 11kV Pfeiffer Road overhead line are ongoing with SA Power Networks, but it is envisaged any required upgrade works would occur parallel with mine site surface facility construction.

The method of upgrade will involve either the installation of voltage regulation or restringing of the overhead line conductor with the existing poles and cross arms remaining. Final upgrade methodology is pending a more detailed investigation by SA Power Networks.

High voltage reticulation around the mine site will be via underground conductors and ground mount high voltage switchgear feeding 11/0.4kV transformers strategically distributed across the site. It is envisaged the majority of surface loads will be supplied at 400V. Underground loads with be supplied at either 400V or 1000V via dedicated transformers as required. Further information can be obtained from the Preliminary Single Line Diagram (17255-SK-002 in Appendix B3) and the Concept Electrical Equipment Layout Plan (17255-SK-004 in Appendix B3). The following provides a brief overview of the main site electrical infrastructure.

- Underground cabling from the connection point on Pfeiffer Road to the Electrical Metering Switchboard located near the site main gate.

- Underground cabling installed nominally along the site roadway from the main gate to the Wheel Wash and Workshop/Admin Substation. Radial HV/LV underground feeder cables will supply power to the various surface facilities distributed around the mine site.
- A high voltage underground feeder cable will supply power from the Workshop/Admin Substation to the Mining Substation which will be located close to the primary ventilation shaft. HV/LV cabling from the Mining Substation will provide power to the underground mining operations via the primary ventilation shaft.
- An emergency back-up diesel generator will be installed close to and connected to the Workshop/Admin Substation. The generator will provide power to critical site loads in the event power is not available from the grid.

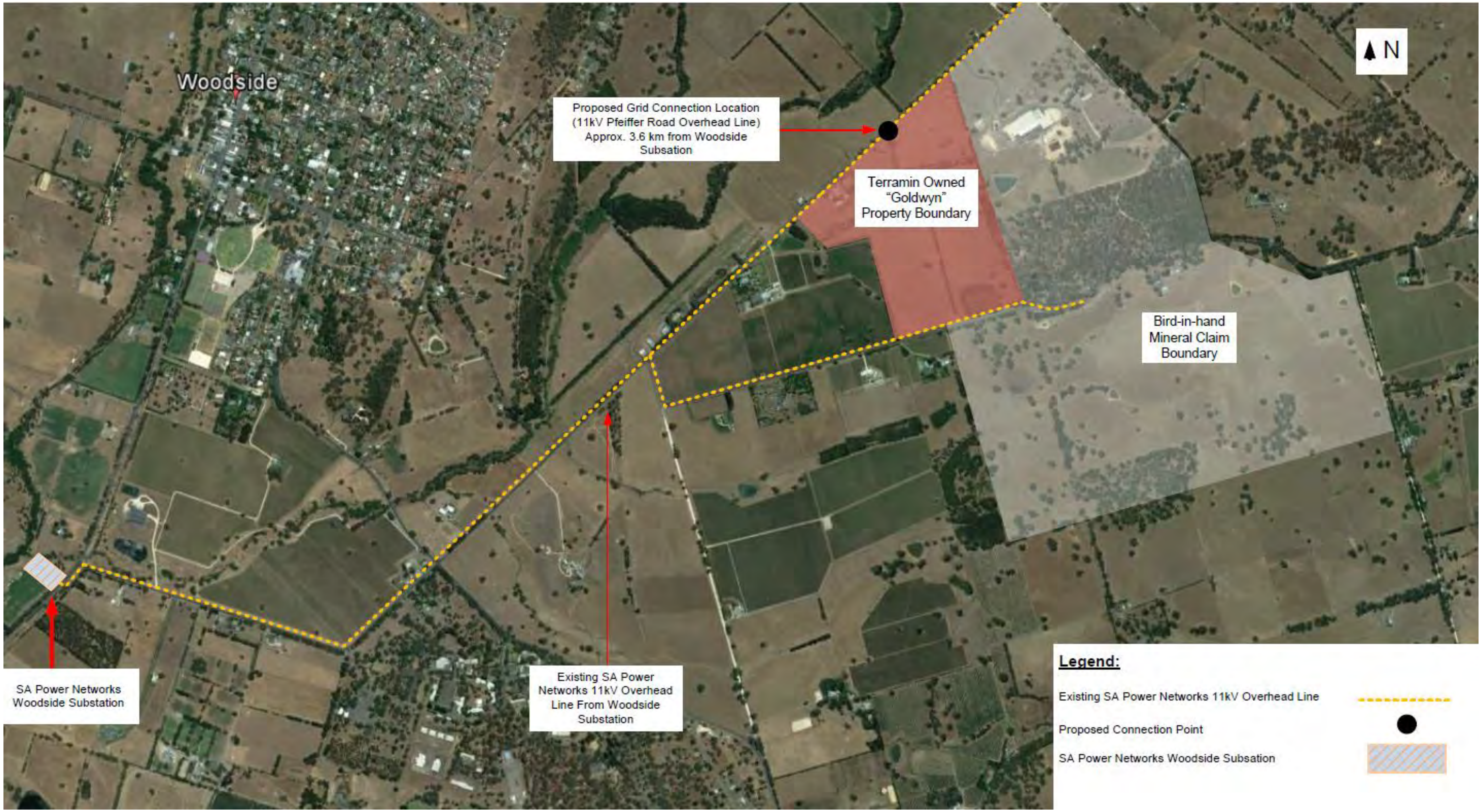


FIGURE 3-149 | MAP SHOWING THE CONNECTION TO THE EXISTING SAPN GRID - AN EXISTING 11KV LINE FROM THE WOODSIDE SUBSTATION, THAT WILL REQUIRED AN UPGRADE PRIOR TO PRODUCTION AT BIH COMMENCING. FOR FULL MAP, REFER TO APPENDIX B3

Typical electrical reticulation equipment to be used will include:

- High voltage and low voltage switchgear - including circuit breakers, load-break switches and earth switches;
- Transformers – Converting 11kV to 1kV (for reticulation underground) and 11kV to 400V for surface facilities;
- Electrical protection relays – To ensure the safety of personnel and to protect electrical equipment;
- Soft starters and variable speed drives – Installed for large motor loads;
- Power quality equipment – Including power factor correction units and Harmonic filters (where required); and
- Emergency Backup Generator – Diesel generator with sound attenuating canopy with a nominal size of 700kVA.

3.7.4.5 INTERNET AND COMMUNICATIONS

According to the nbn™ web site, nbn™ broadband access network is availalbe in the Woodside areas and surrounds for both business and residential. This would be utilised across the site.

3.7.4.6 EMERGENCY SERVICES

The operation at BIH will have onsite emergency facilities including:

- Mines Rescue – fire, rescue, hazmat, vehicle incidents, first aid response (Figure 3-150);
- Fire response capable vehicle;
- Emergency response vehicle capable of patient transfer on site;
- First aid – officers; and
- Site Security.

FIGURE 3-150 | MINES RESCUE CREW WILL BE TRAINED AND AVAILABLE ON SITE FOR FIRST RESPONSE TO EMERGENCIES (COUNTRY FIRE AUTHORITY, 2017)

However, due to the size of the work force at BIH and the potential hazards involved in the operation, additional external services may be required in the case of emergency. Local emergency services resources are not expected to be involved in underground emergency response, as specialised training and accreditation is required for this environment.

Opportunities in working with the local community emergency services include:

- Sharing of resources and providing support to the community in times of disaster;
- Shared training opportunities and resources in the case of community emergencies; and
- Potential for assistance in upgrading local infrastructure and equipment.

Terramin previously worked with the Strathalbyn emergency services groups and assisted in upgrading the local facilities and capability to suit Project based emergency requirements and upgrading the community response capacity. It is envisaged that a similar system could be implemented with Woodside emergency services.

3.7.4.6.1 COUNTRY FIRE SERVICE (CFS)

There is a local Country Fire Service station located at Woodside, The BIH site falls within the CFS Region 1 which covers an area of 10 000 square kilometres of the Adelaide Hills, Fleurieu Peninsula and Kangaroo Island with a population base in excess of 250 000 people.

3.7.4.6.2 POLICE

There is a local Police station located at Woodside, staffed Mon-Fri 9:30am-11:30am and a 24 hour/7day week station located at Mt Barker.

3.7.4.6.3 AMBULANCE

There is a local Ambulance station located at Woodside.

3.7.4.6.4 STATE EMERGENCY SERVICE

There is a local SES station located at Mt Barker.

3.7.4.6.5 HOSPITAL/MEDICAL

There are two local Medical Clinics located in Woodside, and the nearest Hospitals are Mt Barker and Mount Pleasant.

- One Healthcare – Woodside – Medical Clinic, 9am – 5pm (~2.5km);
- Woodside Country Practice – Medical Clinic 8:30 – 5pm (3km);
- Mt Barker District Soldiers' Memorial Hospital - general hospital open 24hrs (15km);
- Mt Pleasant District Hospital - general hospital (24km); and
- Royal Adelaide Hospital – general hospital open 24hrs (30km).

3.7.5 VISUAL SCREENING

It was identified during early stages of community engagement that the visual impact of a mining project prompted some concern. In recognition of this and in respect of neighbouring property owners a position was taken to minimise the visual impact of any proposed changes required to develop the Project.

In order to better understand the existing landscape amenity a specialist landscape architectural firm, Oxigen Pty Ltd (Oxigen) was commissioned to undertake a review of the area with the intention of assisting in blending any proposed Project aspects into the vista. Details of their investigation are included in the Strategic Visual Amenity Plan (Appendix G1)

The layout selected for the BIH Gold Project site has predominantly used the natural topography of the site to position the Project out of view to preserve the existing visual amenity. Minor additions through earth bunding and vegetation are proposed to assist with the visual screening of the site.

The operations area has been designed with a cut of up to 5m into the existing surface to assist in positioning infrastructure behind existing landscape features.

3.7.5.1 EARTH BUNDS

Earth bunds will be used to retain site-won material and provide opportunities to create noise barriers, interrupt wind channels and improve biodiversity through the establishment of new planting associations. Bund alignments are designed to direct rain water away from working areas and towards the stormwater management system (drains, silt traps, dams etc.). Collection dams assist in controlling water velocity and manage sedimentation prior to re-use or environmental release. Planned bunding is shown in Figure 3-151.

FIGURE 3-151 | PLANNED EARTH BUNDING TO ASSIST WITH VISUAL SCREENING OF SITE INFRASTRUCTURE (APPENDIX G1)

A trial bund to control stormwater off of the Bird in Hand Road and prevent erosion in the southwestern paddock was constructed in 2016. The bund is shown in Figure 3-152, a few months after construction and revegetation. The bund was spray seeded with native grass and a soil stabilising mulch. A variety of endemic native trees and shrubs sourced from a local nursery were planted as well. After 12 months the bund is fully covered with vegetation and supports the plan that earthen bunds can be built and revegetated in a timely manner to provide suitable incorporated visual barriers for the Project.

FIGURE 3-152 | NEWLY CONSTRUCTED STORMWATER CONTROL BUND WITH INFILL VEGETATION AND EROSION CONTROL ALONG BIRD-IN-HAND RD (2016)

3.7.5.2 VEGETATION

Planting is proposed in select locations to screen infrastructure from adjacent properties and screen dynamic elements including vehicle movements and the integrated land form (Figure 3-153).

Species are proposed to be selected for growth rate, crown density and robustness within the local environment (see Figure 3-154 and Figure 3-157). Native species are required to improve biodiversity values and resilience and to ensure the highest chance of success within local environmental conditions. A full list of recommended species in included in the Strategic Visual Amenity Plan (Appendix G1)

Some of these area have already had revegetation undertaken as part of the Biodiversity Land Management Plan (Appendix R6), with planting commencing in 2015 after Terramin purchased the Goldwyn property. Figure 3-155 and Figure 3-156 illustrate the progress of one of these areas of plantings to date.

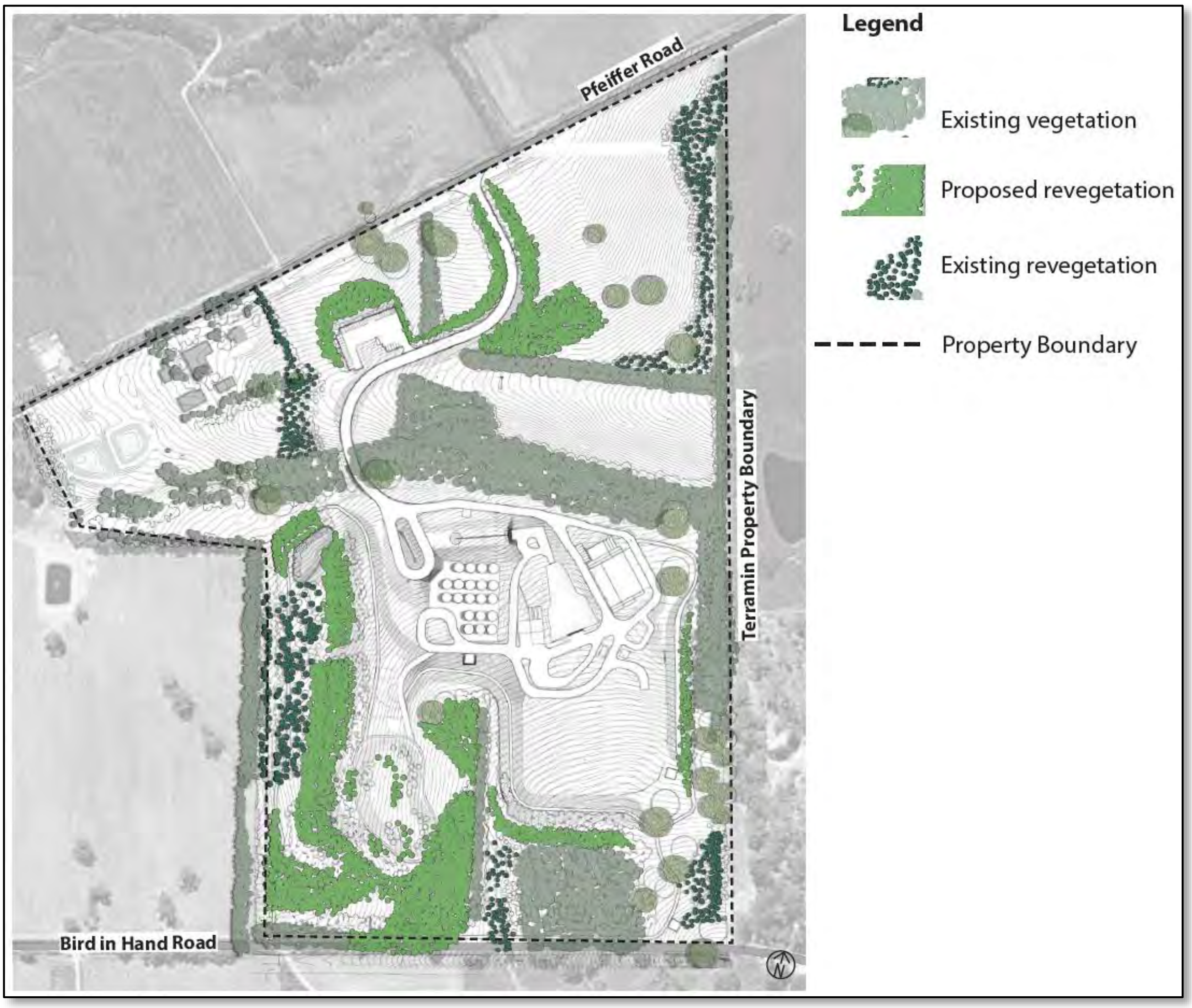


FIGURE 3-153 | EXISTING AND PROPOSED VEGETATION (APPENDIX G1)

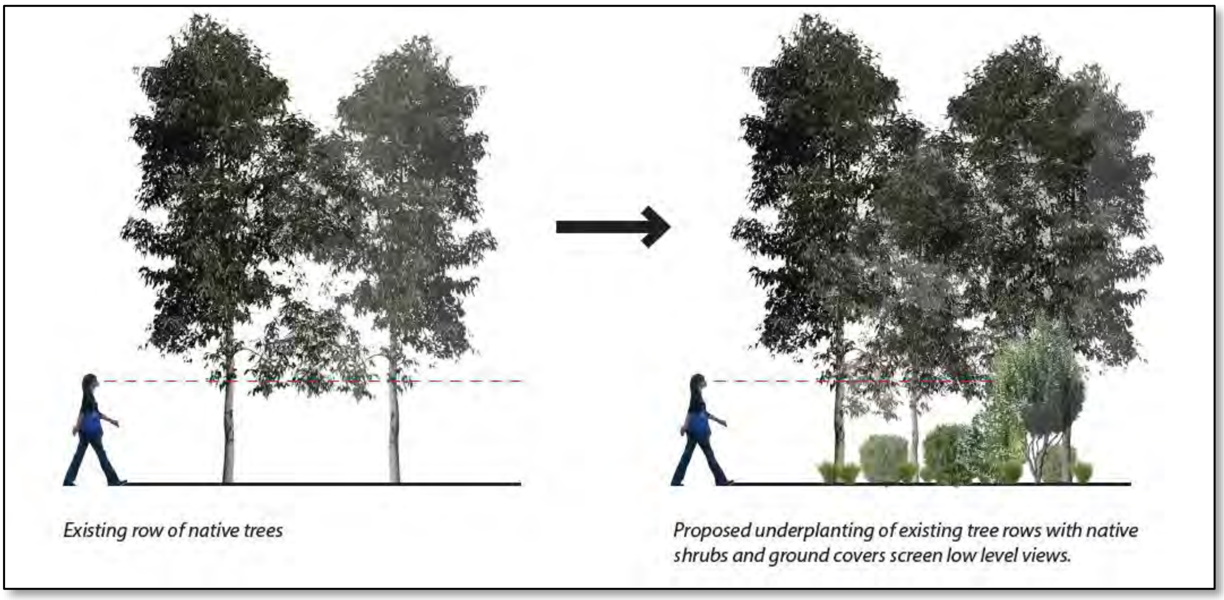


FIGURE 3-154 | INFILL VEGETATION USED FOR VISUAL SCREENING (APPENDIX G1)

FIGURE 3-155 | EXAMPLE OF INFILL VEGETATION PLANTINGS ALONG THE WESTERN BOUNDARY (LOOKING NORTH) OF GOLDWYN (2014)

FIGURE 3-156 | SAME AREA OF INFILL REVEGETATION ALONG WESTERN BOUNDARY IN 2017 (LOOKING SSW)

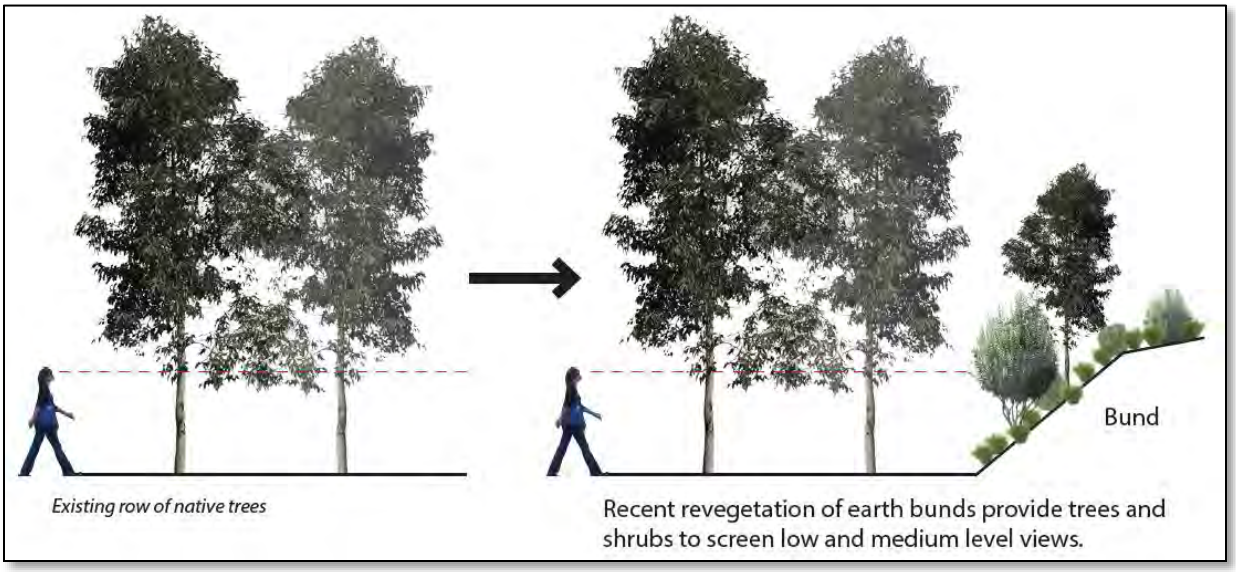


FIGURE 3-157 | EARTH BUNDING AND VEGETATION USED FOR VISUAL SCREENING (APPENDIX G1)

3.7.6 Fuel and Chemical Storage

Fuel and chemical storage on site will be done according to legislative requirements, regulations and Australian Standards including:

- AS 1940-2004: The storage and handling of flammable and combustible liquids;
- AS 2197 Explosives –storage, handling and use ;
- Bunding and spill management guideline (EPA 2007);
- Stormwater Management for was Bays (EPA 517/04 – April 2004); and
- Relevant South Australian Legislation.

3.7.6.1 FUELS, HYDRAULIC OIL

Diesel will be stored on site in a suitable bunded tank, Figure 3-158, estimated 50,000L capacity and will be refuelled via road tankers delivered to site as required. The refuelling area surrounding the tank will also be appropriately bunded. Bunding around storage areas of hydrocarbons will be in accordance with AS standards to prevent/minimise the potential for spills entering the stormwater management system when refuelling.

The tank will be located in the vicinity of the workshop and go-line for convenient, safe access by the mobile fleet, both heavy and light vehicles on site, as well as providing sufficient access for the delivery vehicles.

Bulk hydraulic oils and lubricants etc. will be stored in bulker pods (1000L) in a specific bunded area. Where smaller volumes of hydrocarbons are required (down to smaller 20L drums) for easy transport to equipment they will be stored in bunded storage until required for use. Storage facilities located near the workshop will have suitable bunding for the size of containers in use/storage (Figure 3-158). Mobile storage will be used on maintenance vehicles required to carry products to equipment located underground or around site (Figure 3-159 and Figure 3-160).

FIGURE 3-158 | TYPICAL SELF BUNDED TYPE FUEL STORAGE TANK (FES TANKS, 2017).

FIGURE 3-159 | EXAMPLE OF AN UG VEHICLE SERVICE POD - OILS, GREASE ETC. FOR SERVICING VEHICLES UG (CUSTOM FLUIDPOWER, 2016)

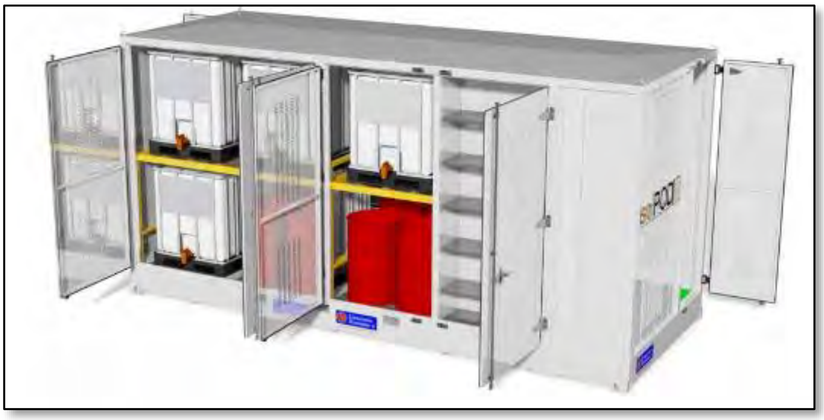


FIGURE 3-160 | LUBE STORAGE (LUBRICATION ENGINEERS PTY LTD, 2017)

3.7.6.2 EXPLOSIVES

The transport storage and use of explosives will be undertaken in accordance with the Australian Standard AS 2187. In accordance with the regulations and statutory requirements for the storage and handling of explosives, all explosives on site will be stored in licenced magazine and/or vehicles:

- Separation of high explosives, detonators and bulking agents;
- Independent ventilation supplied to the underground;
- All signage and security to comply; and
- Only licence facilities and vehicles will be used to store and transport explosive material.

3.7.6.3 WATER TREATMENT

Due to very low expected consumption of these dosing agents during operation, commonly used intermediate bulk containers (IBC's) will be used for transport and storage on-site.

3.7.6.3.1 FLOCCULATION

A flow-tube type dosing / flocculation unit will enable the mixing a suitable flocculent and pH adjustment chemicals to 9.0 prior to the clarifier, whilst the downstream unit will dose sulphuric acid to reduce the pH back to target levels after the clarifier.

Typical chemicals proposed such as ferric sulphate, is a common flocculent used throughout the mining industry and also in industrial applications. It is also a recommended chemical for use in the treatment of drinking water as per the NHMRC's Australian Drinking Water Guidelines (ADWG) since 1983. Caustic soda and sulphuric acid are also common dosing agents used in most, if not all water treatment facilities for pH correction and are typically found in RO units on mine sites, in agriculture and for municipal water systems. These chemicals are also recommended for use in the treatment of drinking water as per the NHMRC's ADWG since 1983.

3.7.6.3.2 BIO-FILTRATION

Acetic acid will be dosed into the bio-filtration unit feed stream, to provide the carbon source required to drive the biological reactions.

3.7.6.4 ION EXCHANGE

Each cation resin bed will be regenerated with a solution of sulphuric acid, with the regeneration waste being directed to the Brine Waste Tank. Regeneration will be followed by rinsing the resin bed with high quality water with the rinsate being sent to the Wastewater Tank.

Each anion resin bed will be regenerated with 10% sodium chloride solution every 4 days in operation.

3.7.6.4 CEMENT BATCHING PLANT

Chemicals required for use in the backfill, ground support and grouting processes will be finalised during final test work on the backfill properties once mining commences, but they will generally will involve:

- Cement – to be stored in horizontal silos and smaller packaging (i.e. 25kg bags) as required, depending on the application and handling requirements;
- Grouting additives (as required); and
- Shotcrete additives (as required).

3.7.6.5 MINING

Typical types of chemicals used for mining purposes (outside explosives, fuel and mechanical chemicals) packaged shipped/stored in required packaging/containers in appropriate locations within the stores area or in temporary area underground for immediate use include:

- Geotechnical i.e. Ground support resins – i.e. for resin bolts;
- Paints – for face mark ups and survey purposes;
- Small quantities of Ventilation gases for testing and calibrating sensors if installed (CO, CO_2, NH_4, NO_x etc.)

3.7.6.6 FLAMMABLE MATERIAL

Australian Standard AS 1940 The Storage and handling of flammable and combustible liquids (Figure 3-161).

- Gas cylinders i.e. Oxy/Acetylene;
- Drums/barrel/pods for liquids: i.e. Oils/lubricants/fuels/Waste oil;
- Segregated storage areas for solids: i.e. Tyres.

FIGURE 3-161 | STORAGE OF LPG FOR SITE USE (HOT WATER) (SAFE WORK AUSTRALIA, 2017)

3.7.6.6.1 MISCELLANEOUS

Some miscellaneous chemical categories will be stored on site. Selection, storage and handling of these chemicals will be according to the applicable Regulations, and Standards and will be subject to a risk assessment process to select.

Agricultural

The *Agricultural and Veterinary Products (Control of Use) Act 2002* came into operation in August 2004. The General Duty under this Act requires persons using chemicals to take all reasonable and practical measures to minimise contamination of land, animals or plants outside the target area and to minimise harm to human health and the environment.

Laundry

Laundry and showering facilities will be available on site for personnel. Detergents and cleaning products will be biodegradable to minimise any environmental impacts, as well as safe for users.

FIGURE 3-162 | PALLET STYLE BUNDING FOR SMALLER QUANTITIES OF LIQUIDS (TRADE ENVIRONMENTAL, 2017)

3.7.7 SITE SECURITY

The site will be split up into different zones, depending on the purpose of activities and the level of security required. A number of fences will be used to prevent unauthorised entry onto the Project. Perimeter fences are currently installed in the form of agricultural fencing with cyclone mesh and barbed wire. This fence will be upgraded/modified to define the operational extents as discussed in section 3.7.7.1. Signs will be installed on these fences once the Project is approved at spacing appropriate to identify the area as a restricted access area. A second higher level security fence will be used to define an inner restricted zone. Access into this area will be limited to patrolled security gates and limited access locked gates. A swipe tag system will be implemented to allow access to areas based on authorisation. Vehicle tags are also likely for regular movements of vehicles, such as the ore haulage trucks, and site light vehicles. Closed Circuit Television (CCTV) networks will also be installed around key locations on site for monitoring.

- Public access – includes the front carpark, the maze area and potentially the heritage chimney area.
- Ore Haulage – includes the ROM loading area.
- Surface operations – includes to the office, workshop, laydown area, water treatment area, IML, Surface Dam.
- Underground operations – includes all underground areas from the portal at the top of the decline, as well as from the surface of the ventilation and egress shafts.

The main access checkpoint will be located adjacent to the carpark and another will be located adjacent to the haul road turnaround loop (for vehicles entering the operating area).

The main access check point will consist of an unmanned boom (or sliding) gate which will be operated via remote control or an intercom system including CCTV infrastructure Figure 3-163.

FIGURE 3-163 | SECURITY GATES FOR PERSONNEL AND VEHICLES (APPENDIX G1)

3.7.7.1 SECURITY FENCING

Security fencing will be constructed around the perimeter of the operational area (Figure 3-164). The type of fencing will be considered following detailed noise modelling. However, it is likely be constructed using a cyclone fence with barb wire (Figure 3-165).

FIGURE 3-164 | SITE FENCING (APPENDIX G1)

FIGURE 3-165 | FENCING TYPES PROPOSED FOR USE (APPENDIX G1)

3.7.7.1.1 SHAFT SECURITY ON THE SURFACE

Additional security fencing will also be installed around the top of the two ventilation shafts and emergency escape way allowing for authorised personnel access only. Fencing and CCTV monitoring will also be placed around the top of the emergency escape raise to prevent unauthorised access to the raise and the underground workings. In the case of the emergency escape way (secondary means of egress) shaft the security fencing will have a gate that allows open access out of the shaft but prevents entry to authorised personnel.

3.7.7.2 UNDERGROUND SECURITY

Access to the underground will be restricted by the security fencing and entry controlled through the operational area and limited to Project employees. There will be no opportunity for an unauthorised person to accidentally enter the underground workings. Accesses other than the portal will be fenced to prevent access. Only those authorised (i.e. inducted into the area as either a visitor, contractor or employee) will be allowed to enter this zone of the operation. A tag board system (Figure 3-166) will be implemented to monitor personnel underground. No blasting will occur while personnel are tagged onto the board. Electronic tagging and monitoring systems are available in the industry and may be used at BIH. In order to eliminate any risk related to power outages compromising information a physical tagging system will still be used, either in isolation, or in tandem with the electronic version. Technology available will be investigated closer to the time of operation. Emergency procedures will be activated if a power outage prevents any risk to health and safety of personnel.

FIGURE 3-166 | EXAMPLE OF A TAG BOARD USED FOR UNDERGROUND MINING OPERATIONS

3.7.7.3 SIGNAGE

Signage will be used throughout all aspects of the site, in accordance with Australian Standards i.e.:

- *AS 1743-2001 Road signs – Specifications* and
- *AS 1319 – 1994 Safety Signs for the Occupational Environment*

Typical classification and example of signs are shown in Figure 3-167 - Figure 3-173.

3.7.7.3.1 TRAFFIC

Signs will comply with the standards use on Australian Roads (Figure 3-167).

FIGURE 3-167 | EXAMPLE OF STANDARD TRAFFIC SIGNS THAT COULD BE USED ON SITE

3.7.7.3.2 WARNING

Signage will be used to warn of hazards or a hazardous condition that is not likely to be life-threatening. The hazard symbol is black on a yellow background and a triangle is depicted around the hazard symbol (Figure 3-168).

FIGURE 3-168 | EXAMPLE OF STANDARD WARNING SIGNS THAT COULD BE USED ON SITE

3.7.7.3.3 MANDATORY

Signage will be used to specify an instruction that must be carried out. Symbols (or pictograms) are depicted in white on a blue circular background. Sign wording, if necessary, is in black lettering on a white background (Figure 3-169).

FIGURE 3-169 | EXAMPLE OF STANDARD MANDATORY SIGNS THAT COULD BE USED ON SITE

3.7.7.3.4 PROHIBITION

Signage will be used to specify behaviour or actions which are not permitted. The annulus and slash is depicted in red over the action symbol in black (Figure 3-170).

