Verdant Minerals Pty Ltd

Ammaroo Phosphate Project - EIS Supplementary Report

August 2018

Table of contents

Table index

Figure index

Appendices

Appendix 1 – Updated Ammaroo Closure Report

Appendix 2 – Tailings Storage Facility Drawings (WSP 2018)

Appendix 3 – Peer Review of AMD Assessment

Appendix 4 – Water Balance (WSP 2018)

Appendix 5 – Historical Rehabilitation Time Series

Appendix 6 – Water Management Plan

Appendix 7 – Peer Review of Groundwater Monitoring Program

Appendix 8 – Tailings Characterisation Report (SCG Minerals Services, 2017)

Appendix 9 – Tailings Process Water Test Work

Appendix 10 – Geochemical Assessment of Phosphate Flotation Tailings (EGI 2014)

Appendix 11 – Declaration – Peer review of AMD Report and Management Plan

Appendix 12 – Barrel leachate results, July 2018

1. Introduction

1.1 Overview

An Environmental Impact Statement (EIS) for the Ammaroo Phosphate Project was submitted to the Northern Territory Environment Protection Authority (NT EPA) in October 2017. As per the NT EPA environmental assessment process the document is a Draft EIS, however for ease of reference, is herein referred to as the EIS.

The EIS was circulated to agencies and available for public comment. A total of 150 written submissions (e.g. comments) on the EIS were received from NT Government advisory bodies and agencies, and two non-government organisations.

These submissions on the EIS are addressed in the form of a Supplement, or Supplementary Report, to the EIS.

Pursuant with clause 12 of the Environmental Assessment Administrative Procedures, Verdant Minerals Ltd (Verdant) prepared this Supplementary Report to address individual submissions to the EIS.

1.2 Structure of the supplementary report

The 150 submissions, and the corresponding Agency/Organisation that made the submission, are tabled in Chapter 2. A response number was assigned to each submission for ease of reference.

The structure of this Supplementary Report is:

- Chapter 1 Introduction - providing an overview of the status of the project environmental assessment process and the structure of the report.
- Chapter 2 Responses – responses to submissions tabled by Agency/Organisation with response number, each individual submission and Verdant’s response to those submissions.
- Chapter 3 Additional Information – provides additional information about environmental impact areas, cross referenced to individual submissions tabled in Chapter 2.
- Chapter 4 Commitments – lists commitments provided in the supplement responses.
- Chapter 5 References
- Appendices –provided to support responses or provide additional information. Reference to Appendices to this report have been named numerically (1, 2, 3 etc.) rather than the usual alphabetical naming (A, B, C, etc.) to avoid confusion with references to the Appendices that are contained within the EIS.

Verdant has, where possible, responded to similar submissions only once and some submissions may be addressed by referring to the response to a previous submission.

1.3 Scope and limitations

This report: has been prepared by GHD for Verdant Minerals Ltd and may only be used and relied on by Verdant Minerals Ltd for the purpose agreed between GHD and the Verdant Minerals Ltd as set out in Section 1.1 of this report.

GHD otherwise disclaims responsibility to any person other than Verdant Minerals Ltd arising in connection with this report. GHD also excludes implied warranties and conditions, to the extent legally permissible.

The services undertaken by GHD in connection with preparing this report were limited to those specifically detailed in the report and are subject to the scope limitations set out in the report.

The opinions, conclusions and any recommendations in this report are based on conditions encountered and information reviewed at the date of preparation of the report. GHD has no responsibility or obligation to update this report to account for events or changes occurring subsequent to the date that the report was prepared.

GHD has prepared this report on the basis of information provided by Verdant Minerals Ltd and others who provided information to Verdant Minerals Ltd, which GHD has not independently verified or checked beyond the agreed scope of work. GHD does not accept liability in connection with such unverified information, including errors and omissions in the report that were caused by errors or omissions in that information.

2. Responses

2.1 Northern Territory Environmental Protection Authority

No.	Agency	Topic	EIS section	Comment (Submission)	Response
1	NT EPA	Project key components	Chapter 2: Project Description Figure 2-2 Section 2.2	Mine site components consist of the removal of overburden and temporary storage in waste dumps and/or placement in completed pits. Clarify timeframe for temporary storage of waste rock in these WRDs, conceptual design and the rehabilitation and closure for these landforms.	<u>Timeframe</u> Waste rock from the open pit will be stockpiled until rehabilitation begins. Pits have been staged so that they are open for a period of five years before rehabilitation and closure would commence. Rehabilitation of each pit may take up to five years. Therefore, waste rock will be stored in waste rock dumps for up to ten years. <u>WRD conceptual design</u> The shape/design of these waste rock stockpiles will depend on the efficient stockpiling of the materials using available mining equipment, and the angle of repose of the material. <u>Rehabilitation and closure</u> Once the waste rock has been returned to the pit the WRD footprint will be rehabilitated if not required for storage of waste rock from another pit. Once the storage area is no longer required it will be rehabilitated as per Section 3.6 of the updated Closure Report (refer Appendix 1). Also, refer to the rehabilitation time series of previous rehabilitation on site (Appendix 5).
2	NT EPA	Tailings Storage Facilities	Chapter 2: Project Description 2.4.3 Table 2-5 Table 2-9 Section 2.6	*A surface tailings storage facility will be constructed to hold the first three years of tailings, after which time tailings will be placed in-pit and capped with overburden during the rehabilitation process. A total of 5.3 Mt of surface tailings storage is proposed for the life of mine.* Clarify whether there is an option to transfer this surface storage of tailings to in-pit as part of mine closure. If surface tailings are to remain on the surface as part of closure, clarify the progressive rehabilitation schedule and options for this landform, including capping when dry and preventing infiltration of rainfall. The NT EPA notes the surface TSF will be designed in accordance with ANCOLD guidelines. If the surface TSF is to be a permanent landform, provide information that demonstrates it meets ANCOLD primary design objectives of: •Safe and stable containment of tailings •Management of decant and rainfall runoff •Minimisation or control of seepage •Cost effective storage system •Planned system for effective closure Provide information on whether the TSF site selection, design, construction, operation and decommissioning would be overseen by an Independent Certifying Engineer.	<u>Surface TSF Closure</u> The surface tailings will remain within the surface TSF as part of closure. Noting the low risk of the solid tailings and associated water (refer to section 3.1.1 for further information) to underlying groundwater, and to surface water ecosystems providing runoff is managed as proposed, the current intent is that the surface TSF will remain open for the life of mine as a contingency for additional tailings storage, and specifically for an alternate use such as rainfall capture and temporary water storage after significant rainfall events; thus potentially reducing the demands on the ground water resource. Once the surface TSF is no longer required, it will be rehabilitated. Rehabilitation will occur only when the deposited tailings have achieved sufficient strength to support earthmoving equipment on the exposed surface of the TSF. The updated Closure Report (refer Section 3.4 of Appendix 1) details the schedule and closure objectives for the facility. As detailed in the Closure Report the post-mining landform will be a shallow convex shaped (gently water shedding) tailings storage landform with radial surface drainage. There is no requirement for the final landform to prevent the infiltration of rainfall as the tailings are not considered to be a source of significant risk to groundwater quality (refer to section 3.1.1 for further information). <u>Surface TSF and ANCOLD design objectives</u> Refer to Section 3.2 for information on the design principles for the surface TSF. Refer drawings provided in Appendix 2 for detailed design of the surface TSF. <u>Certifying Engineer</u> An appropriately qualified Certifying Engineer will oversee the design, construction, operation and decommissioning of the surface TSF. This has been included as a commitment.
3	NTEPA	Tailings Storage Facilities	Waste characterisation	Given the geochemical composition of the tailings (see detailed geochemical assessment report appended to this EIS), the tailings facilities will be unlined. Provide independent peer review of the geochemical assessment report that confirms the tailings is benign and seepage risk is low enough that the surface and in-pit TSFs can be designed to be unlined.	An independent peer review of the AMD assessment and Management Plan has been completed. The peer review report is at Appendix 3. The detailed EGI geochemistry report is available at Appendix 10, and subsequent SGS analysis is provided in Appendix 8. A declaration from the independent peer reviewer, RGS Environmental Pty Ltd, is provided at Appendix 11. The declaration concludes that the GHD document effectively covers the key requirements of a geochemical assessment process for the proposed phosphate mining operation in Northern Territory, and meets the requirements of Australian and International guidelines associated with geochemical assessments at proposed mining operations. The declaration endorses the GHD document conclusions and management recommendations.

No.	Agency	Topic	EIS section	Comment (Submission)	Response
4	NT EPA	Surface Tailings storage facility design and operation	Chapter 2: Project Description 2.6.1 Table 2-9 – TSF concept design parameters	*The slurry (concentration approximately 40% water) then flows out of the raiser and forms its own beach slope which then dictates the future slurry flow patterns and water recovery at the toe of the impoundment wall* The NT EPA recognises the Proponent has committed to water recovery of 20-30% of the water discharged in the tails. Provide information on options to reduce quantity of water in the slurry to further minimise water consumption. Table 2-9 indicates slurry density is 40% solids Clarify the percentage solids for the slurry density – 40% or 60%. In section 2.10 VRM has committed to conducting test work to establish the capacity of the tailings water to separate from the tailings and the capability to extract/recover this water from the tailings facilities, using pumps. Clarify that current water recovery from the tailings is able to achieve 20 -30 % or is achieving this rate of water recycling subject to this further test work.	Refer to Section 3.3 for further information on tailings slurry density and water recovery.
5	NT EPA	Tailings storage facility ANCOLD guidelines	Chapter 2: Project Description Section 2.6.3	*Emergency spillway - it will be located to ensure protection of the facility walls and any downstream infrastructure.* Provide the location of the TSF spillway and provide results of modelling that shows the quality and fate of the overflow water, including consideration of erosion issues.	Refer to Section 3.2.8 and detailed design drawings of the surface TSF provided in Appendix 2.
6	NT EPA	Tailings storage facilities closure	Chapter 2: Project Description 2.6.4	*The surface of the facilities will be capped such that the final profile will be a slightly domed structure to allow for further settlement.* The TSF decommissioning plan must be developed with the overall mine closure plan and the NT EPA recognises it is conceptual at this stage. Provide details on the appropriateness of the proposed capping and that it would be erosion resistant, non-leaching and sufficient to prevent infiltration that may contribute to long term seepage impacts.	The purpose of the cover material is to achieve a stable and functioning landform. There is no requirement for the final landform to prevent the infiltration of rainfall because tailings test work to date (as discussed in Section 3.1.1) indicate that the various soluble constituents that were elevated in the ore and waste rock leachate (ASLP) have been removed (and would be directed to the water storage ponds). The tailings leachate metal and metalloid concentrations are lower being higher than the ADWG (with minor exceptions), and consistent with the underlying groundwater. As with the surface TSF, following the completion of deposition within each in-pit TSF, it is expected that the deposited tailings will be left exposed to the atmosphere to permit ongoing desiccation of the tailings surface and consolidation of the tailings body as a whole. It is expected that a pond of supernatant water will form from the consolidating tailings that will require periodic removal. Periodic removal of the water using a pump will aid in the ongoing consolidation of the tailings. Once the in-pit TSF is no longer going to be used as a potential future storage area, and the deposited tailings have achieved sufficient strength to support earthmoving equipment the exposed surface will be backfilled with waste rock and tailings to reinstate the natural surface levels. The resultant profile will be such that the facility will no longer require the management/recovery of water as any incident rainfall will be shed from the facility. The design will take into account the expected consolidation of the tailings stack. Following capping with mine waste, topsoil will be reinstated across the surface and vegetated. Section 3.4 of the updated Closure Report (Appendix 1) details the further research and investigations that will be undertaken including further assessment of the characteristics of available cover materials. The results of the test work may influence closure methodology (e.g. design, thickness). Also, refer to Appendix 5 for time series photos of test pit rehabilitation completed on the Project site to date.
7	NT EPA	Infrastructure corridor	Chapter 2: Project Description 2.8	*A purpose built haul road, along the same route as the proposed rail spur, to support the trucking of product to the main Adelaide to Darwin railway line remains an option, particularly for the first 5 years of production at the 1 million tonne per annum rate*"(p.41) The proposed rail spur is 105 km in length and the proposed haul road is anticipated to be the same length and proximity. Provide clarification on whether the assessment of impacts to environmental values was conducted for all proposed infrastructure (e.g.	A haul road within the infrastructure corridor is no longer part of the project scope, and is not required for the Project. It is confirmed that impacts to environmental values were conducted for all proposed infrastructure areas – mine areas, rail spur, gas pipeline, access roads, borrow pits, water pipeline corridor and bore field. Comprehensive ground-based surveys, including targeted threatened species surveys and habitat assessments, were conducted throughout all habitat types intersecting the project area (refer to EIS Appendix J for survey effort and results),

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				rail spur, gas pipeline, borrow areas proposed haul road) (i.e. within the same 137 km length infrastructure corridor).	and this provided adequate detail to extrapolate environmental values and associated impacts for all disturbance areas (including areas that may have not been directly surveyed on-ground). No significant environmental values were documented by the surveys, and assessment of potential impacts on ecosystem values is contained in Section 7, Appendix J and Chapter 9-10 of the EIS. This information adequately addresses all the proposed infrastructure elements and highlights the lack of environmental values along the rail corridor alignment. Environmental values are limited to: • the rail corridor (including gas pipeline, access road, rail spur and borrow pits) traverses approximately 4.1 ha of marginally suitable habitat for nest sites for the listed Grey Falcon, and no individuals of this species or nest sites were recorded during survey. • sensitive vegetation type, ephemeral swamp, is not directly impacted by the project, although there is one instance where the rail spur crosses a linkage between swamps.
8	NT EPA	Infrastructure corridor	Chapter 2: Project Description 2.8	*The diversion of water courses for the purpose of construction will be confirmed during detailed design and undertaken by a certified practitioner.* Provide the location and conceptual designs of potential diversion of water courses for the construction of the railway in the infrastructure corridor. The Proponent would need to provide details on how any diversion would achieve the following outcomes: • Maintain existing hydraulic flows to downstream reaches • Maintain sediment transport and water quality regimes	There will be no diversion of ephemeral water courses. The access corridor crosses a broad sandy plain that does not include well-defined or permanent watercourses. Meandering drainage lines may form during rain events through natural erosion and scouring processes, however these drainage lines are expected to be refilled with Aeolian sediment after the rain event and during dry periods. During the construction process, standard erosion and sediment controls will be implemented to manage water during rain events. No diversion of drainage lines will be required. The design of the access corridor will include sufficient cross drainage structures (i.e. culverts) to maintain the existing ephemeral hydraulic flows during rain events and the associated sediment transport mechanisms that occur within the sandy plain.
9	NT EPA	Waste water discharge – sediment dams Process water quality	Chapter 2: Project Description 2.11.1 7.4.2	*Surface water is primarily diverted, and any captured water used for dust suppression.* *During large rainfall events or periods of extended wet weather, the sediment dams would overtop and discharge (via a constructed spillway) into the downstream environment.* Provide details on the fate of this discharge from the sediment dams and potential environmental impacts to the downstream environment. Provide alternatives to relying on sediment dams – best practice requires clean water diversion to minimise water inputs. *Process water storages will be turkey's nest dams (i.e. have no external catchment) in order to minimise intercepted external water volumes. During extreme flood events, all reasonable efforts to avoid discharging of process water would be undertaken. This would include the transfer of process water into the open cut pits.* Provide details on expected water quality of process water and whether turkey nests dams would need to be lined.	Discharge from sediment dams Clean water is proposed to be diverted around the site using a series of flood protection berms (figure 4-1, 4-3 to 4-10 in Appendix G in the EIS) in order to minimise the interception of clean water by mining operations. Runoff from disturbed areas of the site would be managed by a series of catch drains and will be diverted to the process water storages. A silt trap will be installed to minimise sediments entering the lined storages. Refer to comment 13 (below) for further information on management of the process water storages. Process water Process water test work has been undertaken, and the data and analysis is submitted in more detail as part of the Supplement (see Appendix 9). Based on recent tailings liquor samples (110362-110364) process water is within drinking and stock guidelines except for fluoride, which is between 3-5 times the guidelines. It also exceeds average ambient groundwater values for arsenic, barium, manganese and fluoride, but has lower concentrations of all other analytes, including uranium. All analysed concentrations were below available FAE95% guidelines, although some LORs were above the guideline, notably cadmium, copper, zinc and total phosphorous. The process water contained relatively elevated sodium leading to a high Sodium Adsorption Ratio of around 30, hence process water may not be suitable for application to clay soils unless soils or water are ameliorated with calcite (lime) or gypsum. Process water may be used on coarser textured (sandy) soils, which are less susceptible to permeability problems (Blane et al., 1993). Process water used for dust suppression will be subject to a management plan, taking into account the local soil, to manage the risks from elevated nutrients and sodicity. Process water ponds (also referred to as Water Collection Ponds) will be lined. The ponds will be designed to prevent spilling in events where dilution by surface water flows would be less than a factor of 5.

No.	Agency	Topic	EIS section	Comment (Submission)	Response
10	NT EPA	General comment Closure	Chapter 2	Provide details of decommissioning and closure of key components of the project including mine site and non-process infrastructure. e.g. • Infrastructure corridor • Local construction bores proposed every 20 km along the corridor if suitable bore locations are located. • Borrow areas Provide slurry pipeline location on figure 2-2.	Closure Details regarding the closure of the following infrastructure are detailed in the Closure Report (Appendix Q of the EIS): – Infrastructure corridor in Section 3.8 – Construction bores in Section 3.8 – Borrow areas in Section 3.9 There is no slurry pipeline. Rock concentrate will be transported by rail from the processing site to the Port of Darwin. The slurry pipeline referred to in the risk assessment (item 1, item 50) is no longer part of the project configuration and has been replaced by the rail spur.
11	NT EPA	Ecologically sustainable development	Chapter 3: Regulatory Context 3.6	The TOR requested the Proponent demonstrate how it complies with and contributes to the principles and objectives of ESD in the relevant sections of the EIS. As per section 3.2 of the Terms of Reference, provide details on the choice of preferred options and how ESD principles and objectives have been considered in relation to this Project.	Refer to Section 3.5 for further information.
12	NT EPA	Surface water Catch drains	Chapter 7: Surface Water 7.4.1	*Catch drains are typically designed to safely convey the peak runoff generated by the catchment during the 20 year ARI critical duration design storm event, after which they discharge into the environment.* Provide details that demonstrate these catch drains are fit for purpose and would not contribute significantly to soil erosion and sedimentation. Alternative erosion control structures should be provided if these structures contribute less to soil erosion and sedimentation.	The catch drains would typically consist of a trapezoidal cross section with internal batter slopes no steeper than 1: 3 (vertical: horizontal). Catch drains would include stabilisation measures, such as rock check dams, rock lining, and vegetated lining as appropriate, to protect the channel from erosion and scouring up to the selected design storm event. The small amount of sediment that may still be produced by the catch drains would be conveyed to the sediment dams. These measures are consistent with the standard requirements for erosion and sediment control, and will be detailed in the operational erosion and sediment control plan that will be developed following detailed design.
13	NT EPA	Process water discharge	Chapter 7: Surface Water 7.4.2	*During extreme flood events, all reasonable efforts to avoid discharging of process water would be undertaken. This would include the transfer of process water into the open cut pits.* The Proponent should provide commitment to not discharge process water and provide details on transfer procedures and triggers that would be used to initiate this mitigation measure of transferring process water into the open cut pits during extreme flood events.	During extreme rainfall events, and if safe to do so, excess process water will be pumped into the pit to minimise the risks associated with uncontrolled discharge of this water. This is intended to, as far as practical, make the site a nil discharge site (with respect to process water). Triggers for the management of water within the lined process water storages will be confirmed in the water management plan submitted as part of the Mine Management Plan and are dependent on the final design of the process water storage ponds. These triggers will generally consist of a high operating level / emergency transfer threshold to trigger pumping to pits. e.g. 96% capacity or 0.5 m freeboard, depending on final water storage design and pumping capacity Discharges could occur during extreme rainfall events, but, as noted in comment 9 above, would be significantly diluted, above the required factor of 5, by runoff from the broader catchment area.
14	NT EPA	Tailings storage facilities	Chapter 7: Surface Water 7.4.3	*Water will be recovered from in-pit tailings.* Provide the expected water recovery rate from both in-pit and above ground tailings facilities.	Water recovery from tailings will range between 9% and 33% of total water. See also Section 3.3.
15	NT EPA	Mitigation of impacts associated with flooding – flood protection levees Pit protection levee	Chapter 7: Surface Water 7.6.1 Appendix G	NT EPA recognises the proposed flood protection levees would be designed to protect pits from flooding in a 1 in 100 ARI event. Provide details on estimated height of the levees, estimated volumes and materials used to construct these levees. *Scour protection measures (i.e. rip-rap) may be placed at the toe of the flood protection levee to reduce the risk of erosion and scouring of the levee during a flood event.* Provide details on scour protection measures to prevent erosion of the flood protection levees from runoff during heavy rainfall events.	Indicative profile and levels of the proposed flood protection berms are included in Section 5.5 of the surface water impact assessment (Appendix G of the EIS). The finished level of the berm has been estimated by: 1. Extracting the maximum modelled flood depths for the 100 year ARI event along the length of the levee 2. Smoothing the maximum modelled flood depth series 3. Add 0.5 metres (if the freeboard) to the smoothed flood levels to provide a finished level of the levee The volume of material required to construct the berm has been estimated based on the assumed cross section (see Section 3.4) It is estimated that about 58,000 m^3 of material will be required to construct the levee along the eastern side of the pit, and about 17,000 m^3 of material will be required to construct the levee along the western side of the pit (Section 3.4). The modelling (Appendix G in the EIS) indicates that the maximum modelled velocities within the vicinity of the levees is generally less than 1.5 m/s, however there is one location where velocities potentially exceed 2.0 m/s. At this location,

