IMPACT ASSESSMENT

SECTION 4.5
INLAND WATERS ENVIRONMENTAL QUALITY

This page is intentionally left blank

4.5 Inland Waters Environmental Quality

4.5.1 Introduction

Environmental values (EVs) are the qualities of water resources to be protected from activities in the catchment. Protecting environmental values aims to maintain healthy aquatic ecosystems and waterways that are safe and suitable for community use.

This section examines the potential impacts and risks to inland waters environmental quality and sensitive receptors. It explores potential sources, pathways, receptors, and fate of any potentially contaminated waters. It describes the potential impacts to surface and groundwater and outlines the mitigation measures proposed to meet the NT EPAs objective related to inland waters environmental quality.

4.5.1.1 Relevant Legislation

- *Commonwealth Environmental Protection and Biodiversity Conservation Act* (EPBC Act)
- *National Environmental Protection Council Act* (NEPC Act)
- *Water Act*
- *Mining Management Act*
- *Environmental Assessment Act*
- *Waste Management and Pollution Control Act*; and
- NT EPA Environmental Assessment Guidelines on Acid and Metalliferous Drainage (AMD).

4.5.1.2 Overview of Water Resources

Surface water in the Project area and surrounding region is ephemeral. Drainage lines originating in the Jervois Range, include Unca Creek (**Error! Reference source not found.**). Unca Creek and its tributaries drain to the east through the Project area and north-east towards Arthur Creek but flood out through the broad drainage plain to the south-east. Watercourses in the surrounding area include Arthur Creek, 18 km north-east, Daylight Creek, 4 km south-west, Midnight Creek, 7 km south, and Bonya Creek, 11 km south-west (**Error! Reference source not found.**). Aquatic ecosystems in the Project area and immediate surrounds are ephemeral, as watercourses only contain water following good rainfall.

Jervois Dam is an artificial water reservoir at the north-west corner of the Project area, which holds a substantial volume of water for several years following rainfall.

The groundwater system in the mine area is within the fractured and weathered rocks of the Bonya Metamorphics. Groundwater resources in the Jervois Mine area are very poor due to the limited open fracturing and lack of primary porosity of the Proterozoic rock, with recorded flows of 0.5 to 1.6 L/sec. Higher yielding areas are related to localised zones of more intense fracturing and jointing. Groundwater occurs in the Bonya Metamorphics Complex in fractures at about 25 m below ground surface (M.I.M Exploration, 2001). Metamorphic rocks such as schist and gneiss have low permeability and generally contain small amounts of groundwater, which is commonly brackish to saline.

Groundwater availability on Jervois Station has always been a problem (Low and Strong, 1985). Water from Palaeozoic sediments is frequently salty (Black *et al* 1984), but fault and fracture lines in metamorphic and igneous rock may provide fresh water. Deep Quaternary beds through which major water courses flow can yield good supplies of fresh water. Unca Bore on the project area is high in salt content at 3380 TDS.

4.5.1.3 Water Quality Objectives

Environmental values (EVs) are the qualities of waterways to be protected from activities in the catchment. Protecting environmental values aims to maintain healthy aquatic ecosystems and waterways that are safe and suitable for community use. Environmental values reflect the ecological, social and economic values and uses of the waterway (such as stock water, cultural uses, maintaining biodiversity, fishing and agriculture).

The processes to identify EVs and determine water quality objectives (WQOs) are based on the National Water Quality Management Strategy: Implementation Guidelines (NWQMS, 1998). They are further outlined in the Australian and New Zealand Guidelines for Fresh and Marine Water Quality (ANZECC & ARMCANZ, 2000).

There are no currently prescribed EVs for the Project Area. Therefore, based on the NWQMS (1998) and ANZECC & ARMCANZ (2000) guidelines, the following EVs are proposed for the Project:

- Aquatic ecosystems
- Primary industries including stock drinking water, irrigation and general water uses
- Recreation and aesthetics; and
- Cultural and spiritual values.

Adopted water quality objectives

Based on the ANZECC & ARMCANZ (2000) guideline, the condition of the watercourses in the vicinity of the Project is considered as *Condition 2: slightly to moderately disturbed ecosystem*. The adopted surface water quality indicators relevant to meeting the above EVs are sourced from the ANZECC & ARMCANZ (2000) guideline.

Table 4.5-1 shows the adopted water quality objectives (WQOs) for the receiving waters downstream of the Project. The ANZECC & ARMCANZ (2000) WQOs for aquatic ecosystems are considered to be the most conservative of the EVs listed above and have therefore been adopted as the surface water WQOs for most parameters. WQOs for pH, electrical conductivity (EC), turbidity, dissolved oxygen (DO), sulphate and iron were sourced from ANZECC & ARMCANZ (2000) guidelines for either livestock drinking water or recreation.

The following is of note with regards to the adopted WQOs:

- The WQOs in **Error! Reference source not found.** were obtained from the ANZECC & ARMCANZ (2000) guideline for aquatic ecosystems based on 95% of species level of protection, except for pH, EC, turbidity, DO, sulphate, nitrate and iron
- The ANZECC & ARMCANZ (2000) recommended pH level for general water uses is between 6 and 8.5 for groundwater and between 6 and 9 for surface water. The recommended pH limit of between 6 and 8.5 is adopted for the Project
- The adopted WQO limits for EC and sulphate are based on the ANZECC & ARMCANZ (2000) guidelines for livestock drinking water.
- In absence of more site-specific guidelines, the adopted turbidity limit is based on the ANZECC & ARMCANZ (2000) guidelines for upland and lowland rivers in south central Australia: low rainfall area.
- In absence of more site-specific guidelines for arid regions, the adopted DO (%) limit is based on the ANZECC & ARMCANZ (2000) guidelines for freshwater lakes and reservoirs in south central Australia: low rainfall area. No data is available in the guideline for upland rivers, which would have been more representative of the Project area.
- The WQO limit for iron is based on the ANZECC & ARMCANZ (2000) guidelines for recreational purposes.

Table 4.5-1 Adopted surface water quality objectives (WQOs) for the Project, and comparison with observed water quality data

Parameter	Abbreviation	Units	Adopted WQO value [a]	Group A observed water quality (80%ile) [i]
Non-metallic indicators				
pH	pH	pH units	6.0 - 8.5 [b]	7.1
Electrical conductivity	EC	µS/cm	5,970 [c]	4,090
Total dissolved solids	TDS	mg/L	4,000 [c]	30
Turbidity	Turbidity	NTU	50 [d]	1,160
Dissolved oxygen	DO	% saturation	90 [e]	n/a
Sulphate	SO_4	mg/L	1,000 [f]	1.3
Nitrate	NO_3	mg/L	0.7	0.240
Metals and metalloids (filtered, unless otherwise stated)				
Aluminum	Al	µg/L	55	<10 (total) [j]
Arsenic	As	µg/L	24	59.2 (total) [j]
Cadmium	Cd	µg/L	0.2	54 (total) [j]
Copper	Cu	µg/L	1.4	92 (total) [j]
Iron	Fe	µg/L	300 [g]	232 (total) [j]
Lead	Pb	µg/L	3.4	44 (total) [j]
Magnesium	Mg	mg/L	2,000 [h]	0.9
Manganese	Mn	µg/L	1,900	661 (total) [j]
Mercury	Hg	µg/L	0.6	66.9 (total) [j]
Nickel	Ni	µg/L	11	49 (total) [j]
Zinc	Zn	µg/L	8	244 (total) [j]

[a] – Obtained from Table 3.4.1 in ANZECC & ARMCANZ (2000) based on 95% species level of protection, unless otherwise stated.