FIGURE 3-170 | EXAMPLE OF STANDARD PROHIBITION SIGNS THAT COULD BE USED ON SITE

3.7.7.3.5 DANGER

Signage will be used to provide warning when a hazard or a hazardous condition is likely to be life threatening. The word Danger is featured inside a red oval inside a black rectangle (Figure 3-171).

FIGURE 3-171 | EXAMPLE OF STANDARD DANGER SIGNED THAT COULD BE USED ON SITE

3.7.7.3.6 EMERGENCY INFORMATION

Signage will be used to indicate the location of, or directions to emergency related facilities (exits, first aid, safety equipment, etc.). Signs feature a white symbol and/or text on a green background (Figure 3-172).

FIGURE 3-172 | EXAMPLE OF STANDARD EMERGENCY INFORMATION SIGNS THAT COULD BE USED ON SITE

3.7.7.3.7 Fire

Fire management signs advise the location of fire alarms and firefighting equipment. They contain a white symbol and/or text on a red background (Figure 3-173).

FIGURE 3-173 | EXAMPLE OF STANDARD FIRE SIGNS THAT COULD BE USED ON SITE

3.7.8 STORMWATER, SILT CONTROL AND DRAINAGE

Tonkin Consulting Pty Ltd (Tonkin) were engaged by Terramin to develop a Stormwater Management Plan for the proposed Project (see Appendix I3).

The plan outlines the strategy for surface water and stormwater management for the Project and involves a number of measures to provide drainage service and flooding protection for the proposed infrastructure and operational activities on the site, while also providing a high level of water quality treatment.

The two key aspects related to stormwater and flood management are:

- Ensure that all development is kept out of the 100-yr ARI flood extents; and
- Ensure that peak flows leaving the site are no higher than pre-development rates.

The 100-yr ARI flood extents for the main creek that passes through the site have been determined through the development of a 'backwater curve model' known as a HEC-RAS model (Appendix I3), a widely used tool to calculate flood extent near river systems. The model is based on representative sections of the watercourse that passes through Goldwyn.

The existing stormwater, silt control and drainage for the site is discussed in Chapter 2: Existing Environment. And in Chapter 11: Surface Water

With the site averaging ~800mm of rainfall per year, storm water and drainage control will be required to maintain existing water quality entering the local catchment.

The site has been designed to keep the footprint of the Project as small as possible, as well as strategically placing areas to minimise traffic movements and rock movements to assist with this surface water management.

The proposed water quality measures for the site have been governed by the types of pollutants that will potentially be generated by the different areas of the site. The five main catchment areas from highest to lowest pollution production potential are shown in Figure 3-174 and are listed below:

- The Integrated Mullock Landform (IML) which will produce high levels of sediment from the active waste rock stockpile, which will be captured in the surface water dam;
- Runoff from the mine operational area (including the batching plant) where material is taken from the underground mine and transferred to ROM silo to be taken off site or placed in the waste rock stockpile on site;
- The car park and access road;
- The office complex and internal road network; and
- The remainder of the site that will be retained in its undeveloped state, or will be landscaped to direct surface flows back to their original flow paths.

The key elements of the Stormwater Management Plan for the proposed BIHGP site are:

- The separation of catchments based on their potential for pollutant generation such that clean water does not intermix with areas that have higher pollutant levels;
- That the water quality treatment measures are appropriately matched to the pollution production potential for each area of the site;
- Ensuring all development is kept outside of the 100-yr ARI floodplain extents;
- That detention basins have been incorporated to limit peak flows to pre-development levels; and
- That infiltration systems (swales) and on-site retention have been incorporated into the design to mimic the pre-development flow regime such that the site is essentially water neutral from a stormwater runoff perspective.

Figure 3-130 illustrates the proposed layout of the various elements for site stormwater control.

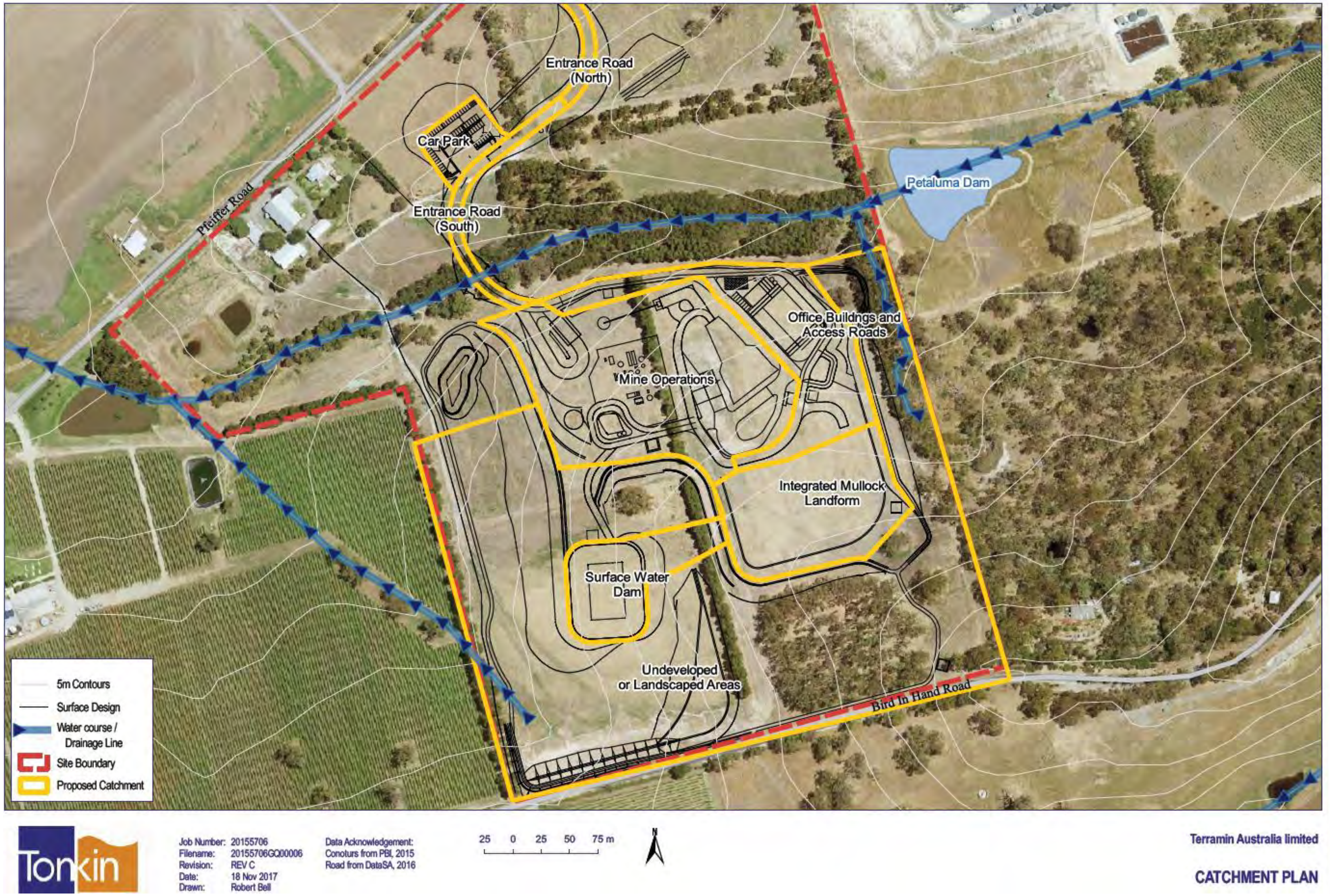


Figure 3-174 | Stormwater catchment zones (appendix I3)

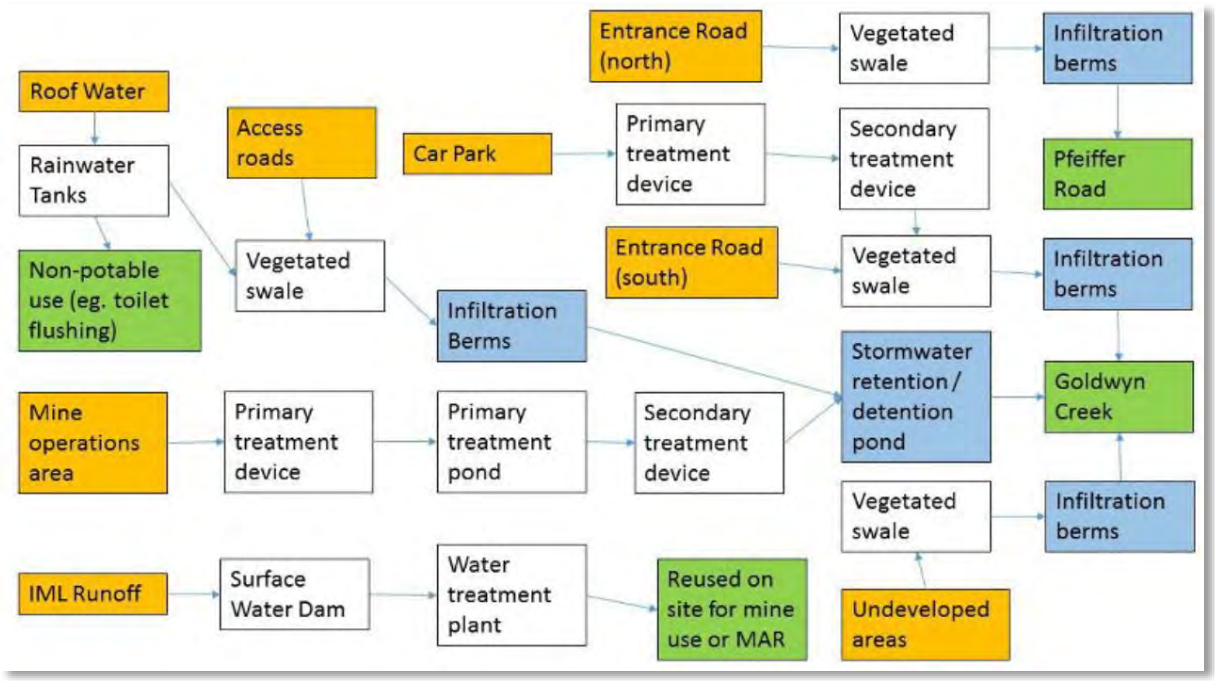


FIGURE 3-175 | SURFACE WATER FLOW CHART (APPENDIX I3)

3.7.8.1 INTEGRATED MULLOCK LANDFORM

The surface run-off from the IML is planned to be intercepted and directed to the mine water storage dam via an open channel before settling of sediment and undergoing treatment on site. Once treated, the water will be recycled for mining purposes (cooling, drilling, dust control etc.) or re-injected via the MAR system into the ground.

3.7.8.2 MINE OPERATIONS AREA

As the mine operational area encompasses roads, storage areas and stockpiles there is potential for moderate amounts of sediment and dust to be produced. All runoff from this area will be directed towards the internal road network where it will be collected in inlet pits and treated through both gross pollutant traps (GPTs) (discussed in section 3.7.8.6.2) and a sedimentation ponds to as a primary treatment and then an oil and grit separator (such as a SPEL unit) to provide secondary treatment (Figure 3-176) (discussed in section 3.7.8.6.3). Ponds will have both a retention and detention component (Figure 3-177).

The retention portion of the pond will facilitate infiltration and evaporation and reduce the frequency of discharge from the pond, particularly during the drier months. During wetter periods, when sufficient runoff has been generated to fill up the retention component, the detention storage within the basin will reduce the rate of discharge leaving the site, by controlling the rate of discharge.

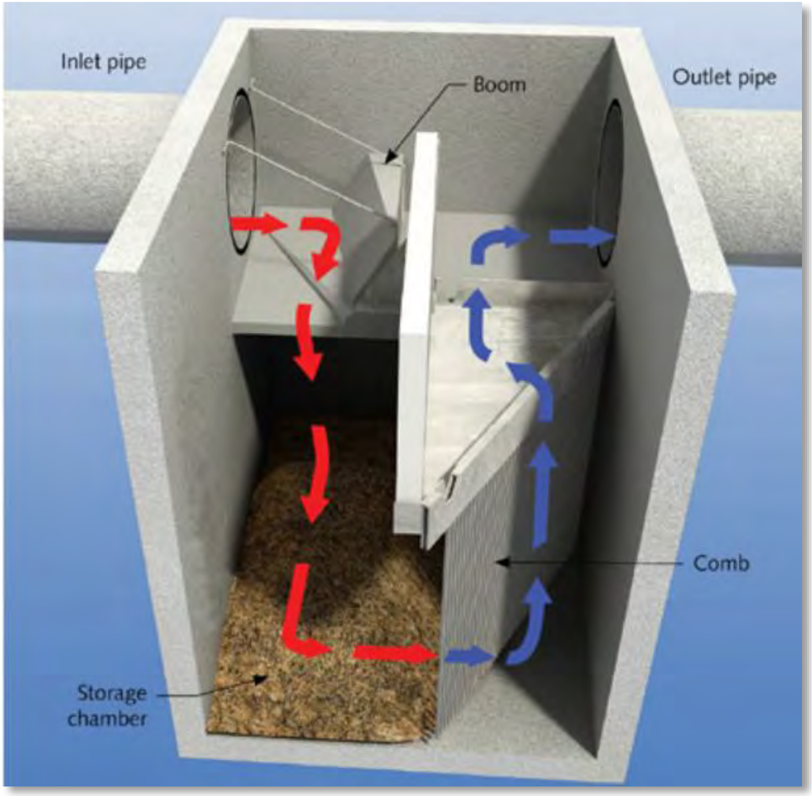


FIGURE 3-176 | EXAMPLE OF PRIMARY STORMWATER TREATMENT - GROSS POLLUTANT TRAP (HOLCIM, 2015)

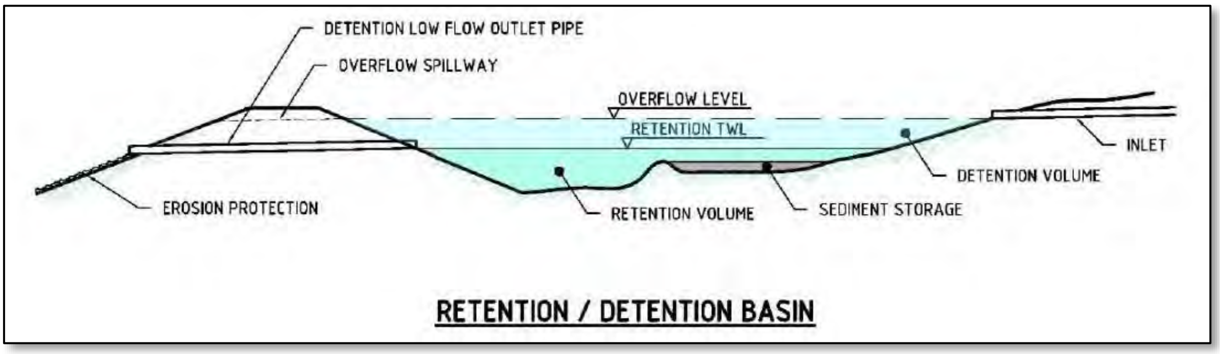


FIGURE 3-177 | CROSS SECTION OF A TYPICAL RETENTION/DETENTION BASIN SUCH AS THAT PROPOSED AT BIH (APPENDIX I3)

3.7.8.3 CAR PARK

Runoff from the car park and a portion of the main access road will pass through both primary (a GPT) and secondary treatment (oil and grit separator) before draining into a vegetated swale which will be graded to discharge into the main creek that runs through the site. The swale will have shallow berms periodically constructed along it to encourage infiltration.

Some of the main access road will drain towards Pfeiffer Road. Similarly to the above, the swale will have shallow berms along it which will retain the majority of the road runoff on-site, with minimal additional discharge to Pfeiffer Road.

3.7.8.4 OFFICES AND ACCESS ROADS.

This area will produce relatively clean runoff. Some of the larger office buildings in the area will be connected to tanks for on-site reuse. The majority of the road runoff will be directed into swale drains that will have shallow berms constructed along them before discharging into the site's main detention/retention pond, Goldwyn Creek or to Pfeiffer Road.

3.7.8.5 UNDEVELOPED AREAS

The site has been designed to minimise the operational area with the focus of limiting the requirement for collecting and treating impacted stormwater. All stormwater falling outside the operational area will be directed into the existing natural drainage systems. The undeveloped portion of the site will be unchanged from current conditions and stormwater will discharge unrestricted into the drainage lines. In some areas, run-off will be locally diverted such that it does not mix with water from other areas of the site. Where water is being controlled it will flow through a network of vegetated swales offsite as per the currently conditions.

A small stormwater pipe passes under Bird in Hand Road at the southern corner of the property. This will continue to be able to pass through the site and into the existing drainage line within the adjacent western property as per the existing conditions.

Some of the landscaped areas, such as the landscaped mound, will require careful management during the construction phase, due to the potential for sediment creation, until the areas are fully established and have implemented erosion control measures such as vegetation, mulching and contour banking. This stage will be managed through a soil erosion and drainage management plan that would incorporate various measures including silt fences, sediment ponds, temporary silt traps and hay bales to capture sediment on site.

3.7.8.6 WATER QUALITY TREATMENT MEASURES

3.7.8.6.1 SWALES

Swales are designed drainage lines that are placed to intercept surface water flows and control water velocity (Figure 3-178). Swales constructed using Water Sensitive Urban Design principles will enhance the settling characteristic of the flow channels through the use of surface treatments (rock lining) and beneficial vegetation planting. Swales provide the following benefits:

- Remove course to medium sized sediments by the vegetated surface;
- Improves infiltration into the soils and hence reduces surface run-off;
- Delaying run-off peaks by reducing flow velocities; and
- Reduces sediment from high velocity erosion.

FIGURE 3-178 | EXAMPLE OF TYPICAL SWALE CONSTRUCTION ON A SLOPE FOR STORM WATER MANAGEMENT (TEMPERATE CLIMATE PERMACULTURE, 2011)

The swales will require occasional maintenance to ensure that they are operating effectively. This includes:

- Removal of sediment build up;
- Repairing localised areas of erosion, scour of damage;
- Removal or management of invasive weeds; and
- Mowing or slashing of vegetation.

When mowing occurs in the swales, cut grass will be removed from the swale to prevent flows transporting the material to the creek during a rain event.

3.7.8.6.2 PRIMARY STORMWATER TREATMENT (PIPED SYSTEMS)

Gross pollutant traps (GPT) are a well-established primary stormwater treatment device. They are typically designed to remove solids greater than 5 mm in particle size conveyed by stormwater, including rubbish, vegetation and other solid debris. The GPT will be the first water treatment device within the stormwater treatment system. GPT's are designed for and require periodic maintenance to remove gross pollutants and free oils from the units.

3.7.8.6.3 SECONDARY STORMWATER TREATMENT

Secondary treatment will be provided downstream of GPTs via an oil and sediment separation device. These are suited to removing hydrocarbons and suspended solids from stormwater, preventing spills and non–point source pollution entering downstream waterways. These separators target the removal of coarse and fine sediments, their associated pollutants and oils.

This type of device has been included in the design adjacent to the mine operational area, to remove fine sediment and hydrocarbons from the stormwater, prior to being discharged further downstream and mixed with runoff generated from other catchments. A similar device is also proposed to serve the car parking area. They will require periodic maintenance to remove pollutants captured by the units.

3.7.8.6.4 DETENTION / RETENTION BASIN

Any ground surfaces modified by the project has the potential to increase run-off. Where under the existing grassland conditions stormwater would have an element of infiltration and evaporation, the modified surfaces are expected to drain a larger portion. For this reason storm water is collected and directed towards a retention/detention basin or pond. While the primary role of the detention pond at the downstream end of the site is to reduce peak discharges, a significant proportion of the pond (the lower 1,100m^3) will provide retention storage to promote further reduction in sedimentation. This pond maintains flow levels to those experienced pre-Project and in retaining runoff provides an opportunity for the water to infiltrate into the base of the pond and evaporate as would occur naturally. This will help to mimic the predevelopment flow regime (equivalent to approximately 60mm of runoff from impervious portion of the site). The retention component of the pond will require periodic removal of sediment. The pond is planted with suitable vegetation to promote a natural habitat and a self-sustaining micro environment.

3.7.8.6.5 WATER TREATMENT PLANT

The proposed site water treatment plant will receive runoff generated by the IML as well as water pumped up from the underground workings. Treated water discharge will not be combined with stormwater flows. These will be treated as separate systems and is outside of the scope of this plan.

Further information regarding the water treatment process is described in 3.7.9.5.

3.7.8.6.6 EPHEMERAL WETLANDS

Ephemeral wetlands have been proposed by Terramin within the ephemeral zone of the creek and along portions of the site's eastern and western boundaries. Whilst they have not been considered as part of the required treatment train for the site, they will act to improve the water quality, both from within the site and any water flowing into the site from upstream, through a range of processes including:

- Sedimentation based on the creation of slower flow velocities;
- Filtration through vegetation;
- Chemical absorption by wetland plants; and
- Biological uptake by plant growth within the wetlands.

3.7.8.7 REAL-TIME MONITORING

Reliance upon regular testing and management is necessary due to the nature of surrounding sensitive receptors to the site. Monitoring stations could be installed at the outlet of the main detention basin to identify if water quality discharges ever exceed predetermined thresholds.

3.7.8.8 BUNDING AND CONTAMINATION CONTROL

Any hazardous materials (including liquid waste) that are likely to be stored on the site will be located within suitable containment that will meet the requirements of the necessary Australian Standards and water quality guidelines. In the rare event that hazardous materials make their way into the stormwater system a further backup is provided in the form the of the site's main retention/detention pond where the water could, if required, be pumped into the surface water dam where it can be treated.

3.7.8.9 EROSION PROTECTION

Details on erosion protection for the site are based on a site assessment undertaken by the University of Adelaide and results are included in Appendix L5.

Surface drainage (overland flow paths and swales) will be protected by erosion control measures, where required (to be determined by assessing expected flow velocities). Erosion control measures typically consist of providing a surface treatment to resist scouring velocities and structures within the channel to reduce flow velocities.

Given the relatively high rainfall in the area, site vegetation cover within the drainage channels will establish naturally. However, other treatment measures will be required to minimise channel flow velocities, where high gradients are experienced. In these areas rock rip rap either utilising local materials won from the site during the construction phase or imported onto site will be installed at critical locations within the channels.

Rock rip rap will be placed:

- at pipe outlet points;
- at the culvert road crossing of the existing creek;
- at the upstream end of the sediment basins; and
- Within swales where flow velocities are estimated to be greater than 2 m/s.

Further detail on erosion control is discussed in Chapter 11 and Appendix L5.

3.7.8.10 POST-CLOSURE MANAGEMENT

3.7.8.10.1 MINE CLOSURE PLANNING

Site drainage and water management design has been undertaken to provide ongoing storm water management through each stage of the Project, mine closure and the future land use. At the end of the Project life, the landscape amenity bunds will be established and self-sustaining. The design of the bunds and the vegetation plans are undertake to promote biodiversity to attain a stage of natural erosion potential, which is <5 tonnes/hectare/year for the Project location.

A combination of mulching and contouring of the bunds to reduce the total erosion is the first stage of the design. During operations the bunds will be monitored to check on the design success and that erosion levels are kept below the 5 tonnes/hectare/year. At the end of the Project life where required, bunds can be reduced in height or re-contoured to suit. It is planned that the landscape amenity bunds remain as part of the post mining landscape, to complement commercially favourable remaining infrastructure for prospective future owners. The revegetated bunding will provide visual amenity benefits as well as increased biodiversity values and habitat for indigenous flora and fauna species, an increasingly valued feature in the community.

3.7.9 Water Management

Terramin has committed publically to the community and regulators, regarding surface and groundwater impacts, to the outcome 'no adverse impact to the supply or quality of water caused by the mining operations to existing users and water dependant ecosystems'. Terramin identified, prior to acquiring the Project, the requirement to understand and manage the hydrological systems in such a fashion that there would be no impact by mining operations to the sensitive water receptors within the catchment, this includes ecosystems dependent upon water, e.g. Inverbrackie creek springs, perched aquifers, groundwater dependant vegetation and groundwater users who have existing licenced groundwater allocations. Given this, leading consultants in the different water management aspects were engaged as a priority to provide advice on leading science and engineering around groundwater understanding and management, Consultants in the fields of hydrology, groundwater numerical modelling, geotechnical modelling, geological modelling, pre excavation grouting, water treatment, electrical pump and control systems and remote water quality monitoring have been engaged. A paradigm of ongoing review and continuous improvement means that models and systems will be iteratively updated as more information comes to light. Due to the work undertaken from 2013 to 2019, the understanding around the hydrological systems is amongst the highest of any sub-catchment in the Western Mount Lofty Ranges Water Allocation Plan zone.

A table describing the principles of the Western Mount Lofty Ranges Water Allocation Plan and Terramin response to each principles has been included in Appendix B8.

An overview of the water system proposed for the Project is shown in Figure 3-88.

Control measures proposed to manage, limit or remedy groundwater impact events must be peer reviewed by a suitably qualified independent expert as required by the Ministerial Determination. Terramin have undertaken peer reviews on the grouting, the groundwater assessment, the managed aquifer recharge strategy and the site water balance. Peer reviewers were chosen for their qualifications and experience in the requisite areas. All peer reviewers' qualifications are included in their respective reports.

In regards to the groundwater model, the final independent peer review report must include; an assessment of whether the model is fit for purpose, verification of model inputs, the results of the review of the model against Tables 9-1 and 9-2 of the Australian groundwater modelling guidelines (National Water Commission Waterlines Report Series No. 82, June 2012), the scope of the review and details of any actions undertaken as a consequence of the findings of the review. This has been completed by Innovative Groundwater Solutions during 2017, and again in 2019 with the updated groundwater model.

Peer reviews undertaken have been included in Table 3-23.

TABLE 3-40 | PEER REVIEWS UNDERTAKEN

Water Management Strategy	Report/Assessment	Peer Review
Grouting	Bird in Hand Gold Project – Grouting for Groundwater Control, Multigrout (Appendix H4)	Bird in Hand Gold Project – External Review – Proposed Grouting Programme, Golder Associates (Appendix H5)
Groundwater Modelling and Impact Assessment (including MAR modelling)	Groundwater Impact Assessment for the Bird in Hand Project, AGT (Appendix H1)	Outcomes of Peer Review of Bird in Hand Gold Project Groundwater Assessment Report, Innovative Groundwater Solutions (Appendix H2 and H3)
Site water balance	Water Balance, Terramin (Appendix K1)	Review of Mine Water Balance Model for BIH Project, Golder Associates (Appendix K2)
Managed Aquifer Recharge System	Managed Aquifer Recharge Investigation, Golder Associates, 2019 (Appendix H9)	Independent peer review of updated modelling for the Bird-in-Hand Gold Project, Innovative Groundwater Solutions Pty Ltd (IGS), 2019 (Appendix H10)
Water treatment proposal	Water Treatment Options Study, GPA, 2017 and 2019 (Appendix J1)	Water Treatment Options Study Peer Review, Golder Associates, 2017 (Appendix J2)

Detailed information on pre-excavation grouting is in section 3.4.2.7.

Detailed information on Managed Aquifer Recharge is below in section 3.7.9.6.

3.7.9.1 WATER BALANCE

The modelled water balance for the Project is discussed in Section 3.4.6.1.

3.7.9.2 WATER INPUTS

Figure 3-180 and Figure 3-179 show the estimated water inflows for the site for both the 70% grouting efficiency inflow volumes and the 90% grouting efficiency inflow volumes over the life of the mine. The main sources for water inputs into the water balance include:

- Ground water from mine workings
- Goldwyn bore allocation
- SA Water (Mains)
- Rain Water

Water will be required on site for the following purposes:

Underground:

- Backfilling – cement water content
- Grouting – cement water content
- Equipment use – drilling, wash downs
- Dust control – watering down headings and stockpiles

Surface:

- Dust control – water truck, sprinkles, sprays etc.
- Irrigation
- Equipment use – drilling, wash downs, wheel wash
- Laundry and ablutions
- Kitchen
- Batching plant – cement content, wash down

Additional rainfall captured during wet years will be used to supplement water coming from the Goldwyn bore and/or SA Water Mains for purposes such as irrigation, toilets, dust control etc.

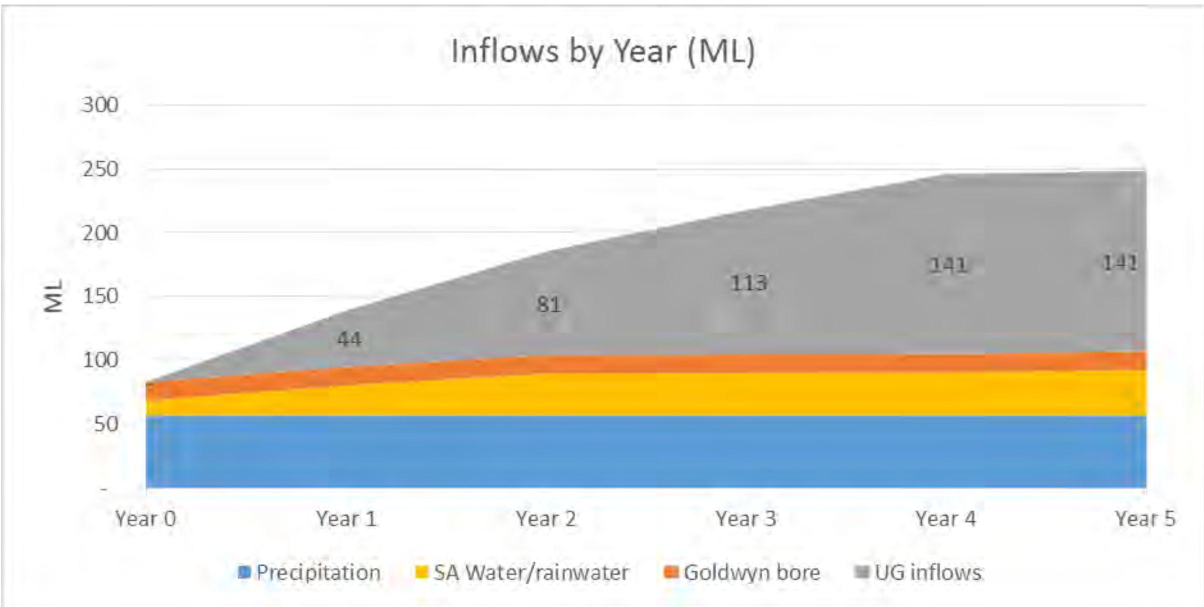


FIGURE 3-179 | SITE WATER INFLOWS BY YEAR (90% GROUT EFFICIENCY SCENARIO)

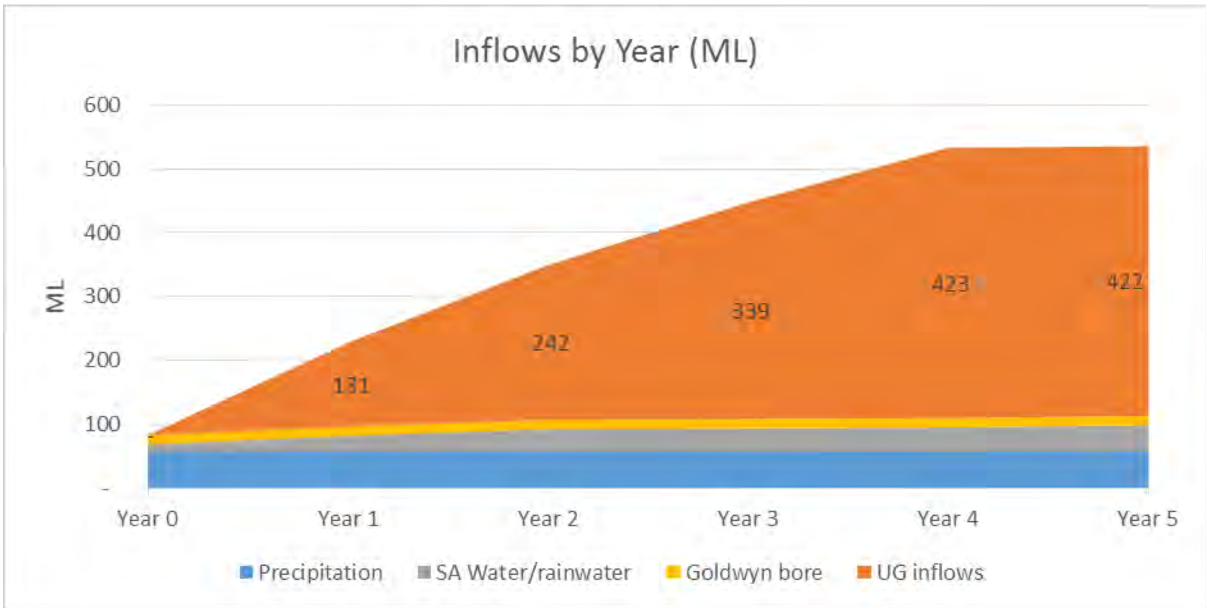


FIGURE 3-180 | SITE WATER INFLOWS BY YEAR (70% GROUT EFFICIENCY SCENARIO)

3.7.9.3 WATER OUTPUTS

Figure 3-182 and Figure 3-181 show the estimated water outflows for the site for both the expected 90% and 70% grouting efficiency inflow scenarios as outflow volumes over the life of the mine. The main losses of water from the system include:

Underground:

- Backfilling – cement water content;
- Grouting – cement water content;
- Ventilation – moisture content of exhausted air; and
- Dust control – watering down headings and stockpiles

Surface:

- Stormwater discharge
- Evaporation;
- Seepage;
- MAR;
- Site use (dust control, wash bays etc.);
- Sewage; and
- Moisture content of ore/mullock.