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					250 mm diameter rock may be required to protect the levee from erosion and scouring. This will be confirmed during detailed design, when the location and extent of the levees is also confirmed.
16	NT EPA	Mitigation of impacts associated with discharge of process water	Chapter 7: Surface Water 7.6.4	*Uncontrolled discharge is considered to be a rare event of minor consequence* (p.118) *Additional monitoring will be implemented if mine-associated water is disposed off-site (and as per the conditions of a Waste Discharge Licence)"* (p.118) The NT EPA notes that a WDL is unlikely to be issued for emergency release and if controlled release of mine-associated water is required to be disposed off-site, the Proponent would need to apply for a Waste Discharge Licence.	Noted – as noted above (comment 13), the site will include emergency management measures to pump excess process water into the pits. This is intended to make the site a nil-discharge site (with respect to process water). Process water test work has been undertaken and is submitted as part of the Supplement (Appendix 9).
17	NT EPA	Groundwater use – Operation	Chapter 8: Groundwater 8.5.2	Ref 1: 4.4 GL of water is expected to be extracted (worst case) but currently there is no reuse included in the water requirements, so water requirement is likely to be less than 4.4 GL. This does not include the slurry pipelines, however there will be water recovery (Table 6-8, Risk Register) Borefield – 12 km south of mine site – Georgina Basin – 3 bores on a 1.5 – 2 km run The NT EPA notes that the Proponent currently estimates abstracting 4.4 GL/yr, however expects this to be lowered once detailed design of the Project incorporates measures for water recycling. The Project is located in an arid region where groundwater resources are a shared resource and have high value. Provide an updated estimate of water requirements, including water balances for the various phases of the Project. Demonstrate that the Project will be designed and operated for best practice sustainable and responsible water use to minimise groundwater abstraction. The Proponent should refer to guidance for water stewardship such as the International Council on Mining and Metals water stewardship framework and Mineral Council of Australia's Water Accounting Framework for the Minerals Industry.	<u>Slurry pipeline</u> A slurry pipeline within the infrastructure corridor is no longer part of the project scope, and is not required for the Project. <u>Water balance</u> The water demand from the borefield is largely driven by the water recovery rates from the tailings. It is expected that the recovery rate will range between 9% and 33% of total water. The updated water balance is provided in Appendix 4. The water balance is for the first 5 years of production, at 1 million tonnes per annum, and accounts for annual water usage of 1.8 GL/year. Full production, at 2 million tonne per annum, will require a 3.6 GL/year (therefore doubling the quantities stated in the water balance). The impact assessment associated with the updated water demand has been reviewed based on the potential water recovery efficiencies and is detailed in Section 3.6. <u>Sustainable water use</u> As the project has developed, Verdant has sought to incorporate measures to reduce water demand. Measures incorporated to date include: - Recovery of tailings water resulting in the reduction of total water demand - Implementation of an independently peer reviewed and Regulator-approved Water Management Plan Verdant will continue to incorporate additional water efficiencies where practicable. It is noted that groundwater extraction is a cost to the project, and Verdant is driven to reduce groundwater extraction for both sustainability and economic reasons.
18	NT EPA	Potential impacts to groundwater resources	Chapter 8: Groundwater 8.7.4	*'It has been estimated that the Southern Georgina Basin has a drainable groundwater volume of 160,000 to 320,000 GL'* The NT EPA notes that this information is drawn from Appendix H, which explains that a specific yield of 4% has been used. Provide an additional estimate of storage based on a conservative 1% specific yield.	Estimated storage based on specific yield of 1% is 40,000 to 80,000 GL. It is noted that the Specific Yield value of 4% is consistent with the value implemented in DENR's groundwater model used to evaluate water allocation in the hydrogeologically equivalent Western Davenport Water Control District.
19	NT EPA	Impacts to existing users – groundwater	Chapter 8: Groundwater 8.7.5	The Proponent predicts the following drawdowns: • 1.5 – 3.7 m at pastoral bore 15 km away • 0.6 – 2.7 m at Ampilawatja 22 km away The Proponent concludes that there is unlikely to be a significant drawdown (> 3 m) The NT EPA notes that the upper estimate for drawdown is > 3 m, which is considered to be significant. Given the uncertainty of the modelling (as discussed by Water Resources, DENR), it seems uncertain rather than unlikely that a drawdown of over 3 m may occur at the sensitive receptors. The Proponent intends to update modelling when further information is available. This should include updated estimates of potential impacts, including discussion around the acceptability of a 3 m drawdown.	Acceptability of drawdown is addressed in Appendix H Section 5.3.4 of the EIS. The revised demand from the borefield will be 3.6 GL/year (refer Section 3.6). The drawdown associated with the revised water demand has been remodelled. The maximum drawdown of 1.2 - 3.0 metres can be expected at the closest pastoral bore Hagen's Bore (RN010717) and drawdown of 0.5 - 2.2 metres will be observed at the Ampilawatja Community borefield (RN011454 and RN011455). See Table 3-13. Availability of water will not be reduced by drawdown since the available drawdown at existing bores is 20 m and the aquifer is much deeper/thicker than that. The potential impact of a less than 3.0 metres drawdown in this context is considered minor to existing users. VRM commit to ensuring no reduction in water availability to other users because of mining. Mitigation measures would include deepening bores and upgrading pumps, though these measures are not expected to be needed.
20	NT EPA	People and communities	Chapter 12 Socio-economic	Provide distances from the Project to the key communities to provide context of proximity of local stakeholders and sensitive receptors.	<u>Distances</u>

No.	Agency	Topic	EIS section	Comment (Submission)	Response
			assessment Table 12-1	Identify those members of the community expected to accept residual risks and their consequences (section 5.1, TOR).	The distances to key communities are illustrated in Table 3-15 and Figure 3-3. See also comment 40. <u>Communities</u> Members of the community expected to accept residual risk and their consequences have been identified in the EIS in Chapter 5 (Table 5-1) and in Chapter 12 (Table 12-1). Detailed information about the consequences identified in the environmental risk assessment (e.g. groundwater drawdown, noise, dust, weeds, traffic) has been identified in the social impact assessment in Chapter 12. A summary of key consequences and the impacted community is provided in Table 3-16 in Section 3.7.
21	NT EPA	Amenity issues	Chapter 12 Socio-economic assessment Appendix L – section 9.7.9	Potential negative impacts on amenity would include noise, dust, additional traffic, light pollution and vibrations from mining activity. Aspects of this issue are dealt with at 6.7.4 as a pastoral productivity issue. The risk rating for impacts on various aspects of amenity is regarded as LOW (#62, #64, #70 and #82) given the distance from populated areas and relatively low level of activity. Section 6.7.4 cannot be found in Appendix L or the Main EIS document. As per 5.11.3 in the Terms of Reference, provide a visual amenity assessment and potential impacts of the Project.	<u>Incorrect section</u> Section 6.7.4 is referenced on page 113 of Appendix L of the EIS and should be Section 6.8.4. <u>Amenity</u> Amenity has been assessed in the context of • noise (Risk 45) • vibration (Risk 47) • dust and traffic (Risk 50, 95) • light (Risk 55) Visual amenity impacts are described and assessed in the context of cultural impact, i.e. connection to country, culture and ceremony (Risk 54) as being a low risk. The risk is discussed in more detail in the EIS, Appendix L, Section 10.
22	NT EPA	Infrastructure and social services	Chapter 12 Socio-economic assessment 12.3.4	*Upgrading of the Murray Downs Road would have particular social and economic benefits for pastoralists and communities because these roads are used to deliver fuel, cattle, food supplies to the store and by growing numbers of four-wheel drive tourists on the Binns track.* In Ref 50 of the Risk Register (Chapter 6), some haul roads may need to be upgraded for use (Murray Down Road and Sandover Road) with potential opportunity to improve community infrastructure (roads) due to increased economic benefits. To maximise positive socio-economic benefits and potentially reduce water usage required to suppress dust on haul roads, provide more details on this option/commitment to potentially seal or resurface roads – particularly those in close proximity to communities.	Risk ref 50 identifies increased traffic on unsealed road resulting in dust and reduced amenity as an impact mainly associated with the construction phase of the Project. The risk is considered a low risk with a rare likelihood of occurrence. The implementation of controls, in addition to those already identified in the risk register, is unlikely to reduce the impact further, and given the short period of impact (18 months – 2 years), the use of temporary controls is appropriate. Murray Downs Road is a public road and Verdant is continuing to discuss the requirements of the Project and the use of Murray Downs Road with the Northern Territory Government (refer to comment 74). The requirement to upgrade Murray Downs Road would be a decision made by DIPL.
23	NT EPA	Tailings management	Appendix G – Surface water impact assessment 2.2.4	Dry tailings capped 1 – 2 m higher than surrounding land. Provide details on: • Consolidation rate and behaviour of tailings • Monitoring details on tailings settlement rates to inform when capping of in-pit tailings can commence • Source and volumes required of capping materials for in-it and surface tailings storage facilities • Permeability of capping materials used to prevent infiltration • Progressive rehabilitation schedule for in-pit and surface tailings based on the above information.	<u>TSF closure</u> Refer to comment 6 for information on surface and in-pit TSF closure. The first in-pit TSF (i.e. first mined pit) rehabilitated will include some level of experimentation to understand the exact nature of the final landform that can then be replicated across the site. Once the first 5 year pit has been mined, a series of rehabilitation trials will be undertaken which will provide a better understanding of: • Tailings, waste rock and overall material consolidation • Level of consolidation required to cover • Landform stabilisation • Land form heights • Effectiveness of cover material • Effectiveness of revegetation options. These tests will occur in the first mining area between years 5-10. In practical terms, the initial rehabilitation of the first 5 year mining area will determine the best approach to rehabilitation and closure of all future mine pit areas. The design of these rehabilitation trials will occur during the first 5 years of mining with due regard to the actual conditions experienced at the site once mining and in pit tailings deposition commences. Further consultations with the pastoralist and traditional owners will occur about the potential for alternate revegetation strategies that may result in some of the

No.	Agency	Topic	EIS section	Comment (Submission)	Response
					mined area being transformed into other agricultural uses, other than revegetating to its current state. Monitoring See Section 3.2.9 for information on monitoring. Capping Cover material will be sourced from mine overburden and soil/grub stockpiles. Further test work will determine the volume of cover material required to achieve the desired landforms. The purpose of the cover material is to achieve a stable and functioning landform and does not need to prevent infiltration. Refer to Appendix 5 for photographic examples of successful rehabilitation methodology applied to test pits. Rehabilitation schedule The surface TSF will not be progressively rehabilitated and will be rehabilitated once no longer required for operations. Refer to comment 2 for further information. The in-pit TSF will be rehabilitated progressively once each pit stage has been completed. Pits have been staged so that they are open for a period of five years before being progressively closed. Rehabilitation of each pit, may take up to five years after mining has ceased in that particular pit. Refer to the updated Closure Report (Appendix 1) for further information on TSF rehabilitation.
24	NT EPA	Water Quality	Appendix G – Surface water impact assessment 3.4 Table 3-1	*There is however limited surface water quality data available from the NT Government Water Data Portal.* With limited baseline data, environmental values and potential impacts cannot be accurately determined. Provide a framework for a water monitoring program (including sites) with the objective to determine site-specific trigger values (SSTV) for all relevant analytes. Include contingency measures that would be activated in the event SSTVs are reached. *Due to the ephemeral nature of watercourses, no surface water quality samples have been collected from the Project site.* There is a general lack of baseline data for surface water and the Supplement should include water quality data collected since submission of the draft EIS or a monitoring program framework, with locations, sampling frequencies and analyses that demonstrates the multiple before-after control-impact monitoring approach would be achieved.	The Water Management Plan is provided in Appendix 6 and details the surface water monitoring program to be implemented prior to operations. The development of SSTVs is problematic in ephemeral systems where the frequency of opportunistic sampling is very low. The water quality monitoring program will continue to analyse results against ANZECC guideline values unless or until site specific guidelines are able to be derived. Site specific trigger values (SSTV) are not required as the project will be a nil discharge operation, up to the 100 year design storm event. The results from surface water monitoring undertaken to date is provided in Section 3.9.
25	NT EPA	Water balance	Appendix G – Surface water impact assessment 4.3	A preliminary water balance prepared by Worley Parsons (2014) quantified the volume of tailings supernatant water that can be reclaimed from the tailings thickener for reuse within the processing plant to augment the mine site water supply. It is understood that water from the Tailings Storage Facility will not be recycled (p.34) Section 2.6 in the draft EIS indicates the TSF facilities (surface and in-pit) will be designed to include water recovery (estimated to be approximately 20 – 30% of the water discharged in the tails to the TSF) from collection ponds using a decant or floating pump station. Provide clarification on the above statement that water from the TSF will not be recycled and update the water balance for the preferred option.	Water recycling Water will be recycled from the tailings storage facility and will be utilised for processing. Water recovery will range between 9% and 33% of total water. Water balance The updated water balance allows for an average rate of water recovery (17%) from the TSF, the updated water balance is provided in Appendix 4. The impact assessment associated with the updated water demand has been reviewed based on the potential water recovery efficiencies and is detailed in Section 3.3.
26	NT EPA	Construction water supply	Appendix H – Ammaroo Phosphate Groundwater Study 5.1.2	The construction water supply comprises a string of bores constructed at 20 km intervals along the infrastructure corridor to provide water for dust suppression and material. Provide details on the maintenance or decommissioning of these bores post construction period of 12 months. Stakeholders should be consulted and agreement reached if any bores are to remain post construction.	Landholders will be offered the bores on completion of construction of the infrastructure corridor. Any bores that are to be owned by the landholders will be detailed in the access agreements. A small number of bores along the infrastructure corridor, whether transferred to the pastoralists or retained by the company, will be maintained to provide water for maintenance activities along the corridor. These arrangements will part of access agreements with the pastoralists. Any remaining bores will be decommissioned) after the construction phase is completed. All bores will be decommissioned as per the requirements of the National Water Commission's National Construction Requirements for Water Bores in Australia (Feb 2012). Maintenance will comprise keeping the bores open to ensure that they yield the required volumes of water.

No.	Agency	Topic	EIS section	Comment (Submission)	Response
					Decommissioning will comprise backfilling the bore with cement grout from end of hole to surface to ensure the borehole is completely sealed. Casing will be cut off below surface and the ground rehabilitated to allow re-vegetation.
27	NT EPA	Mine Pit Excavation	Appendix H – Ammaroo Phosphate Groundwater Study 5.1.3 Figure 12	Groundwater is estimated at 59 m and the maximum pit depth is 45 m. The Georgina Basin Carbonate Aquifer depth varies from the top of the water table at 30 – 80 m below ground level (section 4.4.3). The level of the water table has been inferred from one drill hole APWB1 located adjacent to the mine site. Provide details on the management of any pit-water inflows in the event groundwater is encountered. Provide details of seepage potential of the undefined clays and siltstones layer provided in the cross section in Figure 12.	Groundwater inflow to the mine pit is very unlikely. There are over 3,300 orebody delineation holes for over 108,000 metres of drilling. Almost all these (>97%) terminated at depths below the proposed mine floor. No intersected groundwater. On the basis of these dry holes, the siltstone in the mine floor does not hold perched groundwater. Furthermore, four deep (>100 m) holes were drilled deliberately to look for water under and near the resource. These four holes were dry. These deep holes went well below the notional level of the water table, and proved that there is no groundwater to at least 100 m depth below the resource, because the aquifer isn't present in the location of the resource. Water management in the pit is designed around surface water (i.e. rainfall). Any minor groundwater seepage will be managed by the same pumping infrastructure and re-use strategy that manages surface water run-off within the pit.
28	NT EPA	Tailings Handling	Appendix H – Ammaroo Phosphate Groundwater Study 5.1.4	*Some tailings liquor will seep from storage in the mine pit to the groundwater table. This will result in some increase in groundwater level and change to the chemical composition of groundwater.* Baseline groundwater levels and quality is required prior to construction of the mine pits to determine the level of impact in-pit tailings seepage may contribute. Provide details on the expected quantity and quality of this tailings liquor and the pathways to the groundwater. Provide details on the estimated extent of groundwater level increase and change to groundwater quality to the underlying aquifer.	Section 3.1, provides an estimate of water table rise beneath the TSF and dilution down-gradient of the TSF. Maximum calculated water table rise ranges from 3.6 to 19 m above standing water level. This cannot impact on the environment given the standing water level is some 50 m below ground surface. Refer also to data presented in comment 27. Tailings leachate is expected to migrate very slowly down-gradient due to the low permeability of the fractured rock aquifer and the low hydraulic gradient. After 100 years, the calculated plume will have moved 400 m down-gradient and diluted to a mixture of maximum 10% tailings leachate and 90% groundwater. A groundwater monitoring program that will measure the impact of tailings seepage on groundwater level and groundwater quality is detailed in Section 4.5 of the water management plan and is summarised in Section 3.19 of the Supplementary Report. The monitoring program will be used to validate the calculations of water level and water quality change that are presented in this report. Tailings liquor test work is summarised in Section 3.1.1 Aquatic ecosystem guideline values were exceeded for several metals and nutrients. Aluminium, hardness-corrected copper and phosphorus exceeded the guidelines by more than a factor of 10. Adjustment of pH to between 7 and 8.5 would remove the direct risk form pH and well as aluminium. Phosphorus is unlikely to present a risk unless direct discharge of significant volumes of leachate to surface waterways, as it is readily adsorbed in the soil column is unlikely to be elevated in groundwater. Most analytes were in lower concentrations than the ambient groundwater or exceeded by a factor of less than 10. Only aluminium, barium, nickel and total phosphorus exceed groundwater concentrations by more than a factor of 10. However, the overall chemistries are comparable in terms of highest and best use possible based on the water quality, being of marginal quality for drinking water for livestock.
29	NT EPA	Tailings Seepage geochemistry	Appendix H – Ammaroo Phosphate Groundwater Study 5.3.7	Tailings have been described as non-acid forming, seepage is not saline and neutral tailings exhibit low enrichment thereby presenting a low risk to groundwater. This statement appears to be based on one historical tailings geochemical and static AMD analysis (EGI, 2014, Table 4 - Appendix I). The statement appears to contradict section 5.1.4 in Appendix H although the NT EPA notes this one sample does show low analyte concentrations (Table 4). Provide clarification in the Supplement.	The statements are not contradictory, because the second expands on the first. Section 5.1 in Appendix H in the EIS identifies potential groundwater affecting activities of which tailings handling is one, and Section 5.3.7 in Appendix H describes the impacts of tailing seepage including groundwater mounding and chemical change. Further test work by SGS (2017) of tailings was undertaken in December 2017 and confirms the low contaminant concentrations for a range of leaching solutions. Further information is available in Section 3.1.1. A copy of the SGS Report is provided in Appendix 8.
30	NT EPA	Tailings Seepage – Chemical impacts of tailings	Appendix H – Ammaroo Phosphate	*Saline tailing seepage will not be generated due to the low salinity of process water.* (p.38). Provide details of future tailings leachate test work to confirm seepage from tailings would not be saline.	Further test work of synthetic tailings was undertaken in December 2017 and confirms the low contaminant concentrations for a range of leaching solutions. Further information is available in Section 3.1.1. A copy of the SGS Report is provided in Appendix 8.