[b] – Section 4.2.10.1 in ANZECC & ARMCANZ (2000) for general water uses.

[c] – Table 4.3.1 in ANZECC & ARMCANZ (2000), adopted the lower limit for beef cattle and horses.

[d] – Table 3.3.9 in ANZECC & ARMCANZ (2000) for upland & lowland rivers.

[e] – Table 3.3.8 in ANZECC & ARMCANZ (2000) for lowland rivers and freshwater lakes and reservoirs.

[f] – Section 4.3.3.4 in ANZECC & ARMCANZ (2000) for livestock drinking water.

[g] – Table 5.2.3 in ANZECC & ARMCANZ (2000) for recreational purposes.

[h] – Section 4.3.3.2 in ANZECC & ARMCANZ (2000) for livestock drinking water.

[i] – Group A sites are representative of undisturbed areas within the mineralised zone of Project area.

[j] – Testing on filtered samples was not undertaken.

4.5.2 Relevant Activities

Activities that have the potential to impact upon inland water environmental qualities include:

- Excavation of open cut pit and underground mines
- Impacts to overland flow – flooding and movement of contaminants
- Processing
- ROM/Stockpiles
- Waste production and handling
- Tailings storage
- Workshop contaminants e.g. fuels, greases etc.
- Fuel storage; and
- Camp effluent.

4.5.3 Potential Impacts and Risks

4.5.3.1 Introduction

There are several risks associated with the construction and operation of the Project that could lead to contamination of surface and groundwater. These include contamination of waterways or groundwater caused by embankment failure or overtopping and subsequent uncontrolled release from storage ponds, the processing site and the TSF. Inappropriate storage and handling of hazardous substances may also result in uncontrolled release, spills or passive discharge into drainage lines.

Most aspects of the Project have some potential to cause water contamination, such as, but not limited to the ore stockpiles, waste landforms including the waste rock dump (WRD), magnetite stockpiles or TSF. Key potential sources of contaminants are listed in Table 4.5-2, the dams that capture runoff from these sources are also shown.

Table 4.5-2 Contamination sources and destinations of runoff

Contaminant source	Contaminant type	Destination water storage
ROM and product stockpiles	Sediment, metals	Process water dam
Processing plant industrial area	Sediment, metals, chemicals, oil and grease	Process water dam
Open cut mining pits	Sediment, metals	Process water dam
Waste rock dumps	Sediment, acid	Sediment dams

Potential release mechanisms for water contamination include:

- Erosion of disturbed surfaces
- Inadequate stormwater/runoff separation

- Leaching from WRD and long term stockpiles
- Seepage from the TSF
- Inadequate treatment of waste water prior to discharge; and
- Accidental spills.

Vegetation and flora reliant on surface flows and groundwater uptake may also be impacted by surface water and ground water contamination.

4.5.3.2 Characterisation of Potential Contaminant Rock Materials

Development of the Project would utilise the existing waste rock dumps and TSF where possible to minimise the footprint impacted. The key mine components resulting from development and most relevant to geochemical assessment are waste rock dumps, low grade ore and ore stockpiles, tailings storage facilities, open cut pits and underground workings.

A geochemical assessment of the site for the purposes of characterising (Appendix C1).

The geochemical assessment tested the following:

- 662 waste rock and ore samples from Rockface and Marshall/Reward Deposits to represent the geological and spatial variation of mine materials;
- 22 historic mine material samples to provide some initial guide to potential legacy geochemistry issues; and
- 20 ore feed and tailings samples from metallurgical test work carried out on ore from Rockface, Marshall/Reward, Green Parrot and Bellbird deposits to represent the range of ore and tailings materials likely to be produced.

The results of the assessment indicated that Project open cut and underground mine waste rock materials will comprise mainly non-acid forming (NAF) material. The smaller portion of potential acid-forming (PAF) (including PAF-LC and NAF-HS) materials occur mainly within a halo around the sulphidic ore. Inspection of core samples indicated that PAF units in the waste rock should be readily visually identified, with sulphur (S) a good discriminator of acid-rock drainage (ARD) rock types. This will allow for improved identification and segregation of ARD materials.

A summary of ARD potential by waste rock unit based on results to date is provided below:

- Oxide Waste Rock — NAF with occasional zones of PAF/PAF-LC
- Transition Waste Rock — NAF with occasional zones of PAF/PAF-LC
- Distal — NAF with occasional zones of PAF/PAF-LC
- Proximal — NAF with common zones of PAF/PAF-LC
- Mineralized — Mixed NAF and PAF/PAF-LC
- Felice — NAF
- Vein (Quartz/Tourmaline) — NAF with common zones of PAF/PAF-LC.

Over 90% of the unoxidised ore samples were PAF/PAF-LC with high S (generally greater than 2%S), indicating primary ore stockpiles, and residual primary ore zones in underground workings and open pits will be a potential source of ARD. Oxide ore had much less PAF/PAF-LC as expected, with over 80% of samples classified NAF. Transition ore samples were approximately 50% NAF.

Sulphidic waste rock and ore materials show strong enrichment in a variety of metals/metalloids including Ag, Bi, Be, Cd, Co, Cs, Cu, Mo, Pb, S, Se, Tl, W and Zn with enrichment increasing with proximity to ore. A number of samples were also enriched in Fe and Mn, and individual samples were enriched in As, Ag, As, Bi, Cd, Cu, Hg, Pb, Sb, Se, Tl and Zn.

Water extract testing indicates that the majority waste rock materials will not liberate significant acid, salinity or metals/metalloids. However, under acid conditions mobilisation of Al, Cd, Co, Cu, Fe, Mn, Ni, SO4 and Zn, and possibly Pb, can be expected.

4.5.3.3 Surface and groundwater

Section 3 and Section 4.4 describes the hydrology and hydrogeology associated with the mine site. The following summarises the character of surface water and groundwater at the site.

Surface Water

The Project area is broadly within a desert climate, with unpredictable seasonal rainfall occurring in the summer months of November and April. The average annual rainfall is over 290mmm however climatic records show considerable variation in annual mean rainfall, with some years recording 97.8mm and others 933.4mm (BOM, 2018). Due to unpredictable rainfall events and some annual rainfalls occurring in a single day, there is high probably of extensive flooding.