More detail on the Managed Aquifer Recharge component is located in section 3.7.9.6.

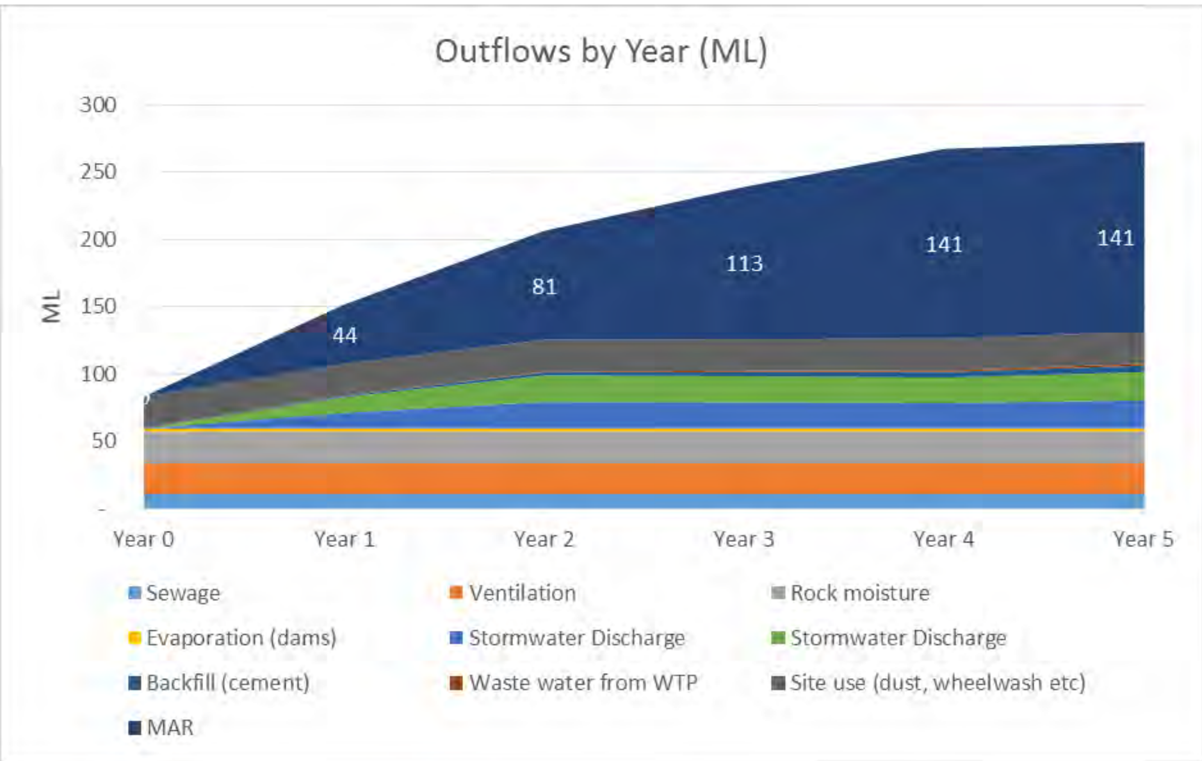


FIGURE 3-181 | SITE WATER OUTFLOWS BY YEAR (90% GROUT EFFICIENCY SCENARIO)

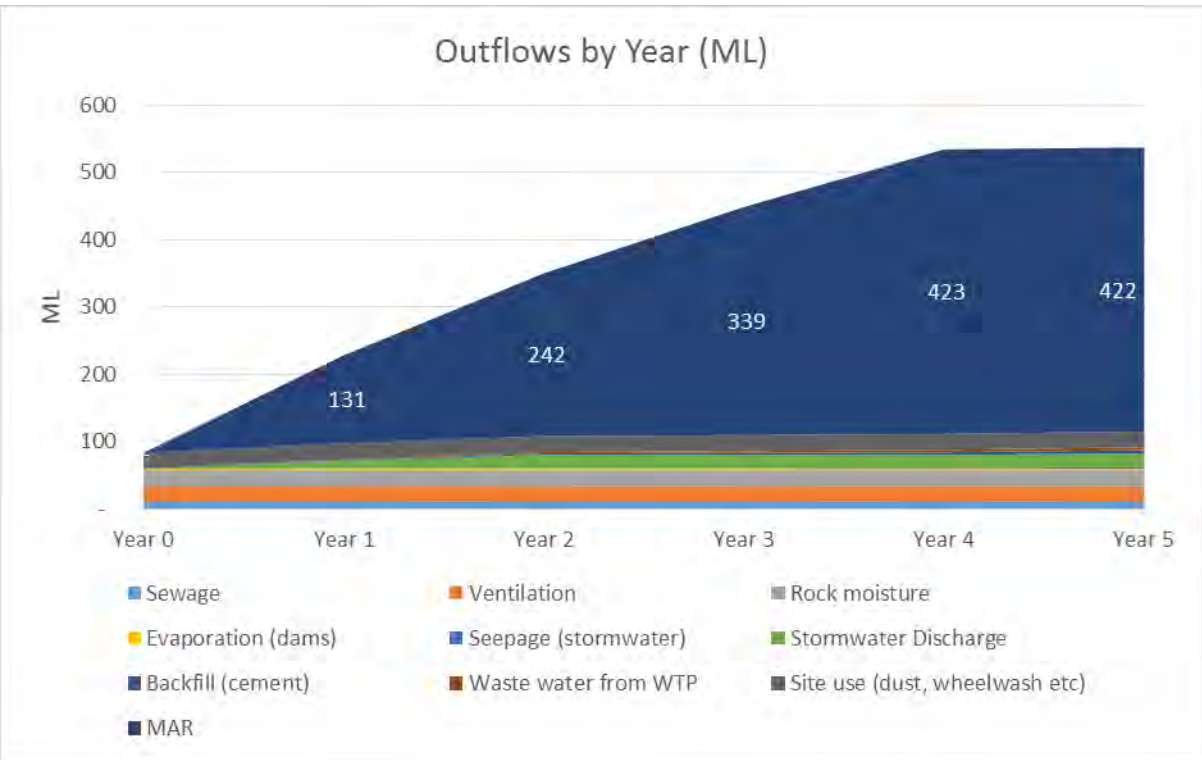


FIGURE 3-182 | SITE WATER OUTFLOWS BY YEAR (70% GROUT EFFICIENCY SCENARIO)

3.7.9.4 WATER STORAGE INFRASTRUCTURE

3.7.9.4.1 SURFACE WATER DAM

The surface mine water storage dam will be constructed as a hill side dam (Figure 3-184) and has been designed to withhold the capacity of the expected water to be pumped from the underground mine workings, as well as expected surface run off from the IML area while taking into account the requirements for the water treatment plant. Table 3-41 summarises the dam's design properties. A minimum freeboard height which is capable of coping with all rainfall duration for 1 in 100 year ARI[1] events will be incorporated into the final design specifications (Adelaide Hills Council, 2016). This is the Adelaide Hills Development Plan requirement for Effluent/Wastewater Dams which the surrounding businesses are required to comply with.

[1] Average Recurrence Interval' (ARI) refers to the expected or average interval between events of a rainfall intensity of a given magnitude being exceeded.

FIGURE 3-183 | LOCATION OF THE SURFACE WATER DAM, CIRCLED IN YELLOW (APPENDIX G1)

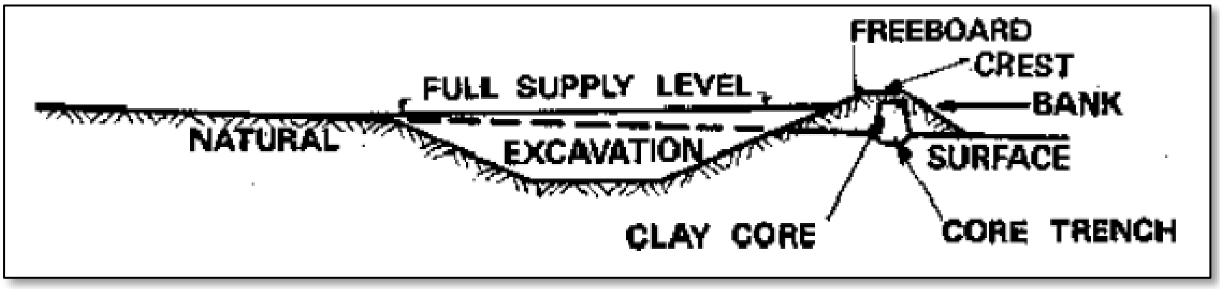


FIGURE 3-184 | CROSS SECTION OF A TYPICAL HILL SIDE DAM (EYRE PENINSULA NATURAL RESOURCES MANAGEMENT BOARD, 2011)

TABLE 3-41 | SUMMARY OF SURFACE WATER DAM DESIGN

Property	Value	Unit
Dimensions (top)	~82 x 62	m
Dam surface area (top)	5,072	m^2
Dimensions (bottom)	~50 x 30	m
Dam surface area (bottom)	1,500	m^2
Depth from top to bottom	5.6	m
Angle of walls	1:3	V:H
Capacity to Crest	17.6	ML
Minimum Freeboard (height equivalent)	1	m
Minimum freeboard	2.9	ML
Minimum volume	0.81	ML
Minimum water height	0.5	m

Scenarios considered in the design of the dam capacity include

- Average daily rainfall
- Extreme rainfall event (50mm/hr for 24hrs) (BOM AEP 1EY), (Commonwealth of Australia, 2017)
- 70% and 90% grouting efficiencies and
- 48l/s inflows (double the 70% grout effective scenario modelled in the 2017 Groundwater Impact Assessment – Appendix H1) – providing a Factor of Safety of 2.0 on the credible worst case scenario

Values for the mine inflows were taken at the maximum modelled values at year 4 of the underground operations (as discussed in Section 3.4.6.2)

A minimum depth of water (500mm) will be maintained to ensure the viability of the proposed floating reed beds (Figure 3-194). In times of low mine inflows, and low rainfall events, this may require the water treatment plant to operate with reduced throughput, with make-up water for underground mining uses to come from the Goldwyn bore.

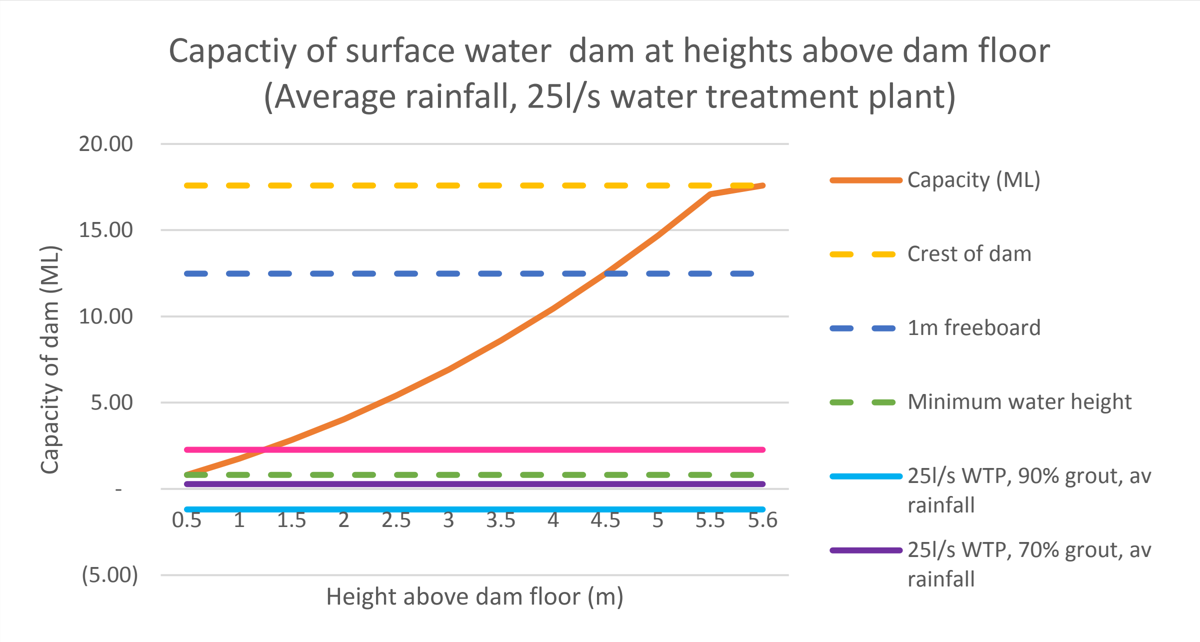


FIGURE 3-185 | GRAPH SHOWING THE DAM CAPACITIES FOR THE THREE INFLOW SCENARIOS, USING AVERAGE RAINFALL VALUES, AND THE WATER TREATMENT PLANT OPERATING AT 25L/S

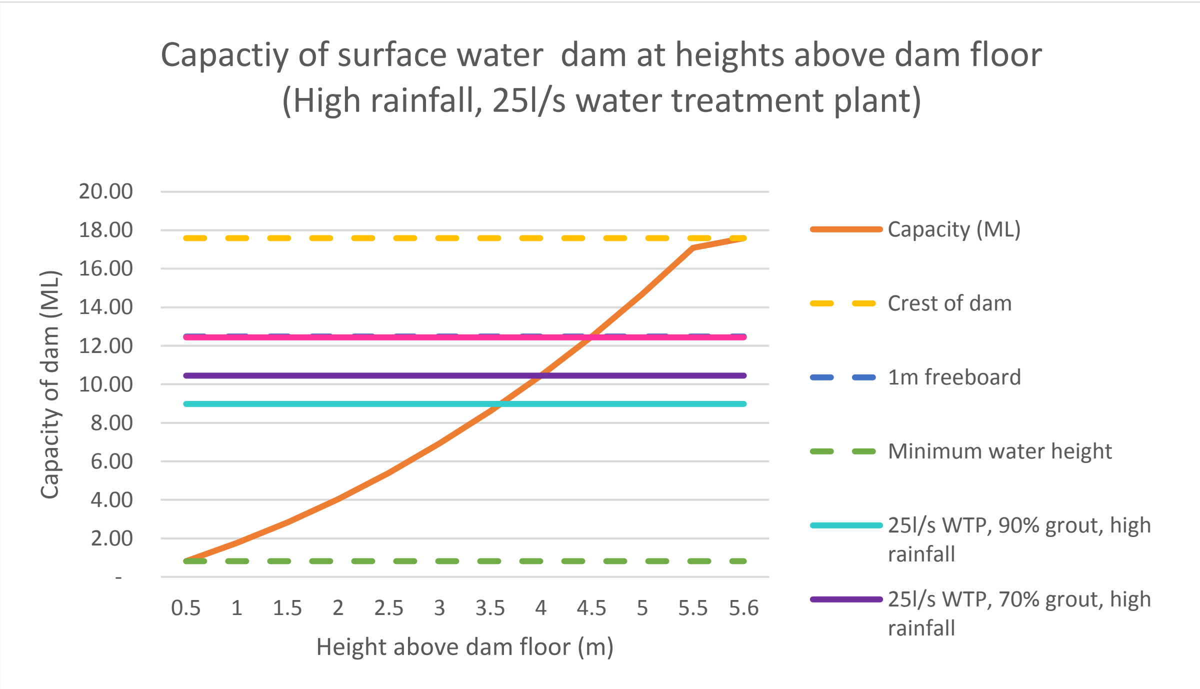


FIGURE 3-186 | GRAPH SHOWING THE DAM CAPACITIES FOR THE THREE INFLOW SCENARIOS, USING HIGH RAINFALL VALUES, AND THE WATER TREATMENT PLANT OPERATING AT 25L/S

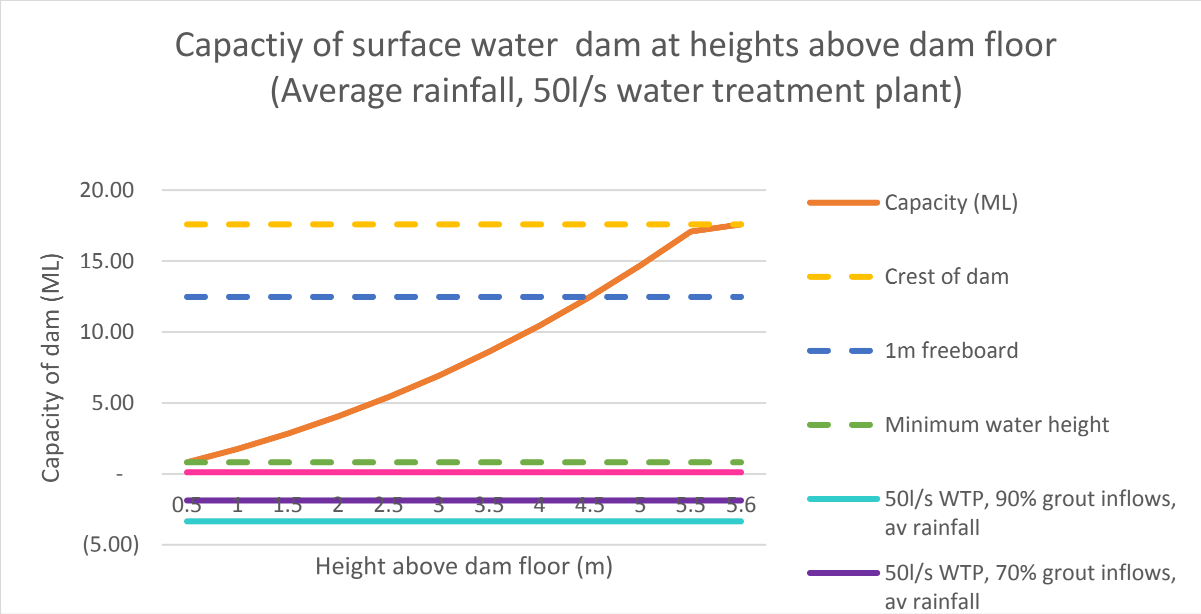


FIGURE 3-187 | GRAPH SHOWING THE DAM CAPACITIES FOR THE THREE INFLOW SCENARIOS, USING AVERAGE RAINFALL VALUES, AND THE WATER TREATMENT PLANT OPERATING AT 50L/S

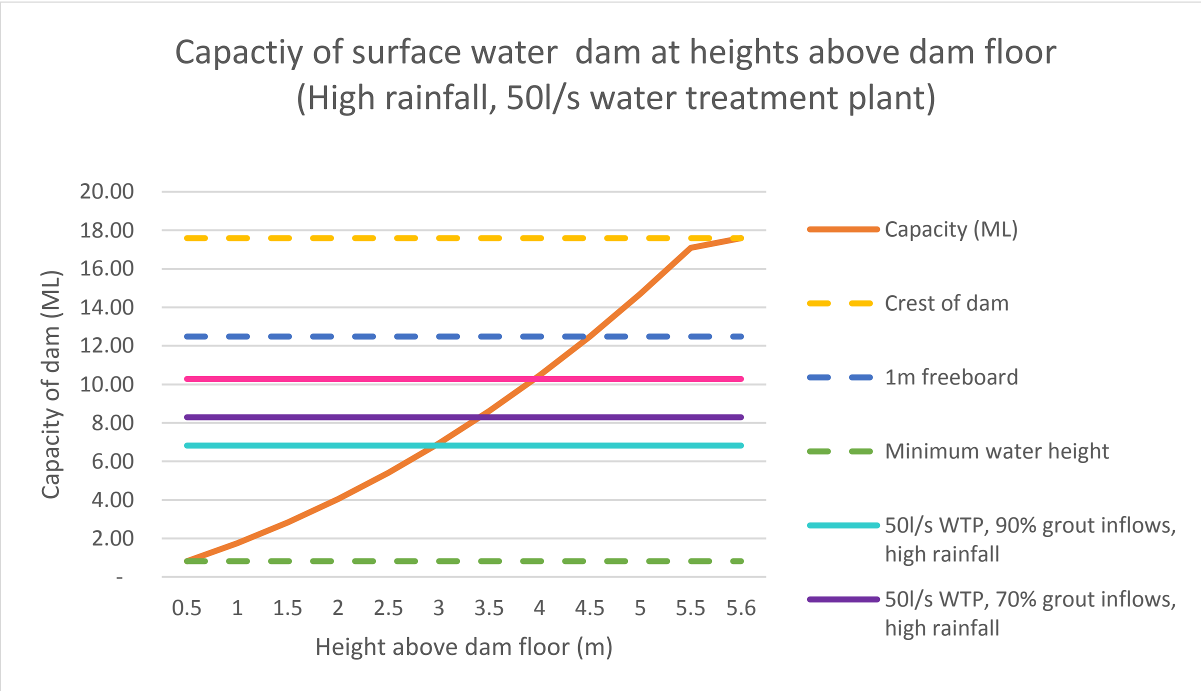


FIGURE 3-188 | GRAPH SHOWING THE DAM CAPACITIES FOR THE THREE INFLOW SCENARIOS, USING HIGH RAINFALL VALUES, AND THE WATER TREATMENT PLANT OPERATING AT 50L/S

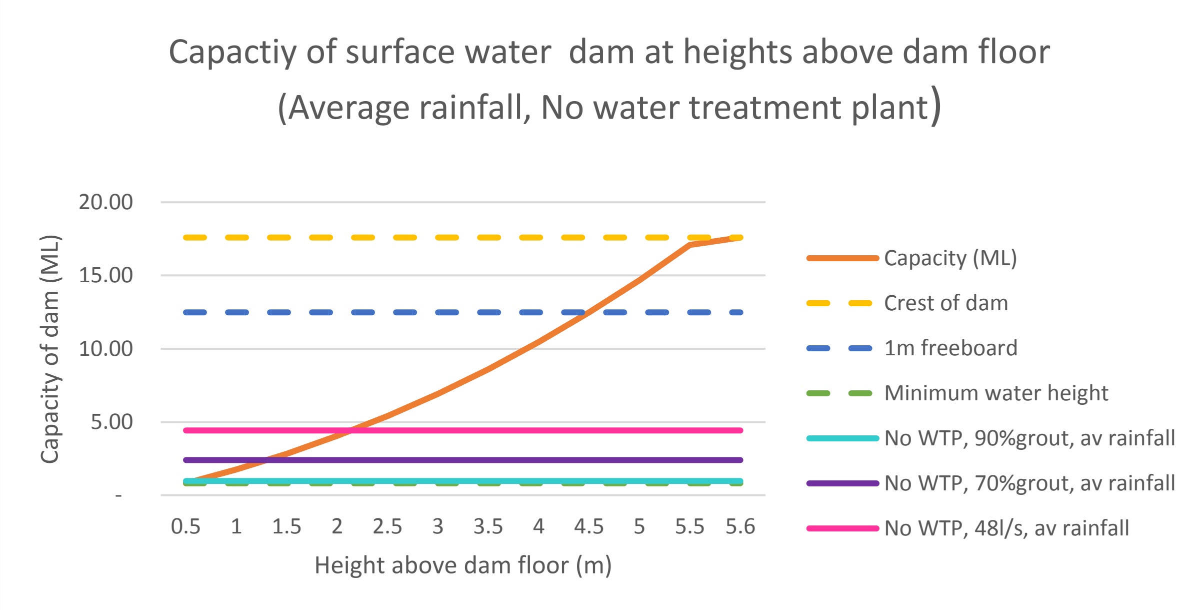


FIGURE 3-189 | GRAPH SHOWING THE DAM CAPACITIES FOR THE THREE INFLOW SCENARIOS, USING AVERAGE RAINFALL VALUES, AND THE WATER TREATMENT PLANT NOT OPERATING

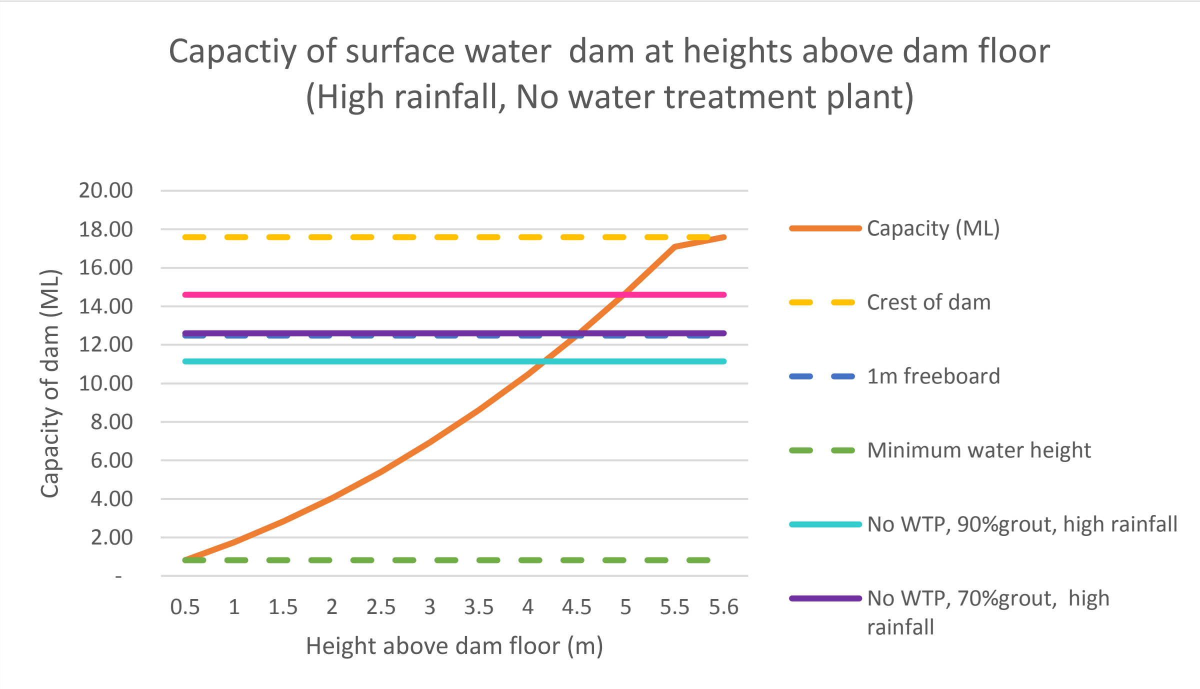


FIGURE 3-190 | GRAPH SHOWING THE DAM CAPACITIES FOR THE THREE INFLOW SCENARIOS, USING AVERAGE RAINFALL VALUES, AND THE WATER TREATMENT PLANT NOT OPERATING

The dam will be lined with clay as the water quality is considered to be similar to stormwater dams utilised in housing developments or agriculture. A polymer lining was assessed as too high an impact on potential visual impact from the south western aspect of the site. There was also risks identified around the potential for damage to any polymer lining in the process of dam maintenance and with the planned vegetation in the dam for nitrate treatment. This will be confirmed through the Feasibility stage of the Project.

3.7.6.4.1.1 SEDIMENTATION CONTROL

Over a period of time, sedimentation will decrease the capacity of the dam. The potential for sedimentation can be mitigated by undertaking certain drainage and erosion control measures aimed at stopping large volumes of sediment from entering a dam. (Water Resources Divsion, 2008)

The process proposed for the Project includes initial silt traps for surface water and for the underground water a clarifier to remove a high percentage of sedimentation as possible prior to entering the dam. Refer to the Stormwater Management Plan (Appendix I3) and the Water Treatment Flow sheet in Appendix J1)

3.7.6.4.1.2 EMERGENCY OVERFLOW

Should a situation arise where the dam capacity is reached, the additional capacity available in the Stormwater retention/detention will be used for backup capacity. In cases where the capacity exceedance is reached due to high rainfall or high groundwater inflows, analytes in the water will be diluted, and possibly suitable to release in the planed stormwater system, subject to quality testing.

More information on groundwater inflows and controls is located in Chapter 10: Groundwater.

More detailed information on surface water controls is located in Chapter 11: Surface Water.

3.7.9.4.2 SURFACE TANKS

Additional storage of water will be required outside to the proposed dams, for various uses around the site. These holding tanks will provide a location for testing of water quality prior to its eventual use, and allow for re-direction of the water if needed i.e. for further treatment, for emergency supplies etc. Storage of water will typically be for the following:

- Rainwater;
- Pre-treatment holding tanks;
- Pre-MAR tanks;
- Fire water (Figure 3-191); and
- Potable water header tanks

FIGURE 3-191 | EXAMPLE OF A FIRE WATER TANK

3.7.9.5 WATER TREATMENT

The water treatment system proposed for the Project was developed by GPA Engineering and details are included in the Water Treatment Options Study Report (Appendix J1). This report was independently peer reviewed by Golder Associates, with the subsequent review included in Appendix J2). Water treatment is discussed also in Chapters 10: Groundwater and 11: Surface water.

All water pumped up from the underground workings as well as water runoff collected from the operational area will undergo treatment to ensure water quality standards are maintained prior to re-cycling or re-injection back into the Managed Aquifer Recharge system (MAR). Treatment is required to ensure the water quality meets the requirements stipulated for MAR in South Australia (as regulated by the Department for Environment and Water and the Environment Protection Agency), and/or for use in the Project. The process for treating water on site at BIH will comprise of three stages.

1. Primary:
    - First stage solids removal
    - First stage analytes removal
    - pH adjustment if required
2. Secondary:
    - Second stage solids removal
    - Second stage analytes removal
3. Tertiary:
    - Third stage analytes removal
    - Final TDS reduction

3.7.9.5.1 PRIMARY TREATMENT

Figure 3-192 shows the primary treatment process from the water being pumped up from underground, underground clarification, and first stage treatment. A Plate Settler Clarifier provides the first stage of treatment. Clarification may require pH adjustment in order to maximise the clarification process. All additives proposed to be used in the treatment of water on site are listed for use in treating drinking water as per the NHMRC's Australian Drinking Water Guidelines (ADWG).

A flow-tube type dosing unit is proposed both upstream and downstream of the Plate Settler Clarifier unit (Figure 3-193). This will enable the mixing of flocculants and pH modifiers to achieve target levels for treatment.

Due to very low expected consumption of these dosing agents during operation, commonly used intermediate bulk containers (IBCs) will be used for transport and storage on-site.