No.	Agency	Topic	EIS section	Comment (Submission)	Response
		seepage – Saline mine drainage	Groundwater Study 5.3.7		Bulk leach testing (e.g. barrel testing) has commenced on waste rock samples. Three leachate cycles have been completed and the leachate analysed (see Appendix 12). Tailing samples will be added to the bulk leach test work when sufficient quantities of tailings are available. This has been included as a commitment. Appendix 9 includes a discussion about tailings water quality test work.
31	NT EPA	Groundwater Monitoring and reporting	Appendix H – Ammaroo Phosphate Groundwater Study 6.2 Table 7 Figure 22	Provide an independent peer review to confirm the groundwater monitoring program proposed would be adequate to • obtain the appropriate level of baseline information, • inform recharge and discharge processes • be capable of detecting changes over time in the groundwater system that may indicate impacts from mining operations.	A peer review of the groundwater monitoring program component of the Water Management Plan is provided in Appendix 7. The recommendations of the peer review have been implemented in the monitoring program described in Section 3.19 of the supplementary.
32	NT EPA	Model Calibration and refinement	Appendix H – Ammaroo Phosphate Groundwater Study 6.3	*Model revision and re-calibration will be undertaken annually if required.”* (p.43) Provide an outline, including timing, of the process to be used to revise the model, re-calibrate and upgrade to a class 2 model. Confirm if future models will be assessed as part of ongoing authorisation under the MM Act.	Refer to Section 4.6.1 of the Water Management Plan.
33	NT EPA	Contingency	Appendix H – Ammaroo Phosphate Groundwater Study 6.4	*Additional water recycling methods will be explored* (p.44) The NT EPA expects the Project to be designed and operated for sustainable water use from the beginning, so this is unlikely to be a suitable mitigating measure following impact. *Alternative water sources will be explored e.g. extending / relocating borefield, but cost prohibitive* (p.44) The NT EPA notes that this is unlikely to be an appropriate mitigating measure if it is cost prohibitive. Include the mitigation measure of modifying pumping regimes if significant impacts associated with groundwater drawdown are identified.	<u>Water recycling</u> Noted. Refer to comment 17 for further information on sustainable and responsible water use. <u>Alternative water sources</u> Noted. Exploration for alternate water sources is cost prohibitive at this stage of the project's development, but once the project is fully financed and becomes operational; if necessary, alternate sources of water could be located within the near region. <u>Modifying pumping regimes</u> Modifying pumping regimes has been included as a mitigation measure in Section 4.6.1 of the Water Management Plan (refer Appendix 6).
34	NT EPA	Purpose of this document	Appendix I - AMD Assessment and Management Plan 1.1	It is noted that additional geochemical analyses of tailings and process residue are currently being undertaken, and not available for inclusion at the time of this report although the implications of likely results are discussed. Provide these additional results in the Supplement to provide confirmation of the above geochemical assessment summary.	Further test work of solid tailings was undertaken in December 2017 and a copy of the Report (SGS 2017) is provided in Appendix 8. The results are summarised in Section 3.1.1.
35	NT EPA	Geochemical assessment summary	Appendix I - AMD Assessment and Management Plan 4.6	*The material is suitable for management in unlined monofil waste rock dumps, with normal sediment and erosion control and monitoring of the key metals and metalloids noted as being elevated in acid and neutral leachate.* (p.42) Provide clarification on whether these waste rock dumps are temporary (i.e. will be used to backfill pits) and any proposed monitoring programs for the waste rock dumps to confirm leachate from waste rock is benign.	<u>WRDs</u> The WRDs are temporary and will be used to back fill pits progressively. Clarification relating to the assessment criteria for ASLP data and requirements for lined or unlined disposal is contained in Section 3.10. Long-term kinetic testing or barrel leach testing of various waste rock types and ore has commenced to confirm the reported expectation of long-term leachate quality from waste rock. Future tailings samples will be subjected to bench-scale testing to compare with previous testing. <u>Leachate monitoring</u> Bulk leach testing (barrel testing) of waste rock bulk samples has commenced. See also Appendix 12.
36	NT EPA	Sensitive vegetation types – Wetlands – drainage floors and floodplains	Appendix J – Flora and Fauna Report for Ammaroo Phosphate EIS 3.4	Drainage floors and floodplains are 'open depressions' which means that they direct run-off from surrounding landforms but lack the presence of distinct drainage channels. For this reason, disturbance to surface hydrology should be avoided within these areas to ensure that 'down-gradient' impacts to receiving environments do not occur. Provide a commitment that disturbance to surface hydrology would be avoided in the vicinity of drainage floors within the mining leases.	Drainage floor (habitat unit 9.1) identified in the north and north east of the ML will not be impacted by the project. The mine camp is the only infrastructure that is proposed to the north of the Murray Downs Road, and it will be constructed outside the drainage floor area. Woodys Dam has been constructed down gradient of the drainage floor directly north of the proposed mine site. Additional drainage floor habitat to the north east of the mine site will not be impacted by the project.

<table>
<tr><th>No.</th><th>Agency</th><th>Topic</th><th>EIS section</th><th>Comment (Submission)</th><th>Response</th></tr>
<tr><td>37</td><td>NT EPA</td><td>Potential impacts to ecosystems – Summary
Inappropriate/ineffective rehabilitation</td><td>Appendix J – Flora and Fauna Report for Ammaroo Phosphate EIS 7.2
Table 7-3
7.9</td><td>The potential impact of ‘Inappropriate/ineffective rehabilitation’ is assessed as a likely moderate impact.
Provide a commitment to detailed Rehabilitation Plan with completion criteria, including appropriate monitoring and management of flora, fauna and environmental values, for progressive rehabilitation in the Mine Closure Plan.
This commitment is to ensure the long term management and monitoring of rehabilitation to reduce impact to ecosystem integrity.</td><td>Commitment provided in Section 1.1 of the updated Closure Report (Appendix 1).
“Verdant Minerals Ltd commits to a the production and provision of a detailed Rehabilitation Plan within with completion criteria, including appropriate monitoring and management of flora, fauna and environmental values, for progressive rehabilitation in the Mine Closure Plan (MCP). Content from this document will eventually be incorporated into the MCP, which will be incorporated into the broader Mine Management Plan (MMP).”
The updated Mine Closure Plan will be submitted to the DPIR as part of the mining authorisation process.</td></tr>
<tr><td>38</td><td>NT EPA</td><td>Potential impacts to ecosystems – Noise</td><td>Appendix J – Flora and Fauna Report for Ammaroo Phosphate EIS 7.16</td><td>None of the biodiversity surveys discussed in this report have recorded any noise-sensitive species present in significant numbers (i.e. bat roosts).
Provide details on the reporting and response requirements if any bat roosts are discovered.</td><td>There are no bat species of conservation significance in the region of the project. Bat roosts were not noted within the project area during the seven biodiversity surveys, nor during the other targeted and habitat ground-truthing surveys.
Bat roost habitat in the region of the project would be limited to areas with large old Coolabah trees that support hollows, Red River Gum’s and rocky cave or crevice features – none of which was identified within the project area during vegetation and habitat surveys.
For these reasons, the request to prepare detailed reporting and response requirements if a roost is discovered, is not considered justifiable.
If a roost is discovered within the project area, the proponent will liaise with DENR regarding the significance of the roost and whether any mitigation is required. This has been included as a commitment in the Biodiversity Management Plan.</td></tr>
<tr><td>39</td><td>NT EPA</td><td>Summary of findings</td><td>Appendix L – Ammaroo project draft economic and social impact assessment.
Table 1-1</td><td>Economic and Social Impact Management Plan – attached to the ESIA.
This Plan is not attached – please provide.</td><td>The Economic and Social Impact Management Plan is provided as Appendix C of the Environmental Management Plan (Appendix E of the EIS).</td></tr>
<tr><td>40</td><td>NT EPA</td><td>Sensitive receivers
Noise</td><td>Appendix P – Noise and vibration impact assessment 3.2
Table 3-1</td><td>Table 3-1 shows distance to the mining lease and noise source, which includes the rail corridor.
Include distance from sensitive receptor to the proposed railway corridor, similar to provided distance to the mining lease.</td><td>Table 3-1 in Appendix P in the EIS has been updated to include the distance from sensitive receivers to the mining lease and the infrastructure corridor (inclusive of the railway spur).
<table>
<tr><th>Sensitive receiver</th><th>Distance to the mining lease (km)</th><th>Distance to the infrastructure corridor (km)</th></tr>
<tr><td>Mine camp</td><td>0</td><td>1.1</td></tr>
<tr><td>Ampilatwatja</td><td>12</td><td>23.2</td></tr>
<tr><td>Imperrenth</td><td>29</td><td>17.5</td></tr>
<tr><td>Imangara</td><td>61</td><td>24.6</td></tr>
<tr><td>Ali Curung</td><td>86</td><td>19.2</td></tr>
<tr><td>Ngkwarlerlanem</td><td>37</td><td>41.6</td></tr>
<tr><td>Indaringinya</td><td>41</td><td>39.9</td></tr>
<tr><td>Illeuwurru</td><td>72</td><td>42.8</td></tr>
<tr><td>Tara</td><td>112</td><td>48.5</td></tr>
<tr><td>Annerre</td><td>114</td><td>27.5</td></tr>
<tr><td>Double D</td><td>28.1</td><td>14.5</td></tr>
<tr><td></td><td></td><td></td></tr>
</table></td></tr>
<tr><td>41</td><td>NT EPA</td><td>Rail noise impact – Modelling assumptions</td><td>Appendix P – Noise and vibration impact assessment 6.4.2</td><td>Atmospheric conditions of 15 °C and 70% humidity were used (p.45)
Provide clarification as to whether these model atmospheric inputs are typically used for arid zones.</td><td>The 15°C and 70% humidity are part of the default noise modelling configuration under the ISO 9613-2 Acoustics – Attenuation of Sound during Propagation Outdoors algorithm.
With regard to the noise propagation behaviour versus weather conditions, noise propagation across the atmosphere is more affected by a change in atmospheric temperature, than the change in humidity. The lower the atmospheric temperature, the less the noise attenuation provided by the atmosphere (i.e. the more the noise travels), and vice versa.
The value of 15°C was selected to represent the approximated mean minimum temperature recorded at the Arltunga Automatic Weather Station (being closest to</td></tr>
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No.	Agency	Topic	EIS section	Comment (Submission)	Response
					Ammaroo site), between 2000- 2017 (http://www.bom.gov.au/climate/averages/tables/cw_015594.shtml). Additionally, the higher the relative humidity, the lesser the noise attenuation provided by the atmosphere. Thus, 70% relative humidity was selected to add a slight measure of conservatism into the noise model.
42	NT EPA	Administration and Plant Area Closure Task Register	Appendix Q – Closure report Table 3-1	Land use information; closure works tasks; schedule of work for research, investigation and trials tasks; schedule of work for progressive rehabilitation; availability and management of closure material sources; key tasks for unexpected (early) closure and/or temporary closure; information gaps; performance monitoring and maintenance schedule is missing for this table that covers the administration and plant area closure task register. Provide the above information for this domain.	A formatting error during finalisation of the EIS removed a portion of Table 3-1 (Appendix Q of the EIS). This table is reproduced in its entirety in Section 3.11.
43	NT EPA	Open Pits Closure Task Register	Appendix Q – Closure report Table 3-3	*The resultant landform will form a minor mound (i.e. an excess of loose material by volume).* Provide conceptual designs, including cover systems, of the resultant landforms – 46 Mt of ore is to be removed over the LOM and with the tailings and waste rock being placed in-pit – the "minor mound" may be a significant landform. Post-Mining Landform Design section states "*Flat area rehabilitation with gently sloping radial drainage (due to the excess of loose material by volume). If settlement occurs in the very long term, it is conceivable that it could take a form that mimics a depression consistent with a doline.* Provide more details on the likelihood of settlement occurring and the likely depth of depression. If this is to occur – would rehabilitation objectives and end land-use not be met (e.g. does not preclude pastoral use or inhibit surrounding pastoral use)? Clarify whether the in-filled pits would be water shedding or allow water infiltration.	Conceptual design Further detailed materials characterisation of the tailings consolidation characteristics and available cover materials will be undertaken prior to the rehabilitation of the first pit. This will occur during years 0 – 5. During the rehabilitation of the first pit (years 5 – 10) the preferred rehabilitation methodology will be determined, and applied to future pits. This will include the determination of the final landform. The Mine Closure Plan will be updated as further test work is undertaken. Settlement Verdant's Mining Engineers, Mining Plus, assumed the following in the mine design: • a swell of 20% of the waste • the nominal strip ratio of 2.5: 1 • the tails are nominally 64% of the feed • the tails have a nominal density of 1.1 t/cubm. • original rock density of 1.7t/cubm • Combine all of these ensure the final volume will exceed original volume by nominally 6%. The final amount of storage above surface is an estimate at this stage but in the opinion of the mining engineers, it is unlikely that in a human lifetime, this 6% swell will settle out. Further settlement may occur over geological time but it is unlikely to form a significant depression and even if a minor depression was ultimately formed, it is difficult to imagine that the area would be unsuitable for pastoral use. Capping The cover material over the pits will permit water infiltration, given the low risk of tailings and waste rock leachate significantly impacting on underlying groundwater or adjacent surface water quality. This will encourage the revegetation of the closed pit.
44	NT EPA	Seeding	Appendix Q – Closure report throughout	The Proponent should provide commitment in the Mine Closure Plan to conduct pre-closure trials and investigations that will inform the success or otherwise of seeding in an arid zone.	Commitment inserted into each section "Arid zone seeding, Conduct ongoing pre-closure trials and investigations that will inform the success of seeding in an arid zone." Refer Appendix 1.
45	NT EPA	Waste Management Facility	Appendix Q – Closure report 3.2	Permanent camp closure task register – include in this table the rehabilitation and closure of landfill and septic/associated infrastructure.	The Closure Report has been updated to include landfill and septic/associated infrastructure (Appendix 1).
46	NT EPA	Tailings storage facility Cover concept design	Appendix Q – Closure report 3-4	*Dry tailings will be capped with a layer of waste rock to a height higher than the surrounding land* *Cover tailings surface with 1 m thick capillary break layer of waste rock* As part of Mine Closure Plan, provide conceptual designs for tailings cover. This table also indicates all tailings would be removed and return water piping (approximate duration 3 – 5 months) – clarify whether this means the surface tailings would be returned to in-pit storage.	Closure Plan Pit rehabilitation is a long term process, including back filling with overburden and capping and final landform stabilisation and revegetation occurring a number of years after the pit closure. A conceptual design for tailings cover will be provided in the Mine Closure Plan included in the Mine Management Plan. This has been included as a commitment. Tailings The statement refers to the removal of tailings piping and return water piping, not tailings within the TSF. The Closure Report has been update to clarify.

No.	Agency	Topic	EIS section	Comment (Submission)	Response
47	NT EPA	Risk Assessment	Appendix Q – closure report	The NT EPA notes the mitigation measures proposed and considers them commitments to further inform the Mine Closure Plan. For the hazard – poor management of waste materials during operations leads to closure plans being unachievable or costly – the Proponent has committed to providing detailed design level five years prior to closure. The NT EPA considers progressive rehabilitation requires detailed designs throughout mining operations rather than a few years pre-closure. The NT EPA notes regular performance monitoring on key aspects is provided as mitigation measure to ensure these aspects are fully understood and accounted for in all closure designs. Provide details of these monitoring programs.	Noted. Added the words "The proposed mitigation measures in Table 5-1 are considered to be commitments to further inform the MCP" to Section 5. Reworded to "Increase level of detail in closure designs during operations (detailed design level throughout mining operations and at least 5 years prior to closure)." Twice in Table 5-1.
48	NT EPA	General comments	Appendix Q – Closure report	Provide evidence that stakeholders (including landowners and pastoralists) have been consulted on agreed post-mining land-uses and include in the Mine Closure Plan. Provide details on completion criteria that will be used to measure rehabilitation success and demonstrate closure objectives have been met.	The Draft EIS stated that pastoralists and Traditional Owners will be consulted prior to decisions on alternate, post mining land uses. It did not state that there had been consultation. Detailed discussions have not been conducted other than our undertaking, made during community meetings with Traditional Owners and during discussions with the Weir family; that the initial intent is to revert the land to its current state and use, but recognising that there may be other agricultural options that we will discuss once the mine is operational and rehabilitation and closure plans are being refined. Specific completion criteria will be established and refined during the rehabilitation trials that will be conducted once the first 5 year mining pit has been completed, such that appropriate closure trials can be conducted. These trials will inform how rehabilitation and closure will be conducted for the remainder of the pits and the specific closure objectives to be met; which at this time is to return the land to a state where is can be used for pastoral purposes (as it is now).
49	NT EPA	Editorial comments	Appendix Q – Closure report	Table 6-8 – text is missing for ref 97– comments on contamination of aquifers from acid metalliferous and saline drainage. There are two section 7.6.1 – hydrological regimes and flooding Provide missing references for Chapters 12-13, 15-17 that were omitted from the draft EIS in Chapter 18. Section 6.7.4 cannot be found in Appendix L or the Main EIS document. To which document does this cross-reference refer? Does the EIS address visual amenity issues? Please provide details. Appendix O – pg 35 is blank – clarify if information is missing.	<u>Risk 97</u> Wording missing from the comments column is as follows: *Saline tailing seepage will not be generated due to the low salinity of process water stream and tailings liquor*. <u>Section numbering</u> Noted. <u>References</u> Chapter 12, 13,15 –17 reference only the Report detailed in the Introduction section of each chapter, and appended to the EIS (e.g. the Air Report – Appendix O is the reference for Chapter 15). Refer to each of these Appendices for a complete list of references. No additional references were used in the drafting of these chapters. <u>Section 6.7.4</u> All references to Section 6.7.4 should be replaced by reference to Section 6.8.4. <u>Appendix O</u> No information is missing from page 35.

2.2 NT Police, Fire and Emergency Services

No.	Agency	Topic	EIS section	Comment (Submission)	Response
50	NT Police, Fire and Emergency Services			<u>NTES</u> NTFRS covers all these areas however, there is at least two hours travel time away with Road Crash Rescue (RCR) equipment. The only concern would be the increased risk of road accidents along the Murray Downs Road and in particular the Sandover Highway. Road crash gear is located at Ali Curung and Harts Range. Ali Curung is an ERG and Harts Range currently has one operational member with limited basic rescue capacity. Police at Ali Curung have not been trained in road crash rescue (RCR) and the next closest option would be the FERG at Ti Tree, which are currently not RCR qualified. In light of the proposed project, relocating RCR equipment to Arlparra and setting it up as an ERG may be considered.	Noted.

2.3 Department of Primary Industry and Resources

No.	Agency	Topic	EIS section	Comment (Submission)	Response
51	Department of Primary Industry and Resources	General		References for Chapters 15 - 17 are omitted from the Draft EIS document in Chapter 18: References. References for Chapters 15 - 17 in Chapter 18: References would assist in locating referenced information.	Chapter 15 – 17 reference only the Report that is referred to in the Introduction section of Chapters 15 – 17 and appended to the EIS (e.g. the Air Report – Appendix O is the reference for Chapter 15). Refer to these Appendices for the list of references. No additional references were used in the drafting of Chapters 15 – 17.
52	Department of Primary Industry and Resources	Impacts to Water	Water quality guidelines	In the draft EIS the Proponent proposes use of the ANZECC & ARMCANZ (2000) 80% protection level, which is suggestive of a high level of disturbance. The proponent may be required to establish Site Specific Trigger Levels (SSTV) for all relevant analytes prior to undertaking works or committing to adopting ANZECC guideline values. The proposal is for operation on a greenfield mining development site. Given the location of the mine site and the relatively pristine environment, there are areas on the site where it may be appropriate for the level of protection to be 95% or greater. It is suggested that the proponent be required to provide justification for the proposed use of the 80% protection figure, rather than use of a higher level of protection that may be more appropriate for the specific receiving environment.	The appropriateness of the application of landfill guidelines is discussed in section 3.10. Refer to Section 3.12 for an assessment against 95% protection levels. Further assessment against the livestock drinking guidelines is provided in Section 3.13. See also comment 24 for a discussion of SSTV's.
53	Department of Primary Industry and Resources	Impacts to Water	Water balance	The water balance provided in the draft EIS only considers inputs/outputs associated with processing (i.e. does not include rainfall or captured runoff) and does not take into account overall site water flows, including to storage facilities etc. Should the project proceed to assessment under the Mining Management Act, the operator will be required to provide a comprehensive water balance for whole of site and more details on water management, including a preliminary Water Account based on the MCA framework.	Noted.
54	Department of Primary Industry and Resources	Impacts to Water groundwater	Aquifer impacts	The potential for the project to impact on the overlying aquifers has not been described. Any connection to upper aquifers (Dulcie Sandstone and Tertiary) would mean risks exist. Impacts to the larger Georgina Basin Carbonate Aquifer may be trivial given its large size, but within smaller aquifers, the impacts potentially caused by the proposal may be significant. If the Georgina Basin Carbonate Aquifer is connected to the overlying aquifers please describe the potential impacts of the project on the any of the overlying aquifers. It is recommended that water resources section of DENR be consulted on the possible impacts to the aquifers.	The Georgina Basin Carbonate Aquifer is connected to the Dulcie Sandstone and Tertiary Aquifers. They are distinct geological units, however they are part of the same regionally extensive groundwater system. Drawdown in the Georgina Basin can impact on these aquifers. The extent of the Dulcie Sandstone and Tertiary Aquifers is shown in Figure 4 of the Ammaroo Groundwater Impact Study (Appendix H of the EIS). In the Ammaroo Groundwater Impact Study (Appendix H of the EIS), the Georgina Basin has been modelled as one continuous aquifer system, hence the model currently does simulate impacts on the Dulcie Sandstone and Tertiary Aquifers. The Tertiary Basins and Dulcie Sandstone are both outside the predicted radius of drawdown resulting from borefield pumping. The Tertiary basin extent is some 60 km to the northwest, while the Dulcie Sandstone extent is located some 35 km to the south west. Therefore, no impact on these aquifers is predicted. Additional detail is provided in 3.18 of the Supplementary.
55	Department of Primary Industry and Resources	Impacts to Water	Process water quality	The Department has some reservations about whether the assessment of process water quality is adequate to assess the level of risk of contamination to groundwater and any barriers or management that may need to be employed. If the NT EPA determines that the project can proceed, and validation of process water quality during operations is different to that anticipated in the Draft EIS, key infrastructure (e.g. lining of tailing storage facilities and process water ponds) may need to be modified to mitigate this risk.	Noted.
56	Department of Primary Industry and Resources	Flood Modelling	Flood modelling	The Todd River catchment is located entirely within the MacDonnell Ranges and comprises relatively steep, rocky terrain with generally sparse vegetation cover giving rise to large flash floods. It also includes a number of surface water storage features (e.g. water holes) and is characterised by shallow gritty or stony soils. By comparison, the Ammaroo site is characterised by a wide area of level to undulating plains and rises on weathered sedimentary rocks,	The remote location of the site, and limited available data, made the estimation of suitable initial and continuing loss parameters relatively difficult. Without other data, the parameters from the nearest recent flood studies were considered and adapted. It was considered that whilst the terrain of the adjacent catchment is different to that within the vicinity of the site, lower loss parameters were considered to be realistic for the area, as the larger flood events that were being considered typically occur during the wet season, following earlier storm events that would partially saturate the local