The Project site is traversed by Unca Creek and its tributaries. Jervois Dam is the largest and most permanent water body in the region. The Unca Creek catchment upstream of Jervois Dam is steep and rocky, with poorly defined, sandy drainage features located along valley floors. The Unca Creek channel downstream of Jervois Dam is generally about 10 m wide and less than 1m deep, with a sandy bed that would become mobile during flood events. Unca Creek is ephemeral.

Water sampled in Jervois Dam is slightly acidic but close to neutral, water quality in Unca Creek is similar to the dam but with increased TSS and metal concentrations (higher than the dam). Appendix C5 contains water quality data from a number of sites around the mine.

Groundwater

The water table through the area generally mirrors the topography - flowing generally from northwest to southeast and locally from areas of higher topography to areas of lower topography such as drainage features and discharging as small seepages adjacent to the rivers and lowlands.

The groundwater system in the mine area is within the fractured and weathered rocks of the Bonya Metamorphics about 25 m below ground surface. Recorded flow rates are generally poor, 0.5 to 1.6 L/sec, higher yielding areas are related to localised zones of more intense fracturing and jointing.

Groundwater is generally fresh to brackish (500-3000 mg/L TDS). However, less than 40% of bores are suitable for potable use (<1000 mg/L), and most bores report water suitable for watering cattle. Groundwater at the mine site in the Fractured Rock groundwater system is also generally too saline for potable use but is suitable for Pastoral (Stock) and Industrial use (i.e. RN006910, RN010321, & RN012917 are suitable for stock due to TDS > 2000 mg/L, elevated F, Fe and SO_4).

There are no known groundwater dependent ecosystems on or near the site.

4.5.4 Impact Assessment

4.5.4.1 Acid Rock Drainage

Results from geochemical characterisation of waste have the following implications for mine materials management:

- Most waste rock from pit and underground development is expected to be NAF and environmentally benign, and will not require specific management for control of ARD. Controlling ARD from the smaller portion of PAF (including PAF-LC and NAF-HS) should be relatively straight forward, but will require selective handling and specific management to prevent ARD into the long term. Long term options could include:
  - in pit or underground disposal below recovery water table levels
  - selective underground disposal of PAF as part of paste backfill; or
  - construction of an infiltration control cover system in-pit or ex-pit.
- Subaqueous disposal is the most secure option for controlling sulphide oxidation and ARD. This mechanism will depend on long-term recovery groundwater and pit water levels, and the volume of PAF mine materials this can accommodate
- Placement of PAF underground along with cement backfill is preferred to surface dumping, but will need to consider the reactivity of the sulphidic materials, and the transmissivity and sensitivity of the receiving groundwater system
- Most of the underground decline and other development not associated with ore extraction would be carried out within distal units, and hence would be expected to be manly NAF, but horizontal ore drives would become more sulphidic and PAF as the contact with the ore zones are approached. Scheduling of underground waste rock should attempt to directly utilise PAF in back fill and avoid bringing PAF materials to surface
- Seepage and runoff from any surface dumped (or stockpiled) PAF waste rock materials may require management during operations to mitigate any potential impacts on the receiving environment. Treatment during operations may include dump surface limestone addition and/or blending to help delay onset of acid drainage, and/or collection of seepage/runoff and treatment.
- Ore and low grade ore materials are likely to be mainly sulphidic and PAF, and represent a potential source of ARD during operations. Ore and low grade ore stockpiles would be managed to ensure capture and monitoring of any seepage/runoff, with contingency for treatment if required
- The final pit voids will include a mix of NAF and PAF materials, with at least a portion likely to generate acid (particularly exposures of fresh mineralised/residual ore materials. Pit water monitoring would be carried out during operations with contingencies for treatment to help control impacts on the receiving environment. Pit closure requirements for the pit will depend on the final distribution and leaching properties of geochemical rock types in the final walls and floors
- The stopes and drives close to the ore are likely to be sulphidic and PAF, and underground seepage water from these zones is expected to be ultimately acidic, although cement backfill may offset this to some degree
- Dewatering of pits and underground workings is likely to require active management during operations to ensure water quality of receiving drainage meets compliance. This could entail

water storage on-site, water treatment, and/or controlled discharge during wet periods at set dilution ratios

- Tailings from fresh ore processing are expected to be PAF, and the proposed TSF will require management to prevent ARD. The TSF will require a secure low permeability base to prevent leaching of process water and oxidation products during operations, and is likely to require an infiltration control cover system for closure. The potential for paste backfill of tailings into underground workings will be assessed further to help reduce the inventory of tailings requiring surface management; and
- Historic mine materials are metalliferous and show varying potential for generating acid, saline, and metalliferous drainage, although on a localised scale. Given the small volume of these materials, the uncertainty of the current effects from these materials on the receiving environment, and the uncertainty in regard to the security of facilities constructed to contain them, reactivation of any of the old facilities for storage of waste rock and tailings as part of the proposed Project should allow for re-handling or incorporation of historic mine materials into management approaches that demonstrate isolation from the receiving environment.

4.5.4.2 Surface Runoff

Water captured and stored in the site water management system would comprise a mixture of runoff water from various catchment land use types and groundwater from seepage into the underground mines. A water management system has been developed to keep the different types of water (contaminated and uncontaminated) in order to prevent unacceptable levels of sediments and contaminants from leaving the lease and entering the receiving waters.

Three key strategies will be adopted:

- **Drainage control** – prevention or reduction of soil erosion caused by concentrated flows and appropriate management and separation of the movement of clean and dirty water through the area of concern.
- **Erosion control** – prevention or minimisation of soil erosion (from dispersive, non-dispersive or competent material) caused by rain drop impact and exacerbated overland flow on disturbed surfaces.
- **Sediment control** – trapping or retention of sediment either moving along the land surface, contained within runoff (i.e. from up-slope erosion) or from windborne particles.

Section 4.2, Section 4.4 and Section 5 discuss sediment and erosion controls in more detail.

The Project has the potential to impact on water quality in Unca Creek and its tributaries due to controlled and uncontrolled releases of water.

The results of the water balance model show that no uncontrolled releases are predicted from the process water dam in any of the water balance model simulations (Appendix C5). Therefore, the Project will not release any mine affected water or dewatered groundwater to the environment.

The water balance model predicts a 10% chance of uncontrolled water releases from the waste rock sediment dams in the first four years of the Project and then an increased chance beyond that. Geotechnical assessment indicates runoff from the waste dumps will be is similar in quality to background runoff from undisturbed catchments (i.e. will not contain acid rock drainage or significantly elevated concentrations of metalloids). The sediment dams are designed to allow TSS and associated metalloids to drop out of suspension and therefore any overflowing water would likely achieve the water quality objectives. Therefore, it is considered that the predicted uncontrolled releases from the waste rock sediment dam are unlikely to have any impact of significance on water quality in Unca Creek, as they will occur when there is likely to be some flow in the receiving watercourses and the uncontrolled releases are likely to be of similar quality to background water quality.