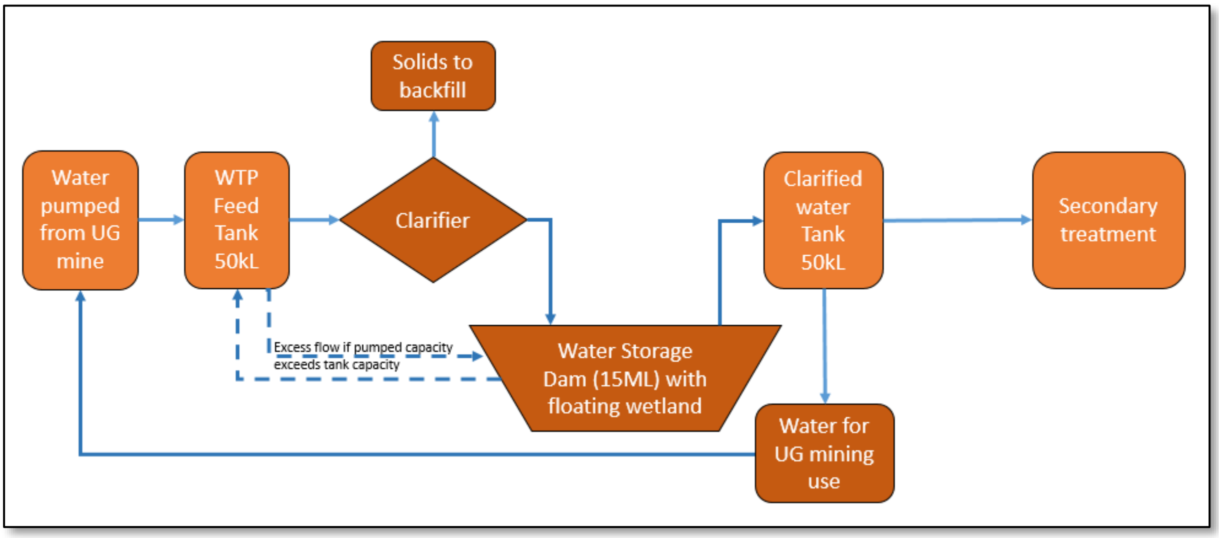


FIGURE 3-192 | BIH WATER TREATMENT PROCESS: PRIMARY TREATMENT

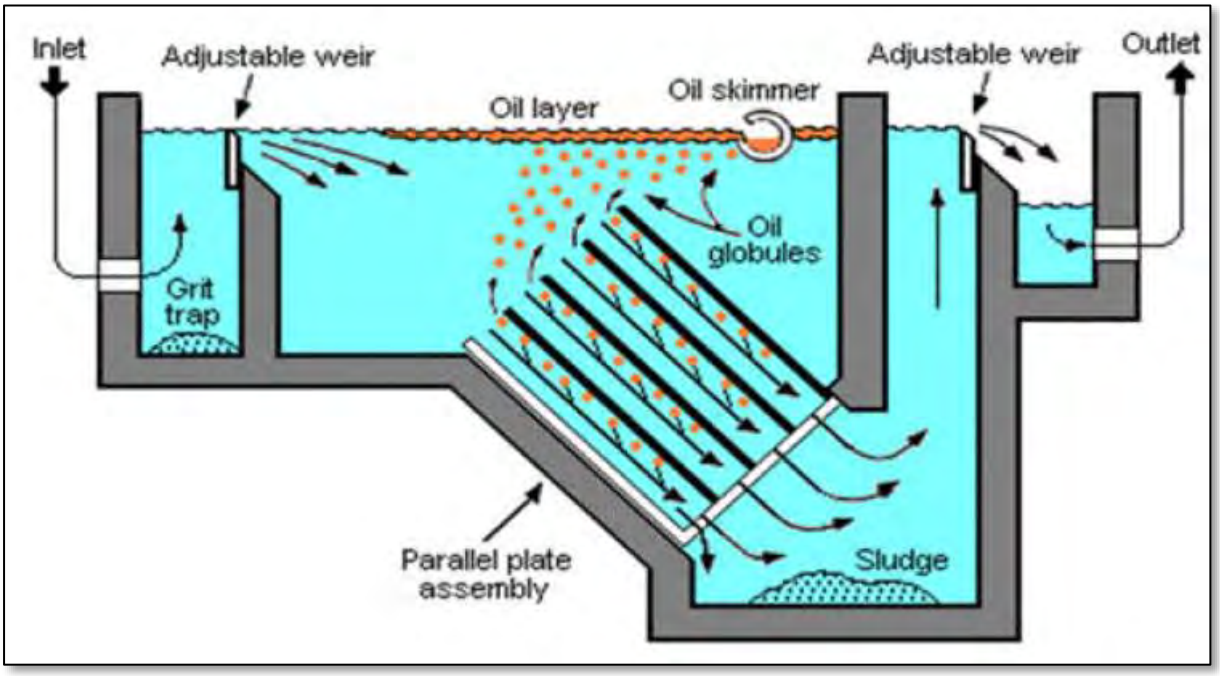


FIGURE 3-193 | VIEW OF THE INTERNAL OF A TYPICAL PLATE SETTLER UNIT. (APPENDIX J1)

Once the solids are removed from the water, it is discharged into the site water storage dam. The dam provides a location for additional settlement and will be equipped with floating wetland gardens. While the water treatment system could operate without these floating gardens, the use of plants to further treat water is well established and provides a naturally generated benefit to the water treatment system. Water is removed from the dam to a clarified water tank for use or further treatment.

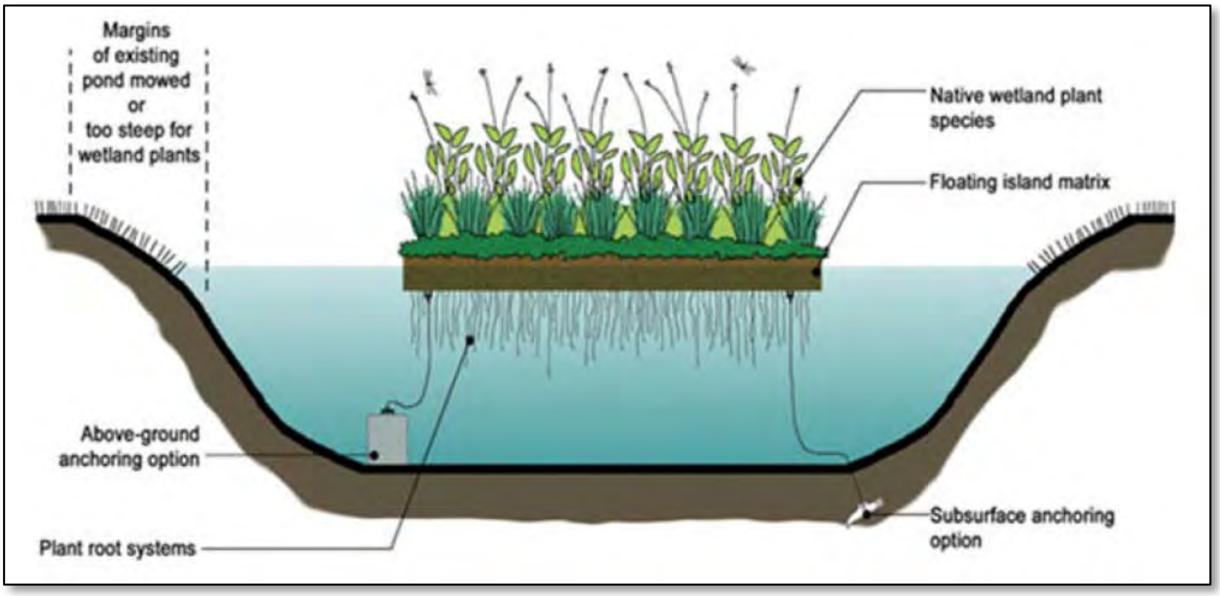


FIGURE 3-194 | EXAMPLE OF A FLOATING WETLAND USED FOR WATER TREATMENT (APPENDIX J1)

3.7.9.5.2 SECONDARY TREATMENT

The secondary stage of treatment (Figure 3-195) aims to reduce the solids below the TSS target in the final treated water. This process will be done with the use of a sand style filter called a Moving Bed bio-filter (Figure 3-196).

Water will be pumped from the Clarified Water Tank into the unit and be directed to the bottom of the sand media bed. It will then flow upwards through the sand media at a rate of about 7 to 9 m/h fluidising the sand media bed. An airlift system would continuously lift (via the central column) some of the sand to a washing chamber at top of the unit. The sand will be washed to remove suspended solids, before being returned into the top of the sand media bed.

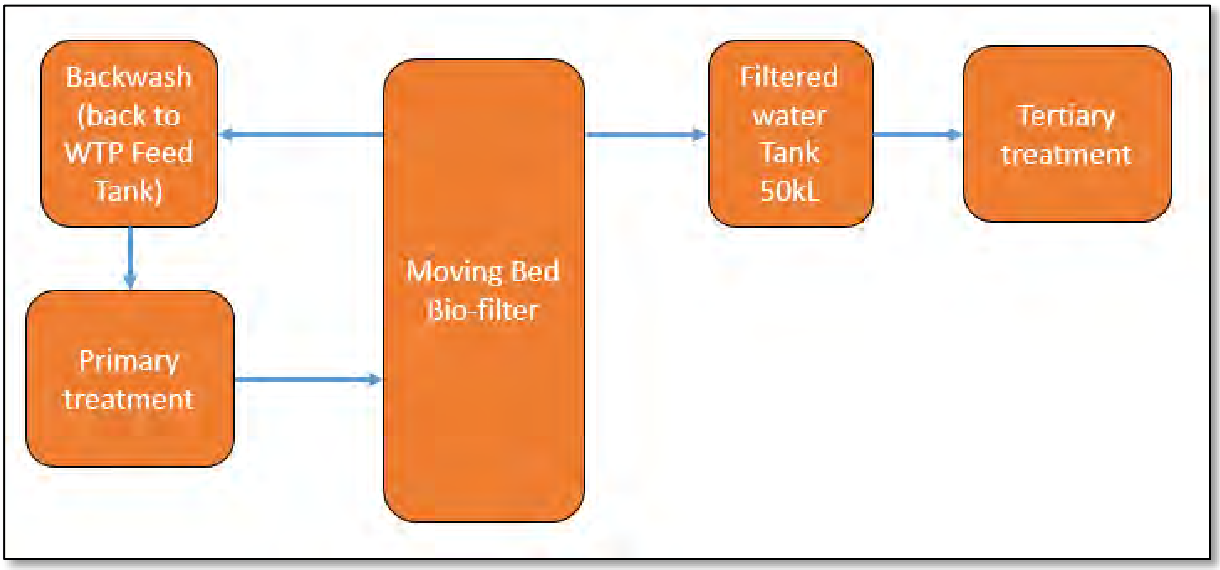


FIGURE 3-195 | FLOW DIAGRAM FOR THE SECONDARY PHASE OF THE WATER TREATMENT

The conditions in the upper parts of the sand bed will promote the removal of analytes by biological activity (Figure 3-196). A small amount of nitrogen gas (estimated 1 kg /hr) will be generated by these reactions which will be released into the atmosphere just above the filtration unit through the airlift system. Given that the normal concentrate of nitrogen in air is 78% the small increase in concentration of nitrogen (<1%) presents no risk related to sensitive receptors, including employees, local community, flora, or fauna.

Acetic acid will be dosed into the unit feed stream, to provide the carbon source required to drive the biological reactions. Approximately 4.3 kg of acetic acid will be required to denitrify each kg of nitrate (as N) which is consumed in the process.

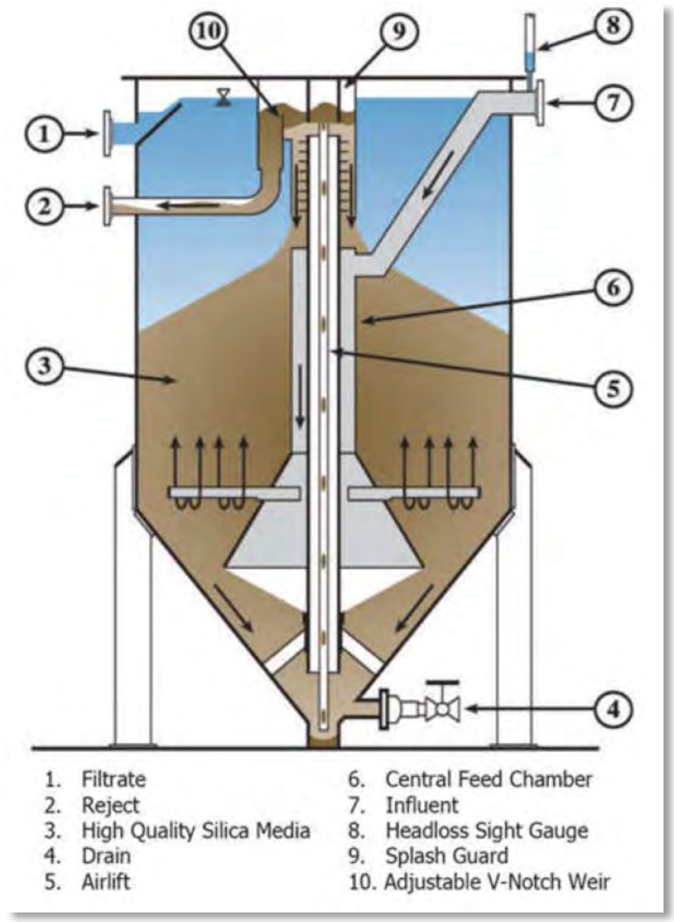


FIGURE 3-196 | VIEW OF INTERNALS OF A TYPICAL MOVING BED BIO-FILTER (APPENDIX J1)

3.7.9.5.3 TERTIARY TREATMENT

Tertiary treatment will achieve the final adjustment of the treated water quality to meet the DEW water quality well drainage permit requirements. An ion exchange system (IEX) was selected as the preferred option for this stage of treatment. A simplified flow diagram is shown in Figure 3-197.

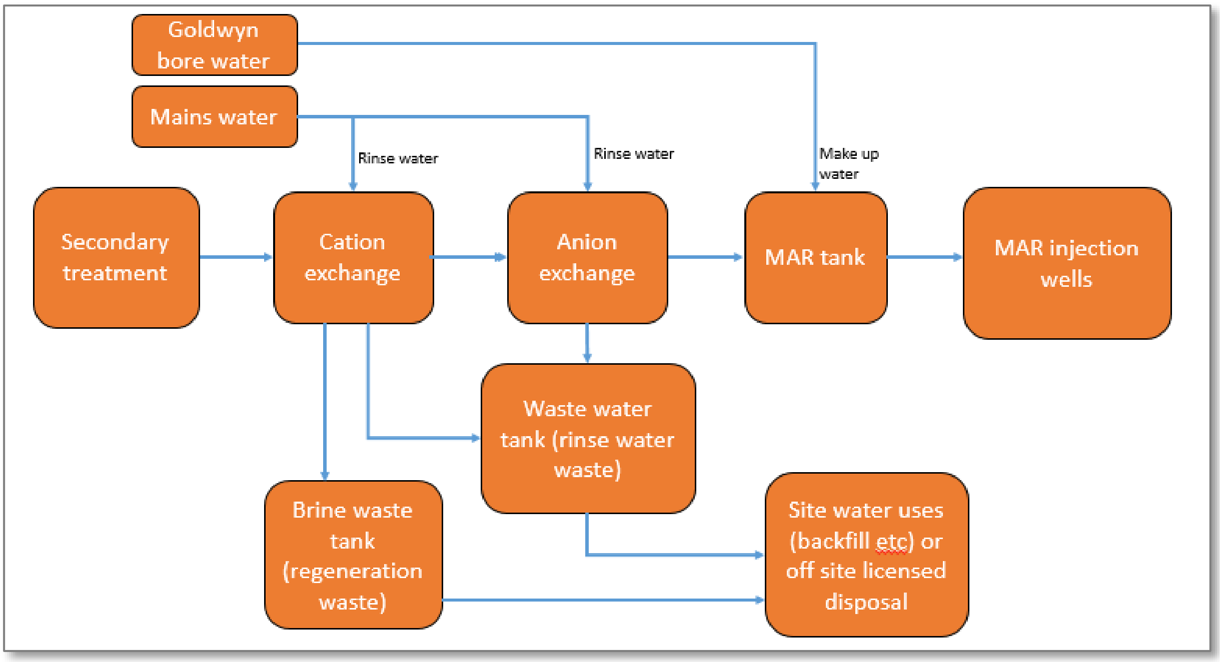


FIGURE 3-197 | FLOW DIAGRAM FOR THE TERTIARY PHASE OF THE WATER TREATMENT

Filtered water will be pumped from the Filtered Water Tank to the IEX, which will consist of two processes:

1) Cation exchange vessels (strong acid cation resin) to remove some cations, in order to reduce the final TDS to target levels.
2) Anion exchange vessels (with nitrate-selective resin) to remove analytes below target levels.

The design of the IEX allows for staging the capacity, starting from an initial 50% capacity (Stage 1). This will take advantage of the expected lower flows during the first few years, and the expected lower levels of analytes passing through the bio-filter system, which will be installed for full capacity from the beginning.

The vessels, piping and control equipment will be factory assembled inside 12 m long containers in a similar layout to that shown in Figure 3-198. To fit within a container, each vessel would need to be limited in size to about 1.2 m diameter, holding about 1m^3 of resin in each. Up to 7 x 1.2 m diameter vessels can be fitted along the long side of the container.

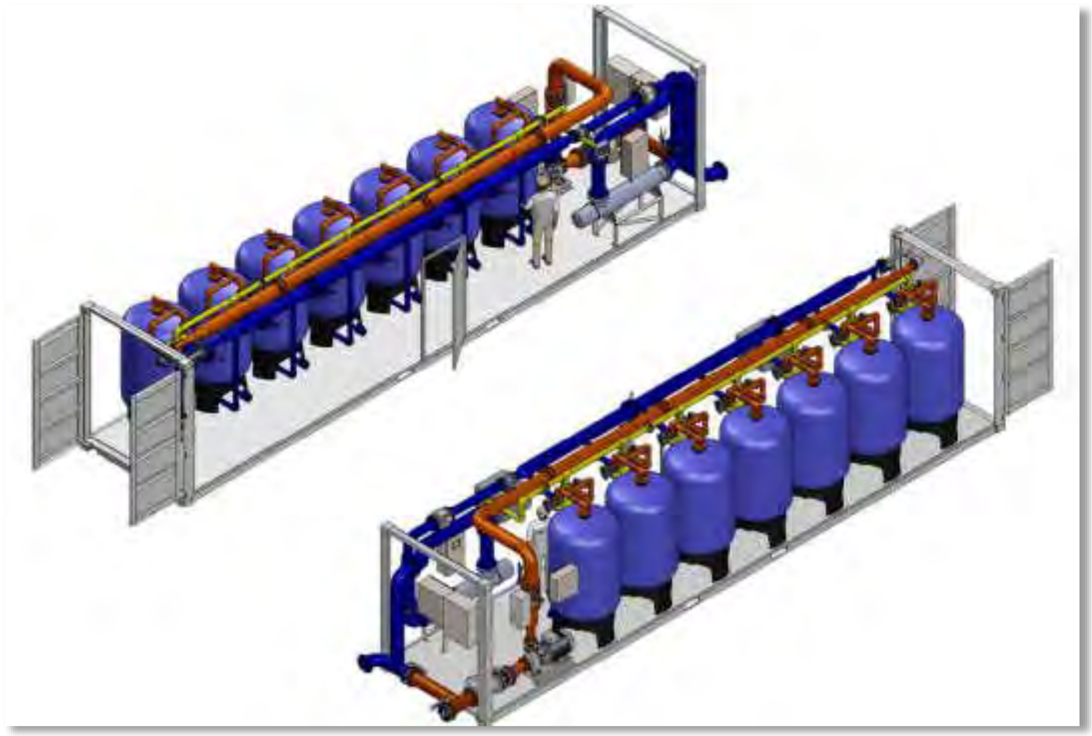


FIGURE 3-198 | TYPICAL ARRANGEMENT FOR CONTAINERISED ION EXCHANGE UNITS (APPENDIX J1)

3.7.9.5.4 WATER TREATMENT EQUIPMENT

Table 3-42 lists the proposed equipment and the relative capacities for the Water Treatment Plant (WPT) for the Project.

All capacities will be reviewed through the Feasiblity stage of the project and resized if required.

TABLE 3-42 | SUMMARY OF KEY EQUIPMENT FOR THE BIH WTP

Equipment	No. Units	Capacity		Dimensions	
		Unit	Value	Footprint	Height (m)
Clarifier	1	m^3/h	104	6 m x 3 m	6
Bio-filter	3	m^3/h	93	3.5 m diameter	5
Ion exchange system	1	m^3/h	86	12 m x 2.5 m	3
Solid recovery unit	1	m^3/h	0.6	6 m x 3 m	3
WTP feed tank (TK-001)	1	m^3	50	4 m diameter	4
Clarified water tank (TK-002)	1	m^3	50	4 m diameter	4
Filtered water tank (TK-003)	1	m^3	50	4 m diameter	4
MAR tank (TK-004)	1	m^3	50	4 m diameter	4
Wastewater tank (TK-005)	1	m^3	50	4 m diameter	4
Brine water tank (TK-006)	1	m^3	50	4 m diameter	4

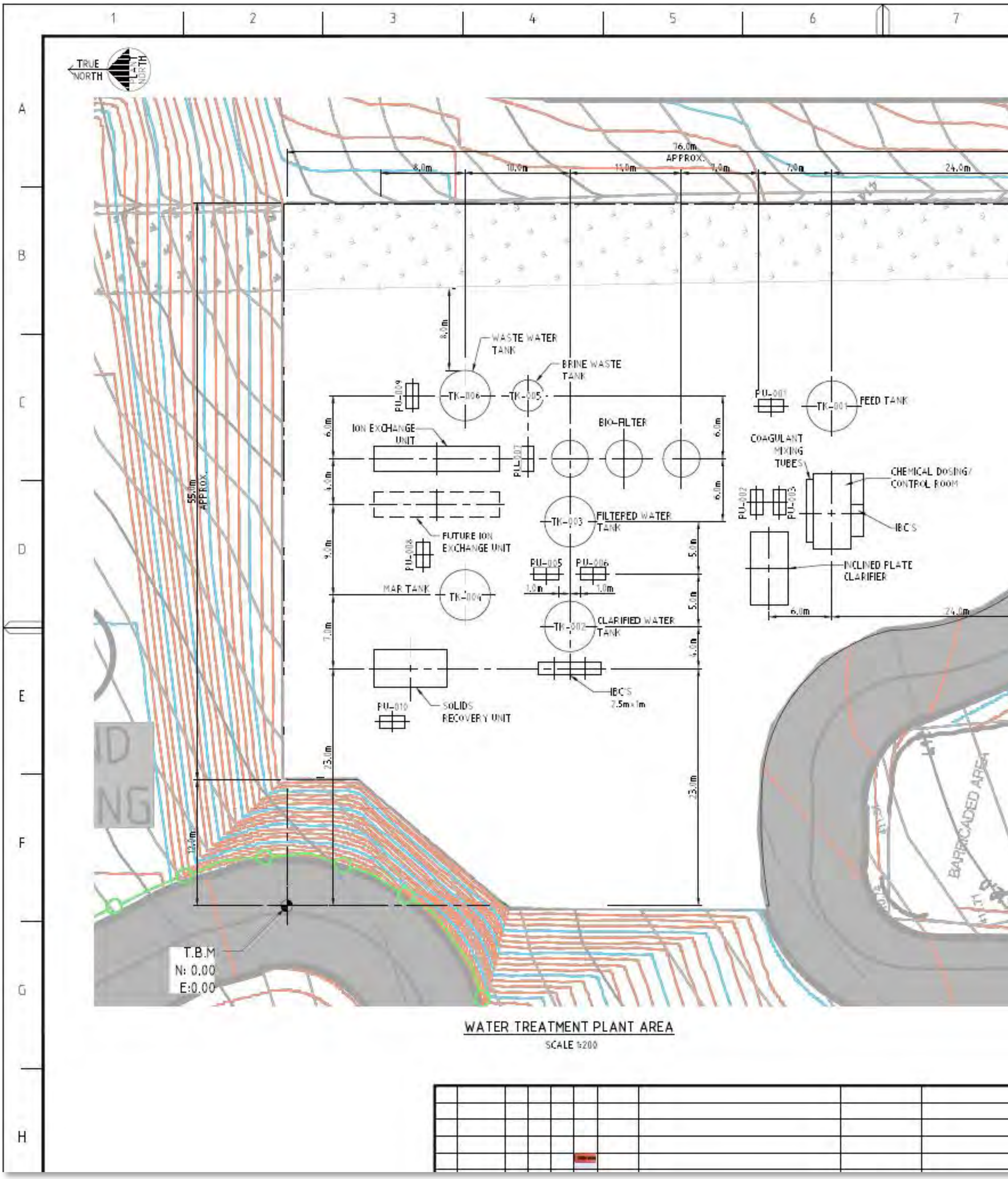


FIGURE 3-199 | PRELIMINARY LAYOUT FOR THE WATER TREATMENT PLANT (APPENDIX J1)

3.7.9.5 GROUNDWATER INFLOW MANAGEMENT

Information regarding the management of groundwater inflows through mine design has been previously discussed in section 3.4. This includes significant information on the pre-excavation grouting process, as well as dewatering infrastructure). The following continues to discuss the other mitigation methods proposed for the Project, with a focus on the Managed Aquifer Recharge system.

- Manager Aquifer Recharge (MAR) (3.7.9.6)
- Depressurisation (3.7.9.7)
- Grouting – pre excavation, post excavation for water management (discussed in detail in 3.4.2.7)

3.7.9.6 MANAGED AQUIFER RECHARGE

Even with grouting, there remains the potential for groundwater to enter the underground workings, this is largely dependent on how effective the grouting process is. Terramin propose that in order to optimise the overarching groundwater management system, Managed Aquifer Recharge is key to insuring the protection and enhancement the existing environmental values of groundwater. MAR is the intentional recharge of water to suitable aquifers for subsequent recovery or to achieve environmental benefits.

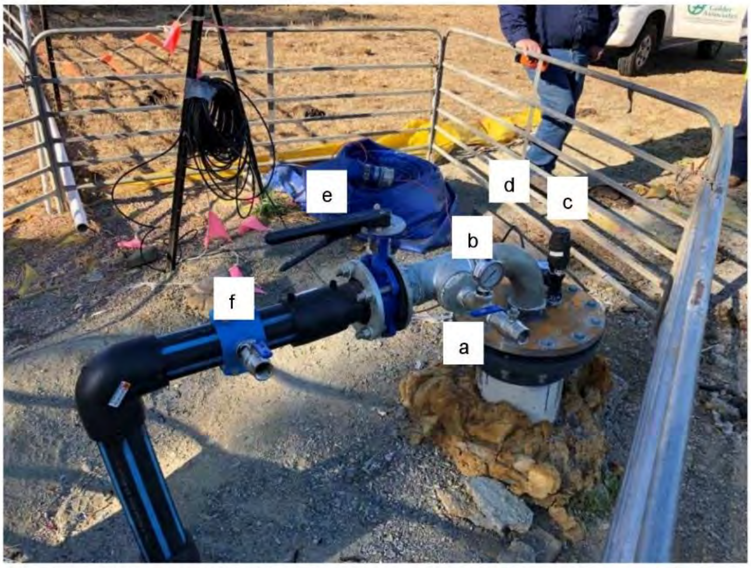
Further details are discussed in Chapter 10, however, a brief outline is included here.

Common reasons for using MAR include:

- securing and enhancing water supplies;
- improving groundwater quality;
- preventing salt water from intruding from other aquifers (i.e. from the Eastern Mount Lofty Ranges);
- reducing evaporation of stored water; and
- maintaining environmental flows and groundwater-dependent ecosystems, which improve Existing amenity, land value and biodiversity.

MAR is also been applied in mining to manage water from dewatering and to ameliorate environmental impacts of dewatering. In mining, MAR schemes using both injection and infiltration have been applied at mine sites both in Australia and overseas.

An example of MAR infrastructure (which was installed during the MAR trial) is included in Figure 3-200.



Injection well head at BHRIB01 showing a) sample tap b) pressure gauge c) air release valve and manual dip access prior to artesian conditions d) pressure transducer cable linked to a telemetry system e) flow control valve, f) purge line.

FIGURE 3-200 | MAR INFRASTRUCTURE

3.7.9.6.1 TERRAMIN'S EXPERIENCE WITH MAR

MAR was utilised by Terramin at the Angas Zinc Mine to reinject of treated water into a fractured rock aquifer adjacent to the mine (Terramin Australia Ltd, 2008) [2]. The reinjection system was managed among the bores with intermittent reinjection as part of the reinjection plan. Over the 12 month period 103.5ML of water was reinjected. Individual bores in the system predicted to sustainably accept 2.5l/s each accommodated reinjection rates of up to 13.3l/s[3] with average maximum reinjection rates of 8.3l/s.

3.7.9.6.2 EXAMPLES OF MAR IN MINING

Examples of MAR systems used in mining are covered in Chapter 10: Groundwater, but include:

- Cloudbreak Mine in Western Australia, in operation since 2008. It returns approximately 73 per cent of extracted water from dewatering back into the aquifer via injection bores, greatly reducing their effect on groundwater levels and quality (Willis-Jones & Roos, 2013).
- Ophthalmia Dam in Western Australia a MAR scheme using infiltration basins. Constructed on the Fortescue River approximately 5 km upstream of the Ethel Gorge, this scheme started operation in 1982.
- Cobre Las Cruces is an open-pit copper mine located in south-west Spain. The mine has a complex drainage and re-injection system consisting of 32 peripheral dewatering wells connected to a ring of 28 injection wells. The scheme has been operating without

[2] Angas Zinc Mine – Aquifer Injection Modelling Report Submitted to PIRSA 9th May 2008, Terramin were issued a *Permit to undertake a Water Affecting Activity, Drain or Discharge Permit* into licenced well on 24th May 2012 from the Department of Water

[3] Angas Zinc Mine Reinjection Monitoring Report May 2013 issued to as part of Angas monitoring requirements

interruption since 2006 and balances the needs of mine dewatering versus maintaining the equilibrium in the aquifer (Baquero, Reyes, Custodio, Scheiber, & Vazquez-Sune, 2016).

3.7.9.6.3 BENEFITS OF MAR

MAR has the potential to provide many benefits to mines. Conserving water is one such benefit; improving operational efficiencies is another, protection of environmental aquifer properties and landowner water assets is a key benefit.

Furthermore, MAR benefits the existing communities that surround mines. Water that is extracted as part of the dewatering process can be re-injected at locations where it can benefit other users and/or groundwater dependent ecosystems. MAR is a valuable tool for addressing the social pressures that could arise in nearby communities; maintaining the public's access to irrigation and environmental water helps offset concerns about the potential impact of dewatering on the groundwater resources in the area.

3.7.9.6.4 MAR SYSTEM PROPOSED

Terramin propose a MAR system to prevent groundwater drawdown surrounding the underground workings for existing groundwater users and ecosystems identified through the groundwater census (sensitive receptors outlined in Chapter 10), located within the immediate vicinity of the underground workings, as shown in Figure 3-201.

For MAR to be viable, the following site criteria must be fulfilled:

- the presence of a geological formation capable of receiving, storing and transmitting water with additional storage capacity
- a suitable source of water for recharge/injection
- an ongoing Existing demand or clearly defined environmental benefit (Waterhouse, Tuff, & Usher, 2017)

In regard to the BIHGP, the groundwater investigation and subsequent groundwater modelling, which has been conducted from 2013 to 2019 and outlined in the Groundwater Assessment located in Appendix H1 and H9, the geological formation has been identified as capable of receiving water through a managed aquifer recharge system. This view is held also by the peer review of the groundwater model, undertaken by Innovative Groundwater Solutions in 2017 and 2019 (review located in Appendix H2 , H3 and H10). This was ascertained through geological logging of the drill core, as well as several pump tests.

The existing groundwater environment is outlined in Chapter 10: Groundwater.

The source and predicted flows of groundwater has been modelled as part of the impact assessment, and based upon expected impact as well as credible worst case scenarios. After studying similar operations and receiving advice from grout experts and specialists specifically on the Project's requirements and the Bird-in-Hand geological context, Terramin expects the groundwater inflows to be reduced by 90% of inflows with no mitigation in place (90% effective) with the use of grout. This approach is supported by the peer review of the grouting proposal undertaken by Golder Associates grouting specialists (Appendix H5), as well as grouting specialists from Western Australia – Hydroseal.

Adequate capacity must be built into the system to manage a credible worst case scenario, and for this reason, have designed the water management system with groundwater inflow management being only 70% effective. This allows for adequate infrastructure to be in place if higher inflows are encountered while ensuring the protection of the supply and quality of groundwater for all sensitive receptors (existing users and water dependent ecosystems) from the operation.

Terramin expect that the peak annual volume the MAR system will need to reinject will be approximately 141 ML, which equates to a peak of on average 4.5 L/s during the fourth year of mining. This is in contrast to the first year, which is on average 1.4 L/s (44 ML/yr). This is due to the difference in the permeability and structure of the rock types, with the Tapley Hill Formation, where the decline and approach development is located, having a much lower permeability (that is, K = 3.5 x 10^{-7} m/sec).

Note that the development located within the Tapley Hill formation will still be subject to the probe drilling and pre-excavation grouting program where required.

A summary of the volumes proposed for the MAR system are below in Table 3-43.

TABLE 3-43 | MODEL-PREDICTED GROUNDWATER ABSTRACTION FROM WMLR

Year	90% Grout with MAR			70% Grout with MAR		
	ML/y	ML/d	L/s	ML/y	ML/d	L/s
1	44	0.1	1.4	131	0.4	4.1
2	81	0.2	2.6	242	0.7	7.7
3	113	0.3	3.6	339	0.9	10.8
4	141	0.4	4.5	423	1.2	13.4
5	141	0.4	4.5	422	1.2	13.4

Lastly, there is clearly an ongoing existing demand or clearly defined environmental benefit to utilising a MAR system, as the area relies upon agricultural use of the groundwater, and the Inverbrackie Creek hosts several groundwater dependent springs. The area is located within a prescribed wells area, and is controlled by the Western Mount Lofty Ranges Water Allocation Plan.