<table>
<tr><th>No.</th><th>Agency</th><th>Topic</th><th>EIS section</th><th>Comment (Submission)</th><th>Response</th></tr>
<tr><td></td><td></td><td></td><td></td><td>with red clayey sands, red earths and texture contrast soils. The proposed mine is located in a geographical low and is surrounded by Acacia tall open shrubland and tussock grasslands.
Given the differences highlighted above, it is recommended that the proponent justify the adoption of the initial and continuing loss values, derived from the Todd River and Emily Creek catchments, for the Ammaroo site and highlight any major differences or important considerations that may need to be taken into account.</td><td>soils thereby reducing the losses. Without other information, this was considered to be a conservative approach for identifying the potential requirements (and impacts of) the access corridor formation and cross drainage, and flood protection bunds.
The concept design of the access corridor and flood protection berms will be reviewed during detailed design, to refine the access corridor formation height, cross drainage structures, and berm heights.</td></tr>
<tr><td>57</td><td>Department of Primary Industry and Resources</td><td>Waste Characterisation</td><td></td><td>The AMD report:
• does not define the source of the samples used for the geochemical assessment, or how they have been stored and for how long.
• provides limited information on the vertical spread of the samples (i.e. sample depths), the lithology descriptions and number of samples per lithological unit and the volumes each lithology represents.
• uses an inappropriate analytical method to discriminate between sulfur species
It is recommended that the proponent be required to provide justification for using the method used for sulphur analysis or provide an amended AMD classification with the conservative approach of using total sulphur as a proxy for sulphide; provide representative information on the spread of sample; and provide statistics (e.g. min, max, mean) for the MPA, NAG pH, ANC and leachate analysis for each lithology.</td><td>See Section 3.15 for further information on geochemistry.
Samples were collected primarily using reverse circulation percussion and limited diamond core and air core. Samples were stored in the open (dry season) for periods of up to a few weeks before transfer to the analysing laboratory. In reactive rocks, this could have allowed some minor oxidisation of sulfides, however any resulting acid sulfate salts would have remained in the sample, hence the analysed NAG and NAPP results would reflect long-term conditions. Given the overall very low sulfur content, the risk of significant sulfide presence or oxidisation is very low.
The spatial and lithological distribution of samples is discussed in Section 3.15.1 and 3.15.2. All lithologies were NAF, based on NAG and NAPP testing, hence the results have not been broken down by lithology. Samples and lithology are shown with NAG, NAPP and NPR in the ABA summary results, which are displayed in section 3.15.1 Table 3-24 ABA results summary.
Sulfide sulfur was derived by analysing for total sulfur by LECO and subtracting acid soluble sulfate sulfur. The low calculated sulfide sulfur is consistent with the oxidised nature of the material and the NAG and ANC results.</td></tr>
<tr><td>58</td><td>Department of Primary Industry and Resources</td><td>Impacts to Air</td><td>Air quality</td><td>The assessment omits the Double D outstation, also located on land owned by the Dinnie Excision (Imperrenth) Aboriginal Corporation, which is 3.9 km closer to the proposed mine than Imperrenth, as a sensitive receptor with regards to impacts by air emissions.
Baseline monitoring of dust has been used from another project site to provide a baseline for ambient conditions at the proposed Ammaroo mine site. Without the relevant reference to the other site there is no opportunity to review the location and details referred to in the Draft EIS. Please include the reference to allow validation of referenced information and a justification as to how the adopted data is appropriate for the proposed Ammaroo mine site.</td><td>GHD have completed additional model runs to predict the dust (PM_{10}) impact at the Double D outstation, located at approximately 494,410 m E and 7,652,074 m S (MGA 1994 Zone 53).
The result for Double D as well as for receptors 1-5 (as presented in the EIS) are shown in the table below. All receptors are below the 60 μg/m³ criterion, with Double D outstation at 27 μg/m³. The background PM_{10} level set for this assessment is 20 μg/m³. Therefore, an estimated dust impact from the proposed operation alone is 7 μg/m³ at Double D.
Double D and Imperrenth experience a similar modelled impact; Double D being slightly higher due to being a few kilometres closer to the mine (further to the south).
<table>
<tr><th>Receptor ID</th><th>Receptor Name</th><th>Particulates as PM_{10} (VIC Mining PEM)</th></tr>
<tr><td>R1</td><td>Mine camp</td><td>58</td></tr>
<tr><td>R2</td><td>Ampilatwatja</td><td>23</td></tr>
<tr><td>R3</td><td>Imperrenth</td><td>25</td></tr>
<tr><td>R4</td><td>Ngkwarlerlanem</td><td>23</td></tr>
<tr><td>R5</td><td>Indaringinya</td><td>21</td></tr>
<tr><td>R6</td><td>Double D</td><td>27</td></tr>
</table>
<u>Baseline monitoring of dust</u>
The baseline monitoring utilised for this assessment was sourced from Chapter 13 (Air Quality) of the Nolan's Project Environmental Impact Statement (GHD 2016)
GHD considers that the regional air sheds for both the Nolans and Ammaroo projects are sufficiently similar such that baseline measurements conducted at the Nolans site near Aileron are representative of the background environment at Ammaroo.</td></tr>
<tr><td>59</td><td>Department of Primary Industry and Resources</td><td>Impacts to Air</td><td>dust</td><td>A monitoring site will be established at the accommodation camp, however the proponent has not indicated why dust monitoring will not be undertaken at the other sensitive receptors identified in the Draft EIS, nor whether this will be a requisite in the proposed Dust Management Plan.</td><td>The results of dispersion modelling presented in the Draft EIS have predicted Maximum 24-hour averages (worst 24-hour period in 365 days) which are less than half of the PM_{10} criterion for all receptors, excluding the Mine Camp (refer to the table presented in comment 58).
The background PM_{10} value applied to the assessment is 20 μg/m³. This value represents one third of the criterion for PM_{10}, and consequently, the background level</td></tr>
</table>

No.	Agency	Topic	EIS section	Comment (Submission)	Response
					accounts for the majority of impact at all sensitive receptors excluding the mine camp, where mining activities drive the majority of the dust impact. This level of predicted impact is considered to be low risk. GHD considers that it is unlikely that any monitoring equipment would record PM_{10} concentrations elevated above background levels at receptors other than the Mine Camp. The installation of dust monitoring equipment at the nearest, and most impacted receptor (Mine Camp) will achieve the following: • Monitor compliance with the criterion at the highest risk receptor. • Enable the comparison of predicted impact to measured impact. • Enable the operator to better understand the cause of upset conditions or efficacy of any additional mitigation measures (if required). The Victorian Mining Protocol for Environmental Management (PEM) provides a useful summary: "*As modelling can only provide general guidance about the potential impacts for large premises that require a Level 1 assessment, monitoring should be conducted so that an evaluation of the local air quality (including the contribution from the mine or quarry site) against the assessment criteria can be undertaken. This type of monitoring is conducted to confirm the modelling predictions and would only be conducted for a limited period of time (e.g. 12 – 24 months)*" (EPA Victoria, 2007, p.13). Further, *"Sampling should be undertaken at sensitive locations such as residences where the modelling has predicted potentially high levels of particles and at least one site should be chosen downwind of the site to reflect the impact of the mining or quarry operations during the most predominant wind directions"* (ibid.).
60	Department of Primary Industry and Resources	Radiological Considerations		The proponent has not identified the methodology that will be used to identify the most appropriate locations for the environmental monitoring sites. To ensure that representative and meaningful data is captured, please demonstrate that the prevailing winds, the layout of the proposed mine site and ancillary infrastructure, offset distances from work areas, and offsite impacts to sensitive receptors have been taken into consideration.	In Appendix K of the EIS, Verdant sought independent advice on the radiological impacts of the operation. It was shown that potential risks are negligible. Ore and waste rock and final product will contain on average less that 1Bq/g of naturally occurring uranium and thorium, which is below the criteria for a material to be classified as radioactive and therefore subject to regulation (also refer Section 3.16). Verdant did commit (in the EIS) to ongoing monitoring to verify the initial estimates, however additional work undertaken during the supplementary to quantify radiological risk has indicated that environmental monitoring is not necessary. See also comment # 105, 111, 133 and Sections 3.15.4 and 3.16.
61	Department of Primary Industry and Resources	Closure	Cover materials	The proponent should demonstrate that sufficient volumes of suitable cover are available for closure or provide alternative options.	No 'capping' material is required for closure. Cover material will be sourced from mine overburden and soil/grub stockpiles. Further test work will determine the volume of cover material required to achieve the desired landforms. The purpose of the cover material is to achieve a stable and functioning landform, and does not need to prevent infiltration.

2.4 Department of Environment and Natural Resources

No.	Agency	Topic	EIS section	Comment (Submission)	Response
62	Department of Environment and Natural Resources, Rangelands, Water Resources and Flora and Fauna Divisions	biodiversity matters Threatened species Likelihood of occurrence		The Draft EIS adequately addresses the requirement for a detailed assessment of the likelihood of occurrence of five threatened species (listed under the Environment Protection and Biodiversity Conservation (EPBC) Act) and their habitat (within and up to 1 km from the project area). The focal species were: • Greater Bilby (Macrotis lagotis); • Southern Marsupial Mole (Notoryctes typhlops); • Black-footed Rock-wallaby (Petrogale latera/is- MacDonnell Ranges race); • Crest-tailed Mulgara (Oasycercus cristicauda); and • Great Desert Skink (Liopholis kintorei). The methods used to identify the likelihood of occurrence and potential impacts on threatened species were adequate and appropriate. Phase one of the methods involved a desktop assessment using standard search tools (EPBC Protected Matters, NT Flora and Fauna Atlas, and Atlas of Living Australia) and expert knowledge of species' habitat requirements. The authors correctly concluded that the likelihood of occurrence of Black-footed Rock-wallaby and Crest-tailed Mulgara is	Noted.

No.	Agency	Topic	EIS section	Comment (Submission)	Response
				negligible. Notably, two additional fauna species- Brush-tailed Mulgara (Dasycercus blyth1) and Grey Falcon (Falco hypo/eucos) were identified through this process as having a medium and high likelihood of occurrence respectively. Targeted field surveys were subsequently undertaken by experienced ecologists for five threatened species with a high or medium likelihood of occurrence. The methods used were appropriate and species-specific (i.e. nest-site and nest-habitat searches for Grey Falcon, and Track-plot surveys (1 ha for 30 minutes) for the burrowing species). The survey techniques employed were in keeping with advice from the Department's Flora and Fauna Division and appropriate habitat was targeted. Sampling (111 sites) was appropriately allocated across major habitats and the main impact areas: the mine leases, the water supply infrastructure and the access corridor sections (Figure 4-3 in the report). Notably, the Track-plot technique is inherently more effective on sandplain, where sign is most evident, than on other substrates such as rocky rises/hills. In this context however, the approach is valid given that the target species are all associated with sandplain habitat. For Marsupial Mole, the Track-plot technique is not optimal. The proponent's classification of available habitat as marginal is, however, appropriate and it adds weight to their determination of a low- likelihood of occurrence of this species within the project's footprint. In summary, the absence of threatened species records from the field surveys should not be attributed to inappropriate/inadequate techniques. Accordingly, the proponent's post-survey re- assessment of a low likelihood of occurrence for each of the focal burrowing species is appropriate. For Grey Falcon, the proponent’s assessment that the project will not intersect nest sites (or potential nest sites) is correct based on available information.	
63	Department of Environment and Natural Resources, Rangelands, Water Resources and Flora and Fauna Divisions	Biodiversity matters Threatened species Impact assessment		The report adequately addresses the requirement for a detailed assessment of any likely impact that the project may have on listed threatened species at the local, regional, state, and national scale. Reflecting the results of the likelihood of occurrence analysis, a risk assessment was undertaken in relation to Grey Falcon only. The proponent accurately concluded that while Grey Falcon may occur on site, the project posed a low risk at the population scale (and beyond) given that only suboptimal nesting habitat is available and that the species is otherwise solitary. The proponent appropriately concluded that negative impacts to any Near Threatened species arising from the project, while unlikely, could be mitigated with species-specific plans of management.	Noted.
64	Department of Environment and Natural Resources, Rangelands, Water Resources and Flora and Fauna Divisions	biodiversity matters Other biodiversity values		The report adequately addresses the requirement for a detailed analysis of the potential impact of the project to ecosystems and vegetation at a local and regional scale, including the potential for ongoing indirect impacts. General biodiversity surveys of sufficient intensity (seven in total) were carried out by experienced ecologists and habitat mapping was undertaken at a scale appropriate for management (1:15000). The proponent accurately reported that no groundwater-dependant ecosystems or sensitive vegetation will be impacted by the project. Adequate consideration was given to the potential for ongoing indirect impacts to habitats such as ephemeral swamps (i.e. changed hydrology) and native vegetation (clearing, fire and seeds).	Noted.
65	Department of Environment and Natural Resources, Rangelands, Water Resources	biodiversity matters Management Plans		The proponent has developed an Environmental Management Plan (EMP) Framework for the project during construction and/or operations. This includes a Biodiversity Management Plan with three sub-plans. The Fauna and Habitat Management Plan (Section 2.7.1 of Appendix E) provides appropriate and adequate recommendations for staff environmental induction, vegetation clearing procedures, and the development of a threat mitigation procedure in the event threatened species are detected. It is recommended that the latter should include	Greater Bilby Should Greater Bilby be found on or near the site the Biodiversity Management Plan will be reviewed and updated to provide additional traffic management protocols to minimise traffic impacts to the species. This has been included as a commitment. Gas pipeline trench During the installation of the gas pipeline, where applicable (i.e. where trenches are open for distances greater than): • Trench plugs and ramps will be installed at maximum intervals of 500 m.

No.	Agency	Topic	EIS section	Comment (Submission)	Response
	and Flora and Fauna Divisions			explicit traffic management protocols, such as a dawn-to-dusk speed limit, if Greater Bilby is found on or near the site. The recommendations in relation to the gas pipeline trench management are generally appropriate but can be improved to adequately manage animal welfare issues associated with entrapment. Specifically, trench plugs and ramps should be installed at maximum intervals of 500 m as recommended by studies on entrapment of fauna in trenches (e.g. Doody et al. 2003', Swan and Wilson 2012, Woinarski et al. 2003) in addition to the proposed daily morning trench inspections. Fauna shelters should be installed with at least one per 500 m interval between trench plugs and optionally include funnel traps to help trap and subsequently remove animals. The total length of open trench and the length of time any section of trench is open should be minimised to reduce animal entrapment. An adequate number of Fauna Spotter-Catcher teams are required to inspect and clear the entire length of open trench each day, within the conditions of their wildlife permits. The Fire and Weed Management Plans (Appendix E) provide appropriate and sufficient measures to reduce the risk of each disturbance type. It is recommended that the highly invasive introduced grass *Cenchrus ciliaris* should be explicitly included in an invasive species management plan, in order to minimise spread in the project area and potential negative impacts due to changes in fire regime and exclusion of native species.	• Fauna shelters will be installed with one per 500 m interval between trench plugs • Funnel traps may be installed to help trap and subsequently remove animals between trench plugs. • Daily trench inspections of entire length of trench. These controls will be included in the Biodiversity Management Plan. This has been included as a commitment. Weed Management Plan A Weed Management Plan is included in the Environmental Management Plan. The identification, control and monitoring of *Cenchrus ciliaris* will be explicitly included. This has been included as a commitment.
66	Department of Environment and Natural Resources, Rangelands, Water Resources and Flora and Fauna Divisions	Water resources Statement of Groundwater Requirement Groundwater Availability		Verdant present a mine plan whereby they will extract up to 4.4 GL/yr for the 25 year life of the mine (LOM) operation. This water is to be sourced from the Georgina Basin aquifers, which are regionally extensive and perceived to store vast amounts of groundwater. Verdant believe that bores that can pump 75 L/s can be expected at their chosen borefield site about 20 km southwest of the mine. Furthermore they have commissioned a class 1 steady state model that when run under a range of scenarios (e.g. order of magnitude Specific yield variation), is shown to result in very little impact on the regional groundwater system. Furthermore, the tailings waste water and material is considered to be benign; this will allow most mine by-product to be dealt with by storing this waste in unlined strip mining voids, which lie above the watertable, as the operation progresses. While the potential for the Georgina Basin aquifers to behave as predicted by Verdant is recognised as feasible, the whole groundwater operation is still largely based on speculation rather than actual data. For instance only one bore (PB01) has been thoroughly tested, and even this 7 day constant rate test was only run at 25 L/s. Thus Verdant's assertion that the potential exists for production bores to produce 75 L/s for the LOM is not yet demonstrated. No reference is made to any bore that produces a similar yield in the Georgina Basin. The risk assessment should address the risk that production bores may not deliver the anticipated yield of 75 L/s each, and the approach to management of this possible outcome.	The Risk Register for the project has been updated to include the risk that bores may not yield the design capacity. The reduction in forecast water usage highlighted (comment 17) reduces this risk. The Borefield construction approach to manage this risk is described in the Groundwater Impact Assessment (refer Section 5.1.1, Appendix H of the EIS) and reproduced below. Bore field construction will entail a staged approach of: 1. Drilling and pump-testing of each production bore. 2. Optimisation of pump specification and flow rate from each bore based on pump test result. 3. Possible increase in the number of bores if installed bores do not achieve the planned 57 L/s flow rate. 4. If required, an increased number of bores will fit within the planned footprint. The spacing between bores will be reduced. Based on the regional understanding of the Georgina basin which is based on detailed geological investigation by NTGS, the aquifer is confidently expected to have the capacity to meet the demand. The risk is only the number of bores needed to extract water at the required rate. Additional bores would fit within the currently planned footprint. Note that the revised water balance (refer Appendix 4) requires at most 57 L/s from each of the two bores (if the third bore is being serviced). Steady-state pumping from three operational bores is 38 L/s per bore. The Phosphate Hill mine in QLD also extracts water from the Georgina Basin Aquifer. That borefield design comprises 5 bores each yielding up to 45 L/s (7 GL/year borefield design capacity). At that site the target aquifer is reported to be 27 m thick. By comparison, the aquifer thickness at the Ammaroo borefield site exceeds 100 m. Should the production bores not deliver the anticipated yield then additional bores will be installed within the vicinity of the existing bores. Additional monitoring bores in the vicinity of the bore field are planned and detailed in 3.19 of the supplementary and in Section 4.5 of the water management plan.
67	Department of Environment and Natural Resources, Rangelands, Water	Water resources Groundwater Quality		The groundwater report recognises that water quality may vary in the region. Regional geological summaries of the Georgina Basin (e.g. Kruse et al. 20114) note the presence of evaporate deposits throughout the Chablowie and Arrinthrunga Formations, which might result in some unexpected variation in groundwater salinity within the aquifers to be exploited here. However, the risk assessment should address the possible risk to the operation, if the water quality declines.	The Risk Register for the project has been updated to include the risk that the salinity of groundwater pumped from the borefield may decline. The risk is considered unlikely as the salinity data in the regional aquifer is quite consistent. The risk is considered of insignificant consequence and any potential impacts will be managed through the existing water treatment process or additional water treatment capacity investments if needed.