4.5.4.3 Groundwater

Potential Receptors

Receptors are considered to comprise third party infrastructure, water supplies and locations with environmental or heritage value that occur within 10 km of the mine lease area and along potential surface or near-surface flow paths.

Key environmental receptors and endpoints potentially sensitive to changes in water quality include:

- Receiving aquatic systems (waterways, wetlands, groundwater recharge zones, aquifers)
- Fauna and livestock (consumption); and
- Humans (recreation and consumption).

There are no identified groundwater dependant ecosystems (GDE's) in the study area and the depth to groundwater generally precludes ecosystem use.

The potential groundwater impacts are:

- Water table drawdown from borefield pumping
- Water table drawdown from dewatering of mine features
- Groundwater contamination from waste rock dump leachate seepage
- Groundwater contamination from tailings leachate seepage; and
- Groundwater contamination from spills at the mine.

Bore Field

The main groundwater impact of the Project is pumping from the water supply borefield. The process water supply comprises four planned bores abstracting up to 3.9 ML per day (45 L/s, 1.4 GL/year) for 10 years. Bores will be completed into the Georgina Basin Carbonate Aquifer at a site 10km to the north of the mine site.

Groundwater modelling was undertaken to predict impacts of groundwater pumping on receptors (Appendix C6). The extraction from the proposed borefield is within the capacity of the aquifer and removes a very small fraction of the immense volume in storage. The results from the drawdown analysis suggest that, for the 10 years scheduled concept mine plan, it is probable that a maximum drawdown of 0.5 – 1.0 metres can be expected at the closest pastoral bore (RN011102 & RN013274) and drawdown of less than 0.5 metre will be observed at the Lucy Creek homestead bore (RN011495), which has an available drawdown of 11 metres based on a total depth (TD) of 18.6mBGL and standing water level (SWL) 7.6mBGL at 13/12/1976. This level of drawdown is not expected to reduce the availability of water for these users since the depth of the bores is greater than 1.0 m below the water table.

Drawdown at the end of mining is predicted to extend less than 2 – 3 km from the borefield to the 0.5m drawdown contour. Groundwater levels are forecast to recover to 90% of pre-mining levels after about 10 years post closure.

The groundwater dependent River Red gum community along the Unca and some tributary creeks may be sensitive to large draw down of the groundwater in the creeks.

Pits and underground mine

The mine excavations extend below the water table and groundwater levels are expected to drawdown due to dewatering.

The water table at the mine site has been measured at 320 - 330 mAHD (20 – 30m below ground level). The maximum pit depth at Bellbird is 100 m below ground surface and Reward is 140 m below ground surface approximately 261 mAHD and 215 mAHD respectively. Bellbird will intersect the water table at the end of year 6 and Reward will intersect the water table after the end of year 1.

The Bellbird and Reward underground mines will be constructed beneath the water table and can expect groundwater inflows at commencement of excavations. Rockface will commence decline construction above the water table, however, the excavation will intersect the water table in the first half of year 1 in the mine schedule.

Dewatering of the Fractured Rock groundwater system due to mining activities will cause declining water levels in the vicinity of the mine tenement, which will have impacts on existing groundwater users. The results from the drawdown analysis suggest that, for the 10 years scheduled concept mine plan, it is probable that a maximum drawdown of 0.5 – 1.0 metres can be expected at a distance of less than 1 km from the tenement boundary.

Post-closure the excavations are expected to slowly fill with groundwater. The underground mines will fill to the pre-mining levels and the pits will form lakes where the final pit-lake water levels will be dependent on the balance between groundwater inflows and evaporation from the pit-lake surface. Modelling predicts that 200 years after the commencement of mining (190 years post closure), the extent of the 0.5 metre drawdown is less than 3 km and no discernible impacts are observed at the closest pastoral bore (RN018078) or at the Orrtipa-Thurra community water supply (18 km).

Leachate seepage from waste rock dumps

Waste rock dump (WRD) leachate quality is identified as being predominantly non-acid forming (NAF). Seepage only occurs under high intensity rainfall events. The fate of leachate downgradient of the waste rock dumps (WRDs) has been forecast using the flow field calculated by the numerical groundwater modelling and random walk particle tracking. The fate of particles seeded beneath the WRDs at the end of LOM are presented in Figure 4.5-1 and at year 200, that is 190 years after the mine closure (Figure 4.5-2)**Error! Reference source not found.**. The WRDs downgradient seepage is expected to be slow due to the low permeability of the Fractured Rock groundwater system and ultimately any WRD seepage is expected to be captured by the local groundwater sinks formed at the Bellbird and Reward pit-lake.

There are no receptors within this distance, and the beneficial use of the water will be unchanged.

Leachate Seepage from Tailings Storage Facility

The mine operation tailings will be stored in a tailings storage facility (TSF) to the west of Reward pit. TSF leachate quality is identified as being potentially acid forming (PAF). Underdrainage will be implemented to intercept seepage from TSF. Without proper control some tailing liquor may seep from storage in the TSF to the groundwater table. This may result in some increase in groundwater level and change to the chemical composition of groundwater.

The fate of leachate downgradient of the TSF has been forecast using the flow field calculated by the numerical groundwater modelling and random walk particle tracking (Appendix C6). The fate of particles seeded beneath the TSF at the end of LOM are presented in Figure 4.5-1 and at year 200, that is 190 years after the mine closure (Figure 4.5-2)**Error! Reference source not found.**.The TSF downgradient seepage is expected to be slow due to the low permeability of the Fractured Rock groundwater system and ultimately any TSF leachate is expected to be captured by the local groundwater sink form at the Reward pit-lake.

There are no receptors within this distance, and the beneficial use of the water will be unchanged.

Thus, although seepage from the tailings storage facility (TSF) to the water table is expected, it is considered to present a low risk to groundwater at this project due to the benign nature of the tailings the Reward pit-lake will effectively capture seepage sourced from TSF preventing the migration of TSF seepage off-tenement.

Groundwater contamination from spills at the mine site

Groundwater contamination might occur through spills of hazardous material at the mine site or during transport. The risk will be managed through appropriate storage and transport of hazardous materials.

Accidental spills or will be managed in accordance with the Emergency Response Management Plan (ERMP) including the Environmental Investigation Procedure.