In order to protect agricultural and ecological values, pipelines for the MAR network are planned for existing fence lines, out of riparian zones and in cleared areas only, as shown in Figure 3-112.

3.7.9.6.5 MAR TEST WORK, VALIDATION AND COMMISSIONING

MAR testwork was undertaken during 2018 and 2019 (approved by EPEPR 2018-009). The reporting of the MAR testwork has been undertaken by Golder Associates and has been included in Appendix H8 and H9 and peer reviewed by Innovative Groundwater Solutions, included in Appendix H10.

The MAR test work demonstrated that the project is able to meet the objectives of the Western Mount Lofty Ranges Water Allocation Plan (**WMLR WAP**), prescribed by the *Natural Resources Management Act 2004* (SA)(NRM Act), which is to *account for the needs of existing water users and protect them from the potential impacts of new users or people wanting more water (Western Mount Lofty Ranges Water Allocation Plan Fact Sheet | October 2013).*

Under the Mining Lease proposal and operational PEPR the MAR system would involve extracting, treating and re-injecting water. The use of MAR during the mining operations would be consistent with the objectives of the Natural Resources Management Act and the Western Mount Lofty Water Allocation Plan (WMLRWAP) which includes the management of water resources that is sustainable, protects the environment and does not impact the existing allocation of existing users (whether domestic or commercial operations). DEW drain and discharge well permits, issued by DEW, will provide additional compliance criteria of use for drainage wells, including the water quality of water able to be reinjected into each well.

The MAR investigations undertaken in support of the Bird-in-Hand Mining Lease Proposal and MAR feasibility assessment described above and the subsequent modelling of aquifer response to both mine depressurisation and MAR indicate the surrounding aquifer is suitable to undergo MAR.

Injection tests were performed on the Tapley Hill formation and Tarcowie siltstone within the proposed ML. The combined injection rate was up to 20 L/s, and similar in nature to the range of mine inflows estimated by modelling and grouting under 70% grouting effectiveness.

In particular, a faulted area in the Tapley Hill formation offers the opportunity of developing high yielding MAR wells with storage held in adjacent less fractured rock. This faulted area promotes higher rates of recharge and the lateral spreading of recharge water.

Pumping and injection tests conducted in the Tarcowie siltstone showed evidence of some structural control around the underground mine area. These features could limit the spread of groundwater level drawdown induced by mining and likewise limit the recirculation of injected mine water towards the mine.

Groundwater modelling of aquifer response to both underground mining and MAR was refined using transient data collected during the pumping and injection tests. This represented a third transient calibration on the developed model and provided a means of refining the model's ability to predict the response of the system that is specific to the intended management actions (i.e. injection of water).

Revised model predictions of groundwater inflows and the associated groundwater level drawdown was consistent with predictions presented previously. Overall, groundwater modelling showed that groundwater level impacts to surrounding groundwater receptors (including the Inverbrackie Creek) are reduced by a combination of grouting for groundwater control and MAR compared to a no MAR scenario.

As the BIHGP lies within the Western Mount Lofty Ranges Prescribed Water Resources Area, a licence or authorisation under the NRM Act may be required for the extraction of the water from the mine[4]. Similarly, a permit under the NRM Act is required to recharge the water to the aquifer under the MAR[5].

Legal review confirms the regulatory path to extraction and reinjection (MAR) as mitigation for a mining operation is to seek a section 128 (1) approval of the NRM Act and utilise the existing Water Trading system under the WAP, or obtaining the requisite groundwater allocation through the existing Water Allocation Plan and water trading framework under the NRM Act. Terramin will seek approval to abstract water from the mine void, and subsequently reinject water via a MAR system so as to not

[4] Section 124(3)(a) or Section 128

[5] Section 127(3)(c) unless allowed under section 129(1)(f)(i) pursuant to an environmental authorisation under the *Environment Protection Act* 1992.

cause a significant adverse impact on existing groundwater users or water dependent ecosystems, as outlined in the WAP. The revised model simulations are discussed in detail in Chapter 10.

The Groundwater Impact Assessment and Modelling Report is included in Appendix H1.

The updated Groundwater Impact Assessment including the MAR Investigation is in Appendix H9.

A peer review of this work was undertaken by Innovative Groundwater Solutions in 2017, and again in 2019 (review located in Appendix H2, H3 and H10).

3.7.9.6.5.1 APPROACH

Figure 3-112 shows the proposed layout of the final MAR system. The system currently has two operating reinjection bores capable of receiving up to 20L/s under pressure and were tested during the MAR Trial program undertaken in 2019 (Appendix H8). The system will be expanded during construction to up to 8 MAR wells, as shown in Figure 3-112 to ensure further MAR contingency throughout the life of mine. Note, 20L/s is well in excess of the expected peak annual average inflow of 4.5 L/s.

Sites are chosen based on the geological and hydrogeological understanding of the aquifer, through drilling records, modelling and experience.

The location of existing monitoring network and operational private wells are shown on Figure 3-201 for reference.

3.7.9.6.5.2 SOURCE WATER

The injection water will be pumped from the mine and placed into the mine storage water dam onsite, before undergoing water treatment (as outlined in section 3.7.9.5). IB4 currently targets the hanging wall, and for this reason has been used to represent the water quality expected to be drawn from the mine. A pumping test was undertaken on this bore IB4 in 2014 at 17 L/s and the results can be found in section 3.2.3 of the Groundwater Assessment (Appendix H1). The chemistry of the source water (obtained from IB4) is presented in Table 3-44 below, and further discussed in comparison to the receptor water in the section below and includes a comparison of the groundwater quality at IB4 against the Australian Drinking Water Guidelines 2016 and ANZECC 95% protection of species. With the exception of zinc, all readings are at or below the Australian Drinking Water Guidelines 2016 and ANZECC levels.

All source water will be subject to the water treatment plant proposed onsite, described in section 3.7.9.5.

TABLE 3-44 | COMPARISON OF GROUNDWATER QUALITY AT IB4 AGAINST THE AUSTRALIAN DRINKING WATER GUIDELINES 2016

Unit Number		IB4 – source 6628-27445	ANZECC 95%	Australian Drinking Water Guidelines 2016
Date Sampled		1-Aug-17 (Nutrients 4/2/2015)		

pH Value	pH Unit	7.72		
Electrical Conductivity	µS/cm	1380		
Total Dissolved Solids	mg/L	774-911		
Suspended Solids	mg/L			
Turbidity	NTU	4.9		
Sulfate as SO4	mg/L	42		
Chloride	mg/L	266		
Calcium (Diss)	mg/L	45		
Magnesium (Diss)	mg/L	24		
Sodium (Diss)	mg/L	218		
Potassium (Diss)	mg/L	8		
Sodium Absorption Ratio		6.52		
Arsenic (Diss)	mg/L	<0.001	0.024	0.01
Cadmium (Diss)			0.0002	
Chromium (Diss)	mg/L	<0.001	0.001	0.05
Copper (Diss)	mg/L	<0.001	0.0014	2
Lead (Diss)	mg/L	<0.001	0.0034	0.01
Manganese (Diss)	mg/L	0.128	1.9	
Nickel (Diss)	mg/L	<0.001	0.011	0.02
Selenium (Diss)			0.011	
Zinc (Diss)	mg/L	0.018	0.008	
Iron (Diss)	mg/L	0.28		
Arsenic (Total)	mg/L	<0.001		
Cadmium (Total)				
Chromium (Total)	mg/L	<0.001		
Copper (Total)	mg/L	<0.001		
Lead (Total)	mg/L	0.002		
Manganese (Total)	mg/L	0.135		
Nickel (Total)	mg/L	<0.001		
Selenium (Total)				
Zinc (Total)	mg/L	0.02		
Iron (Total)	mg/L	0.86		
Nitrite as N	mg/L	<0.01		
Nitrate as N	mg/L	<0.01	0.7	0.7
Nitrite + Nitrate as N	mg/L	<0.01		
TKN as N	mg/L	0.1		
Total Nitrogen as N	mg/L	0.1		
Total Phosphorus as P	mg/L	0.04		
Total Anions	meq/L	15.3		
Total Cations	meq/L	13.9		
Ionic Balance	%	4.74		

*filtered

3.7.9.6.5.3 RECEIVING AQUIFER/EXISTING USERS

Figure 3-201 shows that there are 12 operational wells within a kilometre of the underground workings (when displayed on surface). The interaction to these wells from pumping IB4 was assessed in 2014 during a pumping test conducted at 17 L/s over 6 days. About 25 wells (including nearby private wells) were monitored during the pumping test of IB4 and no groundwater response was observed at these wells (see Figure 3-202 for monitoring bore locations from AGT, 2017 (Appendix H1)).

Water chemistry data obtained from the closest private wells (representing the receiving aquifer), as well as two reinjection bores (BHRIB01 and BHRIB02) is presented in summary below as well as in the groundwater assessment, Appendix H1.

GPA Engineering have analysed the water quality obtained from BHRIB01 and BHRIB02 and provided further refinement of the water treatment plant based on the parameters. This has been included as an addendum to the water treatment plant design located in Appendix J1.

The majority of salinity (total dissolved solids) for these bores are within the range of ~700 mg/L (10th percentile) and 1300 mg/L (90% percentile). Salinity measured at the reinjection wells (BHRIB01 and BHRIB02) ranged between 1050 and 1450 mg/L. The water obtained from the hanging wall fracture (IB4), which is representative of the source water likely to seep into the mine, has a TDS of ~800 mg/L, and for this reason the water treatment plant has been designed to provide water with a quality of less than the reinjection bores (<800mg/L target to allow adequate capacity for change).

Turbidity ranges from under 1 NTU to over 80 NTU, with the average recorded being ~20 NTU. Turbidity measured at the reinjection wells (BHRIB01 and BHRIB02) ranged between 3 and 18 NTU, and as such the water treatment plant has been conceptually designed to target less than 3 NTU as a minimum requirement.

Metals analysis shows that all receptor metal concentrations in the source water (IB4) to be less than the average source water concentration, with the exception of dissolved manganese, and for the vast majority, either equal to or lower than the minimum value obtained, with the exception of manganese, zinc and iron. All source values remain under the ANZECC 200 guideline, with the exception of zinc. Regardless, the water treatment plant has been designed to treat the mine water to a quality that will meet or exceed the analysis data that has been gained from tests on bore samples taken from the reinjection bores and the surrounding area. Bore sampling and testing will be carried out again at the time of MAR commissioning to reconfirm water quality immediately prior to construction.

Nutrient analysis gained from the reinjection bores (BHRIB01 and BHRIB02) returned results within a range of nitrite and nitrate reflective of existing users water quality results previously gained. The range of nitrate (as N) is between the limit of detection (0.01mg/L) and 1.48mg/L. The 90th percentile for nitrate (as N) for the existing users water quality is 0.77mg/L. The target level for the water treatment plant for nitrate (as N) is significantly lower (0.32mg/L) than specified in guidelines for drinking water (11.3 mg/L) and for reinjection into an aquifer with a beneficial use for irrigation (5 mg/L). The target for nitrate is likely to be in the range of 0.2 – 0.5 mg/L, being the lowest nitrate concentration that can be effectively monitored real time by online instrumentation

Subsequently, MAR targets have been selected by GPA and are included in the table below:

TABLE 3-45 | PROPOSED MAR TARGETS

Ionic Constituent	Units	MAR Water (min)
pH		7.5 – 8.3
TDS	mg/L	994[1]
TSS	mg/L	< 10[2]
Sulphate	mg/L	50[5]
Chloride	mg/L	355[4]
Sodium	mg/L	169[4]
Magnesium	mg/L	36[4]
Calcium	mg/L	60[4]
Potassium	mg/L	8[4]

1 The minimum of the TDS range was selected as the lowest TDS measured for the two Receptor Bores (994 mg/L in Receptor Bore #1).
2 The TSS target of < 10 mg/L is set by the MAR guidelines.TSS limit of < 10 mg/L is set by the MAR guidelines. See comments below in Section 3.2.2.
3 Limit equal to the minimum level measured (in Receptor Bore #1).
4 Limit equal to the minimum level measured (in Receptor Bore #2).
5 Limit equal to the maximum level measured (in Receptor Bore #1).
6 Limit equal to the maximum level measured (in Receptor Bore #2).

Metal	Unit	MAR Water (max)
Arsenic	mg/L	0.001[2]
Chromium	mg/L	LOD[1]
Nickel	mg/L	0.003[3]
Lead	mg/L	0.002[2,3]
Total Copper	mg/L	0.003[2,3]
Total Iron	mg/L	0.008[2,3]
Total Manganese	mg/L	0.114[2]
Total Zinc	mg/L	0.003[3]

1 LOD = Limit of Detection by normal laboratory analytical testing
2 Maximum limit equal to the maximum measured (in Receptor Bore #1)
3 Maximum limit equal to the maximum measured (in Receptor Bore #2)

Nutrient	Unit	MAR Water (max)
Nitrate	mg/L	~0.2 – 0.5
Total Nitrogen	mg/L	0.1
Total Phosphorus	mg/L	0.04

The MAR limit for nitrate has been set at 0.2 mg/L, being the minimum nitrate level that can be effectively monitored real time by online instrumentation (see comments below in Section 3.2.2). The MAR target for Total Phosphorus has been set as a maximum level, based on the highest level measured in the two Receptor Bores.

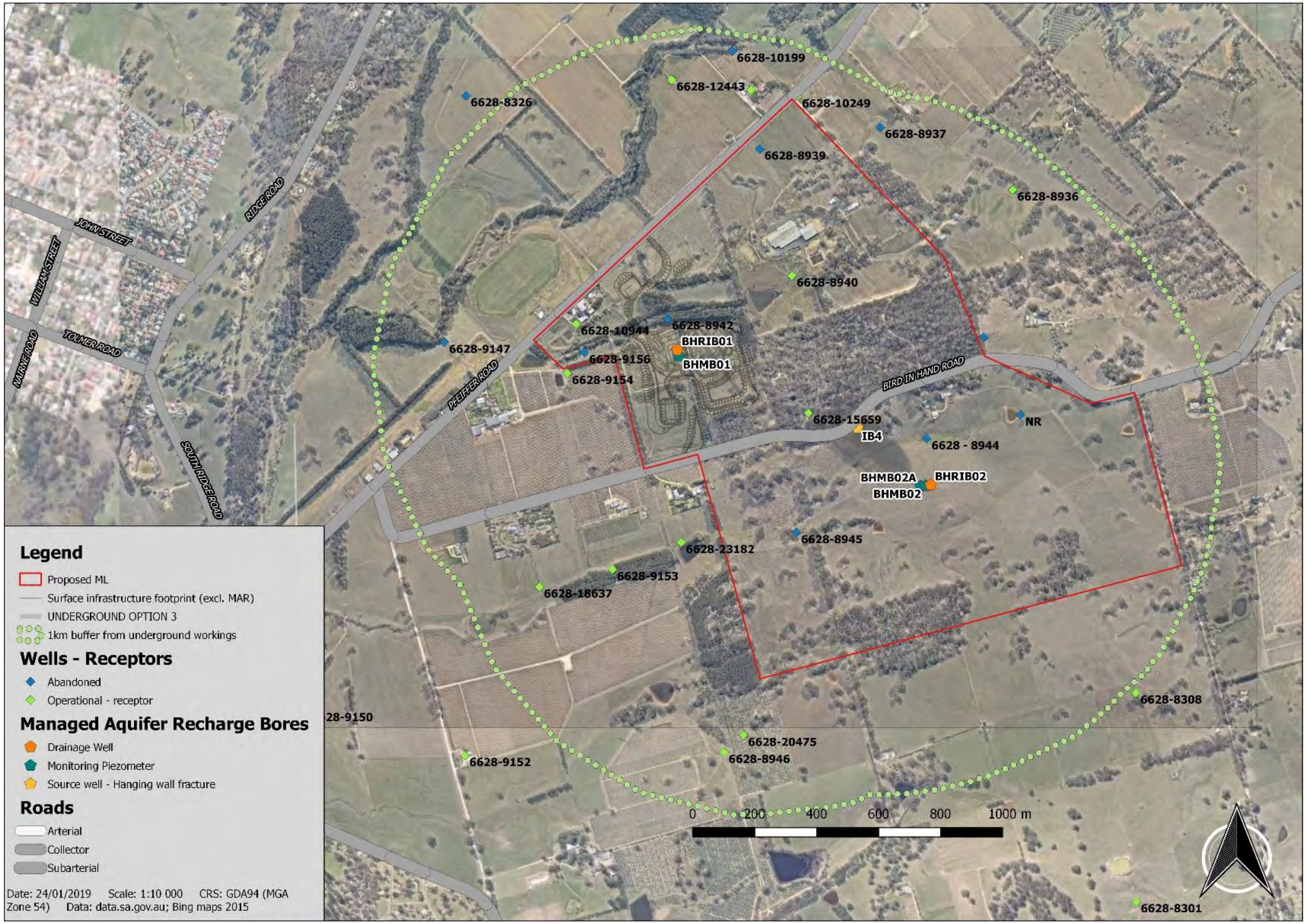


FIGURE 3-201 | OPERATIONAL AND ABANDONED WELLS

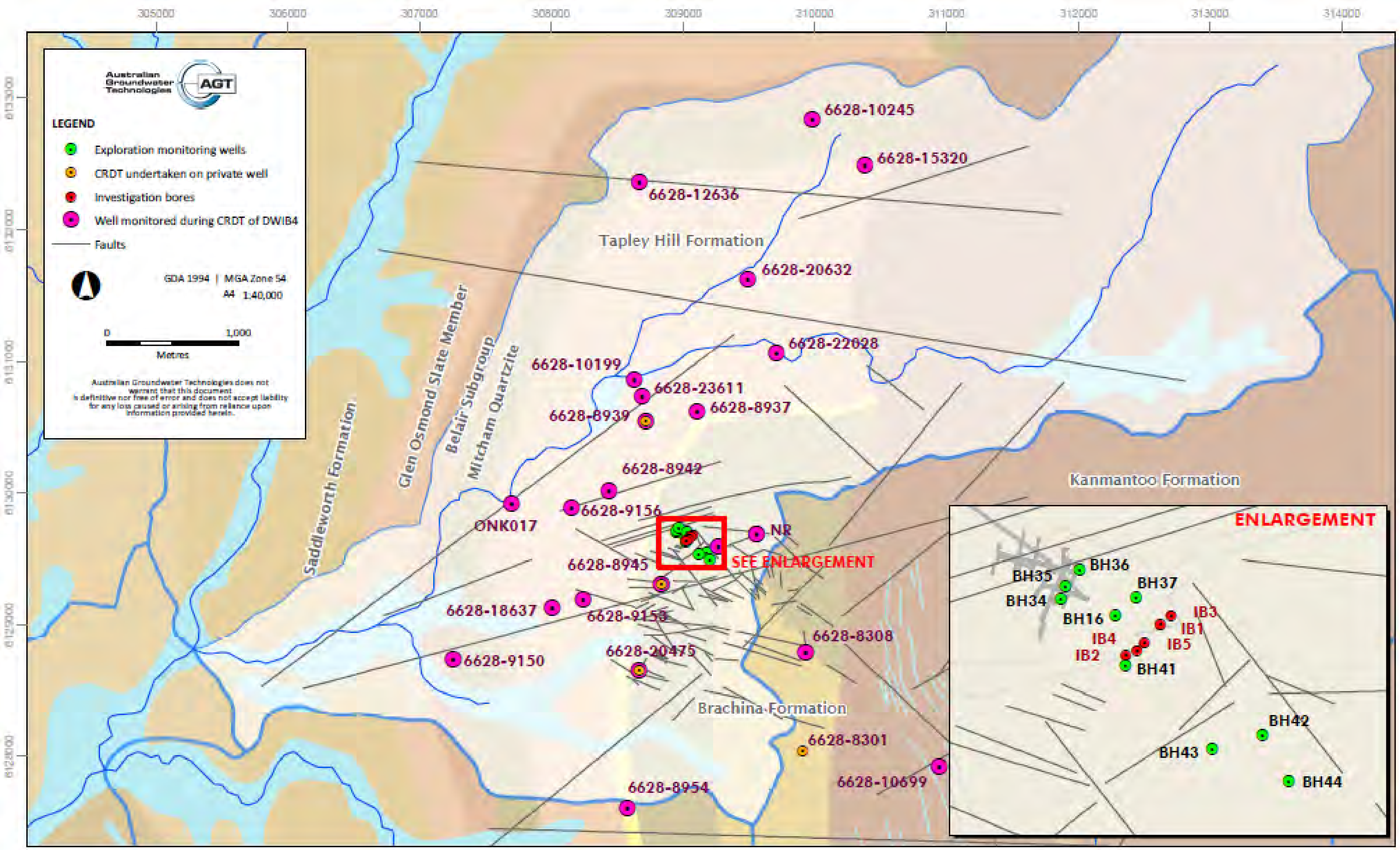


FIGURE 3-202 | WELLS MONITORED DURING THE PUMPING TEST AT IB4

TABLE 3-46 | COMPARISON OF SOURCE AND RECEPTORS – BASIC PARAMETERS

Unit Number	NAT East	NAT North	Aquifer	Date Sampled	pH Value	Electrical Conductivity	Total Dissolved Solids	Suspended Solids	Turbidity	Sulfate as SO4	Chloride	Calcium (Diss)	Magnesium (Diss)	Sodium (Diss)	Potassium (Diss)	Sodium Absorption Ratio
					pH Unit	µS/cm	mg/L	mg/L	NTU	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	
IB4 – source 6628-27445	309032.9	6129644	HW Fracture Zone Tarcowie Siltstone	1-Aug-17	7.72	1380	774		4.9	42	266	45	24	218	8	6.52
BIHRIB01	308451	6129895	Tapley Hill Formation	03-Oct-18	7.5	1620	1050	<5	18.2	66	388	67	38	200	9	4.84
BIHRIB02	309308	6129458		08-Oct-18	7.76	2230	1450	2	3.4	58	594	94	63	239	15	4.68
6628-8308	309930.9	6128789	Brachina	2-Mar-16	8.14	1390	819	<5	0.9	89	235	10	13	251	11	12.3
6628-20475	308664.7	6128652	Tarcowie Siltstone	15-Apr-16	7.45	2200	1200		64.7	41	547	78	51	282	11	
6628-8936	309533.1	6130412	Tarcowie Siltstone	12-Sep-14	7.61	1580	960	12	8.7	50	367	55	31	228	7	6.09
6628-8946	308601.5	6128597	Tarcowie Siltstone	16-Jul-15	7.98	2110	1140		86.1	43	505	62	43	234	10	
6628-8940	308821.2	6130135	Marble	26-Feb-16	7.2	1290	717		2	39	260	60	27	164	7	
6628-9153	308241.5	6129187	Tapley Hill Formation	2-Mar-16	7.93	1680	849		77.3	88	337	43	28	204	7	
6628-9154	308096.2	6129820	Tapley Hill Formation	7-Sep-16	7.8	1320	826		1.9	95	309	42	27	196	8	5.83
6628-18637	308005.3	6129131	Tapley Hill Formation	7-Sep-16	7.78	1240	761		4	116	271	46	30	170	7	----
6628-23182	308463.8	6129274	Tapley Hill Formation	7-Sep-16	7.13	960	582		2	28	231	40	25	116	6	----
6628-10249	308838.8	6130713	Tapley Hill Formation	3-Nov-16	7.47	2260	1510	<5	0.4	112	544	88	48	284	7	6.05
6628-9152	307764.9	6128587	Tapley Hill Formation	21-Jan-15	7.83	1420	845		1.8	123	270	47	32	195	8	
6628-23611	308689.6	6130734	Tapley Hill Formation	31-Mar-15	7.63	1940	1220		21.8	128	462	74	40	269	8	
6628-12443	308433.5	6130767	Tapley Hill Formation	2-Mar-16	7.11	1480	889	108	58.9	183	524	81	47	9	132	2.89
6628-10466	307769.1	6130716	Sturt Tillite	16-Jul-15	8.26	1130	631		3.7	100	224	32	26	116	10	

TABLE 3-47 | COMPARISON OF SOURCE AND RECEPTORS – METALS

Unit Number	Arsenic (Diss)	Cadmium (Diss)	Chromium (Diss)	Copper (Diss)	Lead (Diss)	Manganese (Diss)	Nickel (Diss)	Selenium (Diss)	Zinc (Diss)	Iron (Diss)	Arsenic (Total)	Cadmium (Total)	Chromium (Total)	Copper (Total)	Lead (Total)	Manganese (Total)	Nickel (Total)	Selenium (Total)	Zinc (Total)	Iron (Total)
	mg/L		mg/L	mg/L	mg/L	mg/L	mg/L		mg/L	mg/L	mg/L		mg/L	mg/L	mg/L	mg/L	mg/L		mg/L	mg/L
IB4 – source 6628-27445	<0.001		<0.001	<0.001	<0.001	0.128	<0.001		0.018	0.28	<0.001		<0.001	<0.001	0.002	0.135	<0.001		0.02	0.86
BIHRIB01	0.006		<0.001	<0.001	<0.001	0.192	0.002		0.066	1.24	0.007		<0.001	<0.001	<0.001	0.202	<0.001		0.04	1.43
BIHRIB02	0.002	0.0002		<0.001	<0.001	0.342			0.047	0.46	0.002	0.0001		<0.001	<0.001	0.359			0.049	0.5
6628-8308	0.009		<0.001	0.001	<0.001	0.103	0.003		0.005	0.12	0.009		<0.001	0.011	0.001	0.116	0.004		0.011	0.3
6628-20475	<0.001	<0.0001	<0.001	<0.001	<0.001	0.219	<0.001	<0.01	0.278		<0.001	<0.0001	<0.001	<0.001	<0.001	0.256		<0.01	0.345	2.75
6628-8936	0.009		<0.001	<0.001	<0.001	0.072	<0.001		0.009	0.73	0.01		<0.001	<0.001	<0.001	0.084	<0.001		0.009	0.73
6628-8946	<0.001	<0.0001	<0.001	<0.001	<0.001	0.149	0.002	<0.01	0.037		<0.001	0.0001	<0.001	0.02	0.004	0.168		<0.01	0.097	6.52
6628-8940											0.002	<0.0001	<0.001	0.01	0.001	0.047		<0.01	0.656	0.3
6628-9153	0.001	<0.0001	<0.001	<0.001	<0.001	0.112	<0.001	<0.01	0.013		0.011	<0.0001	<0.001	0.017	0.002	0.142		<0.01	0.022	7.11
6628-9154	<0.001	<0.0001		0.001	<0.001	0.055		<0.01	0.092	<0.05	0.001	<0.0001		0.006	0.004	0.052		<0.01	0.08	0.32
6628-18637	0.001	<0.0001		<0.001	<0.001	0.129		<0.01	0.009	1	0.002	<0.0001		0.002	<0.001	0.132		<0.01	0.012	1.49
6628-23182	<0.001	<0.0001		0.001	0.001	0.157		<0.01	0.014	0.08	0.002	<0.0001		<0.001	0.001	0.143		<0.01	0.006	0.85
6628-10249	0.001		<0.001	0.002	<0.001	0.001	0.002		1.1	<0.05	0.002		<0.001	0.002	<0.001	0.001	0.003		1.18	<0.05
6628-9152																				
6628-23611	0.002	<0.0001	<0.001	0.002	<0.001	0.111	0.002	<0.01	0.4		0.026	<0.0001	0.006	0.01	0.009	0.139		<0.01	0.535	4.11
6628-12443	<0.001		<0.001	0.003	<0.001		0.217		0.379		<0.001		<0.001	<0.001	<0.001		0.005		0.055	
6628-10466	<0.001	<0.0001	<0.001	0.001	<0.001	0.008	0.003	<0.01	0.036		<0.001	<0.0001	<0.001	0.002	<0.001	0.05		<0.01	0.07	0.06

TABLE 3-48 | COMPARISON OF SOURCE AND RECEPTORS – NUTRIENTS

Unit Number	Nitrite as N	Nitrate as N	Nitrite + Nitrate as N	TKN as N	Total Nitrogen as N	Total Phosphorus as P	Total Anions	Total Cations	Ionic Balance
	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	meq/L	meq/L	%
IB4 – source 6628-27445 (nutrient sample date – 4 Feb 2015)	<0.01	<0.01	<0.01	1	1	0.04	15.3	13.9	4.74
BIHRIB01	<0.01	<0.01	<0.01	<0.1	<0.1	0.07	17.8	15.4	7.38
BIHRIB02	0.02	0.8	0.82	<0.1	0.8	0.05	24.1	20.6	7.65
6628-8308			----	----		0.26	14.7	12.8	7.02
6628-20475	<0.01	<0.01	<0.01	0.1	0.1	0.04	23	20.6	5.37
6628-8936						0.1	17.1	15.4	5.22
6628-8946	<0.01	<0.01	<0.01	1.7	1.7	0.21	21	17.1	10.5
6628-8940	----	----	----	----	----	----	13.2	12.5	2.54
6628-9153	<0.01	<0.01	<0.01	<0.1	<0.1	0.27	16.7	13.5	10.5
6628-9154	<0.01	<0.01	<0.01	<0.1	<0.1	<0.01	16	13	10.1
6628-18637	<0.01	0.01	0.01	<0.1	<0.1	<0.01	14.9	12.3	9.4
6628-23182	<0.01	0.52	0.52	<0.1	0.5	0.09	11.2	9.25	9.77
6628-10249						0.06	24.2	20.9	7.4
6628-9152	<0.01	0.02	0.02	<0.1	<0.1	0.02	14.8	13.7	3.98
6628-23611	<0.01	0.02	0.02	1.3	1.3	0.22	21.3	18.9	5.99
6628-12443	0.02	1.48	1.5	4.2	5.7				
6628-10466	<0.01	<0.01	<0.01	0.8	0.8	0.15	11	9.04	9.79

3.7.10 *Rehabilitation Strategies and Timing*

Further details regarding the proposed closure strategies for the BIH site are described in section 3.10. Below give a brief outline for the supporting surface infrastructure. Table 3-30 includes activities to be undertaken onsite on a year by year basis.

3.7.13.1 *ACCESS*

The new access to the site, including the car parking area and the creek crossing will be left in place post mining operations as it will proved a suitable access to a wide range of potential future land uses, whether private, public, or commercial.

3.7.13.2 ACCOMMODATION AND OFFICES

The offices are considered a valuable asset for various potential land uses post mining operations and the current proposal is for them to remain in place for future use. Due to the modular nature of the types of buildings being considered, it could be possible for them to be removed, if the new land owner had no use for them.

3.7.13.3 WORKSHOP

The workshop will remain in place for future land use.

3.7.13.4 PUBLIC SERVICES AND UTILITIES

Upgraded connections to public services and utilities (power, water, sewage etc.) will remain in post mining operations.

3.7.13.5 VISUAL SCREENING

The majority of the visual screening development on site will remain in place post mining operations. This includes the revegetated areas and the visual amenity bunding constructed on site.

- Bunding that will be adjusted post mining include the top soil storage bund – this will be spread over any areas post final rehabilitation ready for revegetation
- ROM area – the ROM system will be removed post mining operations and the area landscaped to sustainable slopes and batters (Table 3-49), covered in top soil and revegetated.

Table 3-49 | Summary of closure strategies for surface bunds (Appendix L5)

Bund (name)	Recommendations for closure plans
Northern topsoil bund	Remain as vegetated mound
Car park	Mulching and vegetation managed by new owners
Southern bund extension	Remain as vegetated mound
Water storage dam	Remain as vegetated and contoured slope. Minimal maintenance will be optional for new owners
Eastern screening bund	Height to be reduced by 1.5 m, with same length, contouring and dense shrub cover.
Hillside screening bund	Remain as vegetated and contoured slope. Minimal maintenance will be optional for new owners.
Stormwater bund	Mulching up kept by new owners
Central bund	Retaining walls and vegetation will remain

3.7.13.6 FUEL AND CHEMICAL STORAGE

Unless agreements are made with the purchaser of the property, the fuel and chemical storage facilities will be emptied and removed from site. It is possible, with the workshop remaining, that some chemical and fuel storage facilities and infrastructure would remain, or would be upgraded by the new owners.

3.7.13.7 SITE SECURITY

Site security – fencing, CCTV etc., will remain in place post mining operations.

3.7.13.8 STORMWATER, SILT CONTROL AND DRAINAGE

The storm water infrastructure on site will remain to handle any future run off from the hardstand, workshop and offices areas. The water storage dam will be left in place.