No.	Agency	Topic	EIS section	Comment (Submission)	Response
	Resources and Flora and Fauna Divisions				Additional water treatment might comprise desalination, alternatively borefield pumping might be managed, for instance pumping more from bores that yield better quality water, or re-locating bores.
68	Department of Environment and Natural Resources, Rangelands, Water Resources and Flora and Fauna Divisions	Water resources Groundwater Monitoring	Section 6.3 Appendix H	Verdant present an appraisal and a class 1 groundwater model of the Georgina Basin aquifer in the vicinity of Ammaroo. This model, however, can only be regarded as a best guess rather than actual data. In recognition of this, Verdant proposes that the model be further calibrated (annually if required) and developed to a class 2 type model when actual aquifer performance data becomes available during the LOM (Section 6.3 Appendix 8). In addressing the management risk of impact to other users of the groundwater system (Environmental Management Framework, ref. 1 and 3), the action to conduct a strategic monitoring program that confirms modelled drawdown data should be proposed. In the event that drawdown propagation does not occur as predicted, mitigating measures should be proposed.	The strategic monitoring program is detailed in Section 4.5 of the Water Management Plan (refer Appendix 6). Mitigating measures in the event that drawdown propagation does not occur as predicted are described in Section 4.6 of the Water Management Plan. The method of model calibration is described in Section 4.6.1 of the water management plan An overview is provided in Section 3.20 of this supplementary report.
69	Department of Environment and Natural Resources, Rangelands, Water Resources and Flora and Fauna Divisions	Water resources Groundwater Monitoring	Section 6.2 Appendix H	Monitoring is proposed by Verdant; however, it appears that this is yet to start. Although specialist monitoring bores are proposed (Section 6.2, Table 7, Figure 22), no mention of when these bores will be drilled, how they will be constructed etc. is presented. This is less than desirable as monitoring should begin before a mine starts not after; this way any changes from the pre-mining situation can be assessed. The monitoring program proposed by Verdant (Section 6.2) is considered inadequate. The monitoring bores are only proposed within the predicted area of drawdown from the borefield, no Verdant monitoring bores are proposed to be drilled beyond the predicted impact area (Figure 22). Furthermore, the reliance on existing stock or station bores as observation bores both beyond and within the predicted impact area is not adequate as access and suitability of bore conditions cannot be guaranteed in such bores. Purpose built dedicated monitoring bores is the usual expectation for monitoring points for groundwater appraisals.	The monitoring implementation schedule is detailed in Section 4.5.2 of the Water Management Plan (refer Appendix 6) and described in Section 3.19.2 of this supplementary report. Purpose built monitoring bores adjacent other users (e.g. Stock, Station and Community bores) will be located 200 m from the third-party users bore. Details are provided in the Water Management Plan. Section 4.5.1 and Section 3.19 of this Supplementary Report. Maps are shown as Figure 3-16 and Figure 3-17.
70	Department of Environment and Natural Resources, Rangelands, Water Resources and Flora and Fauna Divisions	Water resources Water Allocation Planning		Verdant also note that around 0.5 GL/yr of groundwater may be enticed out of the adjacent Western Davenport Water Allocation Plan area as a consequence of this mine's water use. This needs to be recognised as an allocation in the Plan.	The estimated flux across the WDWCD is presented as Table 3-14 of the Supplementary. This table includes the 5th, 50th and 95th percentile estimate of flux in order to address the certainty of the modelled volumes.
71	Department of Environment and Natural Resources, Rangelands, Water Resources and Flora and Fauna Divisions	Water resources Spillage/Contamination risk to groundwater		The western part of the infrastructure corridor travels over the Western Davenport Water Control district central Aquifer zone for about 30 km (Figure 11, Appendix H). Groundwater in this area is used for a variety of purposes including community water supplies. A toxic substance spill in the infrastructure corridor is a contamination risk to the groundwaters of the Western Davenport region. Such a risk is not recognised by Verdant. Risk # 94 (in risk table; EIS) notes the possibility of a transport spill; however, considers it unlikely and of low risk and if it is phosphate spill, only a threat to surface waters.	The risk associated with a chemical or hazardous material spill resulting in the contamination of groundwater has been assessed in the risk register (refer risk # 98). The risk assessment does not differentiate between groundwater areas as any degree of contamination is considered a negative impact regardless of the potential use of the groundwater.
72	Department of Environment and Natural Resources, Rangelands, Water	Water resources Licencing and Regulation		NT Portions 749 and 1290 are located outside of any Water Control District (WCD) (i.e. to east of the Western Davenport WCD boundary). The proponent should be aware of other water users in the area and any impact the proposed activity may have on the rights of those water users. Information on other users may be sourced from NR Maps (Natural Resource Maps) available at: http://nrmaps.nt.gov.au/ and the Department's Water Licensing Decision Portal at:	Noted – refer to Section 4.2 of the Water Management Plan (refer Appendix 6).

No.	Agency	Topic	EIS section	Comment (Submission)	Response
	Resources and Flora and Fauna Divisions			https://denr.nt.gov.au/land-resource-management/water-resources/water-licensing-portal As can be noted in NR Maps, there is indication that registered bores have been drilled or constructed on the subject properties. Further information on the location and records of registered bores can be found using the web mapping application NR Maps (Natural Resource Maps NT): https://nt.gov.au/environment/environment- data-maps/natural-resource-maps-nt Any bores used or drilled in associated with the proposed development should be registered with the Department of Environment and Natural Resources. The Water Act does not currently apply to mining or auxiliary activities. When the Water Act is amended to apply to mining activities, all mining operators should ensure: • measures are in place to quantify, record and report monthly, the volume of water extracted from surface water or groundwater resources; • groundwater bores are constructed and maintained in accordance with the National Uniform Drillers Committee, "Minimum Construction Requirements for Bores in Australia" ; • all groundwater bores are registered with the Department of Environment and Natural Resources and clearly and permanently labelled with a registered bore number; • water meters comply with the Department of Environment and Natural Resources 'Non-Urban water metering policy' and 'Non-urban water metering code of practice for water extraction licenses'; and • a plan is prepared that demonstrates how and when water will be used over the life of the project. The plan should include elements addressing detailed construction or development schedules relating to water infrastructure requirements (e.g. bores , water supply, distribution or irrigation systems ; projected water use (monthly for 10 years); water drainage and wastewater management; a description of the surrounding environment and facilities and the potential impact water extractions and drainage associated with the activity may have on the areas available water resource and other persons entitled to that resource including the environment.	
73	Department of Environment and Natural Resources, Rangelands, Water Resources and Flora and Fauna Divisions	erosion and sediment control		This submission has not been assessed by the Department's Land Management Unit. With regard to erosion and sediment control, the following standard response is provided: • Be prepared by a suitably qualified and experienced professional in erosion and sediment control planning; and be reviewed and approved by a Certified Professional in Erosion and Sediment Control (CPESC). • Be prepared in accordance with the IECA Best Practice Erosion and Sediment Control Guidelines 2008 (or higher standard). • Be the final environmental management plan to be prepared (as it relies on completion of final design) and be a stand-alone document which contains all necessary information to facilitate its implementation without requiring the user to reference other documents . • Be cross-referenced with other relevant environmental management plans to ensure consistency (e.g. plans relating to Water Management, Stormwater Management, Site Rehabilitation, etc.). • Include details of both temporary and permanent erosion and sediment control methods and treatments to be implemented for all stages of the project (pre, during and post works). • Comprise an over-arching strategic document outlining the principals, practices and methods to be implemented, as well as site-specific dimensioned plans identifying the location of works and prescribed controls; and be accompanied by relevant Standard Drawings and Construction Notes.	Noted – upon completion of final design, an ESCP will be prepared by a suitably qualified professional and experienced; and included in the Mine Management Plan and submitted as part of the mine authorisation process. This has been included as a commitment.

No.	Agency	Topic	EIS section	Comment (Submission)	Response
				• Include information regarding proposed timing and staging of works, site manager contact details, maintenance and monitoring requirements, and reporting procedures. Implementation of the CPESC-approved ESCP should be regularly monitored by a suitably qualified third party auditor, to the satisfaction of the Consent Authority. Information regarding best practice management can be obtained from the following sources: • IECA: www .austieca .com.au • DENR: https://nt.gov .au/environment/soil-land-vegetation • DIPL: https://transport. nt.gov .au/infrastructure /specification-services /technical-specifications o LPSDP: http://www .industry.gov.au/resource/Programs/LPSD/ Pages/LPSDhandbooks.aspx o SER: http://www .ser.org/page/SERDocuments	

2.5 Department of Infrastructure, Planning and Logistics

No.	Agency	Topic	EIS section	Comment (Submission)	Response
74	Department of Infrastructure, Planning and Logistics Transport and Civil Services	Traffic impact assessment Traffic	Traffic impact assessment	This Department notes that the proponent has acknowledged in its TIA that "*The current alignment of Murray Downs Road passes directly through the project site, and so it is proposed that Murray Downs Road be realigned to bypass the site. The original alignment of Murray Downs Road will be converted to a private road to service the project, with access to the general public restricted*". The Department is represented on the Major Projects Working Group in relation to the Verdant Minerals Ammaroo Phosphate Project. The proposal for realignment is neither endorsed or rejected and is subject to ongoing negotiations with the Department. As the Proponent has identified its preference for a realignment of the Murray Downs Road to support general public use, the Proponent should undertake appropriate studies and environmental assessment on its preferred alignment to identify any constraints prior and be inclusive of its assessment. It is noted that the TIA includes a number of recommendations regarding the proposed activities and the associated impacts within the NTG managed public road corridor system. It is expected that the recommendations will be adopted by the Proponent. It is also reiterated that until agreement is reached on any realignment of the road no permission is given for any mining activities in the existing road reserve. The standard requirements for a Construction and Operational Traffic Management Plan, design documents for all new (either temporary or permanently) or upgraded accesses must be submitted to the Director Corridor Management, Transport and Civil Services, DIPL as the approving Road Agency.	The realignment of the Murray Downs Road and the relevant responsibilities, standards and approvals will be part of an Ammaroo Phosphate Project Development Agreement that is being negotiated with the NT Government through the Major Projects Working Group. Appropriate documents will be submitted to DIPL in due course. It should be noted that most of the length of the proposed realignment is contained within the Minerals Lease(s) that are the subject of this EIS.

2.6 Department of the Attorney General

No.	Agency	Topic	EIS section	Comment (Submission)	Response
75	Department of the Attorney-General and Justice, NT WorkSafe	Health and safety		The Draft EIS covers the applicable legislation and recognises the process that need to be considered to ensure compliance with NT WorkSafe administered legislation.	Noted.

2.7 Department of Trade, Business and Innovation

No.	Agency	Topic	EIS section	Comment (Submission)	Response
76	Department of Trade, Business and Innovation	Economic and social impact assessment		This project would provide socio-economic benefits including employment and business opportunities to the region as well as the broader Territory economy.	Noted.

2.8 Department of Tourism and Culture

No.	Agency	Topic	EIS section	Comment (Submission)	Response
77	Department of Tourism and Culture Parks and Wildlife Tourism NT Heritage Branch			The Parks and Wildlife Division of the Department of Tourism and Culture has noted that the Project is approximately 50km from the nearest park or reserve, Iytwelepenty/Davenport Ranges National Park, and does not have any foreseeable impacts on the interests of the Parks and Wildlife Division or the land it manages.	Noted.
78	Department of Tourism and Culture Parks and Wildlife Tourism NT Heritage Branch	Tourism NT Rail schedule		Tourism NT requires the Proponent to demonstrate that the proposed daily train schedule transport from the loading point to Darwin does not disrupt the Ghan passenger rail service between Adelaide and Darwin. A specific schedule has not been provided in the Draft EIS (Section 2.8.3 or Chapter 12).	The management of the daily train schedule and the adherence to the schedule is a matter for the rail operator and is outside of the control of Verdant Minerals.
79	Department of Tourism and Culture Parks and Wildlife Tourism NT Heritage Branch	Tourism NT Traffic impact assessment Traffic and road repair		Tourists using the Binns Track to access the Davenport Ranges National Park from the south pass over the portion of Murray Downs Road and unsealed road that will be utilised in the project by heavy vehicles. The Draft EIS acknowledges that it is not known whether the Murray Downs Road is able is to accommodate the increased traffic associated with the project. The Sandover Highway is utilised by 4WD tourists travelling from Queensland to the Northern Territory and the road is already in a state of disrepair with highly variable road conditions. It is unclear in the current draft EIS how further negative impacts on the road will be managed.	Murray Downs Road will be upgraded to support the construction phase of the project. Following construction the mine site inputs and outputs will be via the rail spur
80	Department of Tourism and Culture Parks and Wildlife Tourism NT Heritage Branch	Heritage Branch Heritage matters		Heritage Branch are satisfied that all heritage and archaeological issues have been adequately addressed for this project. The Draft EIS includes a very comprehensive Heritage Assessment, which identifies the major issues, potential impacts to sites, relevant mitigative measures and procedures for applying for permission to disturb/destroy archaeological sites. The Heritage Assessment also recommends that a Cultural Heritage Management Plan be developed to specifically address impacts, unexpected heritage finds and any other remaining requirements for historic and cultural heritage. A copy of the Cultural Heritage Management Plan should be provided to Heritage Branch.	The draft Cultural Heritage Management Plan is provided as Appendix B of the Environmental Management Plan (Appendix E of the EIS). The CHMP will be updated to include an unexpected heritage finds procedure. The CHMP will be submitted to the Heritage Branch for endorsement prior to the commencement of construction. This has been included as a commitment.
81	Aboriginal Areas Protection Authority	Sacred sites		Sacred sites are known with this area of interest. Verdant Minerals has applied to the Aboriginal Areas Protection Authority for an Authority Certificate for the project area, including transport corridors. The EIS document makes numerous references to the existence of sacred sites within the project area and describes how risks associated with these sites will be managed. References are made to the processes of the Sacred Sites in relation to the management of these risks. However, the Authority's engagement with Verdant Minerals has consisted of one meeting to discuss the processes of the Act. References in the EIS to Verdant Minerals having accessed the register of sacred sites held by the Authority are not supported by the Authority's records, though it is possible that a third party previously accessed the register on their behalf.	A key mitigation for the management of sacred sites is acquiring an Authority Certificate from AAPA. On 19 January 2018 Verdant Minerals was advised by the NT EPA that : • AAPA did provide additional comments (No. 145-150 below) • AAPA is in receipt of an Authority Certificate application from Verdant Minerals for the project area • Third parties did access the Authority's register on behalf of Verdant Minerals for the project area. The risk register and Cultural Heritage Management Plan will be updated on receipt of the Authority Certificate.

No.	Agency	Topic	EIS section	Comment (Submission)	Response
				The Authority is of the view that the level of engagement between Verdant Minerals and the processes of the Northern Territory Aboriginal Sacred Sites Act does not support the statements in the EIS relating to sacred site protection and the Act.	

2.9 Central Land Council

No.	Agency	Topic	EIS section	Comment (Submission)	Response
82	CLC	Sacred site protection		A key CLC function under the ALRA is to assist Aboriginal custodians in the protection of sacred sites on land in the area of the Land Council (whether or not Aboriginal land) (s.23 (1)(ba). The CLC has conducted sacred site clearances in the area of the phosphate deposit for exploration activities and recently over the proposed infrastructure corridor. Numerous 'exclusion zones' protecting sacred sites have been provided to the company. The CLC requested that this sensitive and confidential information be treated carefully in the EIS and that sacred site protection information and the location of archaeological material be either removed from maps that will be subject to the public version or for those chapters to be closed to the public.	Noted – reference to the location and nature of cultural exclusion zones and archaeological sites / artefacts (including maps) were removed from the publically available EIS. The final identification of sacred sites and associated restricted work areas will be encompassed in an AAPA Authority Certificate that will be issued in due course, subject to the completion of a final survey and a Native Title Agreement that is currently under negotiation.
83	CLC	Sacred site protection		It is stated that 'No direct impact to CLC exclusion zones is predicted (Chapter 3.1). Under a comment in line item 51 of the Risk Register, it is noted that '(T)here are 2 major sacred sites in the Mineral Lease and 1 near the actual mine location' , and that '(T)here are no soaks by the Project footprints'. These statements are incorrect and misleading. There are 7 identified sites and 1 grave site within the Mineral Lease Application areas. Two of the sacred sites are soakages, one of which will be directly impacted by the mine footprint. A total of three sites are located within the mine footprint and two sites are located in close vicinity to the proposed realignment of the Murray Downs road. It is noted that a sacred site clearance for the Mineral Lease applications is planned for early 2018. Native Title Holders have asked for ongoing access to sacred sites surrounded by and in close proximity to the deposit – this will be a matter for further discussion under the agreement negotiations.	Noted – Verdant will discuss these matters with the CLC over the ensuing weeks as we work towards attaining AAPA certificates for the project.
84	CLC	Archaeological Material		Archaeological sites and artefacts have been identified in relation to the Project area. This material is of cultural interest to the Native Title Holders who wish to be consulted about and to participate in the management of this material. The EIS states that a Cultural Heritage Management Plan will be designed which should also enable consultation and participation by Native Title Holders.	Noted – a Cultural Heritage Management Plan is provided as Appendix B of the Environmental Management Plan (Appendix E of the EIS). Section 4.3 confirms the consultation process and provides provisions for Native Title Holders / Traditional Owners to review prior to implementation.
85	CLC	Traditional Practices		Traditional hunting and gathering practices are important for the Native Title Holders and Traditional Owners of the land. Hunting and gathering practices will be impacted by the Infrastructure Corridor, as crossing the railway line will be difficult. As the project progresses, consultation with Native Title Holders is requested to discuss possible crossings for continued ease of access to important hunting grounds.	Noted – Verdant is committed to discussing these matters further with the Native Title Holders during future discussions. The CLC should note that the rail spur will be largely of limited height above ground with gentle batters, and crossable in most places by foot. Furthermore, vehicle crossing will be established where the spur crosses pastoral fence line tracks.
86	CLC	Water Groundwater		Community residents of Ampilatwatja and Native Title Holders have expressed concern about threats to their potable water supplies as a result of the Project, both from drawdown and possible contamination.	Refer to comments 19, 33 and 68 for further information on drawdown impacts and comments 28 and 71 for further information on potential contamination.
87	CLC	Water Groundwater		The executive summary should clearly state how much water is proposed to be used by the Project per year. It mentions cubic meters/hour, which is hard for an average reader to put into any kind of context. The report should clearly state that use of over 4 GL/year for 25 years is planned. The figure can be found in the 60 page technical report in Annexure H (section 5.1.1).	Water demand was detailed on page xi of the Executive Summary, stating '*A conservative estimate of the project's maximum use of ground water resources includes 876 ML total during construction, and 4.4 GL pa, or 110 GL total during operations.'* This water demand did not account for the recycling of tailings liquor. The updated water demand for the Project is 3.6 GL/year and is based on an average recovery rate (refer comment 17 for further information). It is noted that the construction phase is 2 years and the operations phase is 25 years.

No.	Agency	Topic	EIS section	Comment (Submission)	Response
88	CLC	Water Groundwater		The Company acknowledge that the water resource it plans to use from the Georgina Basin is connected to the Dulcie Sandstone and that this formation contains a significant aquifer yielding potable quality water. Yet they do not address any effects on the Dulcie aquifer that such planned extraction from the Georgina Basin may have.	Refer to comment 54.
89	CLC	Water Groundwater		A drawdown of up to 2.7 m is predicted at the Ampilawatja community bore-field and up to 3.7 m at the nearest pastoral bore. Over a 25 year period, the CLC seeks clarification as to whether there will be significant additional costs required to pump water from those depths and if current yields (in L/s) will be obtainable?	The current yields at the community bores will still be obtainable. Refer to comment 19 for further information. The additional pumping costs would be small. The depth to water in the Ampilwatja community bore field is approximately 50 m below ground. Pumping costs scale approximately linearly with depth, so an increase in water level depth of 2.2 m would result in increased power consumption of approximately 2.2 m / 50m = 4%. VRM commit to ensuring no reduction in water availability to other users because of mining. Mitigation measures include deepening bores, and upgrading pumps, though these measures are not expected to be needed.
90	CLC	Water Groundwater		The Report state that there are no Groundwater Dependent Ecosystems (GDE) in the study area and that the area is not covered by the Commonwealth Atlas for potential GDEs. This last statement is misleading. It could be taken to mean that the Atlas indicates there are no GDEs present, when in fact it means no data in the region has been analysed. The report makes the assumption of no GDEs based on the depth of groundwater (i.e. it is too deep to support GDEs). However, a mapping study similar to that done by Water Resources for the draft Western Davenport Water Allocation Plan, with ground truthing, is preferred to support the view.	Most studies suggest a threshold depth of around 8 to 10 m for reliance on groundwater by vegetation. While some plants may extend roots much deeper than this, water tables at such depth are unlikely to support GDEs. At depths of over 20 m the probability of groundwater use is low (Froend and Zencich 2001). Ground truthing has occurred during the biodiversity field studies that concluded GDEs were not within the study area. DENR has agreed with the 'no data' conclusion, and is currently undertaking GDE regional mapping study – refer to DENR Water Resources
91	CLC	Water Groundwater		The study seems to criticise the volumes of water for allocation in the Western Davenport Water Control District to industry, agriculture and SIR (Strategic Indigenous Reserve – also known as Strategic Aboriginal Water Reserve). It comments that the proportion allocated to industry is 'surprisingly low'. Yet these allocations are based on the priorities of stakeholders and the requirements for maintaining GDEs and cultural sites based on modelling done by Water Resources.	Noted.
92	CLC	Water Groundwater		Clarification is required in relation to the Mine Staging Plan. It notes 25 years for the Plan (which we understand is the proposed mine life) yet the map also shows a 30 year pit shape (Vol 1. page 25), and yet another 40 year pit shape (Appendix I figure 4-1 and 4-2 pp 22-23). What are the comparative differences in water use (and other impacts) of a 25 year mine compared to a 40 year mine?	The draft EIS is for a 25 year mine life. It is acknowledged that there is a resource that could potentially support a much longer mine life and therefore providing an extension of the economic opportunity that this project provides the region. It is envisaged that that actual environmental impacts of the operation will be well understood over a 25 year LOM and the appropriate approvals to continue mining will be sought at the time.
93	CLC	Water Groundwater	(Appendix H. Chapter 4.3)	The methodology calculation needs to be provided to enable cross checking of the results. The report states that the overall water balance error is less than 0.1% (Appendix H. Chapter 4.3) however, information showing how this value is calculated has not been provided.	The water balance of a numerical model is checked to be sure that the model is calculating correctly. It is calculated as the difference between water in and water out of the model. For this model water in is Storage Change and water out is Pumping (Table 5 of the CloudGMS report appended to the Groundwater Report, Appendix H of the EIS). The difference between the two is the Error. Reported as a percentage it is the Error divided by the total water out.
94	CLC	Water Groundwater		Clarification is sought on the impact and monitoring processes in relation to the tailing liquor seeping from storage in the mine pit to the groundwater table. It is stated that this will result in some increase in groundwater level and change to the chemical composition of groundwater (Appendix H. Chapter 5.1.4), yet it is unclear how this would come about and how will it be monitored.	Refer comment 28 for further information on potential impacts. Refer to Section 4.5 of the Water Management Plan for further information on monitoring (Appendix 6).