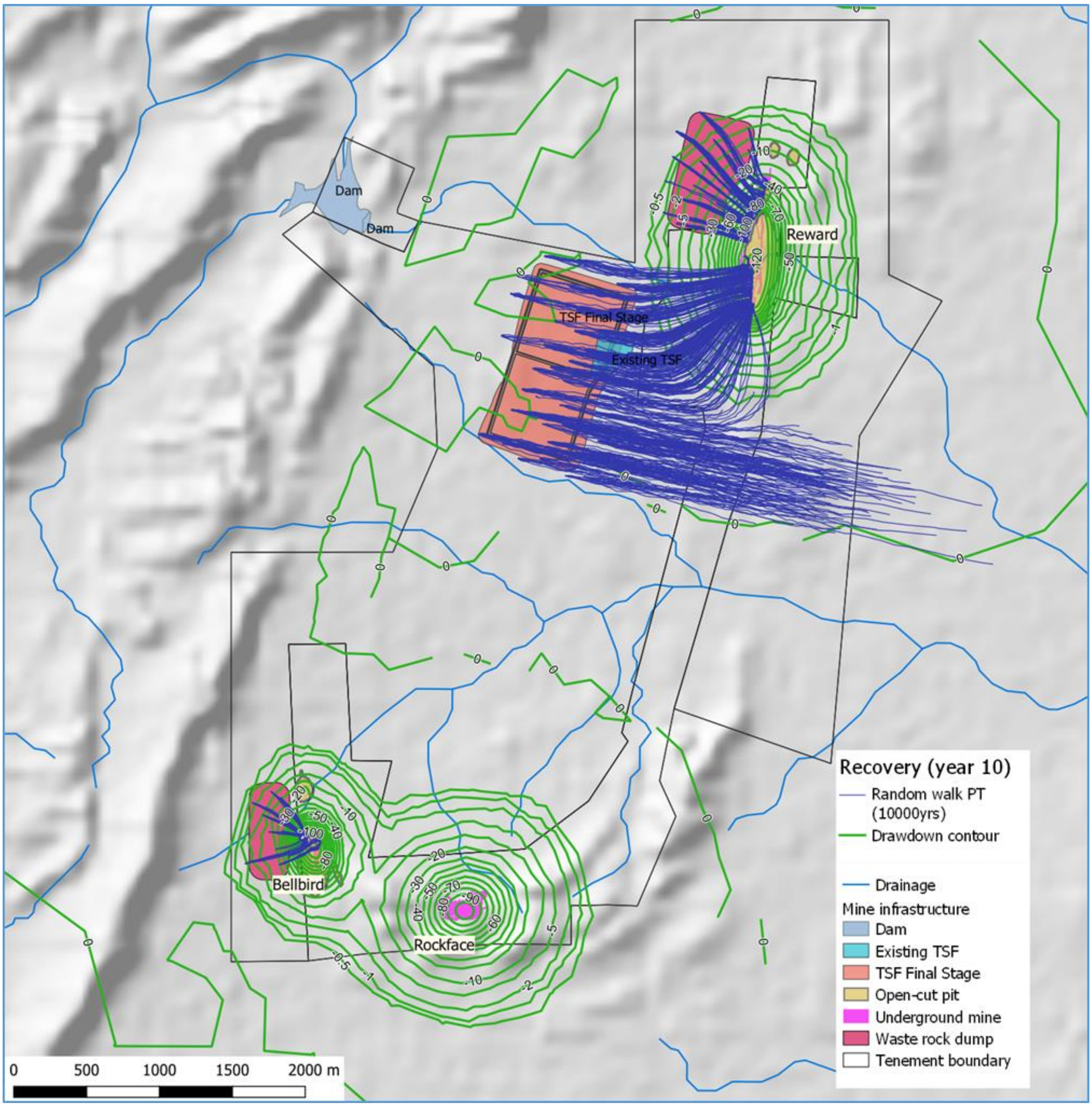

Figure 4.5-1 Random walk particle tracking and drawdown contours at end of LOM year 10 (CloudGMS 2018)

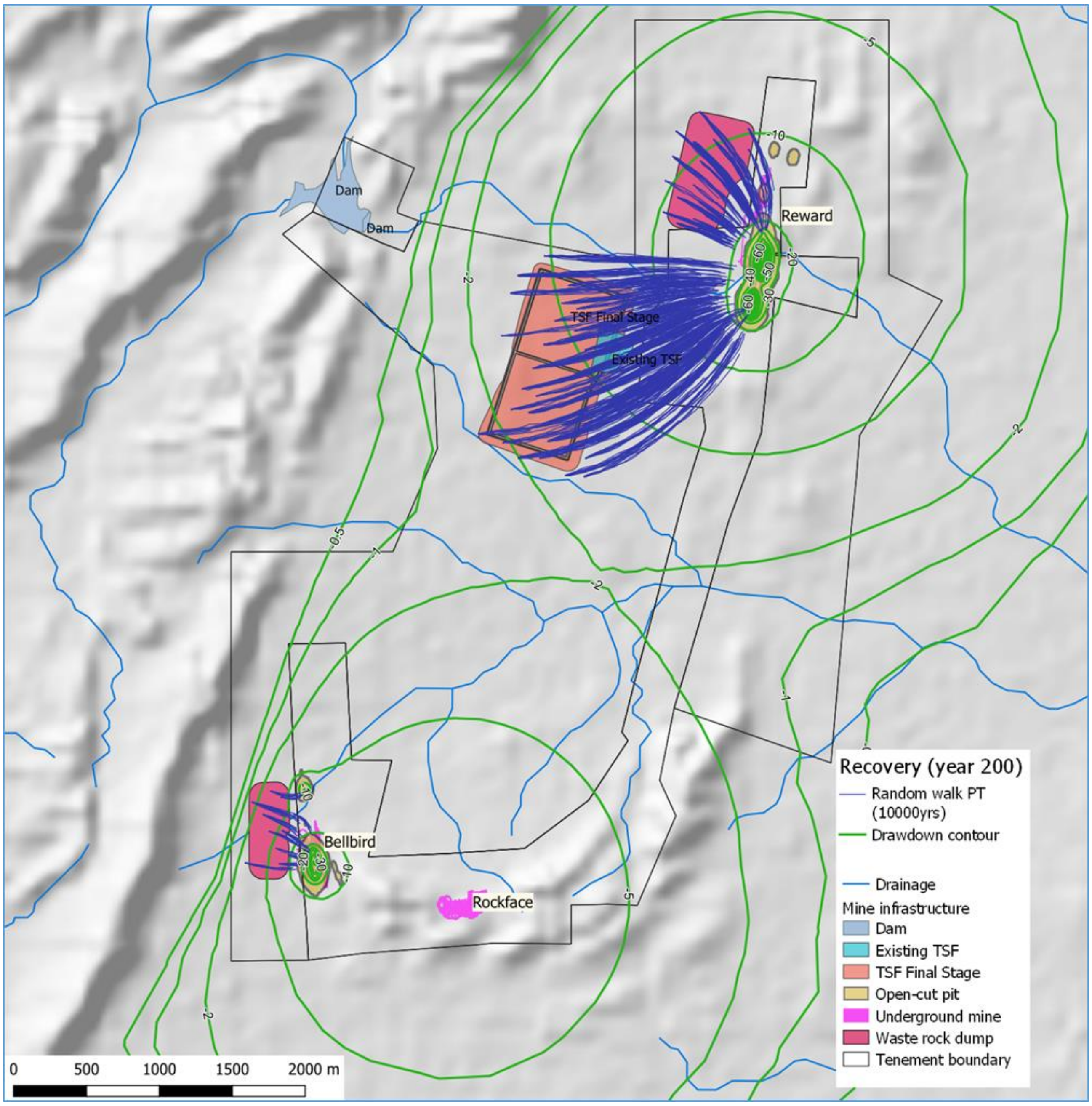

Figure 4.5-2 Random walk particle tracking and drawdown contours at year 200 (ie 190 years since mining ceased) (CloudGMS 2018)