3.7.13.9 WATER MANAGEMENT

The water treatment plant and the MAR system will be de-commissioned and removed once mining is completed. An agreement may be made to the purchaser of the property to leave any of this infrastructure in place for future operations, but this will be dependent upon agreement from DEM via the closure planning process.

3.8 MODES AND HOURS OF OPERATION

During establishment and construction, the site will be operated day time only, Monday to Saturday. Once the site has been constructed with bunding and aspect mitigating the impact of the Project on the surrounding sensitive receivers the site will go to continuous operation – 24 hours per day, 7 days a week, 365 days of the year. In conjunction with other mitigation practices (i.e. site design) some activities during the operational period, have been restricted to minimise potential impacts on sensitive receptors, near neighbours, and traffic interactions on haulage routes during busy periods.

Mine life phases are construction, underground development, production and closure.

Modes and hours of operation for construction and production were developed in conjunction with the Noise Impact Assessment (Appendix O3). Unlike other surrounding businesses and properties, Terramin have committed to implementing a noise limit for construction, and have based this on the Rural Industry, of where the project is zoned by the Adelaide Hills Council. Other surrounding businesses and properties do not have any construction limits in regards to noise.

Terramin set the objective of designing an operating project (development and production) which blends into the acoustic surrounds of the area, and which is at least 10 d(B)A lower than the legislated *Environment Protection (Noise) Policy 2007* (the Noise EPP), making the proposed limits align with Rural Living, as opposed to Rural Industry, which is where the Project is actually zoned.

More information on Noise is located in Chapter 16 and the Noise Impact Assessment is located in Appendix O3.

3.8.1 Daytime only

3.8.1.1 CONSTRUCTION ACTIVITIES

Construction activities will occur during daytime periods from Monday to Saturday. This will typically include a pre-start meeting onsite at 6am, and then construction of required site infrastructure of the day. All construction activities would be constricted by the outcome and draft measurable criteria, which is proposed as 57d(B)A for daytime. Construction activities (excluding pre-start meetings) will be planned to be between 7am and 7pm, as prescribed by the Noise EPP. If there are any activities which may fall outside this window, consent will be applied for and EPA procedures followed.

Surface construction is estimated to take approximately one year, and includes the construction of:

- access roads and culvert over the riparian zone;
- Site earthworks (site preparations and foundations, landscaped amenity bunding, IML excavation)
- Boxcut and decline
- Workshop, offices and changeroom/staff facilities (ablutions)
- Cement batching and water treatment plants

Typical tradespeople onsite through construction will include project managers, civil earthworks machiney operators, builders (infrastructure installers), concreters, roofers, electricians, plumbers, as well as mining professionals and mining operators once the decline construction commences.

Blasting utilised for site preparation (surface blasts) and well as early stages of decline development has proposed a draft measurement criteria of *All blast times and charge weights will be recorded in a register to demonstrate all construction blasting exceeding [XXX] kg*[6] *charge weight will only be conducted between 10am and 6pm*. This charge weight is proposed to be calculated as part of the final construction design specifications, however would need to comply with AS2187.2.2006 *Use of explosives*. These times have been chosen to reflect times where residents are less likely to be home.

All other blasting would need to comply with AS2187.2.2006 *Use of explosives*, specifically the air overpressure and vibration requirements.

Detailed information regarding blasting and impacts on receptors is located in Chapter 17: Air overpressure and Vibration and in the Blasting Impact Assessment located in Appendix P1.

3.8.1.2 OPERATIONAL ACTIVITIES

- Office hours will be Monday – Friday 8am-5pm
- Where possible, site deliveries, heavy maintenance work and potentially "noisy" activities schedule during day time periods, noting that some activities will be unplanned and may fall outside ideal times, i.e. in the case of emergencies.
- Blasting activities through production – mining blasts are proposed to occur during daytime periods – generally at the end of a shift (6-7am/6-7pm).
- Haulage times between APF and the Project are proposed daily between 9am and 10pm, with exclusions of:
  - 6am – 9am Monday – Friday (commuter and school);

[6] Maximum allowable weight to be proposed and approved through the PEPR development

- 3pm – 4:30pm Monday – Friday (School); and
- 10pm – 6am (overnight).

3.8.2 Night time activities (10pm – 7am)

- Limited vehicle movements, lighter maintenance activities and other potentially noisy activities will be restricted during night time periods (10pm – 7am).

3.8.3 24 Hour/7 day per week activities

Once the site is operational, the following activities will be occurring:

- Underground mining including ventilation system;
- Transport of material from the UG mine to either the IML and/or the ROM silo;
- Backfilling and ground support operations;
- Water treatment and MAR system;
- Maintenance activities; and
- Environmental monitoring.

3.9 VEGETATION CLEARANCE

The surface design requires no clearance of existing native vegetation as defined by the *Native Vegetation Act 1991* (SA). All proposed surface infrastructre has been designed to avoid and preserve significant River Red Gums (*Eucalyptus camaldulensis*) located within the Goldwyn property. The location of these trees is illustrated in Figure 3-203. A companion planting and fencing initiative has been commenced around lone River Red Gums to help preserve the trees, provide further habitat for native fauna and promote improved health by reducing erosion and grazing pressure.

The site contains agroforestry trees located alongside the primary drainage line located within the proposed site, as well as along primary fencelines. These trees were planted in 1992 and have undergone a natural thinning process. 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, the proposed locations of which are shown in Figure 3-203. 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, is shown on Figure 3-203 as 1 & 2. This represents a small proportion of the existing 5.4ha of forrestry plantings. The agroforestry trees to be cleared are of poor health, often blowing over in strong winds and provide little in hollow habitat or in terms of food sources for nectarivorous or seed eating fauna.

The likelihood of the presence of threatened flora in these areas is very low to rare. The property has had unfettered access and was grazed by cattle and horses in both of these areas for decades prior to Terramin aquiring the property in 2015. There is an evident grazing line on all shrubbery and trees and all groundcover is limited to predominently pasture grasses (*Phalaris sp*) and introduced weeds, including thistles and cleavers. More information on the weeds present onsite has been included in Chapter 2 and Chapter 19. Again companion planting of native groundcovers has been undertaken in riparian zones and grazing exluded to improve ecosystem health.

FIGURE 3-203 | PROPOSED AGROFORESTRY CLEARANCE

3.10 DESCRIPTION OF MINE SITE AT COMPLETION

Terramin engaged landscape architects Oxigen Pty Ltd (Oxigen) to provide technical landscape architectural input into the BIHGP Mine Closure Plan and is included in Appendix X1.

The Mine Closure Plan provides details of the proposed land form and remaining site infrastructure following completion of mining activities. The landscape component of the plan considers the existing site and land form, the proposed operational mining phase and the proposed mine closure following the cessation of mining activity. Table 3-30 includes activities to be undertaken onsite on a year by year basis, including closure.

It is the intention of Terramin that the Goldwyn property is 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 the regulators at the completion of mining. This section describes the Project site at the time of completion. As part of the completion plan a range of site infrastructure elements are proposed to be retained due to their values to potential future landowners.

Owing to the small size of the site, opportunities for progressive rehaiblitation are limited. The landscaped amenity bunds created during construction will be vegetated as soon as is practical, as will disturbed areas not required for mining. This vegetation will remain throughout operations and closure.

Rehabilitation of exploration sites has been detailed above in section 3.3.7.The only land to be disturbed which is not within Goldwyn is the MAR pipeline and bore system. All land disturbed by the MAR pipelines and MAR bores will decommissioned and removed, and reseeded in consultation with the appropriate landowner. Consultation with stakeholders has been undertaken as part of the preparation of this Mining Lease Proposal to ensure that the views and concerns of these groups are considered as early as possible in the mine closure planning process. There is a general consensus within the WCCC that the Mine Closure Plan should be reviewed in the 12 months leading up to mine closure to ensure that the mine's PEPR still reflects the requests and requirements of the community, and to allow unforeseen opportunities to be taken advantage of by the community at that point in time. Pending this, Terramin expect to complete all on ground rehabilitation activities outlined below within 12 months of announcement of closure. Table 3-30 includes activities to be undertaken onsite on a year by year basis including closure.

If lease conditions have been met under the requirements of an approved Mine Closure Plan (submitted as part of the PEPR), there would be no residual liability subsequent to surrender of the tenement, however this would be reviewed prior to the sale of the land, with the intention the landholder would assume liability for the site upon purchase.

3.10.1 POTENTIAL LAND USE OPTIONS

Terramin's property is located within the Adelaide Hills Council (AHC) local government area and is within the Adelaide Hills Council Development Plan's 'Onkaparinga Valley Policy Area'. The land is zoned Watershed (Primary Production).

The zone's objectives and principles of development control aim to prevent development that may lead to deterioration in the quality of surface or underground water within the Mount Lofty Ranges Watershed, and also to maintain land in primary production.

Complying land uses also include agriculture, agricultural industry, forestry, farming, dairy and horticulture.

The development proposed for the Project site includes features and infrastructure that has potential for many uses after mining is complete. These options include:

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

In discussions with neighbouring businesses and in acknowledgement of developments in the agricultural/horticultural industry moving towards state of the art glasshouse fruit and vegetable production, it is recognised that the operational areas that will have been established for the Project would suit numerous post mine options. The reformed area would suit the construction of intense primary production or secondary 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 will 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. The proposed area is shown on Figure 3-208.

3.10.2 Landforms

The landforms existing during operations will remain in place at mine completion with the exception of the following:

- Integrated Mullock Landform (IML);
- Run Of Mine (ROM) facilities;
- Eastern bund; and
- Mine entrances.

It is planned that the IML will have all of the mullock removed and placed back underground as part of the underground closure plan. The peak volume for this storage area is during the second year of mining, just as backfilling commences underground, and the decline to reach the orebody is completed. From that point until the mine completion, the quantity of material stored on the IML reduces each year. Calculations for this have been undertaken on the assumption that all mullock material will be brought to surface for temporary storage, rather than keeping it underground were possible to minimise handling and transport requirements.

The base area of the IML will be left in a condition such that it is available as a hardstand area for potential future commercial use (e.g. green houses, shedding and other building subject to approval).

The figures below (Figure 3-204, Figure 3-205, Figure 3-206 and Figure 3-207) show the cross sections through the IML area indicating the re-shaping and rehabilitation as outlined in the sections above.

The ROM facility will have all ore handling infrastructure removed (silo, conveyor, hoppers etc.) and the landform around this area will be re modelled into a permanent, stable landform, covered with top soil and suitable vegetation.

The eastern bund will be re-formed along with the eastern side of the IML to form a long term stable landform, vegetation will be re-instated to assist with soil stabilisation.

All entrances to the mine will be sealed off from entry. For the purpose of the mine closure plan the objective of creating a safe and stable landform is pursued. In doing so it is proposed that the mine portal will be filled in to prevent possibility of surface subsidence and to allow the full hardstand area to be utilised for any future requirement. Once filled, it will be landscaped to stabilise soil erosion and surfaced with appropriate material for its use as a hardstand.

Post mine completion, risks to the safety of the public from loss of stability in the surface landforms will be such that they are as low as reasonably practicable.

Should there be interest from outside parties in mine infrastructure at the time of mine closure, other possible uses for these areas could be considered. Further details will be provided in the Mine Closure Plan at the time the PEPR is submitted, as well as reviewed prior to mine closure commencing.

FIGURE 3-204 | PLAN VIEW SHOWING THE LOCATION OF SECTION A-A (FIGURE TAKEN FROM APPENDIX X1)

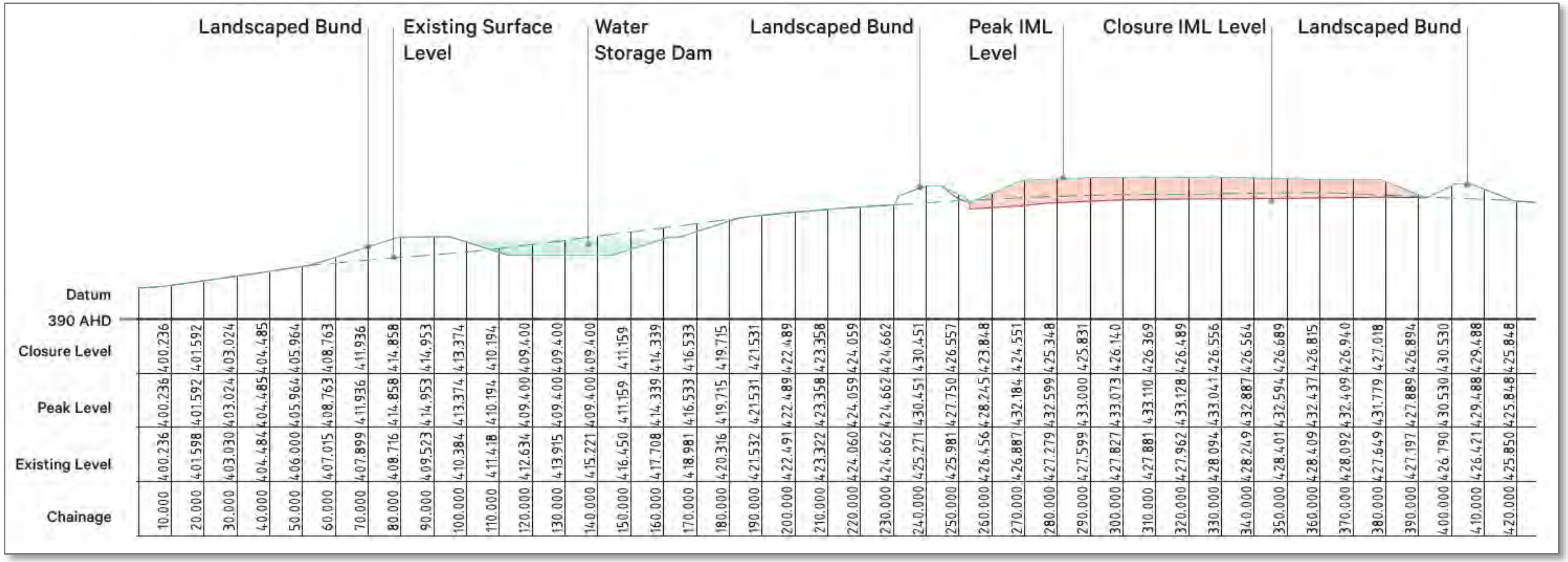


FIGURE 3-205 | SECTION A-A LOOKING NORTH THROUGH THE IML, BUNDING AND SURFACE WATER DAM. SHOWING EXISTING SURFACE, OPERATION SURFACE AND CLOSURE SURFACE (FIGURE TAKEN FROM APPENDIX X1)

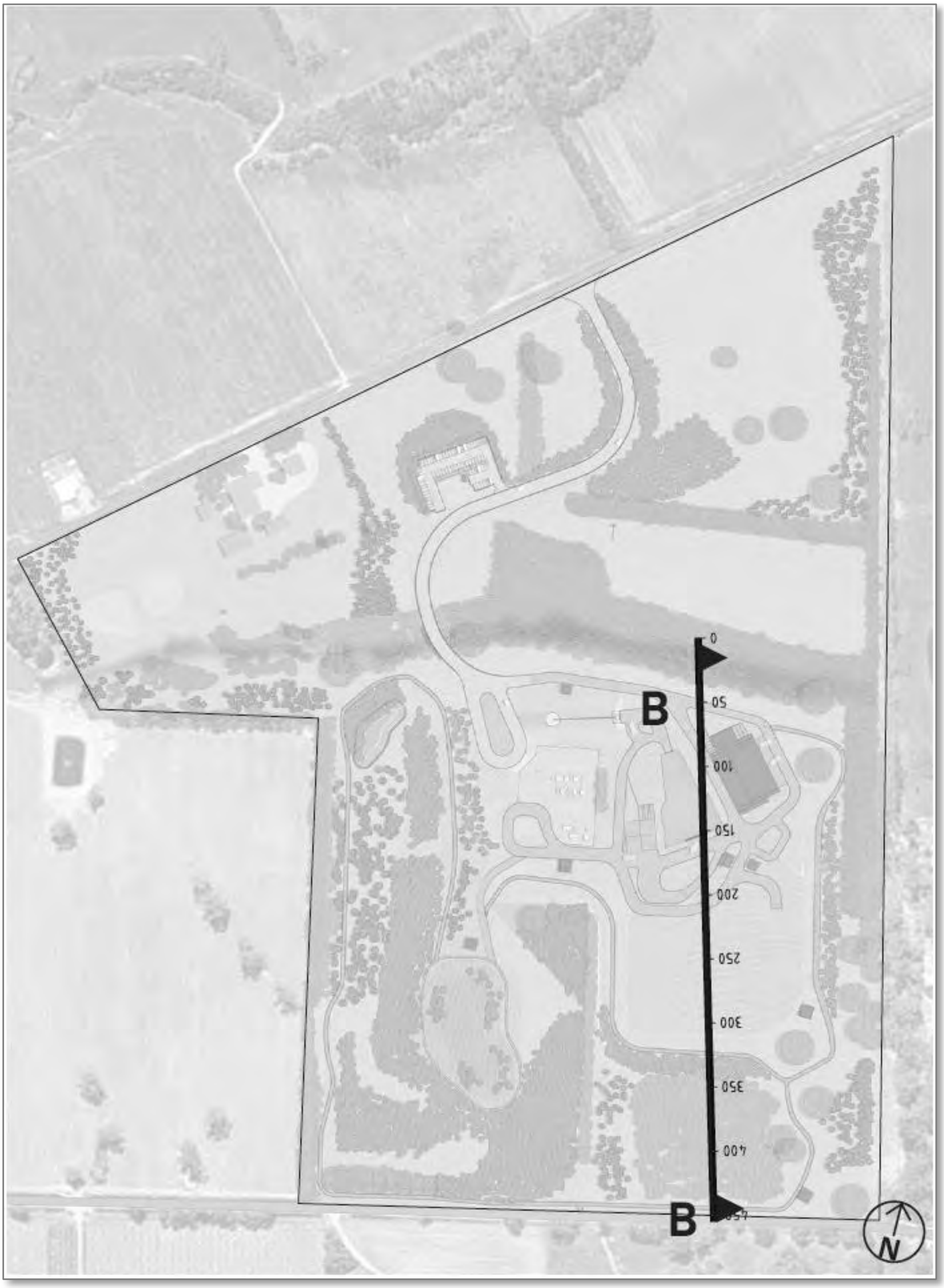


FIGURE 3-206 | PLAN VIEW SHOWING THE LOCATION OF SECTION B-B (FIGURE TAKEN FROM APPENDIX X1)

Chainage	Existing Level	Peak Level	Closure Level
0.000	401.845	401.845	401.845
10.000	401.552	401.702	401.702
20.000	403.760	403.728	403.728
30.000	404.999	404.751	404.751
40.000	406.525	406.573	406.573
50.000	407.847	407.581	407.581
60.000	409.193	407.999	407.999
70.000	410.485	408.914	408.914
80.000	411.594	410.028	410.028
90.000	412.519	411.453	411.453
100.000	413.328	412.876	412.876
110.000	414.147	414.024	414.024
120.000	414.920	414.682	414.682
130.000	415.767	414.644	414.644
140.000	416.543	414.569	414.569
150.000	417.275	414.418	414.418
160.000	418.129	414.896	414.896
170.000	419.019	415.524	415.524
180.000	419.907	416.147	416.147
190.000	420.810	416.761	416.761
200.000	421.749	417.388	417.388
210.000	422.643	417.840	417.840
220.000	423.477	419.354	418.484
230.000	424.290	423.103	419.372
240.000	425.195	425.754	422.667
250.000	426.084	429.546	423.904
260.000	426.872	431.672	424.978
270.000	427.677	432.746	426.046
280.000	428.328	433.825	427.113
290.000	428.993	434.905	428.181
300.000	429.721	433.811	428.810
310.000	430.492	430.818	429.210
320.000	431.212	435.847	435.695
330.000	431.942	434.871	434.871
340.000	432.575	432.577	432.577
350.000	432.611	432.441	432.441
360.000	432.311	432.272	432.272
370.000	432.073	432.072	432.072
380.000	431.933	431.928	431.928
390.000	432.032	432.032	432.032
400.000	432.259	432.259	432.259
410.000	432.340	432.237	432.237
420.000	432.397	432.389	432.389
430.000	432.602	432.606	432.606
440.000	432.713	432.708	432.708

FIGURE 3-207 | SECTION B-B LOOKING EAST THROUGH THE IML SHOWING EXISTING SURFACE, OPERATION SURFACE AND CLOSURE SURFACE (FIGURE TAKEN FROM APPENDIX X1)

3.10.3 Proposed vegetation covers

In planning for the closure of the Project, topsoil is harvested and stockpiled for reuse on site to provide a growing medium for landscape bunds and revegetation works. Topsoil can be ameliorated to improve nutrient content and water holding capacity with organic compost and gypsum following further site specific soil testing prior to entering closure.

Much of the revegetation and land rehabilitation will be undertaken during the construction and operational phase of the project, and will remain in place. Once operations have ceased, and the infrastructure not considered beneficial to future owners is removed, topsoil spread over re-formed areas and final revegetation coverage will be completed.

Vegetation will be managed throughout operations and on-going weed and pest control continued as per the Biodiversity Management Plan (Appendix R6), until self-sustaining systems are established. It is acknowledged that irrigation of native species is not ideal for long term root establishment. In order to assist in the establishment in the early year’s irrigation may be required. Irrigation will be sourced from the Project water allowance if necessary.

FIGURE 3-208 | REHABILITATION AND BIODIVERSITY PLAN (FIGURE TAKEN FROM APPENDIX X1)

FIGURE 3-209 | PROPOSED MINE CLOSURE VEGETATION (FIGURE TAKEN FROM APPENDIX X1)

This plan for revegetation aligns with the drafted outcomes for the project.

- Adelaide Hills Council Biodiversity Strategy 2013 (Adelaide Hills Council, 2013)
- No permanent loss of abundance or diversity of native vegetation 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 the *Native Vegetation Act 1991 and Native Vegetation* Regulations 2017 is obtained.

- 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 on the mining lease.

3.10.4 NATURAL CONTOURS NOT DISTURBED

The proposed Project sits predominantly within the company's property Goldwyn. Outside the Goldwyn property there is no proposed earth works or reshaping of contours. A system of bore holes and associated pipes and control lines are planned however no reshaping of land will be required outside of Goldwyn. Landscaping on Goldwyn has been planned to minimise the surface disturbance and considers the natural contours as part of the redesign and stormwater management.

The images below illustrate the regions that will not have their original contours disturbed.

The main areas left undisturbed include:

- The remnant endemic vegetation area to the SE of the Goldwyn property;
- The region to the east of the Heritage listed Chimney;
- Large section of the upper NE corner paddock; and
- Areas to the West and south of the existing farm house and shed.

The series of figures below (Figure 3-210, Figure 3-211 and Figure 3-212) show the landform at the three stages, existing, during operations and after closure.

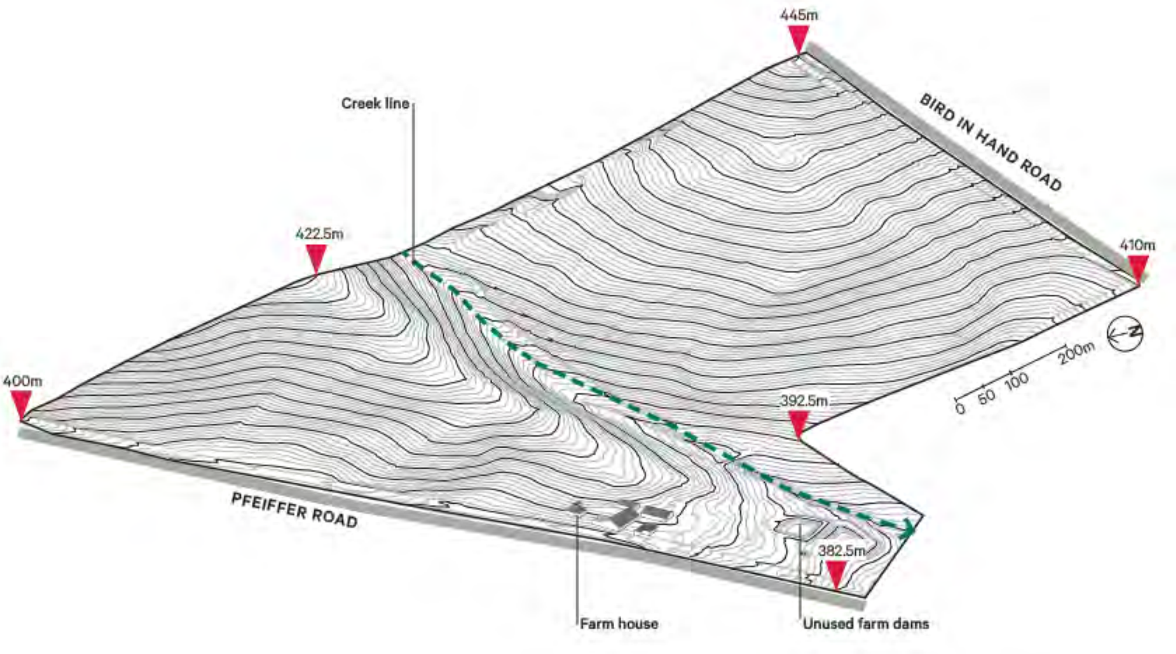


FIGURE 3-210 | EXISTING LANDFORM (FIGURE TAKEN FROM APPENDIX X1)

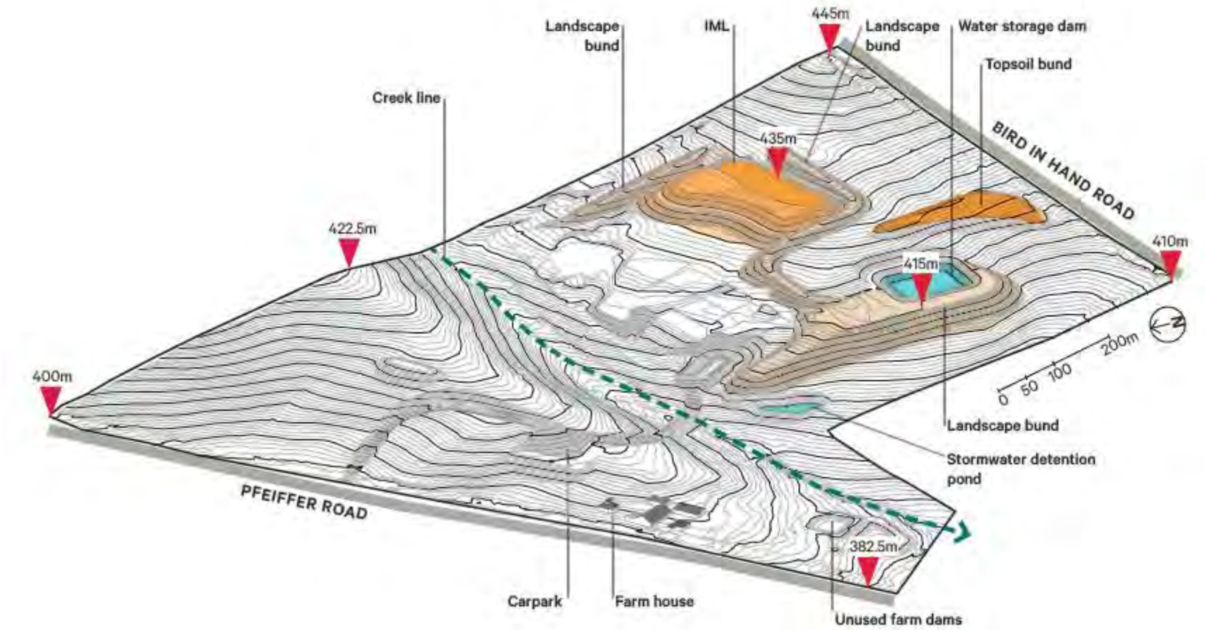


FIGURE 3-211 | OPERATIONS LANDFORM (PEAK IML FOOTPRINT) (FIGURE TAKEN FROM APPENDIX X1)

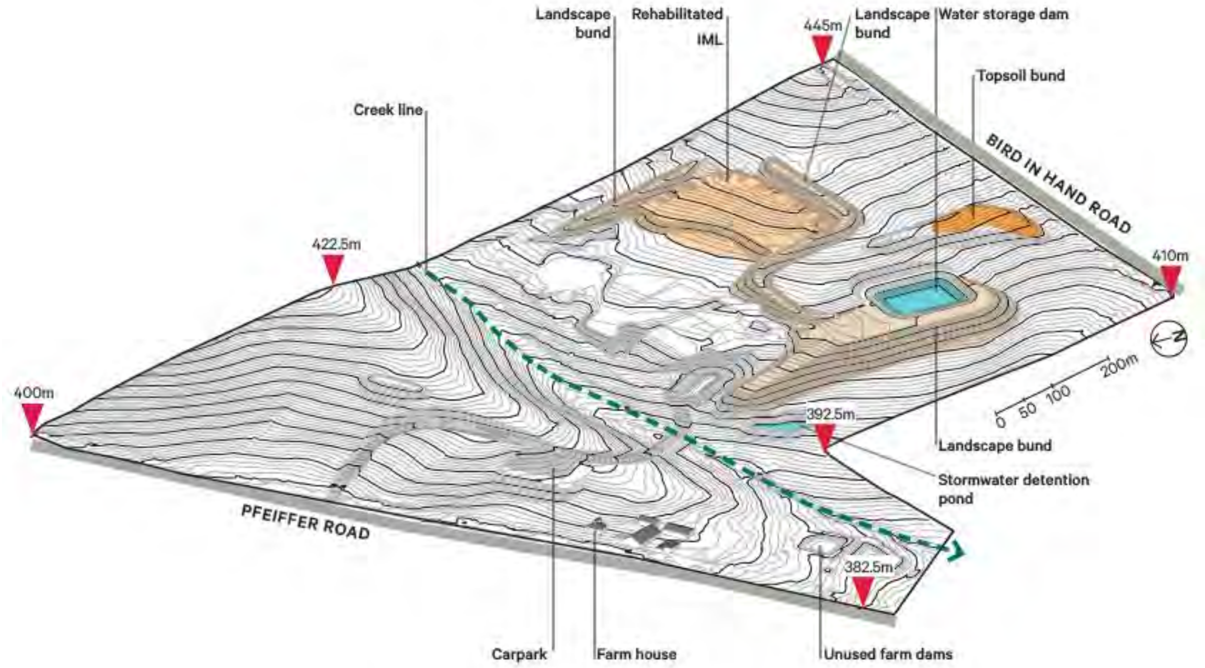


FIGURE 3-212 | CLOSURE LANDFORM (FIGURE TAKEN FROM APPENDIX X1)

3.10.5 Remaining mining infrastructure

All plant and equipment (unless otherwise agreed with the Chief Inspector of Mines) will be removed from the site.

Infrastructure, having potential commercial value to the next land user that is planned to remain on site includes (Figure 3-213, Figure 3-214 and Figure 3-215):

- Access road and carpark;
- Creek crossing;
- Offices and workshop;
- Laydown area;
- IML (Remodelled as a hard stand area);
- Water treatment area (remodelled as a hardstand area);
- Surface water dam (and associated pump house);
- Access road to offices and workshop;
- Original farm buildings (including any upgrades into training/admin centres);
- Potable water supply, sewage and power connection;
- Gas storage and associated connection can be retained if purchases required (will supply hot water to offices); and
- Former structure pads will be retained as hardstand areas.