No.	Agency	Topic	EIS section	Comment (Submission)	Response
95	CLC	Surface water		The area covered by the Hydraulic model (Appendix G. Figure 3-5) does not cover the full areal extent of the Mineral Lease Applications. The gap coincides with the adjoining Infrastructure Corridor, which together with the elevated processing plant and levees are expected to divert water from the north. Figures that were chosen for the summary on surface water (chapter 7) in the EIS does not show this. The modelling done pays little attention to the effects on the re-routed road to Murray Downs. To address this deficit, the CLC requests that the re-routed road is included in the amended Water Management Plan.	The flood modelling does cover the portions of Murray Downs Road realignment that could be affected by flooding, however it does not include the geometry of the proposed Murray Downs Road. The design of the proposed Murray Downs Road will be confirmed during detailed design, however it is likely to be partially combined (or within the vicinity of) the modelled flood protection berm. Therefore, the flood impacts indicated are considered to be a reasonable estimate of the potential flood impacts associated with the Murray Road realignment.
96	CLC	Surface water		The Report does not provide a clear explanation on the water treatment when there are extreme floods events. It states that during such extreme flood events, “all reasonable efforts will be made to avoid discharging of process water.” It also states that transfer to open cut pits is left as an option. The CLC seeks clarification as to what treatment this water will be subject to before that would happen?	No treatment would occur during an extreme storm event. Excess water would be pumped to the open cut pit to minimise the risk of uncontrolled discharges. Following the storm event, the intercepted water will generally be reused on site for process water and dust control or will be left to evaporate.
97	CLC	Surface water		The report misleads the reader as to how the Tailing Storage Facility will operate. In the document, reference is made to an article (Worley Parson, 2014) that supernatant water can be reclaimed from tailing thickening (Appendix G. 4.3) among which recycled water from the tailings thickener is listed as an available water resource. However, the Report also states that ‘water from the Tailings Storage Facility will not be recycled.’ Placing this narrative is misleading as it presents a method that is not to be used in practice. The CLC seeks clarification as to what the actual methods will be in managing supernatant water from the Tailings Storage Facility.	The statement ‘*water from the Tailings Storage Facility will not be recycled’* should be read in the context that the draft EIS water balance did not account for recycled water from the TSF. An average rate of water recovery, equating to 0.4 GL/year, has been has been allowed for in the updated water balance (refer Section 3.1 and Appendix 4). The impact assessment associated with the resultant water demand has been reviewed based on the potential water recovery efficiencies and is detailed in Section 3.6.
98	CLC	Transport issue – sharing the road Traffic and safety		During the construction phase of the Project the company intends using the Murray Downs Road for access to the Project area. The road is the main access to Ali Curung and Ampilatwatja. Traditional owners and community members have raised concern about the safety given heavy vehicle use and the current condition of the road, especially on the Murray Downs Road and the single strip of bitumen to Ali Curung.	Murray Downs Road is a public road and will continue to be managed by the NTG as per their standards. Verdant is currently discussing the project road use and the need for road upgrades for project requirements with the NT Government. Risk 84 in the risk register details controls including: • - Traffic Management Plan that separates construction from local traffic where possible, including a community education / awareness communication. • - Install Trucks Entering signs at identified locations where concentrations of heavy vehicles are expected. • - Codes of behaviour for truck drivers • - Explore with locals whether certain times of day contribute to more or less road safety. Refer to comments 22 and 74 for further information on the use of Murray Downs Road. The legacy for people in the region, including the communities and the pastoralists, will be a better and safer road
99	CLC	Transport issue – sharing the road	(Vol 1. Chapter 2.8.2).	The Report states that the Company will ‘go through appropriate measures to confirm conditions and criteria to determine controls required for crossings’ (Vol 1. Chapter 2.8.2). While it is noted that the Company’s recognition of this issue is noted in the Risk Assessment, the CLC maintains its concerns as to the lack of attention given to the risks to local commuters and wishes to be informed throughout the process of the Project on the suggested upgrade and improvements to road conditions.	Only one public road will be crossed by the railway – Taylor Creek Road. The rail will be designed and operated as per: • National Rail Safety Law (South Australia) 2013 that specifies the requirement for a Safety Management System and the requirement to consult with affected stakeholders. • AS4292 – Railway safety management. AS4292 details railway safety requirements including the provision of a railway safety management system. • AS1742.7 – Manual of uniform Traffic Control - railway crossings and details the signage requirements for rail crossings.
100	CLC	Transport issue – sharing the road Road quality and traffic		Native Title Holders and affected community members are worried that increased usage of heavy vehicles without mitigation will deteriorate the road quality. The CLC is also concerned by the uncertainty surrounding planning for the rail spur. The EIS indicates that a Haul Road along the same route as the Infrastructure Corridor will remain an option, particularly for the first 5 years of	<u>Road quality</u> Murray Downs Road is a public road and will continue to be managed by the NTG as per their standards. Verdant is currently discussing road use and project requirements with DIPL. <u>Haul road</u>

No.	Agency	Topic	EIS section	Comment (Submission)	Response
				production (Vol 1. Chapter 2.8.). It is stated (in 2.8.2) that it will be used for transport during construction of the railway. If there are complications such as delays during constructions of the railway or the Mine, the CLC advocates for this alternative route to be used to ease transportation on the public roads.	A haul road is no longer part of the project scope and is not required for the Project. The railway will be constructed prior to the export of ore.
101	CLC	Transport issue – sharing the road Dust and traffic		Excessive dust during use of the Murray Downs road has been raised particularly by residents at the Imangara community and Imperrenth outstation located to the north- west of the Project area. Verdant has to told Native Title Holders that they are willing to discuss sealing roads near communities. The CLC reiterates that these are the wishes from the Native Title Holders	Noted – refer to comment 22 for further information on dust management on roads. Verdant will continue to engagement with relevant communities throughout the project development phase.
102	CLC	Flora and Fauna		The CLC is concerned about the impact on fauna by the Infrastructure Corridor and the Mineral Lease areas. The Native Title Holders believe there are Bilbies in the Project area and the CLC can share data that supports this view. Map 2017-412, attached in Appendix 1 shows, the Infrastructure Corridor and MLAs bisect part of the known range of the Greater Bilby based on CLC and NT Species Atlas records (e.g. known population from records up to 2010 on the railway line near Illeuwurru and other records from further north and east). In addition, there are records close to the eastern boundary of the MLAs closer to Ampilatwatja. The conclusions in the Report are of a different sort e.g. '… the lack of evidence supporting the presence of the species, and also the absence of suitable refuge habitats (and known populations) in the region, indicate a low likelihood that Greater Bilby occupy these desert sandplain areas …' However, statements like that are contradicted by, e.g. '… long-term seasonal home range of a group of Greater Bilby may be large (up to hundreds of square kilometres) …' indicating there is a strong possibility that Bilbies would occur or access the area impacted by this proposal.	The Flora and Fauna report does not preclude the possibility of bilbies occurring within the bioregion. Instead, it presents an argument that there is a low chance of them occurring in the specific project footprint – based on the results of a comprehensive habitat survey that has been adjudged to be adequate by DENR's Flora and Fauna Division (see comment 62). The 2010 records mentioned in this comment are not in the NT Fauna Atlas or Atlas of Living Australia, nor were they disclosed by DENR during pre-survey discussions. Most of the Greater Bilby records in the NT Fauna Atlas within the project area and surrounds are historic (pre-1970), including many records from the early 1900's. There are a four post-1970 records within the project region including two recorded 40 km east of the project area from the early 1980's; one near Murray Downs homestead in 1978, and two road kill records along the St Hwy north of Barrow Ck. It is because of the existence of historic records and potentially-suitable habitat that such a comprehensive survey was undertaken. In the absence of any signs of bilbies, it was concluded that whilst they may have once occurred, there is now a low likelihood of bilbies occurring in areas of potential suitable habitat (desert sandplains) within the project footprint; and essentially no likelihood in red earth-dominated areas to the east. This finding is consistent with the general range contraction that Greater Bilby have suffered in the past 50 years. Additional mitigation measures around driving and trench management protocols to minimise impacts to threatened fauna, including bilbies if found; have been described in the response to comment 65.
103	CLC	Flora and Fauna		The EIS notes '… Three predator species, including foxes and cats, were identified within the project area are a concern. Predation is a major threatening process to the Greater Bilby …' Given the identified presence of Bilbies in proximity to the Infrastructure Corridor and that linear corridors are known to become vectors for predator dispersal, the CLC recommends greater consideration be given to potential impacts on Bilbies (e.g., restricting range movement, predation). Further, the CLC recommends that a more extensive and targeted tracking survey be carried out by an experienced Bilby survey team with the view to developing an appropriate management response as needed. In addition, other significant species (e.g. marsupial mole, Golden Bandicoot) are proximal to the proposed transport corridor as well as the large areas in close proximity to the Project area, with 'no data'.	<u>Predation</u> Introduced predators are highly likely to occur in the region. Given the current extent of vehicle and cattle tracks, cleared fence and seismic lines, and cattle disturbance throughout the project footprint, those predators are likely ubiquitous (tracking surveys consistently recorded Feral Cat sign across the entire project area; fox and dingo records were rare). Consequently, the creation of an infrastructure corridor is unlikely to facilitate further dispersal of introduced predators. <u>Survey effort</u> The habitat and tracking survey conducted throughout all project areas were designed to be comprehensive and targeted towards identifying the presence or likely presence of Greater Bilby. The survey team was selected to include personnel with experience in tracking bilbies and their habitat features – see Section 4.3 of Appendix J of the EIS (Flora and Fauna Report). These personnel were also acknowledged as having a suitable level of experience and credentials by the DENR, and the survey techniques were discussed with DENR prior to the survey being undertaken. As was noted in Appendix J in the EIS several local indigenous rangers from Ampilatwatja Community also participated in surveys within the mine area and provided local knowledge on the presence of the target threatened species. Their involvement along the access corridor was not possible due to logistical issues. Furthermore, additional fauna surveys of the mine area were conducted during different years and conditions (with no bilby records resulting) to further enhance survey effort. Therefore, an additional tracking survey for Greater Bilby is not considered to be required. A low likelihood of occurrence was given to Greater Bilby for the western half of the transport corridor (see Flora and Fauna report of EIS for justification).

<table>
<tr><th>No.</th><th>Agency</th><th>Topic</th><th>EIS section</th><th>Comment (Submission)</th><th>Response</th></tr>
<tr><td></td><td></td><td></td><td></td><td></td><td>Generally, species with a low likelihood of occurrence do not qualify for specific management; as general fauna management as part of Environment Management Plans should be adequate for reducing impacts. Additional mitigation measures re driving and trench management protocols to minimise impacts to threatened fauna, including bilbies if found, have been described in the response to comment 65.
With regards to Marsupial Mole, refer to DENR comments (submission 62)
Historic records
Because of their age, and the changes that have occurred in the interim, historic fauna records (pre-1970) are generally not used when assessing the likelihood of occurrence of a species within a particular region. In terms of Golden Bandicoot referenced in the comment, that particular species is considered extinct in the mainland NT and now only occurs on a few islands in north eastern Arnhem Land (see https://nt.gov.au/__data/assets/pdf_file/0017/205505/golden-bandicoot.pdf). This species was once widespread across the landscape and records situated close to the project area are all historic.</td></tr>
<tr><td>104</td><td>CLC</td><td>Flora and Fauna</td><td></td><td>Operational staff may need training to identify threatened flora and fauna, as well as reporting encounters with flora and predators by users of the infrastructure corridor (observation and kill log).</td><td>Noted – training will be provided to all staff as part of the site induction for the purpose of reporting encounters. This has been included as a commitment.</td></tr>
<tr><td>105</td><td>CLC</td><td>Operational matters</td><td></td><td>Pollution is a concern in relation to the mining proposal. The Company states that ore and waste rock are expected to hold radiation levels equal to 1 µBeq/m3.
Appendix K contains an Executive Summary of Radiation considerations. However, the full radiological impact assessment (RIC) Report referred to in the EIS should had been included in the EIS so the figures can be reviewed.
The EIS includes the AMD assessment and management plan in Appendix I with numerous geochemical analysis included. It is inconsistent to exclude the Radiation Assessment Report. Further, amounts of radioactive elements in the product have not been considered following beneficiation.</td><td>In Appendix K of the EIS, (a technical memorandum) Verdant Minerals sought independent advice on the radiological impacts of the operation. It demonstrates that potential risks are negligible.
Ore and waste rock and final product will contain on average less that 1Bq/g of naturally occurring uranium and thorium, which is below the criteria for a material to be classified as radioactive and therefore subject to regulation.
Indicative uranium and thorium concentrations are provided in the following table. Additional data is included in Section 3.16
As can be seen, in all cases, the concentrations of U and Th do not exceed the threshold 1 Bq/g for definition of a radioactive material, and are therefore are not subject to regulatory control.
<table>
<tr><th></th><th>Ore (ppm)</th><th>Overburden (ppm)</th><th>Tailings (solid) (ppm)</th><th>Tailings (liquid) (mg/l)</th><th>Product (ppm)</th></tr>
<tr><td>Uranium</td><td>22.7</td><td>16.9</td><td>16 / 7.1</td><td><0.001</td><td>14</td></tr>
<tr><td>Thorium</td><td>8.8</td><td>12.5</td><td>- / 8.0</td><td><0.001</td><td>6.8</td></tr>
</table></td></tr>
<tr><td>106</td><td>CLC</td><td>Operational matters</td><td>Vol 1 section 2.10</td><td>The EIS Report indicates that the primary filtration treated water will use sand filters (Vol 1. 2.10.1). The CLC seeks further information as to the source from which this sand will be obtained and where it will be disposed of after being used.</td><td>Sand filters are manufactured pieces of equipment sourced from commercial suppliers. Sand for the water treatment plant will not be extracted from the area of the Project. Filtration equipment will be installed and replaced as necessary.</td></tr>
<tr><td>107</td><td>CLC</td><td>Operational matters</td><td></td><td>Information in the EIS regarding dust pollution is considered deficient. For assessment of modelled data the Report uses the Criterion by EPA Victoria from 2007. PM10 concentration from mine activities and potential background is expected to be below 60 µg/m3. The Report states that the air pollution regulation allows for PM10 60 µg/m3 during an averaging period of 24 hours (Vol 1. 2.12 and Table 2-15, Table 15-3 and Figure 15-3). The CLC seeks clarification as to why the assessment is not based on the standard of pollutants put by the NEPC (The National Environment Protection (Ambient Air Quality) Measure (NEPM) Feb 2016, Table 1).
This Federal document puts the maximum concentration standard at 50 µg/m3 per day.
Further, Figure 15-4 needs clarification. The Figure has two contours plotted across the Mineral Lease area. As mentioned in 15.4.1 one of these is the 60 µg/m3 but there is additionally a contour closer to the plant and across the re-routed road with a 100 µg/m3. Whilst the Report notes that there remains some risk of non-compliance, the CLC seeks clarification as to how this contour complies with guidelines.</td><td>Victorian Mining PEM
The PM_{10} 60 $\mu g/m^3$ during an averaging period of 24 hours is derived from the Victorian Protocol for Environmental Management - Mining and Extractive Industries (‘The Mining PEM’, EPA Victoria Publication 1191, December 2007). This is an incorporated document of the State Environment Protection Policy - Air Quality Management (SEPP (AQM)).
The Mining PEM specifies the assessment criteria for the predicted emissions. As the mine is yet to be built, an air dispersion model is used to provide these predicted values. In the case of PM_{10}, the criterion is the ‘Intervention Level’ from SEPP(AQM). This 24-hour averaged criterion is numerically lower than the 1-hour criterion used in modelling assessments of stack sources (see Schedule A of SEPP(AQM)). The PM_{10} Mining PEM criterion has been developed based on the protection of human health so that “the beneficial uses of the air environment (as specified in SEPP (AQM)) are protected” (EPA Victoria, 2007, p.7).
The National Environment Protection (Ambient Air Quality) Measure (NEPM) Feb 2016, Table 1, however, is concerned with the measurement of population exposure to various pollutants. Clause 13 92 defines performance monitoring stations as “Performance monitoring station(s) must be located in a manner such that they contribute to obtaining a representative measure of</td></tr>
</table>

No.	Agency	Topic	EIS section	Comment (Submission)	Response
					the air quality likely to be experienced by the general population in the region or sub-region". Concentration standards Concerning standards and goals, for PM_{10} the standard is 50 μg/m^3 during an averaging period of 24 hours (and also an annual standard of 50 μg/m^3) while the goal is for this standard not to be measured by the state jurisdictions to be exceeded (see Schedule 2). The exception to the goal not being achieved is "*the influence of natural events and fire management*" (see Clause 18 (3)). As an introductory note, the NEPM (AAQ) states "*The Measure is to be implemented by the laws and other arrangements participating jurisdictions consider necessary: see section 7 of the Commonwealth Act and the equivalent provision of the corresponding Act of each participating State and Territory*." In Victoria, the State Environment Protection Policy (Ambient Air Quality) is the arrangement made – aka SEPP(AAQ). "*The SEPP AAQ standards do not apply to individual sources but to regional air quality. They apply at sites that are generally representative of the exposure of the general population not at peak sites*" (EPA Victoria, 2007, p.4). Moreover, Clause 3 of NEPM (AAQ) states "*Participating jurisdictions must: (a) for … particles as PM_{10}, monitor, assess and report in accordance with the protocol in this Measure*".
108	CLC	Rehabilitation		It is stated that there is currently no allocation in the water balance (Figure 2.9) for recycling the water from the tailings facilities. The Report assumes that seepage from tailings is minimal due to the finely ground nature of the tailings and most moisture being lost through evaporation. However, this position is later contradicted with the statement: 'The TSF facilities (surface and in-pit) will be designed to include water recovery (estimated to be approximately 20-30% of the water discharged in the tails to the TSF) from collection ponds using a decant or floating pump station.' (Vol 1. Chapter 2.6).	The recycling of water from the TSF was not accounted for in the water balance presented in the draft EIS, as the water balance presented the 'worst case' scenario in the EIS. Refer to comment 17 for further information on water recovery from tailings.
109	CLC	Rehabilitation		The TSF embankments will be constructed from silt/clay fill but the tailings will not be lined. After the first 24 hours the tailings are assumed to be 40% water. It is stated that expected tailings will be consolidated to a dry density in the order of 0.7t/m3 to 0.9 t/m3 over a period of several years (2.6.2). Once the tailings are sufficiently stable they will be capped with a layer of waste rock up to approximately 1-2 m higher than the surrounding land. The CLC seeks further information on what dry density would be sufficiently stable to start the capping process, including the proposed density it will be capped at.? Further clarification is required from the implied expectation of 'several years' before capping which could be inconsistent with the mapped mine stages of 4 years.	Refer to comment 2 and 23 for further detail on TSF closure and cover. It is noted that the mine stages are 5 years from year 6 onwards.
110	CLC	Rehabilitation		The EIS states that poly acrylamide flocculants will be used more than once in the processing (Vol 1. Chapter 2.5.8). It is used as a thickener (among others for dewatering) and traces will undoubtedly end up in the tailings storage. The CLC seeks information as to the effects (if any) on tailings stability / dewatering and the environment through the use of the flocculants. Further, will other flotation chemicals and water treatment chemicals set out in Table 2-8 have an impact on tailings stability and on the environment? Importantly, we seek clarification as to monitoring of groundwater in areas adjoining the Project area that could be affected by tailings seepage, particularly for chemical contamination.	Flocculants The flocculants are used to aid sedimentation (settling of solids) and to recover water due to the settling / consolidation of the solids in the tailings thickener and the TSF. There will be traces of flocculants in the tailings. The floc is bound to the solids due to its interaction with the solids in the tailings thickener. It is expected that the "residual" flocculants in the tailings will help to bind the top layer in the TSF to mitigate dust erosion. The flotation collector is an organic material and is therefore biodegradable over time. The soda ash is used to modify the pH for processing purposes and this will help in preventing any chances of AMD formation on the TSF or in the pits. The use of flocculants, flotation reagents and water treatment chemicals will have no impact on the stability of the TSF and will aid the recovery of water. Groundwater monitoring A copy of the Water Management Plan is provided in Appendix 6 and details the monitoring to be undertaken. An independent peer review of the groundwater monitoring component of the Water Management Plan has also be undertaken and is provided in Appendix 7.
111	CLC	Rehabilitation Geochem samples		It is stated that one sample of synthesized tailings was analysed for total metals, sulphur, NAG and NAPP. Furthermore, when compared to the waste	Sample locations Refer to comment 57.