4.5.5 Mitigation and Monitoring

During the development of the Project, risks have been considered and where possible removed or reduced as part of the design process. Risks relevant to water resources and water dependent environments and users have been considered. The elimination of risk is achieved by removing a source, pathway or receptor. If this proves impractical then a risk is managed by the implementation of project controls, which are outlined in the Environmental Management Plan (Section 5).

All works undertaken at the site, including construction, operation and decommissioning, will be subject to the an overarching Environmental Management Plan (Section 5), which includes mechanisms for monitoring, auditing and non-conformance correction as part of the quality control and continual improvement process.

In order to maintain the environmental values of receiving waters around the mine, a series of sub-plans have also been prepared; Water Management Plan, Groundwater Management Plan, Erosion and Sediment Control Plan, Waste Management Plan, and Mine Rehabilitation and Closure Plan (refer Section 5). Through the implementation of the environmental plans, it is not anticipated that there will be any adverse impacts from water contamination to the downstream environment.

4.5.5.1 Approach to Mine Water Management

A Water Management Plan has been prepared for the Project (Section 5). Mine water will be managed based on quality using the mine water quality classification system (refer Section 4.4 and Section 5). The classification of mine water in each storage is affected by the water source (e.g., catchment, land use interactions, etc.), water use and interactions with other waters on site. Water from different sources will be managed separately (Figure 4.5-1).

The quality of water stored in each mine water storage will be sampled regularly as part of the mine's proposed water quality monitoring program to identify trends in water quality over time, inform mine water management decisions and comply with the water discharge license.

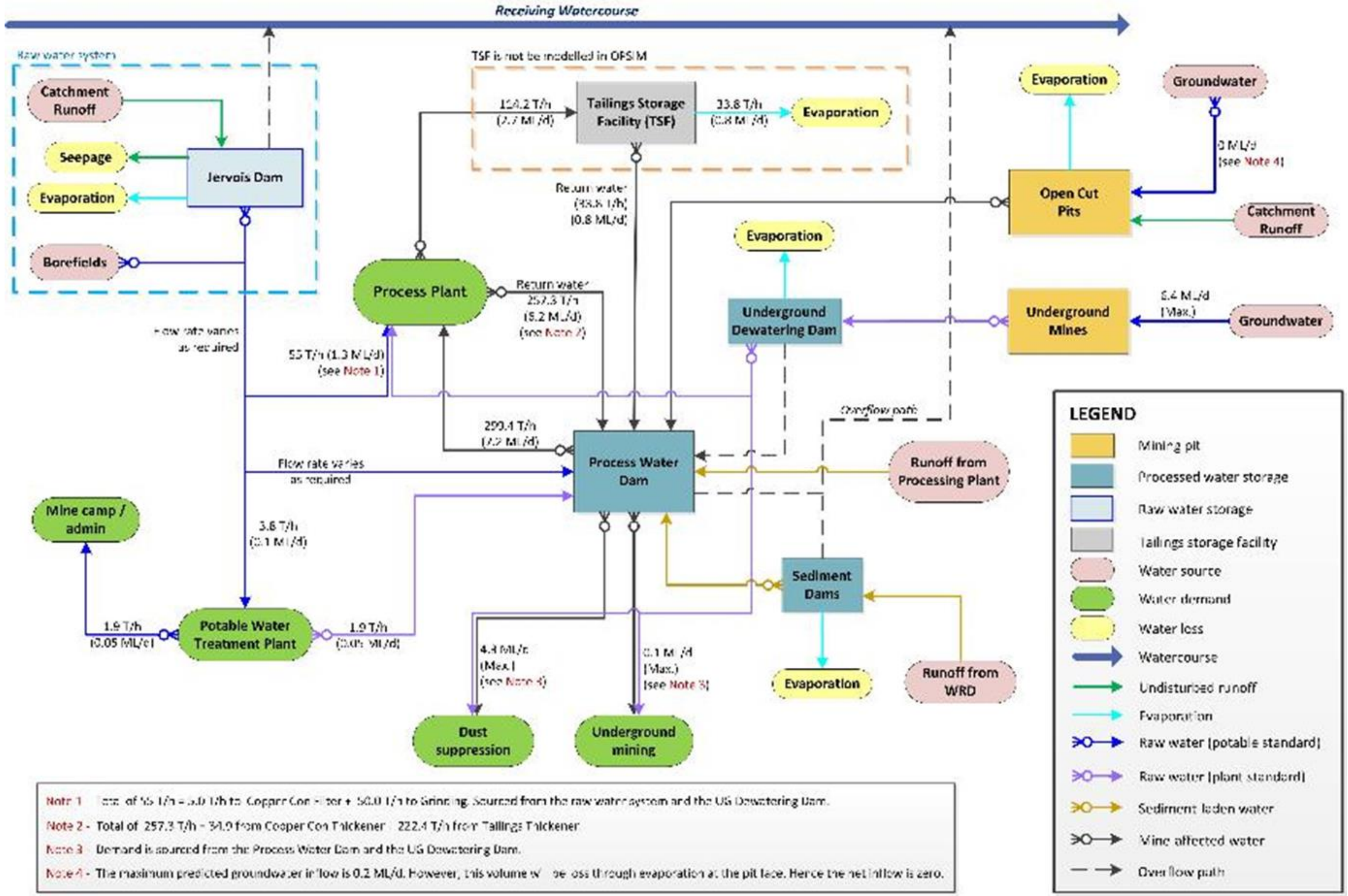

Figure 4.5-3 Water management system schematic

The Project design has incorporated a number of control measures to minimise the potential for the release of contaminants to the environment. These include:

- Diversion of clean water around the site
- Collection of potentially contaminated water (e.g. mine affected water, and groundwater seepage)
- Process water dam (180 ML) which will receive: mine affected runoff, pumped transfers from waste rock dump sediment dam, pump transfers from open cut pits and overflows of raw water from the underground mine dewatering dam
- storage of diesel at the mine site in self-bunded tanks
- Selection of waste rock material and dump methodology so that runoff will generally be similar to background runoff
- Repair and enlargement of Jervois Dam
- Tailings Storage Facility (TSF) with sufficient capacity to contain all runoff from tailings storage area. No runoff, process water or tailings will be released from the TSF.
- Sediment dams to collect runoff and allow suspended solids and associated metalloids to drop out of suspension; and
- Flood protection bunds along the right bank of Unca Creek and the Unca Creek Diversion to protect the final void and the TSF from flooding up to the PMF.