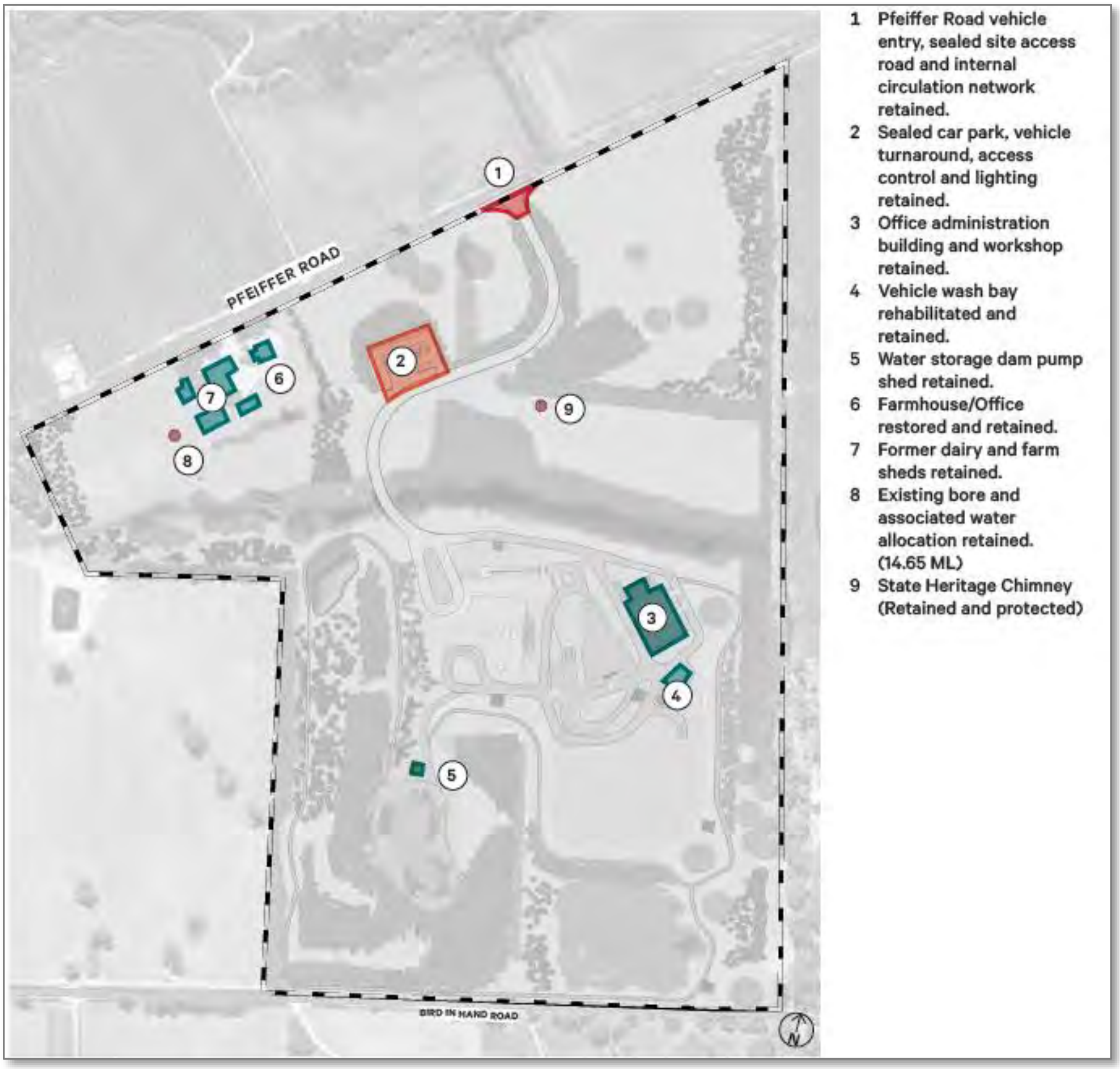


FIGURE 3-213 | BUILDINGS AND STRUCTURES TO REMAIN AT MINE COMPLETION (APPENDIX X1)

FIGURE 3-214 | INFRASTRUCTURE AND HARDSTAND REMAINING AT MINE COMPLETION (APPENDIX X1)

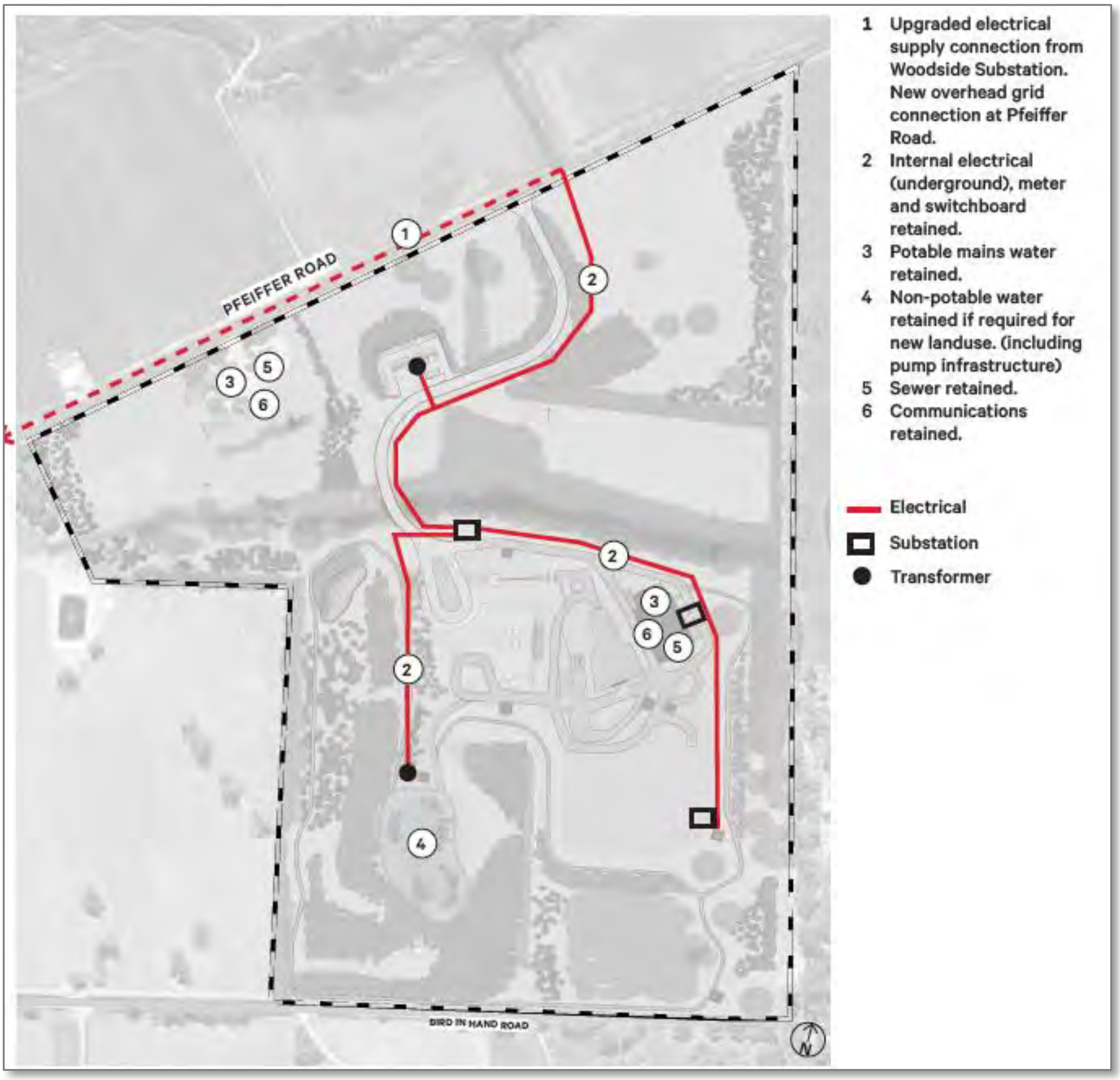


FIGURE 3-215 | SITE SERVICES REMAINING AT MINE COMPLETION (APPENDIX X1)

3.10.6 WASTE DISPOSAL AREAS AND SITE CONTAMINATION

All waste produced on site will be managed in accordance with the EPA waste hierarchy. The disposal areas, including the IML (mullock and water treatment solids recovery), will be confined during operations and audited for contamination at the end of operations. Provision of a report prior to entering closure monitoring phase by a suitably qualified site contamination consultant verifies that a site contamination assessment and if required remediation in accordance with the *National Environmental Protection (Assessment of Site Contamination) Measure 1999* (NEPM) and relevant EPA legislation/guidelines has occurred, ensuring there is no unacceptable risk to human health or the environment as a result of the contamination when compared with relevant baseline concentrations and relevant NEPM investigation levels. All mine by-products will be placed back underground in the backfilling of the required mine voids as part of the mine completion process.

All other waste material will be disposed of according to the site's waste management plan, and either removed for recycling, or transported to a suitable, licences facility to safely dispose of the material. The aim of the management plan is to manage the waste on site, such that it is kept to a minimum at all times throughout the operation.

No contamination of natural water drainage systems, streams and rivers, groundwater, land and soils will occur either on or off site resulting from permanent disposal or temporary storage of mine ore or mullock material.

This will be confirmed during the closure stage through the provision of a report once prior to entering closure monitoring phase. The report will be undertaken by a suitably qualified site contamination consultant to verify that a site contamination assessment and if required remediation in accordance with the NEPM and relevant EPA guidelines for the site has occurred. The focus is to confirm that for closure there is no unacceptable risk to human health or the environment as a result of contamination by the Project when compared with relevant baseline concentrations and relevant NEPM investigation levels.

3.10.7 Mine Voids

A geotechnical assessment of the mine, it's voids and backfill material placed throughout the operation will be undertaken as part of the detailed planning for Mine Closure through the PEPR development stage to ensure that the required zones of the mine (and their potential impacts on the surface) will not damage any third party infrastructure nor cause injuries/ deaths resulting from collapse of the underground workings.

Basing the initial conceptual plans (Figure 3-216, Figure 3-217) on the requirements for the closure of the Angas Zinc Mine the following will occur:

- All shafts (ventilation and escape way) will be filled, plugged and sealed;
- The mine portal will be plugged and sealed; and
- Ore drives and underground excavations will be backfilled as required to manage all possibilities of subsidence (and other potential impacts) occurring to receptors (Figure 3-56 and Figure 3-57).

Existing mine voids of the original mine workings, will be left unchanged, and there is no intention at this stage to excavate into these areas.

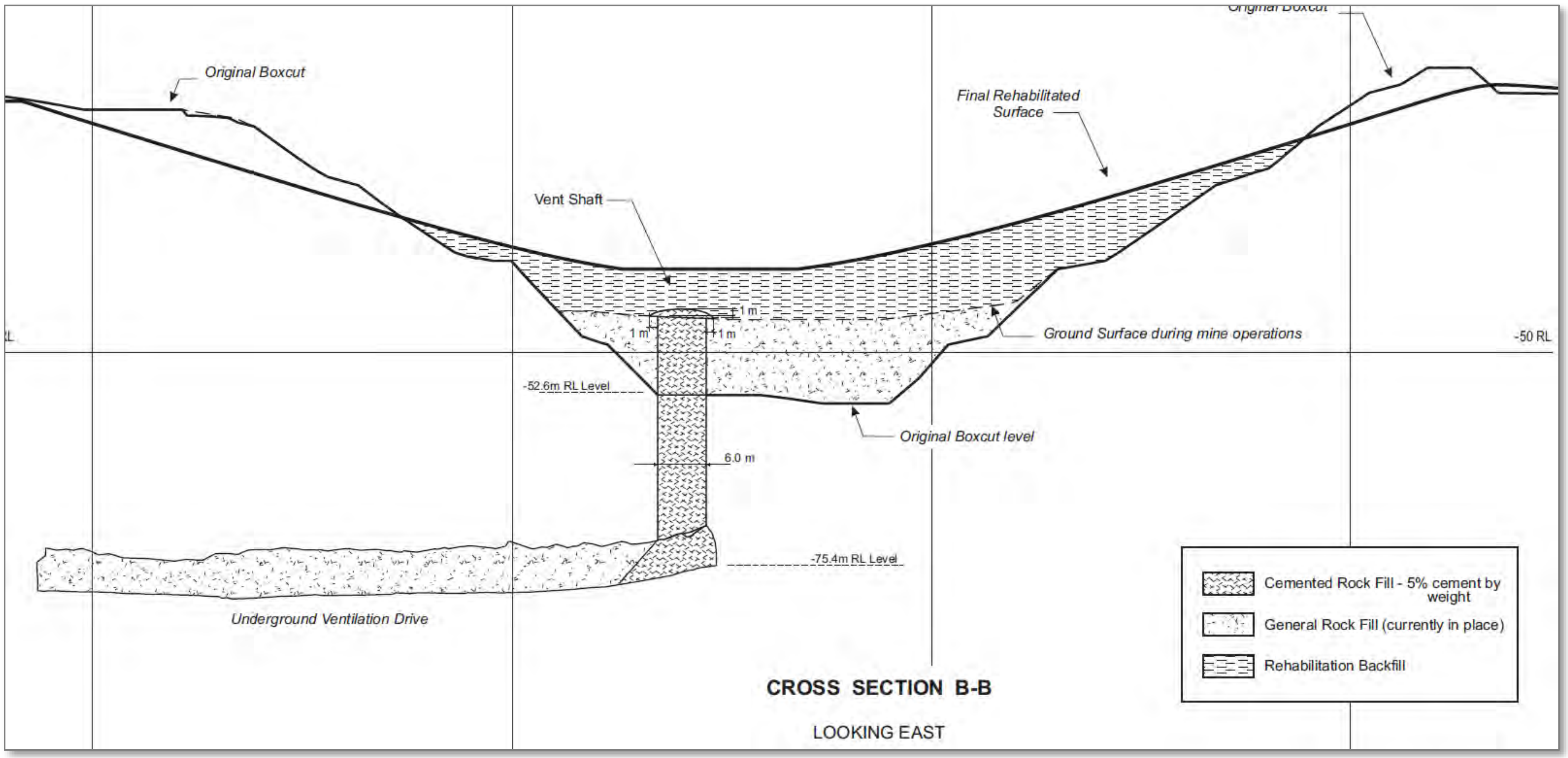


FIGURE 3-216 | A SIMILAR SYSTEM TO THAT APPROVED AS PART OF THE CLOSURE PLAN STRATEGY FOR THE ANGAS ZINC MINE FOR BACKFILLING OF THE VENTILATION RAISE WILL BE USED AT BIH FOR THE RAISES AT THAT SITE (TERRAMIN AUSTRALIA, 2017)

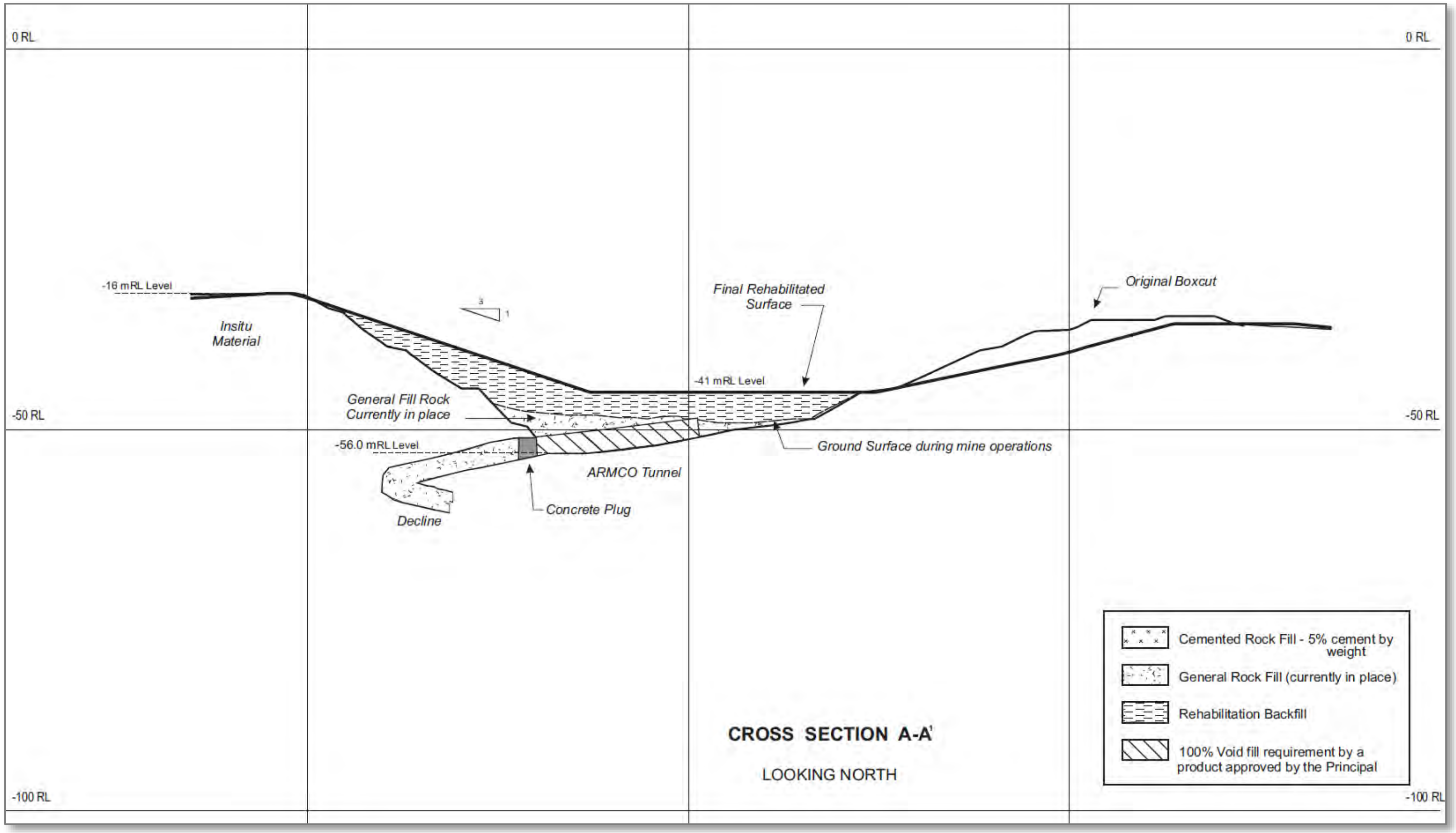


FIGURE 3-217 | A SIMILAR SYSTEM TO THAT PROPOSED AND APPROVED IN THE CLOSURE PLAN FOR THE BACKFILLING OF THE ANGAS ZINC MINE PORTAL AND UPPER DECLINE WILL BE USED AT BIH MINE (TERRAMIN AUSTRALIA, 2017)

3.10.8 LOCATION OF STORED/EXPOSED HAZARDOUS MATERIAL

The keeping, handling, conveying, using or disposing of a dangerous substance, or in transporting dangerous goods is controlled in South Australia by the Dangerous Substances Act 1979 (SA) and associated Regulations. All businesses must ensure that the use, storage and disposal of such materials must be undertaken to avoid endangering the health and safety of any person and prevent the risk of environmental harm. All hazardous materials will be assessed for their suitability for use and approved prior to being brought to site. The use and stored of hazardous materials will be undertaken in accordance with the recommendations of SafeWork SA and the specific MSDS. All hazardous material brought onto site for the project will be removed according to the relevant hazardous materials legislation and guidelines, Australian Standards and site polices. Any hazardous material required on site once the mine is closed, i.e. for ongoing land management requirements (i.e. weed control etc.) or the future infrastructure use (gas supply for ongoing office hot water) etc., will be stored in compliance with the law and existing PEPR requirements until the ML is relinquished. Upon relinquishment of the ML, all hazardous chemicals will be removed in accordance with PEPR requirements.

3.10.9 EXPECTED FINAL WATER LEVELS

Extensive hydrology investigation has been undertaken to understand the existing surface and groundwater systems and interaction with the Project (refer to Chapter 10). Water modelling has been undertaken to provide a tool to predict the effect on groundwater flows and levels as a result of mining. In undertaking this work the current impacts associated with seasonal variations in water harvest and recharge are considered, along with historical records from the previous mining periods and the 30 years of water supply to Inverbrackie. Just as the existing mine has refilled with water and integrated into the regional aquifer, so too will the proposed mine at the end of the Project. With the proposed system of ground water management, it will be a relatively short timeframe for the groundwater levels to return to their previous state. Independent of the operational water management systems proposed, at the end of the Project life the model predicts that levels will return to within 2m of original levels, in the first 12 months after mining ceases (Figure 3-101).

A well census documented at least 30 operational wells within the Inverbrackie Creek Sub-Catchment and some outside the catchment to the east of the Bird-in-Hand Gold Project.

Most private wells abstract groundwater from the Tapley Hill Formation to the north and western side of the Marble outcrop, and to a lesser extent the Tarcowie Siltstone. The locations of operational wells are shown on Figure 3-218.

Groundwater inflows into the proposed mine will cause a radial zone of depressurisation during the mine life, which if not managed will likely impact groundwater supplies to some private wells.

Groundwater modelling showed that groundwater level impacts at private wells can be reduced by grouting ahead of development and eliminated by reinjection of treated mine water to offset groundwater drawdown around the mine.

Terramin expects the groundwater inflows to be reduced by 90% of inflows (90% effective) with the use of grout. Adequate capacity must be built into the system to manage a credible worst case scenario, and for this reason, have designed the water management system with groundwater inflow management being only 70% effective with the use of grout.

The predicted drawdown at operational wells for each mining scenario is presented in Table 3-50 (based on revised modelled scenarios reported in Golder 2019). Negative drawdown values represent a groundwater level rise, whilst positive values represent a groundwater decline. Operational wells within the Inverbrackie Creek subcatchment which have not been specifically identified are outside the credible worst-case zone of impact and do not have a credible impact pathway, and thus will not be impacted.

With the proposed system of ground water management, it will be a relatively short timeframe for the groundwater levels to return to their pre-mining state. Even if operations only achieve 70% effective sealing of inflow with grouting regime with MAR, modelling predicts that levels will return to within 2m of original, in the first 12 months after mining ceases.

A comparison of the residual groundwater drawdowns, with and without MAR at five years post mining are presented for the Tapley Hill Formation and the Tarcowie Siltstone (Figure 3-101). Groundwater modelling 5 years post mining shows that without MAR, there is a small residual drawdown of 1 to 4 m across the main irrigation area, and no residual drawdown with MAR.

Table 3-50 | Predicted drawdown at operational wells – Mining year 5.5

Well		Baseline DTW (m)	Well Depth (m)	Depth to Water	Pump depth	70% (m)	70% + MAR (m)	90% (m)	90% + MAR (m)
6628-8936	TS		50.9		27.4	7	-1.5	3	-1
6628-8940	TH		UKN			15	-2	8	-1
6628-10944	TH	11.69	76	11.84	60	6	-1.5	5	0
6628-9154	TH	4.2	51.5	22.20	30.5	7	-2	2	0
6628-23182	TH	13	64	13.2	~58	15	-1	9	0.5
6628-9153	TH	3.1 - 5.6	134	6.71	45.7	10	-2	5	0
6628-8946	TS	16.57 - 24.0	UKN	19.35		10	0	4	0
6628-20475	TS	20	70	25.08	60	10	0	4	0
6628-8950	TS	8.1	22.9	10.90	26	5	0	2	0
6628-8952	TS	26.8 - 30.14	45.7	24.10	50	5	0	2	0
6628-18637	TH	11.87 - 23.4	70	16.54	45.7	7	-1.5	3	0
6628-9152	TH	11.00	91			3	0	1.5	0
6628-10249	TH	12.07 - 21.31	98.8	18.00		3	0	1.5	0
6628-8301	K	9.14	100.58		80	7	0	3	0
Springs associated with Inverbrackie Creek - upstream		-	Not applicable			2	0	1	0
Springs associated with Inverbrackie Creek – down stream		-				2	0	1	0

Note: If a well is not included in this table, it is not expected to be impacted by Terramin's activities due to distance from the site.

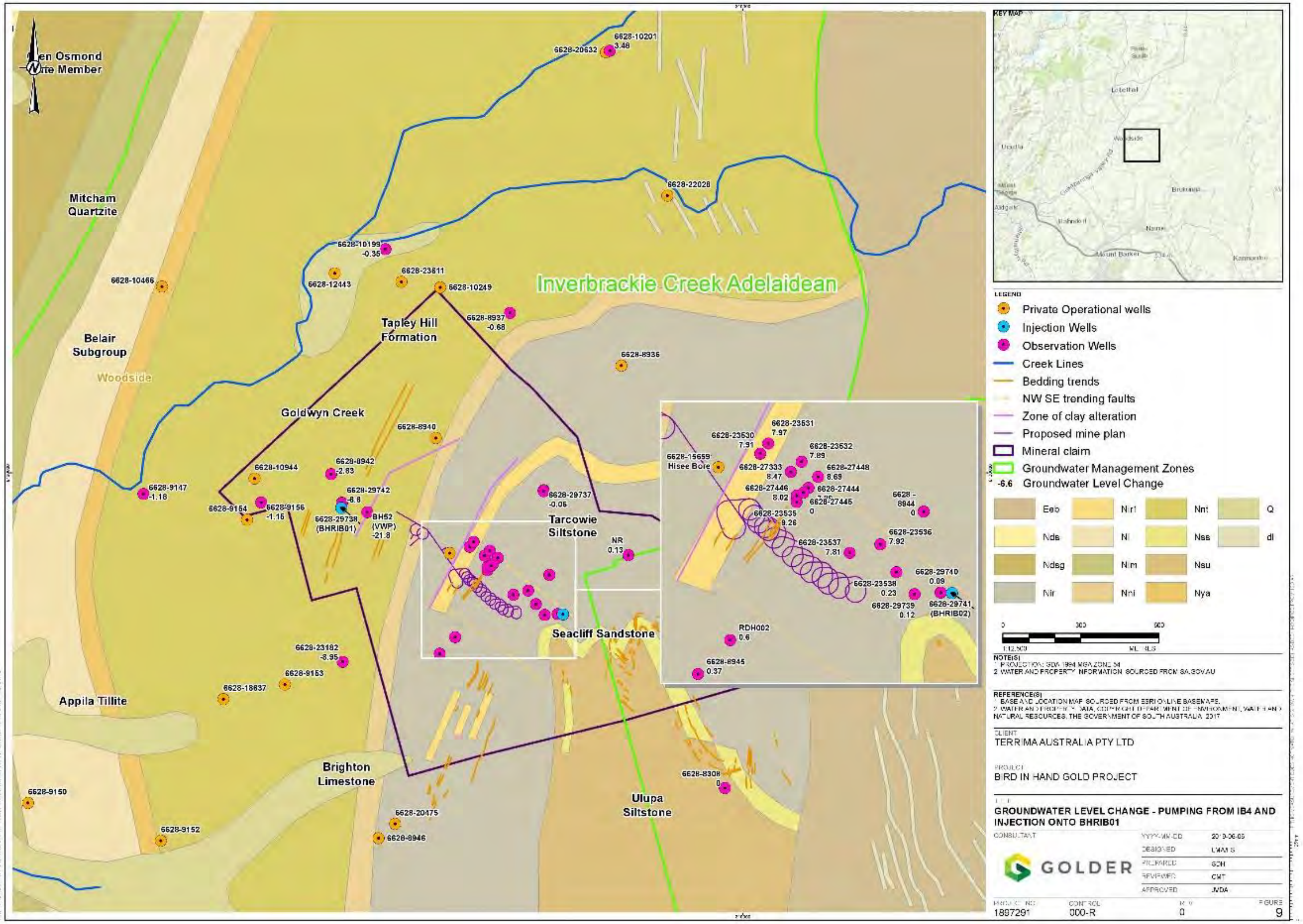


FIGURE 3-218 | OPERATIONAL WELLS, INSTALLED INJECTION WELLS, AND CREEK LINES (APPENDIX H9)

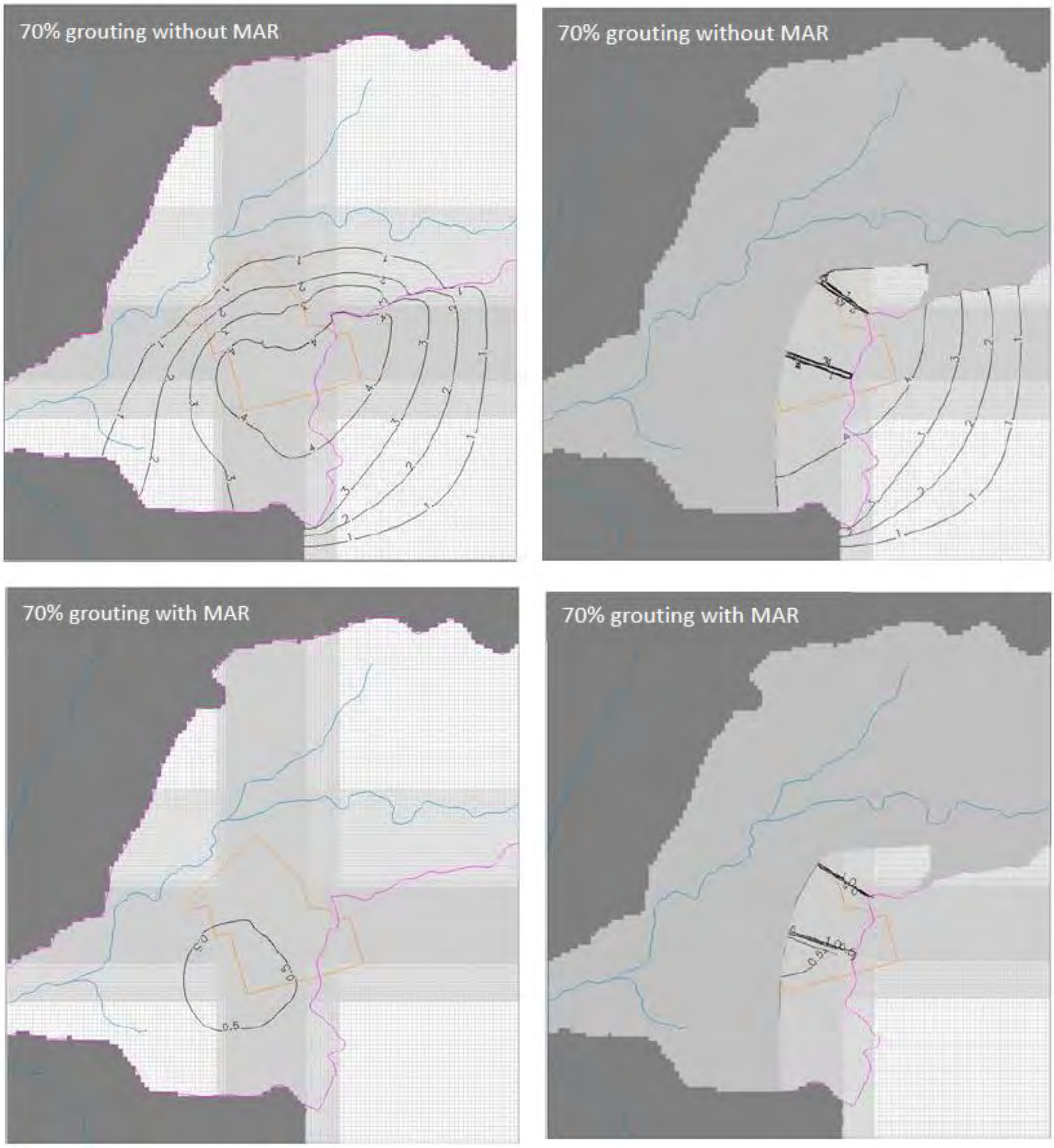


FIGURE 3-219 | RESIDUAL DRAWDOWNS FIVE YEARS POST CLOSURE TAPLEY HILL FORMATION (LEFT), TARCOWIE SILTSTONE (RIGHT)

3.10.10 WATER MANAGEMENT INFRASTRUCTURE

3.10.10.1 MANAGED AQUIFER RECHARGE SYSTEM

Following mine closure the MAR system is expected to be decommissioned. Depressurisation and reinjection bores will be sealed and capped according to DEWNR approved guidelines - Minimum Construction Requirements for Water Bores in Australia 3rd Edition (2011) regulated by DEW. Associated pipelines will be decommissioned and removed, with disposal of all associated infrastructure as per the Waste Management Plan.

All land disturbed by the MAR pipelines and MAR bores (as shown in Figure 3-112) will be ripped and reseeded in consultation with the appropriate landowner.

3.10.10.2 WATER TREATMENT PLANT

It is planned for all water treatment plant infrastructure to be removed once mining and rehabilitation has been completed. The area occupied by the infrastructure will be rehabilitated as a hard stand area.

3.10.10.3 SURFACE WATER DAM

A hillside dam will be constructed for the storage of water during the Project as shown by 4 in Figure 3-220. This structure will be left in place for future land use, as water storage. The pump shed and power supply will also remain.

3.10.10.4 STORMWATER MANAGEMENT INFRASTRUCTURE

Stormwater management infrastructure will remain in place and functional for the reformed closure design. All flows will be directed to the stormwater retention/detention pond via silt and hydrocarbon traps as installed, prior to it entering the Goldwyn Creek via the WSUD and swale system, shown in Figure 3-220.