No.	Agency	Topic	EIS section	Comment (Submission)	Response
				rock, it had slightly elevated metals and fluoride but was low in salinity and was non-acid forming. Additionally, uranium content is also shown to have low values. It remains unclear from the EIS as to how one laboratory sample can be used as representative and sufficient to draw any scientifically sound conclusions. It is also noted that sample locations mostly cover the eastern part of an outlined 40 year extent of pit (Appendix I. 4.2.2). Only a handful of the tested samples fall within the area of the first 5 years of mine stage activities. The EIS also states that samples are from various depths. However, there is no data provided on the depths in the sample tables. The CLC asks for these shortcomings to be addressed in the Supplement to the EIS. More robust data would be beneficial for the CLC in order to properly consider the long term impact of this mine.	Tailings test work Large quantities of synthetic tailings are rarely available at the design phase of a mining project. Two tailings batches have been subjected to static and kinetic leaching tests as discussed above, and as reported in EGI (2014, Appendix 10) and SGS (2017, Appendix 8). The tailings leachate quality is generally consistent with existing groundwater quality, although as some analytes exceed freshwater ecosystem trigger values (ANZECC & ARMCANZ 2000 FAE95%) direct, untreated discharge of liquor to sensitive surface water bodies should be prevented.
112	CLC	Rehabilitation		We agree with the advice of GHD that given the rarity of pre-mining tailings samples, any trial tailings solids and liquor samples should be subject to the full suite of geochemical monitoring for waste rock and leachate listed in section 6.3.2.	Noted. Further test work on tailings has been completed and is presented in Appendix 8.
113	CLC	Employment		As stated in the general comments section above, if the Project is to proceed, Native Title Holders and local community members wish to benefit from employment opportunities generated by the Project. The CLC notes that: 'Some of the local workforce may work an alternative roster to fit work and community needs' (Vol 1. Chapter 2.12.1.). The CLC requests information as to whether there is an understanding of the type of jobs to be available at the mine and an estimate of how many positions this may involve.	Verdant Minerals agrees that development of the Ammaroo Project creates the opportunity for local community members to benefit from employment. Refer to Section 7.9.1 of the Economic and Social Impact Assessment (Appendix L of the EIS) for further information.
114	CLC	Employment		On work opportunities for people living in the nearby communities the EIS estimates that 20% of employment opportunities. The CLC suggests that a training plan is developed to make these estimates into goals.	The estimate of 20% of employment from local communities, which includes Tennant Creek, is a goal. The CLC should note that initially, the Project would not be in a position to train a work force, as the economic cost would be too great. The project will be reliant on accessing existing, appropriately skilled, job ready people from the region. This also highlights the importance of local people participating in the education and vocational training opportunities that are provided by the Government to ensure they are able to take advantage of the opportunities that this project presents. Verdant is willing to discuss how the CLC can contribute to ensuring local people become 'job ready' further with the CLC.
115	CLC	Employment		We highlight the statement in the EIS regarding community consultation in Ampilatwatja, which states the consult was cancelled although 'key stakeholders and community members' were spoken to. There are no reports on attempts to follow-up with these community members to reschedule another meeting. The Native Title Holder Meetings organised by CLC between 2011 and 2016 (referred to in the EIS) were regarding exploration matters and by their nature did not include other community members. The EIS also states that another meeting at Barkly Regional Council was cancelled and moved to August 2017. There is no note as to whether the matter was followed up afterwards.	The CLC has failed to acknowledge that Verdant Minerals held community meetings to discuss the Project and the EIS, which were arranged by the CLC at the request of Verdant Minerals, in Ampilatawatja and Murray Downs prior to the submission of draft EIS. The CLC is not always aware of interactions that Verdant Minerals facilitates with community members independently of the CLC. For example, Verdant Minerals attended a community event and BBQ at Ampilatwatja in September 2017. This event was organised by the local representatives of the Barkly Shire Council and Verdant Minerals sponsored the jerseys that were presented to the men's AFL and women's softball teams. The Barkly Shire Council, in particular local representatives, and CEO have been regularly updated on the progress of the Project. The exploration program was largely completed in 2012, other than some infill drilling completed in 2015. Meetings between 2013 and 2017 were not about exploration matters and the material presented at these meetings outlined what the Phosphate Project would look like, with diagrams, photos and schematics of a phosphate mine and associated processing plants included in the presentations. Additionally, meetings between 2013 and 2017 were arranged by CLC at the request of Verdant Minerals. If they did not include other community members, then Verdant Minerals cannot be held responsible. With that said, these meetings were always well attended with numbers of people ranging from 80-120 in attendance, which included both native title holders and members of the community.
116	CLC	Employment		In the summary on Workforce and accommodation in the main EIS draft submission (Chapter 2.12) it 'estimated that jobs could comprise; 20% local	Verdant Minerals has committed in the EIS to utilising local employees where feasible. The comments in the EIS relating to 20% local arise in response to

No.	Agency	Topic	EIS section	Comment (Submission)	Response
				(Alyawarre communities across the Barkly and Tennant Creek)'. Yet, other statements from the Company in the Report give little hope to people in communities who may be unemployed and are willing to get certificates, or already have skills. This is the case given that in the Report it states that 'Verdant is more likely to recruit workers already in jobs than make an immediate dent in the unemployment queues.' The CLC also questions using statements that generalise community members, e.g. '… poor skills and a lack of experience in the workforce (particularly with long shifts), poor English ...' (Vol 1. Chapter 12.3.3). The Company should consider how they value using staff who live close to the Project and thereby may become long term assets to the Project	feedback from many stakeholders, and in particular, education and training providers, about barriers to employment such as the numbers of people who are both work-ready and want to work in a mine. The estimation is therefore designed to provide a realistic picture, which may take time to become a reality, rather than over-promising.
117	CLC	Corrections		Imperrrenth is situated to the north-west of the Project area (not the south-west, Appendix G, 3.1).	Noted.
118	CLC	Corrections		Link error to Figure 5-1, 6-1, 6-2, 6-3, 6-4, Table 6-5, Table 6.6, Table 6-7, in List of Tables and figures (Appendix I)	Noted.
119	CLC	Corrections		Link error to reference in Appendix H, 7.4	Noted.
120	CLC	Corrections		Link error to reference in Appendix I, 1.4.3, 1.4.4,	Noted.
121	CLC	Corrections		Link error to reference in Appendix O, 4.5	Noted.

2.10 Arid Lands Environment Centre

No.	Agency	Topic	EIS section	Comment (Submission)	Response
122	ALEC	groundwater		The proposed borefield of the Ammaroo project is located in a region that is servicing the needs of multiple industries and interests. Located on the eastern edge of the Western Davenport region the project is linked to the groundwater flux of the Western Davenport Water Control District. The Water Allocation Plan (WAP) for this district is currently being determined through a process of public consultation through a water allocation committee. While the EIS has anticipated an impact on the groundwater of the region, this relationship has not been sufficiently investigated. There is a hydrographic high on the edge of the control district that will be impacted by water extraction for the mine. Any changes to this hydrographic high may influence groundwater quality. Changes to the hydrographic high should be further investigated by the Proponent to ensure that groundwater quality is not compromised by the pumping regime. This should include independent, third person verification of the modelling used to predict drawdown on domestic and stock bores.	The groundwater modelling considers impacts on the WDWCD. Refer to the Groundwater Impact Assessment (Appendix H of the EIS). Groundwater movement across the WDWCD boundary has been reported from the model and is reported in Table 3-14 of the Supplementary. Independent third person verification of the modelling that produced this estimate has been undertaken and is appended as Section 7.4 of the Groundwater Impact Assessment (Appendix H of the EIS). The volume of water that moves across the boundary is a negligible proportion of the water stored within the WDWCD aquifers. Stored volume of WDWCD is: 144,733 GL* The maximum flow across the boundary during the life of mine is 29 GL (95th percentile estimate). The induced flow across boundary is 0.02% of stored volume. Changes to water quality based on this volume change are not credible or quantifiable. * Knapton (2017) Development of a Groundwater Model for the Western Davenport Plains, Table 31)
123	ALEC	Groundwater GDEs		The EIS has stated that the bore field will not impact any Groundwater Dependent Ecosystems (GDEs) under an assumption that the water level is too deep to support GDEs. An independent assessment of this methodology is required to verify these claims. That the Proponent discloses the GDE mapping methodology used to enable independent verification of level of protection afforded to GDEs. The Proponent should disclose the mapping and monitoring regime that was relied on to verify the claim that no GDEs are present in the area that may be impacted by drawdown	Noted. DENR has agreed with the conclusion that GDEs will not be impacted by the project, and is currently undertaking GDE regional mapping study – refer to comment 64.
124	ALEC	Groundwater Baseline monitoring		The EIS notes the need for 30 months of baseline groundwater modelling data. This must be done before any approval decision can be made. As the	The Water Management Plan details the groundwater monitoring to be undertaken prior to the commencement of operations. The Water Management Plan is provided in Appendix 6.

No.	Agency	Topic	EIS section	Comment (Submission)	Response
				number and location of baseline groundwater monitoring bores is yet to be determined, construction should not be able to commence in 2018. That the Proponent discloses the baseline groundwater modelling strategy before an assessment decision is made.	
125	ALEC	Groundwater Drawdown		Drawdown of 0.6 to 2.5 metres is anticipated for the domestic bores supplying the community of Ampilatwatja. This is for the current 25 year lifespan of the mine. However, due to the size of the resource there is potential to extend the life of the mine beyond 25 years. Any anticipated extension of mine life should be factored into groundwater pumping models to ensure that drawdown will not impact both the availability and quality of water supplying Ampilatwatja. That the Proponent commits to a more strategic and comprehensive monitoring regime that models the impact of drawdown on the quality of Ambiplatwija bores and the quality of sources on the eastern edge of the Western Davenport Water Control District.	Refer to comment 31 and Section 3.19 for further information on groundwater monitoring.
126	ALEC	Groundwater Quality		The Proponent should model any potential impacts on groundwater quality for domestic community bores as well as stock bores. That the Proponent commits to undertaking a solute transport model to ensure there are no risks to groundwater quality of the stock and domestic bores.	Further information on solute transport of tailings seepage is provided in the Section 3.1.
127	ALEC	Surface water Infrastructure corridor and ephemeral swamps		The construction of the access corridor occurs in an area that supports several ephemeral swamps. The location of these swamps is unknown and the impact of construction on the hydrology of those swamps is unclear. The Proponent should provide more information on both the location of those swamps and any anticipated hydrological or geomorphological impacts.	As noted in comment 36, the indicative locations for cross drainage structures within the infrastructure corridor have been located at low points indicated in the currently available survey data. These points are expected to coincide with the “ephemeral swamps” indicated in Appendix J in the EIS (Figures 3-3 to 3-5). In doing so, the proposal should generally maintain flows to the swamps.
128	ALEC	Water Process water		The nature and volume of liquid discharges on site are not completely clear. The Proponent should provide more detail on the Reverse Osmosis (RO) discharge, recycling rates, evaporating rates and leaching so that they can be integrated into a more holistic water balance for the project. The Proponent is not intending to recycle all water used on site, so other than evaporation there must be waste water discharges and the Proponent must detail how this will be managed. That the Proponent provides more detail on treatment of saline water produced by the RO plant.	RO waste water will be directed to the surface or in-pit TSF.
129	ALEC	Water Regulatory context		Regulatory reform of the Waste Management and Pollution Control Act (WMPC) as well as the Water Act has commenced. It is important that the Proponent anticipates further investigations to fulfill licencing requirements under those Acts regarding waste and water extraction. This is because the exemptions under those two acts for mining are going to be removed in the medium term, meaning the project will be subject to additional licencing requirements. The Proponent should prepare information to ensure compliance with new requirements such as total volume and composition of waste water discharges.	Verdant will be compliant with current Commonwealth and NT legislation. Should the legislative requirements change then Verdant will meet these new requirements.
130	ALEC	Waste characterisation	Appendix I	The progressive rehabilitation and infill of the pits is a beneficial and low-impact activity supported by ALEC. It will reduce the overall leachate load which would otherwise be concentrated on a single site of tailings storage. However tailings and waste rock processing for the phosphate deposit poses specific problems. Further studies are required on waste rock characterisation with synthesised tailings samples.	Refer to comments 29, 30 and 34 for further information on tailings.
131	ALEC	Waste characterisation Water quality	Appendix I	While the EIS has not anticipated the occurrence of metalliferous, acidic and saline leachate management problems, the chemical analysis of the ore deposit and waste rock has identified significant exceedances of environmental guidelines. Appendix I has noted exceedances of the Australian Drinking Water Guideline for lead and fluoride: “only lead and fluoride exceeded health based ADWG 2011…”. Lead was recorded at levels 100 times greater than the Australian Standard Leachate Protocol in a few samples. While those exceedances were not characteristic of all the tests the magnitude of the readings indicates a possibility of elevated lead and zinc levels in the leachate.	Refer to Section 3.12, 3.13 and 3.14 below.

No.	Agency	Topic	EIS section	Comment (Submission)	Response
				As there are instances of significant guideline exceedance the Proponent should commit to a precautionary approach when progressing the mine pits. It is important that there are mechanisms in place that guarantee lead levels are not concentrated into the tailings through the beneficiation process.	
132	ALEC	Waste characterisation	Appendix I	Only one sample was analysed to determine an estimate of the chemical analysis of the tailings. One synthesised tailings sample is not enough to gain a valid estimate of the tailings composition. Section 4.2.3 of Appendix I recommended additional leachate and soil erodibility testing, but the reason for this is not clear. One important question is what were the limitations that lead to recommended additional leachate testing? It would be important to know evaporation rates to give a more precise estimation of the total tailings water that will transport leachate. ALEC recommends additional synthesised leachate sampling and analysis to get a clear understanding of the leachate risk. There is currently insufficient information to make an informed cumulative assessment of tailings leachate and metal deposition. While the sample results may be compatible with unlined management strategies, the chemical analysis shows definitively that there are areas with levels of metals above health guidelines. The Proponent should take a precautionary and adaptive approach by adopting lined pits if tailings leachate exceeds environmental guidelines. ALEC requests more detailed information on process outputs, specifically residence time of leachate, volumes lost to evaporation or leaching and an estimate of the chemical composition of leachate. The Proponent should not dismiss the possibility of lining pits. Lined pits may become necessary at a later point if additional synthesized tailings analysis indicates metal concentrations that exceed environmental and health guidelines. • That the Proponent provides a comprehensive estimated analysis of the chemical composition of the tailings leachate. • That the Proponent commits to additional leachate and soil erodibility studies. • That the Proponent model an estimated volume of what that will be leached into the groundwater through the surface tailings storage facility. • That the Proponent commits to an ongoing and progressive testing plan of the leachate from the surface and in pit storage.	<u>Leachate test work</u> Further test work by SGS (2017) of tailings was undertaken in December 2017 and confirms the low contaminant concentrations for a range of leaching solutions. Refer to Appendix 8 and Section 3.1.1 for further information. Bulk leach testing (barrel testing) of waste rock bulk samples has also commenced. See also Appendix 12. <u>Leachate quantities</u> Impacts to groundwater as a result of seepage from the in-pit TSF are discussed in Section 3.1. <u>Monitoring</u> The Water Management Plan (Appendix 6) outlines the monitoring requirements for the surface and in-pit TSFs and includes downstream monitoring locations.
133	ALEC	Radiation		Phosphate deposits are often associated with elevated radiation levels due to high concentrations of uranium and thorium. While the target formation is low in those elements, radiological considerations should nevertheless remain a key consideration of the ongoing monitoring and management framework. It is vital that the Proponent verify the conclusions of the radiological assessment to guarantee there are no radiological risks of the project. Before any assessment decision is made the Proponent should independently validate the radiological conclusions and demonstrate that the potential impacts are indeed negligible. Uranium and thorium analysis should be included in subsequent synthesised tailings sampling.	Verdant Minerals recognizes that phosphate deposits, particularly in the USA and Northern Africa are often associated with elevated radionuclide concentrations. This is not the case with the Georgina Basin of Australia phosphates. This is outlined in section 11.3.3 of the EIS. In Appendix K of the EIS, the company sought independent advice on the radiological impacts of the operation. It was shown that potential risks are negligible. Additional data is included in Section 3.16.
134	ALEC	Biodiversity Tailings water and birds		The use of Tailings Storage Facilities (Tailings Dams) can create a near permanent source of water for migratory birds and other localised species to make use of. There should be ongoing monitoring programs to investigate the possibility of interaction between those species and the tailings storage facilities, both in pit and surface. It is important that preventative actions are taken to ensure that species are not threatened by mining waste water and tailings. This should include lining or covering the facilities. That the Proponent covers lining tailings storage facilities to protect the health of migratory and listed birds e.g. the Grey Falcon.	According to the AMD Assessment and Management Plan (Appendix I of the EIS), the tailings water is non-acid-forming, non-saline, non-metalliferous and non-radioactive. The risk assessment within that document concludes that the residual (i.e. managed) risk of ecological receptors being negatively impacted upon by TSF water is low. Section 9.6.10 of the EIS presents a mitigation of impacts associated with tailings water ingestion, and includes developing a monitoring program <u>if</u> fauna mortality is observed. The results of that monitoring would then be used to design specific management responses – from which there is a suite to choose.
135	ALEC	Biodiversity Stygofauna		The biodiversity management plan has not considered the impact of the project on stygofauna populations. Considering there are likely to be increased levels of phosphates and certain metals, it is important that the Proponent investigate the possible existence of stygofauna populations and ensure they are not at risk from the leaching of tailings or process water.	Further information on Stygofauna is provided in Section 3.17.

No.	Agency	Topic	EIS section	Comment (Submission)	Response
				That the Proponent investigates the possible existence of stygofauna in the aquifers of the proposed bore field.	
136	ALEC	Energy		The EIS notes the intention of the Proponent to use solar energy but there is no commitment to a minimum level. Since the release of the Government's Roadmap to Renewables report, all new self-generating enterprises should commit to producing 50% renewable energy by 2030. Recommendation 7(d) of the report suggests a minimum renewable/solar energy capacity should be installed by all self-generating enterprises through a condition of environmental approval. As the lifespan of the project takes it beyond 2030 it would be most cost effective for the Proponent to install a minimum 50% renewable capacity during construction rather than retrofitting at a later stage. This will ensure the project is proactively compliant with NT Government policy. Recommendation That environmental approval is conditional upon a commitment from the Proponent to source a minimum of 50% of the required energy from renewable sources.	A project of this nature requires economic baseload power to drive its processing equipment and other power demands throughout the project. Whilst the final power solution will include solar power generation, it is unlikely that renewables will account for 50% of all power generation.
137	ALEC	Closure		The Proponent should be required to demonstrate the financial capacity to comply with the closure plan as outlined in the EIS. Completion of the closure plan should not be conditional upon the profitability of the enterprise. Demonstrating commitment to sustainable closure including demonstrated financial capability, even in the event of insolvency is fundamental to the project acquiring an ongoing social licence.	Existing NT legislation requires a mine operator to calculate closure costs regularly, and there is a robust process to assist guide this calculation. The DPIR independently completes their calculation and then the results are compared, and a security is agreed and subsequently lodged.
138	ALEC	Closure		The rehabilitation objectives listed in Appendix Q are ambiguous and unambitious. Returning the land to a state that is "similar" to the pre-mining condition is indeterminate. Land condition in the region is measured to be at a lightly to moderately degraded condition. It is important for the Proponent to clarify whether therefore the closure objective is to return the land to a light-moderate condition of degradation. Recommendations • That rehabilitation returns the land to a condition that enhances and restores environmental value not only aims to return to a degraded pre-mining state. • That improvement of environmental condition is included as an objective of the rehabilitation and closure plan	The following is amended in/added to Section 2.6 of the updated Closure Report (Appendix 1): The rehabilitated landform objective is to: • Reinstate natural (unmanaged) ecosystem(s) similar to (or better than) the pre-mining state that do not preclude pastoral use or inhibit surrounding pastoral use. • Rehabilitation will achieve a stable and functioning landform that is consistent with the surrounding landscapes and other environmental values, and will remove potential for long term, post closure impacts on downstream water quality, beneficial uses and environmental values. "The pre-mining state is typical of that associated with cattle grazing in central Australia with a moderate level of habitat degradation and the rehabilitation objective is to return the land to a moderate (or light-moderate) level of habitat degradation."
139	ALEC	consultation		ALEC has concerns that the community of Ampilatwatja has not been fully informed about the environmental risks of the mine. The EIS notes that a community consultation in the community was cancelled at the last minute, which meant that only informal consultation occurred. It is important the Proponent demonstrate transparent and holistic consultation with the use of interpreters to ensure there is widespread awareness of the environmental risks of the project. The Proponent should commit to additional consultation that is transparent and inclusive. A formal community consultation must be held with independent interpreters provided	Refer to comment 115 for further information on consultation.
140	ALEC	Cultural heritage		It is also concerning that the cultural heritage management plan has been omitted from the EIS which precludes independent third-party verification of the findings of that chapter. The Cultural Heritage Management plan must be publicised	The Cultural Heritage Management Plan is provided as Appendix B of the Environmental Management Plan (Appendix E of the EIS). Specific information relating to heritage places and sacred sites has been withheld at the request of the CLC and is not available to the public (refer Comment 82).