Authorised Discharge, Water quality objectives and trigger values

The water quality objectives (WQOs) adopted for the Project have been described earlier and it is anticipated that these WQOs will be applied to any water discharge licence issued for the Project site.

The water balance model suggests that managed releases will not be required from the Project, however a water discharge license will still be required to ensure flexibility for water management at the Project. Managed releases from an authorised discharge point are permitted only when the managed release will not contribute to the exceedance of water quality trigger levels specified in the water discharge license.

4.5.5.2 Erosion and Sediment Control

Erosion and sediment control has been discussed in Section 4.2. An Erosion and Sediment Control Plan (ESCP) has been prepared to assist in the management, reduction and mitigation of erosion and consequent sediment transport within and from the Jervois mine (refer Section 5.1F). The primary goal of the ESCP is to prevent unacceptable levels of sediments and contaminants from leaving the lease and entering the receiving waters. The ESCP adopts three core strategies to achieve this:

- **Drainage control** – prevention or reduction of soil erosion caused by concentrated flows and appropriate management and separation of the movement of clean and dirty water through the area of concern.

- **Erosion control** – prevention or minimisation of soil erosion (from dispersive, non-dispersive or competent material) caused by rain drop impact and exacerbated overland flow on disturbed surfaces;and
- **Sediment control** – trapping or retention of sediment either moving along the land surface, contained within runoff (i.e. from up-slope erosion) or from windborne particles.

Strategies to minimise increased risk of erosion during the operation phase of the mine site include:

- Minimise the extent of the disturbance
- Prompt revegetation of non-operational disturbed area
- Ensure both temporary earthworks and permanent land-shaping provide a landform that minimises erosion; and
- Design temporary runoff collection, conveyance and disposal systems to minimise erosion prior to commencement.

Erosion and sediment control structures will be regularly inspected and monitored for performance. Water quality (turbidity) in sediment dams at the Jervois mine will be monitored following a significant runoff event occurring. Controlled releases will only be made if testing indicates that water is of suitable quality to meet water quality objectives and water discharge license conditions.

4.5.5.3 Management of hazardous substances

Storage and handling of hazardous substances will be carried out as specified in their relevant MSDS, including regular inspection and maintenance of storage facilities. Storage, transport and use of explosives on site will be conducted in accordance with AS 2187 Explosives Code – Northern Territory.

Procedures for transport and storage of hazardous substances will be implemented as part of the Health and Safety Management System and will be in accordance with the requirements of the *Transport of Dangerous Goods by Road and Rail (National Uniform Legislation) Act 2016* and *Transport of Dangerous Goods by Road and Rail (National Uniform Legislation) Regulations 2016*. Hydrocarbons, flammable and combustible material will be stored according to the requirements of *AS1940-2004 The storage and handling of flammable and combustible liquids*.

4.5.5.4 Groundwater Monitoring

Groundwater monitoring will comprise:

- Monitoring of drawdown in proximity to the process water supply borefield
- Monitoring of drawdown between the process water supply borefield and third-party bores
- Monitoring of drawdown in proximity to the mine excavations (pits and underground workings)
- Monitoring of drawdown between the mine excavations (pits and underground workings) and third party bores
- Monitoring of dewatering volumes from the pits and underground excavations
- Monitoring at third-party bores; and
- Monitoring adjacent to the TSF to assess mounding and groundwater quality changes due to any seepage.

Proposed monitoring locations around the Project mine site are presented in Figure 4.5-4.

Water levels at all bores will be measured monthly typically by data logger, downloaded at least annually.

Water quality will be monitored annually at all observation bores, and quarterly at pumping bores, WRD and TSF seepage monitoring bores. A full suite of analytes per Table 4.5- will be analysed at all bores. The monitoring suite and frequency will be reviewed and optimised following two years data collection.

The volume of water pumped from each bore, and the borefield total will be recorded at least monthly, using totalizer flow meters at each bore head.

Table 4.5-3 Groundwater monitoring analytical suite

pH Value	Aluminium	Manganese
Electrical Conductivity	Antimony	Molybdenum
Total Dissolved Solids	Arsenic	Selenium
Total Alkalinity as CaCO3	Beryllium	Silver
Sulfate as SO4 -	Barium	Vanadium
Chloride	Cadmium	Tin
Calcium	Chromium	Uranium
Magnesium	Cobalt	Boron
Sodium	Copper	Iron
Potassium	Nickel	
Silicate	Lead	
Fluoride	Zinc	
Nitrate as N	Mercury	

4.5.5.5 Groundwater trigger levels and mitigation measures

Watertable drawdown from borefield pumping and mine dewatering

Monitoring of bores will be undertaken as described above.

The groundwater model will be run annually to estimate drawdown at each of these observation bores using the groundwater pumping data recorded at the process water supply borefield and mine dewatering.

Trigger: measured drawdown at observation bores exceeds the range of drawdown predicted by modelling.

Mitigation measures:

- Development of a Class 2 Groundwater flow model will be undertaken in accordance with the Australian Groundwater Modelling Guidelines (Barnett et al., 2012)
- Make-good measures at other users to ensure water availability. For example, deepening bores and upgrading pumps
- Increased process water efficiency to be studied and implemented if practicable; and
- Modified pumping regimes to be implemented if significant impacts associated with groundwater drawdown are identified.

Waste rock dump leachate seepage

Waste rock is anticipated to be deposited to WRDs dry, however, seepage may result during significant rainfall events. It is unlikely that these events will result in groundwater level rises, although deterioration of water quality may occur. Groundwater quality downgradient of waste rock dumps will be monitored at 4 observation bores to detect for the impacts of seepage if it occurs.

Trigger Levels:

- Water level rise beyond seasonal variation; and
- Water quality deteriorating from baseline.

Mitigation measures:

- Assess the impact of water table rise; and
- If seepage from the WRDs causes unacceptable impacts (change in beneficial use) then design and implement seepage management measures.

TSF leachate seepage

Groundwater levels and water quality downgradient of tailing storage will be monitored at 6 observation bores to detect for the impacts of seepage if it occurs.

Trigger Levels:

- Water level rise beyond seasonal variation; and
- Water quality deteriorating from baseline.

Mitigation measures:

- Assess the impact of water table rise.

If tailing seepage causes unacceptable impacts (water table rise to near surface or change in beneficial use) then design and implement seepage management measures.