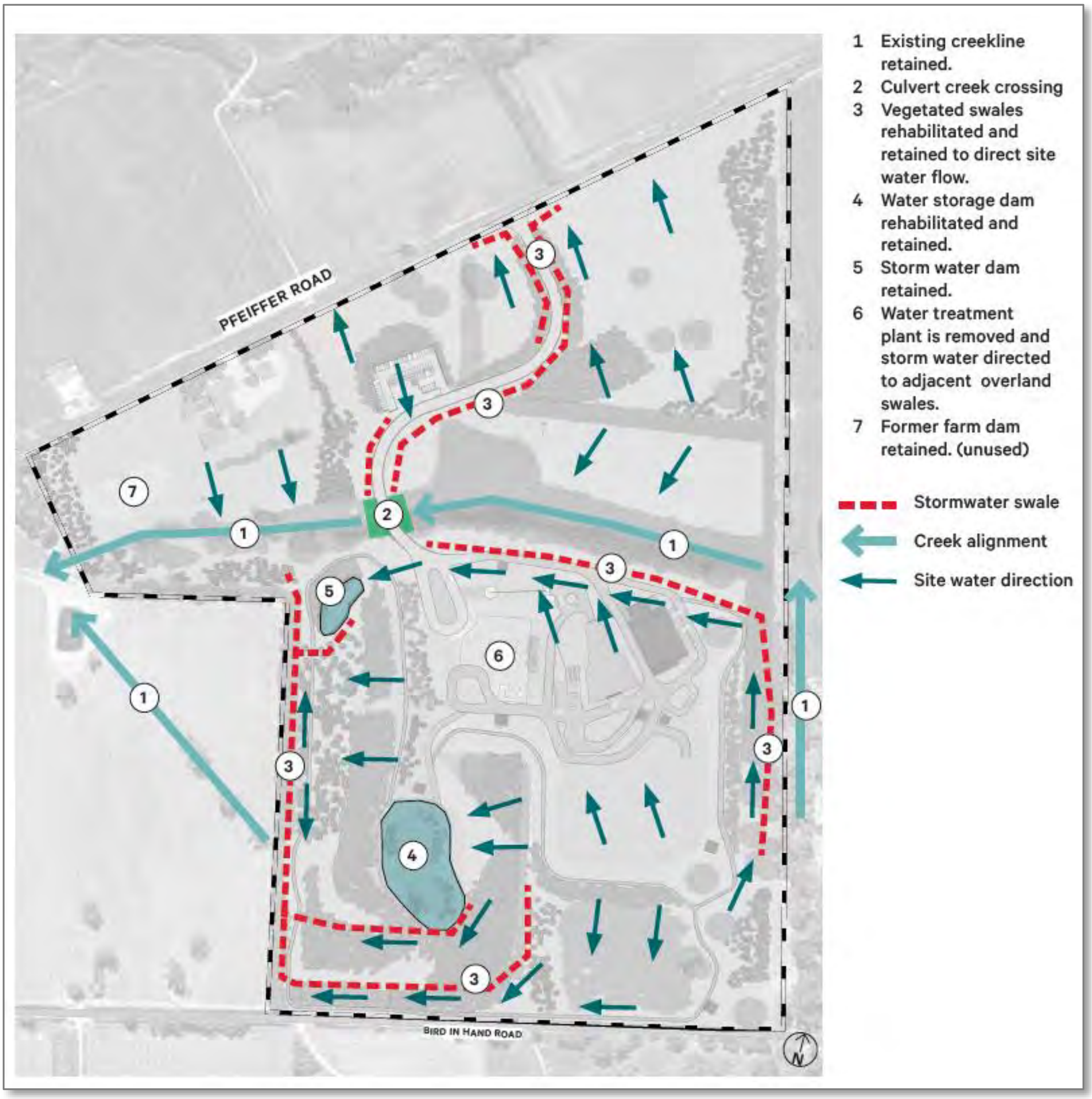


FIGURE 3-220 | PROPOSED STORM WATER FLOW AFTER MINE CLOSURE (APPENDIX X1)

3.10.10.5 CREEK PROTECTION

The placement of the new creek crossing and culverts to protect creek flow while providing safe traffic access will remain in place, and the existing creek flows will be maintained (Figure 3-221).

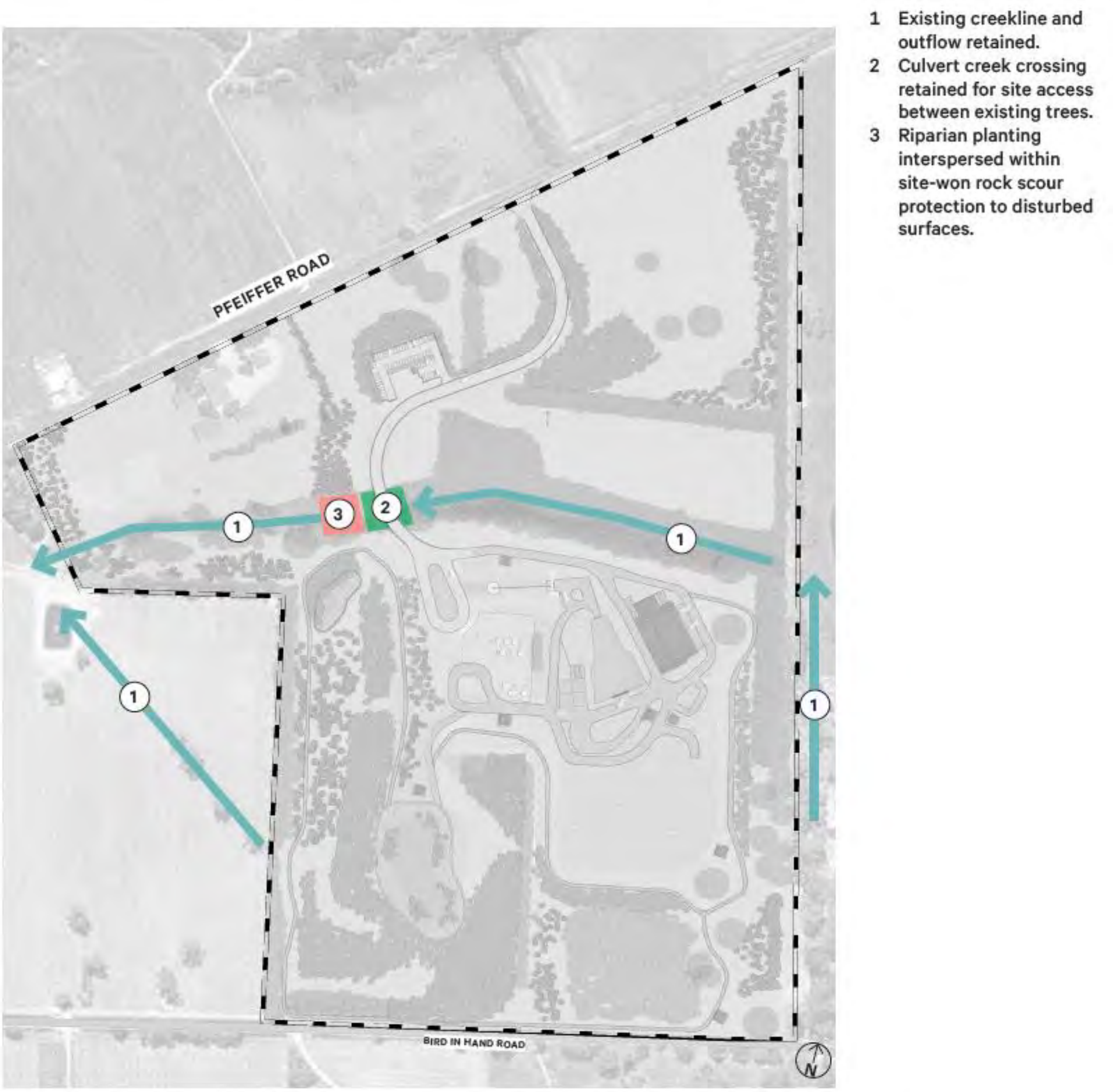


FIGURE 3-221 | EXISTING CREEK FLOWS WILL BE PROTECTED WITH THE SITE DESIGN, INCLUDING THE NEW BRIDGE AND CULVERTS FOR VEHICLE ACCESS. (APPENDIX X1)

3.10.11 PROPOSED OUTCOMES AND MEASURABLE CRITERIA FOR CLOSURE

In accordance with the methodology presented in chapter 6, draft outcomes have been developed for mine closure. See Table 3-51.

All outcomes are supported by draft measurable criteria which will be used to assess compliance against the draft outcomes during the relevant phases (closure).

All Outcomes for the entire project are presented in Appendix D1.

TABLE 3-51 | PROPOSED OUTCOMES AND CLOSURE CRITERIA

Proposed Outcome	Draft Measurement Criteria
Ensure the site is left in a stable, non-polluting state indefinitely Stabilise disturbed areas and prevent sediment from leaving the site No adverse impact to the supply or quality of water by the mining operations to existing users and water dependant ecosystems	During rainfall events which generate runoff, three samples will be taken to measure turbidity at the car park, south-western drainage line, central drainage line (Goldwyn Creek) and at the overflow point of the surface water retention dam as per sampling method AS/NZS 5667.1:1998 standards. A paired t-test will demonstrate that turbidity at the car park, south-western drainage line and at the overflow point of the surface water retention dam is not significantly greater (p-value ≤ t-test value) from the mean of the samples taken at Inverbrackie Creek upstream of the ML at that point in time over a consecutive period no less than 2 years. Sampling will be undertaken once if possible within a 12 month period prior to Mineral Lease surrender document submission.
	A report by an independent and suitably qualified expert (to DEM's satisfaction) will verify once prior to application for surrender that all available information demonstrates that representative revegetation test sites have been rehabilitated to a safe, stable landform and have achieved, or by trends, may be confidently predicted to reach and pass sustainability thresholds as defined by Landscape Function Analysis (Sustainability thresholds for each parameter are interpreted as the points of maximum curvature on the sigmoidal curve shape as per Tongway and Hindley (2005).
	Once prior to application for surrender, an audit/inspection of the final landforms conducted by a suitably qualified and experienced independent consultant, demonstrates that the final landforms are constructed to specifications and will be physically stable post mine completion.
No adverse impacts on soil quality within the mining lease that could compromise the post mining land use	All chemical and hydrocarbon spills are remediated to meet EPA standards within 48 hours of the spill, or a longer time agreed by the Director of Mines.
	Provision of a report once prior to entering the closure monitoring phase by a suitably qualified site contamination consultant verifies that a site contamination assessment and if required remediation in accordance with the NEPM and relevant EPA guidelines has occurred, ensuring there is no unacceptable risk to human health or the environment as a result of the contamination when compared with relevant baseline concentrations and relevant NEPM investigation levels.
Ensure all underground voids are filled to the extent that subsidence cannot occur at any time after mine closure Ensure that no damage occurs to third party infrastructure and no injuries/ deaths result from collapse of the underground workings. Ensure that, in constructing and operating the lease, and post mine closure, that there are no public injuries/deaths resulting from unauthorized entry to the mine site	An independent and suitably qualified expert (to DEM's satisfaction) report will demonstrate that the risk of subsidence has been managed for the prevention of surface subsidence after cessation of underground mine operation.
	Survey monitoring of mine void backfill to demonstrate mined production voids have been backfilled in accordance with PEPR methodology after cessation of underground mine operation.
	Surface survey monitoring will be undertaken every six months for the first year post underground mining cessation and annually thereafter at 9 fixed geotechnical survey stations located along Bird in Hand Road. Survey monitoring will demonstrate - no differential settlement of more than 50mm or as compared to baseline subsidence monitors located on Pfeiffer Road, over a 2 year period immediately after the cessation of underground mining.

Proposed Outcome	Draft Measurement Criteria
Ensure that upon mine closure, the site is left in a stable, non-polluting state indefinitely post closure 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	An independent and suitably qualified expert (to DEM's satisfaction) conducts a construct to design audit of the vertical entrances into the mine (shafts) against the design and confirms that shafts have been backfilled and constructed to design specifications within three months of the completion of the shafts being backfilled.
	An independent and suitably qualified expert (to DEM's satisfaction) conducts a construct to design audit of the decline plug against the design and confirms decline has been backfilled and constructed to design specifications within three months of completion of decline being backfilled.
No adverse impact to the supply or quality of water by the mining operations to existing users and water dependent ecosystems	An independent and suitably qualified expert (to DEM's satisfaction) will review all groundwater data geochemical groundwater data and numerical groundwater modelling (groundwater levels and water quality) developed for mine void recharge scenario to verify no adverse impact to the supply or quality of water by mining operations to existing users and water dependent ecosystems by reviewing all data collected pre-mining, operations and closure, once prior to application for surrender.
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.	An independent and suitably qualified expert (to DEM's satisfaction) verifies once within 24 months before submission of surrender application through a report that representative revegetated areas have achieved or by trends may be confidently predicted to reach and pass sustainability thresholds as defined by Landscape Function Analysis (Sustainability thresholds for each parameter are interpreted as the points of maximum curvature on the sigmoidal curve shape as per Tongway and Hindley (2005).
	Survey of heritage trees by an independent and suitably qualified expert (to DEM's satisfaction) demonstrates that heritage trees (MCP Appendix AD) have not been impacted by mining activities through rehabilitation and closure phase
The form, contrasting aspects and reflective aspects of mining structures are visually softened to blend in with the surrounding landscape.	Upon completion of rehabilitation activities independent verification and a photo point assessment will demonstrate that the Strategic Visual Amenity Plan (G1) and Concept Closure Plan (X1) has been fully implemented.
The Lessee must ensure that upon mine closure, all plant and equipment (unless otherwise agreed with the Chief Inspector or Mines) is removed from the site	Upon completion of rehabilitation activities, a visual assessment of the proposed ML will demonstrate all metalliferous mining plant, equipment, infrastructure and rubbish has been removed from site (unless otherwise agreed with the Chief Inspector of Mines).

3.11 RESOURCES INPUTS

3.11.1 Workforce

Detailed workforce requirements and timelines have been developed for the Project. A summary of workforce position and timelines has been included in Table 3-52 to Table 3-58 and Table 3-59.

Traning of employees is likely to be required, such as in safety, first aid, operations of equipment, procedures and in other operational aspects. Training will be undertaken where required for all staff and employees will be given the opportunity for professional development where possible.

3.11.1.1 CONSTRUCTION

The construction workforce would vary over the construction phase of the Project as tasks are commenced, commissioned and completed. Workers would nominally commence work between 6 and 8am and finish between 5 and 7pm.

3.11.1.2 OPERATIONS

Table 3-52 to Table 3-58 summarise the estimated workforce requirement for the BIH Project. While the source of the employees and contractors working onsite cannot be known with certainty, it is expected that the workforce will be sourced locally where possible and employees will be encouraged to reside locally. Approximately 140 FTE site operational staff will be required between BIH and the APF over the 5 year mine life. Over the mine life, personnel numbers vary as construction, development and ore production overlap.

The workforce would generally operate on 12-hour shifts, with four mining crews working on a rotating roster, with the exception of some technical and administrative staff which would have alternative shift arrangements. Workers would nominally commence work at 6am and finish at 6pm.

Four of the positions identified in Table 3-53 and Table 3-54 are currently employed by Terramin and are envisaged to be a part of the BIHGP. Table 3-59 includes conceptual timelines for job creation for the BIHGP.

Table 3-52 | Estimated Management Workforce

Management	
General Manager	1
GM PA	1
Total Management	**2**

Table 3-53 | Estimated Administration Workforce

Administration	
Site Clerk	1
Safety & Training Superintendent	1
Environment and Community Relations Superintendent	1
Environmental Officer x 3	3
Purchasing Officer	1
Storeman	1

IT Administrator	1
Total Administration	**9**

TABLE 3-54 | ESTIMATED TECHNICAL SERVICES WORKFORCE

Technical Services	
Underground Mine Manager	1
Mine Geologist	1
Graduate Mine Geologist	1
Snenior Mining Engineer	1
Geotechnical/Mining Engineer	1
Mine Surveyor	1
Mine Foreman	1
Geo-tech/sampler x 2	2
Mine Trainer	1
Total Tech Services	**10**

TABLE 3-55 | ESTIMATED MINING WORKFORCE

Mining	
Crew A, B, C, D	
Shift Supervisor	1
Development Jumbo Operator	2
Production Jumbo Op	1
Backfill Supervisor (D/S Only)	1
Shot firer	1
Shotcreter/Ground Support/Grouting	1
Loader x 2	2
Truck x 2	2
Nipper	1
Total per Crew	**12**
Total Mining	**46**

TABLE 3-56 | ESTIMATED MAINTENANCE WORKFORCE

Maintenance	
HV Electrician x 2	2
Leading hand fitter x 4	4
Shift fitter x 4	4
Apprentice fitter	1
Boiler maker	1
Water Management x 2	2
Total Maintenance	**14**

TABLE 3-57 | ESTIMATED PERMANENT CONTRACTOR WORKFORCE

Permanent Contractors	
Cleaners x 3	3
Drill Consumables	1
Subcontractor x 3	3
Concrete Supply x 3	3
Haulage (includes Ore and Con from AZM)	
Haulage Driver x 4	4
Haulage maintenance x 3	3
Haulage safety 1	1
Haulage Admin x 2	2
Total Perm Contractors	20

TABLE 3-58 | ESTIMATED TOTAL WORKFORCE AT THE BIRD IN HAND SITE

Total Workforce Numbers	
Total Terramin Employees	81
Total Permanent Contractors	20
Total	101

TABLE 3-59 | CONCEPTUAL TIMELINES FOR JOB CREATION (INCLUDING POSIITONS AT THE ANGAS PROCESSING FACILITY)

Position	Time employed				
	Year 1	Year 2	Year 3	Year 4	Year 5
Management	2	2	2	2	2
Bird in Hand site					
Management	1	1	1	1	1
Technical	5.5	9	9	9	9
Administration	6.3	7.9	9	9	9
Mining	14.1	38.3	42	42	42
Maintenance	6.3	14	14	14	14
Contractors	0	7	10	10	10
Angas Processing Facility					
Administration	2.5	4.7	5	5	5
Process Management	0.8	3.9	5	5	5
Mill Crews	0	11.8	28	28	28
Cleaners	0	1.6	3	3	3
Construction and General					
General	24	5.4	1	1	1
AZM	0	5.2	0	0	0
BIH	1	1	1	1	
Haulage	0	2.5	10	10	10
Total	**63.3**	**115.3**	**140**	**140**	**140**

3.11.2 ENERGY SOURCES

3.11.2.1 EXPECTED SOURCES OF ENERGY

- Electrical – grid, generator back up and solar where practical
- Diesel – trucked in and stored on site
- Gas (Liquid Petroleum Gas) – trucked in and stored on site

Potential efficiency gains will be investigated further during detailed design.

3.11.2.2 TOTAL ANNUAL ENERGY USAGE

3.11.2.2.1 ELECTRICAL

During the Construction phase, electricity will be sourced from a connection to the existing 11kV overhead line located across the road from the Mine entrance on Pfeiffer Rd. The Pfeiffer Road 11kV Overhead line forms part of the Inverbrackie Feeder which originates at the Woodside Substation, approximately 3.5km from the mine site. Minor temporary diesel generation will be used to support this supply during construction. Estimated total electricity consumption during this phase is 0.86GWh.

For the Production phase, the 11kV Overhead Line between the Woodside Substation and the mine site may require upgrade. It is envisaged that this work would occur during the construction phase and will likely include re-stringing the existing line with higher capacity conductors, with existing poles and cross arms to remain. This work will be subject to planning and approval by SA Power Networks (SAPN).

Mine closure phase electrical use would see a gradual decline in demand from production levels to those similar to the levels expected for construction as drilling activities, and pumping activities ramp down and the removal of any non-permanent infrastructure is removed over the estimated 12 month period after mining finishes.

Zero emission energy, such as solar generation on office/shed roofs will be further investigated. It is expected this electricity generation will supplement the offices supply.

FIGURE 3-222 | TYPICAL ELECTRICAL SUB-STATION FOR SUPPLYING ELECTRICITY TO THE MINE

TABLE 3-60 | ESTIMATED ANNUAL ELECTRICAL USE AND CALCULATED GHG EMISSIONS

Project Phase	Electricity Use (GWh)	Estimated GHG Emissions CO2-e Per Annum (tons)**
Surface Construction	0.86	460
Underground Development	8	4,300
Production	16	8,480
Closure	4.5	2,400

3.11.2.2.2 DIESEL

Diesel will be used to fuel all mobile equipment on site. Estimated mobile fleet diesel use during the Construction phase is 2,100kL over 12 months and during Production phase the approximate peak annual use will be 2,300kL. The closure phase is expected to be slightly lower than the construction phase at 1,800kL. Figure 3-158 illustrates the typical storage method of diesel on a mine site.

Mobile fleet diesel use and the associated calculated Greenhouse Gas (GHG) emissions are listed in Table 3-61

Diesel will also be used as a power source of backup generators to supply emergency electricity.

TABLE 3-61 | ESTIMATED ANNUAL DIESEL USE AND CALCULATED GHG EMISSIONS

Project Phase	Diesel Use (kL)	Estimated GHG Emissions** (CO_{2-e} tonnes)
Construction	2,100	5,666
Production	2,300	6,206
Closure	1,800	4,857

3.11.2.2.3 GAS

Liquid Petroleum Gas (LPG, LP Gas, Propane) will be used to heat water for ablutions, laundry and kitchen facilities on site. It could also be possible to utilise it to power back-up generators rather than the diesel. Similar to industry, a 4.5kL cylinder will be used on site to store the gas (Figure 3-161), as per required standards and legislation i.e.:

- AS/NZS 1596:2014: The storage and handling of LP Gas;
- AS 4332-2004: The storage and handling of gases in cylinders.

Based on the average annual 2011, 2012 and 2013 consumption at Angas Zinc Mine of approximately 75L/person per year, the estimated annual Operations phase requirements for BIH is 3,900L, based on 60 persons. For Construction and Closure with an estimated 40 and 20 people each respectively, annual consumption is estimated as 2,500L and 1,300L, as summarised in Table 3-62.

TABLE 3-62 | ESTIMATED ANNUAL GAS (LPG) REQUIREMENTS AND ASSOCIATE GHG EMISSIONS

Project Phase	Gas Use (L)	Estimated GHG Emissions** (CO_{2-e} tonnes)
Construction	3,000	6,915
Production	4,500	10,373
Closure	1,500	3,458

A summary of total project greenhouse gas emission estimates is summarised in Table 3-63.

TABLE 3-63 | SUMMARY OF TOTAL GREENHOUSE GAS EMISSIONS FOR THE BIH SITE

Project Phase	Total Estimated GHG Emissions** (CO_2-e tonnes)
Surface Construction	13,041
Production	29,359
Closure	10,714

3.11.2.3 CARBON OFFSETS

The carbon sequestration from revegetation has been estimated using the *Carbon sequestration from revegetation: South Australian Agricultural Regions,* developed by the Department of Environment, Water and Natural Resources (DEWNR) in 2013.

South Australia has the potential to sequester a significant amount of carbon in revegetation and managed remnant vegetation in our landscapes. Dedicated environmental plantings such as Terramin's revegetation planting can be used to store atmospheric carbon, deliver economic and environmental benefits, enhance biodiversity and provide greater resilience to climate change for our communities (DEWNR, 2013).

DEWNR's Carbon Sequestration from Revegetation project (supported by State NRM Program, Australian Government Department of the Environment, Australian Government Department of Agriculture and the Future Farm Industries CRC) provides evaluations of the growth, productivity and carbon sequestration rates of native plants species planted in woodlots and environmental planting across several regions of South Australia. This research also details the development of allometric techniques for assessing plant biomass for carbon accounting and inputs into national Carbon Farming Initiative carbon accounting tools (DEWNR, 2013).

The pre-determined Carbon sequestration from revegetation: South Australian agricultural regions calculator was used to quantify the 10.5 Ha revegetation that has been proposed. Using site specific data on rainfall, soil characteristics, plantation type and density, the calculator estimates an above ground sequestration rate of almost 30 tonnes per hectare per year of carbon dioxide (CO_2-e t/ha/yr) – see Table 3-64. This is in comparison of the AMLR regional average of 25 CO_2-e t/ha/yr and a state average of 5 CO_2-e t/ha/yr. Over a 5 year mine life, this equates to carbon dioxide sequestration of approximately 1571 tonnes. Carbon dioxide sequestered over 25 years from the revegetation plantings equates to 8,839 tonnes in total, topping out at 30,829 tonnes over 100 years.

Carbon sequestration graphs from the calculator have been included in Table 3-64.

TABLE 3-64 | ESTIMATED SEQUESTRATION RATE FROM CARBON SEQUESTRATION FROM REVEGETATION: SOUTH AUSTRALIAN AGRICULTURAL REGIONS (DEWNR, 2013)

Estimated Sequestration Rate	Average over 5 years
Above Ground Biomass (DM t/ha/yr)	16.44
Above Ground Biomass (C t/ha/yr)	8.16
Above Ground Sequestration (CO_2-e t/ha/yr)	29.93

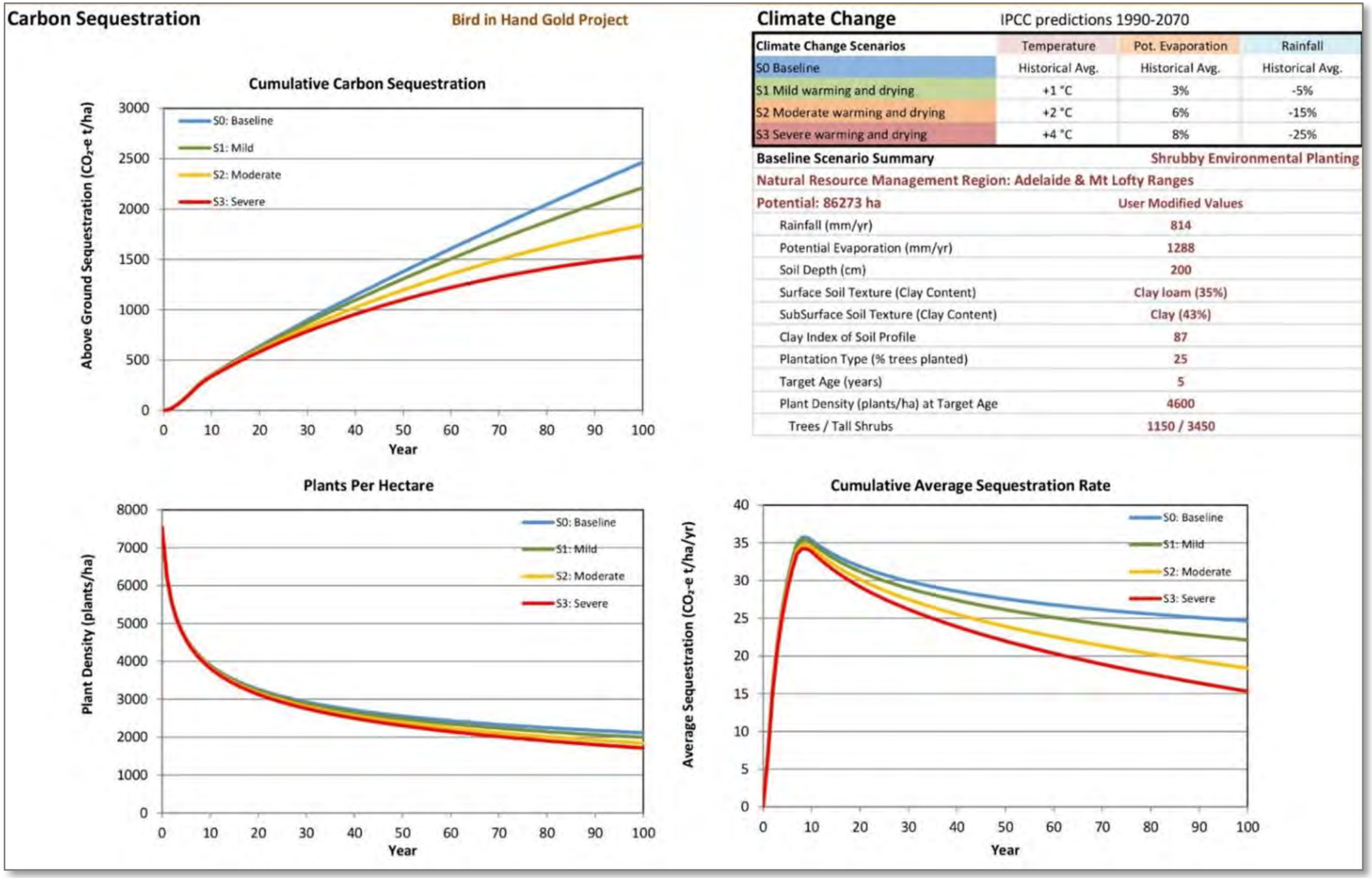


FIGURE 3-223 | CARBON SEQUESTRATION GRAPHS (DEWNR, 2013)

3.11.3 Water Sources

There are numerous water sources available in the area for the project. Available sources include:

- Operational bore within the Terramin owned Goldwyn property;
- SA Water Mains – line runs along Pfeiffer Rd;
- SA Waste Recycled water – the line for this runs along Reefton Rd, approximately 500m from the operational area of the BIH mine;
- Water allocation trading - purchase of water allocations from other catchment users; and
- Site captured rainfall.

The use of the SA Water recycled water is restricted in its use due to the level of nutrients and pathogens in the water. If the water was to come into contact with people, it would have to undergo further treatment, such as chlorination, UV treatment, and filtration to reduce to potential health risk associated with coming into contact with it. It may be possible to add these treatments onto the proposed water treatment plant for the site, but may prove to be cost prohibitive compared to other available sources not requiring treatment.

As the water catchment is already fully allocated, it is expected that Terramin will be able to trade licenced allocation with other users within the district to provide any shortage in supply, as has occurred during 2018 (additional 60 ML secured).

By utilising the available roof spaces to capture rain fall, there is potential for an average of approximately 50 ML to be captured a year for use on site towards irrigation, toilets and dust suppression needs. Potentially more water would be available in wetter years, and more water traded in dryer years, as currently less than 50% of allocated water is used in the sub-catchment generally (pers. comm, DEW, 2018).

Water sources and the estimated usage by year for both the 70% and 90% grout effective scenarios are shown in Table 3-24 and Table 3-25.

Total annual groundwater allocated in the Inverbrackie Creek Subcatchment is approximately 1500 ML, excluding 5 ML domestic and stock allocations. Terramin's current allocation is 14.65 ML, which is less than 1% of the current available water in the trading system. If Terramin were to purchase an additional 100 ML of groundwater through trading, this would equate to approximately 8% of total allocations (114.65 of 1500 ML). This disregards any water purchased through SA Water (either mains or recycled purple pipe). This is indicative based on current knowledge, however, final analysis of source water percentages will be defined as part of the PEPR as water sources are secured through contract negotiations through trading and SA Water.

3.11.4.1 RECYCLED WATER

Where possible, water used on site will be recycled, and depending on use it will be required to undergo treatment to ensure the quality meets the standards required.

Water used underground for mining, outside of cement usage and losses due to moisture content of mine air and ore/mullock, will be pumped to the surface for treatment and then sent back underground for use. It is estimated that approximately 95 ML of water per annum is circulated through the system for underground mining activities with the majority of this volume being recycled (~ 90% recycled/recirculated).

Other water streams that will be recycled include wheel wash and wash down pads where only small amounts of makeup water will be required.

3.11.4.2 WATER DISCHARGES

Streams where water will be discharged or recycled from site include:

- Stormwater run-off via stormwater management system and into Goldwyn creek – the majority of this water will be not be in contact with the operational area and will follow the existing run off streams.
- Reinjection – to balance the groundwater ingress into the mine, water will be reinjected back into the aquifer to maintain ground water levels and quality for existing ground users. The quality of this water is required to match the existing quality of the aquifer. Quantities will be dependent on the needs of the groundwater levels and will change over time as groundwater use changes, seasonal impacts, recharge from other sources, mine progress and other groundwater inflow mitigation strategies proposed for the site (discussed in Chapter 10)
- Information on the water treatment system proposed is included in section 3.7.9.5
- Sewage – water used for ablutions, and office will be connected to the Bird on Hand Wastewater Treatment Facility located on Bird in Hand Road. In the event that this is not possible, it discharged via approved septic system via standard seepage and evaporation mechanisms.
- Natural seepage – a large percentage of the site will be left unsealed and will absorb some of the stormwater falling on the site.
- Ventilation system – very minor quantities of water will be lost to the atmosphere via evaporation from the air underground contacting the wet surfaces.
- Dam evaporation – very minor quantities of water will be lost to the atmosphere via evaporation from the dams on site, as well as from the vegetation transpiration of plants.

Water sources and the estimated usage by year for both the 70% and 90% grout effective scenarios are shown in Table 3-24 and Table 3-25.

3.11.2.4 ESTIMATED ANNUAL WATER BUDGET

Please refer to section 3.4.6and 3.7.9 for details on the estimated annual water budget.

3.12 REFERENCES

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