4.5.5.6 Post-mining monitoring and maintenance

During mine closure, an extensive closure monitoring program will be incorporated into the updated mine closure rehabilitation plan (refer Section 5) to investigate the success of rehabilitation and whether completion criteria are being achieved and to identify any additional work required to meet success criteria. Rehabilitation will be monitored during operations and after final rehabilitation has been completed.

Monitoring will include:

- Plant establishment, growth, diversity and cover
- Evidence and type of erosion
- Water quality including groundwater and surface water
- Air quality
- Landform stability including cover system performance
- Soil quality; and
- Fauna.

It is expected that maintenance will be required on localised eroded areas and drainage lines for the first couple of years after closure until vegetation is established, including repair to surface water management structures, repair of any erosion areas or reseeding of areas due to poor vegetation establishment.

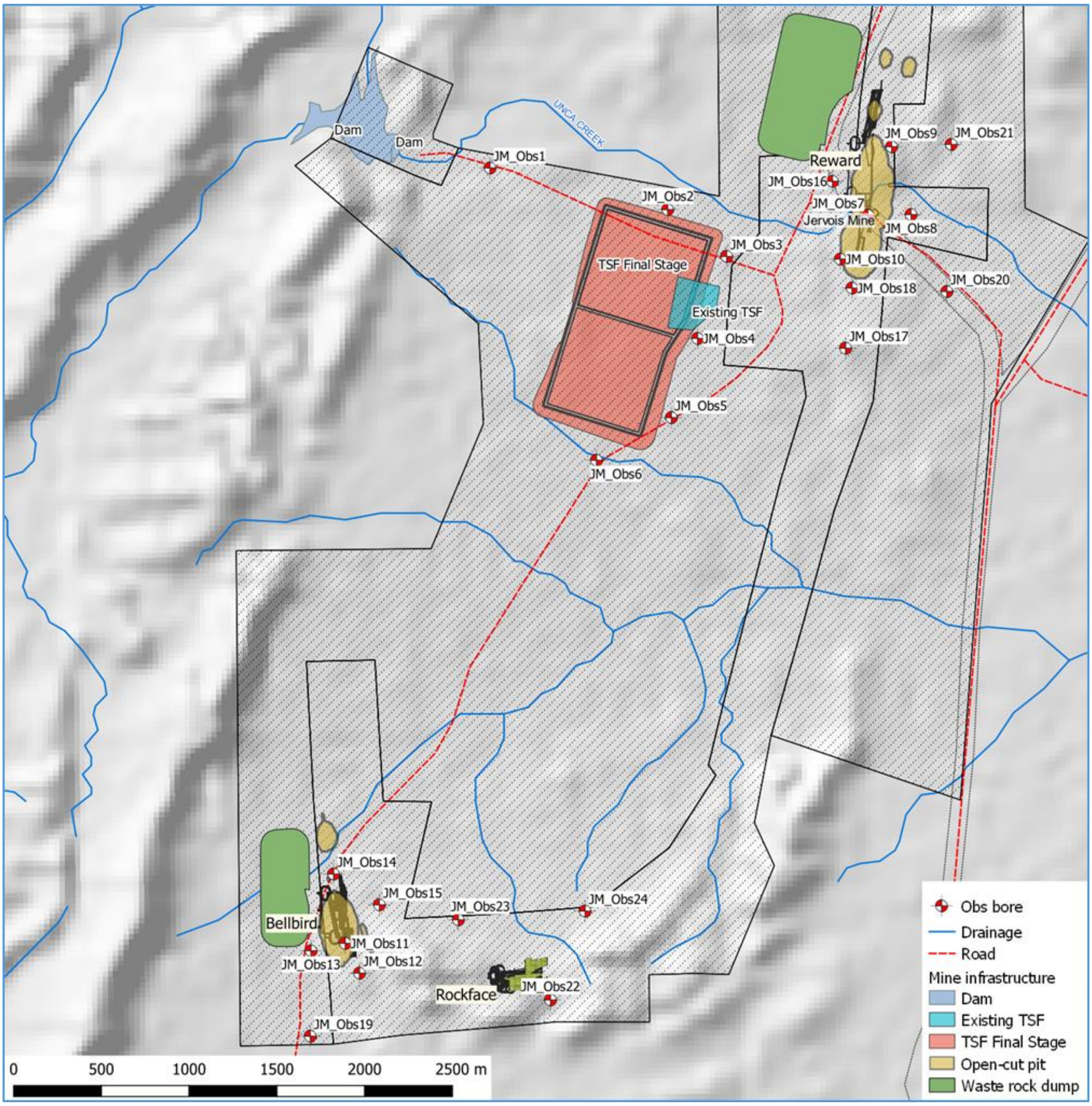

Figure 4.5-4 Locations of planned observation bores around the Jervois mine site

4.5.5.7 Waste Management

A Waste Management Plan has been prepared to provide a framework to manage potential environmental risk associated with non-mineral waste. Key strategies include:

- **Inert waste and municipal solid waste** – a landfill be constructed at the Project site for the disposal this waste. Wastes that would go to the landfill would include: inert waste (concrete, clay and other unwanted inert waste), general waste (including food scraps), non-recyclable plastics, non-recyclable glass and glass bottles, used air filters, PPE, other benign solid waste

- **Sewage and greywater** - Sewage and grey water will be treated by licensed onsite sewage treatment facilities including a plant and septic tank systems as required
- **Recyclable waste** - Where practicable, recyclable waste including class 1, 2, 5 plastics, aluminium and steel cans, scrap steel, cardboard, paper, recyclable glass bottles and other recyclable waste will be collected in designated areas or bins, collected and transported to off-site recycling collection facilities by licensed contractors
- **Green waste** - Cleared vegetation will be stockpiled and used for rehabilitation where possible or stockpiled and burnt on site in designated areas; and
- **Listed waste** – solid listed wastes will be collected in designated containers, collected and transported off-site for treatment and/or disposal by licensed contractors. Acidic solutions or acid in solid forms, perchlorates and other chemical waste from the laboratory will be collected and transferred to designated containers, neutralised with a suitable alkali (lime) and discharged into the tailings dam feed stream. Reagents used for processing in the processing plant, including process water will be recycled and reused where possible. Excess process water will be discharged into the tailings dam.

4.5.5.8 Emergency Preparedness and Response

Potential environmental emergency situations are to be managed through the Jervois Mine Emergency Response Plan. This plan will be developed by KGL to ensure that the potential environmental emergency situations arising from a variety of causes, directly or indirectly related to the Jervois Mine are addressed.

This plan will provide clear guidance on the:

- Emergency Procedures to be undertaken upon the unlikely event of an environmental emergency situation occurring; and
- Emergency contact register including the contact names and phone numbers of key Project personnel, other relevant authorities, and off-site emergency services.

The Environmental Management Plan and the various sub-plans also reference the Emergency Response Plan to create an integrated system.