2.11 Power and Water Corporation

No.	Agency	Topic	EIS section	Comment (Submission)	Response
141	PWC	Groundwater management	Section 4.3.1 Appendix H	•The aquifer description in section 4.3.1 of the groundwater study (appendix H) indicates an unconfined sedimentary basin of tertiary age which overlies the Georgina Basin Carbonates, the target aquifer for this project. It is recommended that the EIS outlines the procedures and/ or guidelines which will be followed in order to ensure correct plugging of each borehole to prevent leakage and interaction between the Georgina basin aquifer and the Tertiary aquifer.	All bores will be constructed and abandoned in accordance with the National Uniform Drillers Licensing Committee, 2011, Minimum Standards for Water Bore Construction in Australia, Third Edition, 2012. Bore construction and decommissioning is described in Section 3.21 of this Supplementary Report It is noted that the Tertiary aquifer is located some 60 km northwest of the project borefield and will not be impacted by pumping or mining (refer comment 54 and Figure 3-15.
142	PWC			The project borefield, located 20km east of the Western Davenport Water Control District, is noted as a potential alternative groundwater source (Page 45 of the GHD report). It is recommended that details of drawdown and impact of extraction in this area are outlined in the EIS.	Text of page 45 of the EIS states 'Local construction bores will be made available approximately every 20 km along the corridor if suitable bore locations can be located. If not, construction water supply will be sourced from the project borefield system and delivered via truck.' The impact associated with drawdown in the borefield, if used for construction purposes, will be less than what has been modelled for the operation of the mine. The construction and operations phases will not run concurrently and therefore the worst-case scenario for groundwater drawdown is as per mine operations (as detailed in Appendix H of the EIS).
143	PWC	groundwater		The area of interest for the bore transects straddles the Western Davenport Water Control District. This means that some bores will require licences to extract, while others along the transect will not. A detailed description of the localities of each bore is recommended to gain a better idea of which will require permits and which will not.	The location of construction bores is discussed in more detail in Section 3.22. Mining activities are currently exempt from the Water Act. It is noted that the proposed future amendments to the Water Act will require water extraction licences for mining activities. Verdant will seek water extraction licences as required under the amended Act. This has been included as a commitment. The final location of construction bores (for the infrastructure corridor) will be determined during the detailed design phase.
144	PWC	groundwater		Given the estimated volume of extraction over the projects operational period, PWC Regions and Remote would like to be kept up to date with the Final EIS to ensure our operational monitoring program is adequate to capture any potential changes to community water source that may arise from the commencement of the Verdant Minerals Phosphate project.	Noted – the Supplementary Report (this document) will be circulated to PWC by the NT EPA.

2.12 Aboriginal Areas Protection Authority

No.	Agency	Topic	EIS section	Comment (Submission)	Response
145	AAPA	Sacred sites		The data displayed at *Table 5 AAPA Sacred Sites within the subject area*, is not a definitive representation of the Authority's records in this area. Only the Authority Certificate will provide the complete relevant record.	Noted – Verdant will seek an Authority Certificate from AAPA prior to the commencement of construction. All works will be conducted in accordance with the conditions of the Authority Certificate. This has been included as a commitment.
146	AAPA	Sacred sites		The data displayed at *Figure 23 Restricted Works Areas and sacred sites in the vicinity of the subject area,* is not a definitive representation of the Authority's records in this area. Only the Authority Certificate will provide the complete relevant record.	Noted – refer Comment 145.
147	AAPA	Sacred sites		The sacred site point is not indicative of the specific site location and extent, and may not represent the location of any specific features of a sacred site. Only the Authority Certificate will provide the complete relevant record.	Noted – refer Comment 145.
148	AAPA	Sacred sites		Where the applicant is in receipt of an official Authority Certificate from AAPA prior to the conduct of works, and conducts the works in accordance with the conditions of the Certificate, the Authority would be satisfied that due diligence has been observed.	Noted – refer Comment 145.
149	AAPA	Sacred sites		Sacred Sites as defined by the NTASSA, will form the subject of the Authority Certificate conditions, where such conditions are required for the protection of sacred sites in the context of the proposed works.	Noted – refer Comment 145.
150	AAPA	Sacred sites		The Authority Certificate does not negate the need for consent, approval or permission for the subject works or use of the land which may be required under another statute.	Noted – Verdant will seek all necessary approvals required under NT and Commonwealth legislation. This has been included as a commitment.

3. Additional Information

3.1 Tailings Seepage

3.1.1 Tailings and Leachate Chemistry

Table 3-1 to Table 3-6 summarise the chemistry of:

- Tailings liquor (Tails 1 Liquor) (EGI 2014);
- Tailings liquor (Tails 3 additional + Quebec Tapwater)
- Five sequential batch leaches of tailings using a deionised water solution, based on the USEPA Multiple Extraction Procedure (MEP) (Tails 1 E1 to E5) (EGI 2014);
- Tailings filtrate (Sample 14-5788-1) (EGI 2014); and
- Tailings leachate, based on the USEPA TCLP procedure, using three solutions:
  - Standard TCLP acetic acid solution at pH 4.93 ± 0.05 (Tails TCLP). Reflecting exposure to organic waste and not applicable to mine-site disposal;
  - Deionised water (Tails DI Water). The most representative of exposure to rainwater leachate; and
  - A deionised water solution bubbled with CO_2 at pH5.3. Representative of deep drainage through humic soils.

Results were compared with:

- ADWG 2011 aesthetic and health-based guidelines;
- ANZECC & ARMCANZ, 2000 long-term irrigation values (LTV), livestock drinking water, guidelines for the protection of 95% of freshwater aquatic ecosystem species
- Average site groundwater chemistry.

Human health risk

The leachate and liquor analyses were generally within drinking water guidelines (Table 3-1, Table 3-2), except for arsenic, lead and nickel, which equalled or only slightly exceeded the guideline, by a factor of less than 2, in 1 sample each. Fluoride exceeded drinking water guidelines in all Tails liquor and initial 3 leaching cycles but was below the guidelines in the 4th and 5th cycle and in the TCLP samples. This suggests that deleterious solutes are removed in the first flush, reporting to the lined process water storage ponds, and the tailings solids and liquors are unlikely to present a human health risk, unless the entire water supply was made up of tailings decant or leachate. The tap water sample did not exceed any guideline values.

Irrigation risk

All samples were generally within irrigation guidelines (Table 3-3), with the exception of:

- A slightly alkaline pH and elevated Sodium Adsorption Ratio (SAR) indicating that if used for irrigation, addition of gypsum may be required to prevent soil dispersion (ANZECC and ARMCANZ, 2000);
- Elevated fluoride, which could be a problem with fodder crops fed to livestock (ibid.)

- Elevated phosphorus, which could lead to excessive nutrient loading if irrigation runs off in large volumes into adjacent waterways (ibid); and
- Elevated molybdenum may impact on crop yield (ibid).

Based on these results, tailings leachate and decant does not present a significant risk to the environment if used for irrigation unless on a large scale adjacent to waterways, which is an unlikely scenario.

Livestock Drinking water

With the exception of pH and fluoride, all samples were within drinking water guidelines for sensitive livestock. Only the first flush of the MEP samples exceeded guidelines for fluoride, indicating that the tailings are unlikely to present a risk to livestock drinking water supplies.

Aquatic Ecosystems

Guideline values were exceeded for several metals and nutrients. Aluminium, hardness-corrected copper and phosphorus exceeded the guidelines by more than a factor of 10. Most of the exceedances are attributable to the high (alkaline processing additives) or low (acid-buffered leeching solutions) pH solutions. Adjustment of pH to between 7 and 8.5 would remove the direct risk from pH and well as aluminium (MAMD, 2007). Phosphorus is unlikely to present a risk unless direct discharge of significant volumes of leachate to surface waterways, as it is readily adsorbed in the soil column is unlikely to be elevated in groundwater (WADER, 2015). Tailings decant will be stored in lined ponds, designed to the appropriate dam construction guidelines. This will minimise seepage loss, minimising the risk of impacts on underlying groundwater, and prevent overflow except in extreme rainfall events, minimising the risk to aquatic ecosystems.

Ambient Groundwater

Most analytes were in lower concentrations than the ambient groundwater or exceeded by a factor of less than 10. Only aluminium, barium, nickel and total phosphorus exceed groundwater concentrations by more than a factor of 10. However, the overall chemistries are comparable in terms of highest and best use possible, based on the water quality, being of marginal quality for drinking water for livestock.

Table 3-1 Tailings leachate and liquor compared to ADWG Aesthetic values.

Sample ID	Method	Na	SO_4	Al	Cu	Fe	Mn	Zn	Total NH_3 as N (@pH 6.0 to 9.0)
Units		(mg/L)	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(mg/L)
ADWG(2011) Aesthetic		**180**	**250**	**0.200**	**1.0000**	**0.3**	**0.100**	**3.000**	**0.500**
Tails 1 liquor	Tails Liquor	141	58	0.020	0.0030	<0.05	0.040	<0.005	<0.01
Tails 1 E1	MEP	44	14	0.700	0.0050	0.400	0.006	0.015	0.010
Tails 1 E2	MEP	21	4	0.400	0.0030	0.200	0.005	0.009	0.050
Tails 1 E3	MEP	16	2	0.200	0.0020	0.100	0.003	0.005	0.020
Tails 1 E4	MEP	12	2	0.090	0.0030	<0.05	0.007	0.005	0.020
Tails 1 E5	MEP	10	2	0.120	0.0020	<0.05	0.004	0.006	0.020
14-5788-1	Concentrate filtrate	110	3	0.200	<0.01	0.190		<0.01	
Tails TCLP	TCLP	1050	< 2	0.464	0.0061	0.120	0.141	0.021	
Tails DI Water	TCLP	14.8	< 2	2.220	0.0023	1.120	0.014	0.010	
Tails pH5.3 CO2 buffer	TCLP	16.8	< 2	2.330	0.0019	1.020	0.00452	0.006	
110362	Tails Liquor	230	28	<0.03	<0.003	<0.02	0.021	<0.02	<0.020
110363	Tails Liquor	274	36	<0.05	<0.005	<0.03	0.016	<0.03	<0.020
110364	Tails Liquor	300	67	<0.05	<0.005	<0.03	0.035	<0.03	<0.020
Tap water	Tap Water	13	15	0.0018	0.009	0.119	0.004	0.012	<0.020

1-10 x Guideline

Table 3-2 Tailings leachate and liquor compared to ADWG Health values

Sample ID	SO_4	Sb	As	Ba	Be	B	Cd	Cr	Cu	Pb	Mn	Hg	Mo	Ni	Se	Ag	U	F	NO_2 as N	NO_3 as N
Units	(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)	mg/L	(mg/L)	(mg/L)	(mg/L)
ADWG(2011) Health	**500**	**0.003**	**0.010**	**2.000**	**0.06**	**4.0**	**0.002**	**0.05**	**2.0000**	**0.010**	**0.500**	**0.001**	**0.0500**	**0.0200**	**0.010**	**0.1**	**0.017**	**1.5**	**0.910**	**11.29**
Tails 1 liquor	58	<0.001	0.004	0.008	<0.001	0.40	<0.0001		0.0030	<0.001	0.040	<0.0001	0.0200	<0.001	<0.01	<0.001	0.010	3	<0.01	<0.01
Tails 1 E1	14	<0.001	0.010	0.300	<0.001	0.20	<0.0001		0.0050	0.0030	0.006	<0.0001	0.0100	<0.001	<0.01	<0.001	<0.001	4	0.010	0.01
Tails 1 E2	4	<0.001	0.008	0.070	<0.001	0.10	<0.0001		0.0030	0.0020	0.005	<0.0001	0.0030	<0.001	<0.01	<0.001	<0.001	3	0.020	<0.01
Tails 1 E3	2	<0.001	0.007	0.060	<0.001	0.08	<0.0001		0.0020	0.0020	0.003	<0.0001	0.0010	<0.001	<0.01	<0.001	<0.001	2	<0.01	<0.01
Tails 1 E4	2	<0.001	0.005	0.040	<0.001	0.07	<0.0001		0.0030	0.0010	0.007	<0.0001	<0.001	<0.001	<0.01	<0.001	<0.001	1	<0.01	<0.01
Tails 1 E5	2	<0.001	0.004	0.050	<0.001	0.05	<0.0001		0.0020	0.0010	0.004	<0.0001	<0.001	<0.001	<0.01	<0.001	<0.001	1	<0.01	<0.01
14-5788-1	3						<0.002		<0.01	<0.01				<0.01					0.010	0.06
Tails TCLP	< 2	< 0.002	0.008	0.300	0.00096	0.312	0.00044	0.0037	0.0061	0.0028	0.141	< 0.00001	0.0007	0.0219	0.00053	< 0.0005	0.002070	0.68		
Tails DI Water	< 2	0.0004	0.002	0.013	0.00041	0.105	0.00015	0.0041	0.0023	0.0142	0.014	< 0.00001	0.0010	0.0022	0.00009	< 0.0005	0.001070	0.9		
Tails pH5.3 CO2 buffer	< 2	0.0003	0.002	0.011	0.00026	0.041	0.000033	0.0033	0.0019	0.0078	0.0045	< 0.00001	0.0006	0.0016	0.00006	< 0.0005	0.000636	0.89		
110362	28	<0.003	<0.003	0.005	<0.03		<0.003	<0.003	<0.003	<0.003	0.021	<0.0001	0.0100	<0.003	<0.5	<0.003	<0.003	6.3	<0.20	<0.20
110363	36	<0.005	0.005	0.048	<0.05		<0.005	<0.005	<0.005	<0.005	0.016	<0.0001	0.0250	<0.005	<1	<0.005	<0.003	6.57	<0.20	<0.20
110364	67	<0.05	0.008	0.015	<0.05		<0.005	<0.005	<0.005	<0.005	0.035	<0.0001	0.0240	<0.005	<1	<0.005	<0.003	7.12	<0.20	<0.20
Tap water	15	0.0002	0.000	0.006	<0.001		<0.0001		0.009	<0.0001	0.004	<0.0001	0.0003	0.0002	<0.02	<0.0001	<0.0001	0.06	<0.020	0.25

1-10 x Guideline

Table 3-3 Tailings leachate and liquor compared to long-term irrigation values

Sample ID	Lab pH	Na	Cl	SAR	Al	As	Be	B	Cd	Cr	Co	Cu	Pb	Mn	Hg	Mo	Ni	Se	U	V	Zn	F	Li	Total N	Total Kel N	Total P
Units		(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)	mg/L	(mg/L)	(mg/L)	(mg/L)		(mg/L)	(mg/L)	(mg/L)
ANZECC (2000) Irrigation LTV	**6 to 8.5**	**115**	**175**	**2**	**5.000**	**0.100**	**0.1**	**0.5**	**0.01**	**0.1**	**0.05**	**0.2000**	**2**	**0.200**	**0.002**	**0.0100**	**0.2000**	**0.020**	**0.010**	**0.1**	**2.000**	**1**	**2.5**	**5**	**5**	**0.05**
Tails 1 liquor	8.30	141	86	9	0.020	0.004	<0.001	0.40	<0.0001		<0.001	0.0030	<0.001	0.040	<0.0001	0.0200	<0.001	<0.01	0.010		<0.005	3		0.1	0.1	0.03
Tails 1 E1	8.60	44	26	9	0.700	0.010	<0.001	0.20	<0.0001		<0.001	0.0050	0.0030	0.006	<0.0001	0.0100	<0.001	<0.01	<0.001		0.015	4		0.1	0.1	0.35
Tails 1 E2	8.80	21	5	5	0.400	0.008	<0.001	0.10	<0.0001		<0.001	0.0030	0.0020	0.005	<0.0001	0.0030	<0.001	<0.01	<0.001		0.009	3		0.2	0.2	0.43
Tails 1 E3	8.90	16	2	4	0.200	0.007	<0.001	0.08	<0.0001		<0.001	0.0020	0.0020	0.003	<0.0001	0.0010	<0.001	<0.01	<0.001		0.005	2		<0.1	<0.1	0.43
Tails 1 E4	8.90	12	1	3	0.090	0.005	<0.001	0.07	<0.0001		<0.001	0.0030	0.0010	0.007	<0.0001	<0.001	<0.001	<0.01	<0.001		0.005	1		<0.1	<0.1	0.59
Tails 1 E5	9.00	10	1	2	0.120	0.004	<0.001	0.05	<0.0001		<0.001	0.0020	0.0010	0.004	<0.0001	<0.001	<0.001	<0.01	<0.001		0.006	1		<0.1	<0.1	0.53
14-5788-1	7.70	110	5	5	0.200				<0.002			<0.01	<0.01				<0.01				<0.01					
Tails TCLP	5.04	1050		32	0.464	0.008	0.00096	0.312	0.00044	0.00367	0.00098	0.0061	0.0028	0.141	< 0.00001	0.0007	0.0219	0.00053	0.002070	0.002	0.021	0.68	0.0011			5.83
Tails DI Water	10.20	14.8		1	2.220	0.002	0.00041	0.105	0.00015	0.00409	0.00035	0.0023	0.0142	0.014	< 0.00001	0.0010	0.0022	0.00009	0.001070	0.017	0.010	0.9	0.0012			2.46
Tails pH5.3 CO2 buffer	10.24	16.8		2	2.330	0.002	0.00026	0.041	0.000033	0.00326	0.00029	0.0019	0.0078	0.0045	< 0.00001	0.0006	0.0016	0.00006	0.000636	0.015	0.006	0.89	0.0014			0.698
110362	8.42	230	2	26	<0.03	<0.003	<0.03		<0.003	<0.003	<0.003	<0.003	<0.003	0.021	<0.0001	0.01	<0.003	<0.5	<0.003	<0.003	<0.02	6.3		0.42		1.4
110363	8.50	274	3	24	<0.05	0.005	<0.05		<0.005	<0.005	<0.005	<0.005	<0.005	0.016	<0.0001	0.03	<0.005	<1	<0.003	<0.005	<0.03	6.57		<0.40		2
110364	8.51	300	3	33	<0.05	0.008	<0.05		<0.005	<0.005	<0.005	<0.005	<0.005	0.035	<0.0001	0.02	<0.005	<1	<0.003	<0.005	<0.03	7.12		0.43		0.68
Tap water	7.35	13	19		0.018	0.0002	<0.001		<0.0001		<0.0001		<0.0001	0.004	<0.0001	0.0003	0.0002	<0.02	<0.0001	0.0002	0.012	0.06				0.055

1-10 x Guideline

10-100 x Guideline

Table 3-4 Tailings leachate and liquor compared to livestock drinking water guidelines

Sample ID	Lab pH	TDI Calc from Major	Ca	SO_4	Al	As	B	Cd	Cr	Co	Cu	Pb	Hg	Mo	Ni	Se	U	Zn	F	NO_2 as N	NO_3 as N
Units		(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	(mg/L)	(mg/L)	(mg/L)	(mg/L)
ANZECC (2000) Livestock	**6 to 8.5**	**2,000**	**1,000**	**1,000**	**5.000**	**0.500**	**5.00**	**0.01**	**1.000**	**1.0000**	**0.5000**	**0.1000**	**0.002**	**0.0500**	**1.0000**	**0.020**	**0.200**	**20.000**	**2**	**30.000**	**400**
Tails 1 liquor	8.30	414	9	58	0.020	0.004	0.40	<0.0001		<0.001	0.0030	<0.001	<0.0001	0.0200	<0.001	<0.01	0.010	<0.005	3	<0.01	<0.01
Tails 1 E1	8.60	123	1	14	0.700	0.010	0.20	<0.0001		<0.001	0.0050	0.0030	<0.0001	0.0100	<0.001	<0.01	<0.001	0.015	4	0.010	0.01
Tails 1 E2	8.80	65	1	4	0.400	0.008	0.10	<0.0001		<0.001	0.0030	0.0020	<0.0001	0.0030	<0.001	<0.01	<0.001	0.009	3	0.020	<0.01
Tails 1 E3	8.90	52	1	2	0.200	0.007	0.08	<0.0001		<0.001	0.0020	0.0020	<0.0001	0.0010	<0.001	<0.01	<0.001	0.005	2	<0.01	<0.01
Tails 1 E4	8.90	45	1	2	0.090	0.005	0.07	<0.0001		<0.001	0.0030	0.0010	<0.0001	<0.001	<0.001	<0.01	<0.001	0.005	1	<0.01	<0.01
Tails 1 E5	9.00	29	1	2	0.120	0.004	0.05	<0.0001		<0.001	0.0020	0.0010	<0.0001	<0.001	<0.001	<0.01	<0.001	0.006	1	<0.01	<0.01
14-5788-1	7.70	335	18	3	0.200			<0.002			<0.01	<0.01			<0.01			<0.01		0.010	0.06
Tails TCLP	5.04		62.9	< 2	0.464	0.008	0.312	0.00044	0.00367	0.00098	0.0061	0.0028	< 0.00001	0.0007	0.0219	0.00053	0.002070	0.021	0.68		
Tails DI Water	10.20		7.25	< 2	2.220	0.002	0.105	0.00015	0.00409	0.00035	0.0023	0.0142	< 0.00001	0.0010	0.0022	0.00009	0.001070	0.010	0.90		
Tails pH5.3 CO2 buffer	10.24		3.53	< 2	2.330	0.002	0.041	0.000033	0.00326	0.00029	0.0019	0.0078	< 0.00001	0.0006	0.0016	0.00006	0.000636	0.006	0.89		
110362	8.42	565	3	2	<0.03	<0.003		<0.003	<0.003	<0.003	<0.003	<0.003	<0.0001	0.0100	<0.003	<0.5	<0.003	<0.02	6.30	<0.20	<0.20
110363	8.50	676	5	3	<0.05	0.005		<0.005	<0.005	<0.005	<0.005	<0.005	<0.0001	0.0250	<0.005	<1	<0.003	<0.03	6.57	<0.20	<0.20
110364	8.51	738	3	3	<0.05	0.008		<0.005	<0.005	<0.005	<0.005	<0.005	<0.0001	0.0240	<0.005	<1	<0.003	<0.03	7.12	<0.20	<0.20
Tap water	7.35	74	12.50	15	0.018	0.0002		<0.0001		<0.0001		<0.0001	<0.0001	0.0003	0.0002	<0.02	<0.001	0.012	0.06	<0.020	0.25

1-10 x Guideline

Table 3-5 Tailings liquor and leachate compared to freshwater aquatic ecosystem protection (95 % of species) guidelines

Sample ID	Lab pH	EC	TDI Calc from Major Ions	Al	As	B	Cd	Cr	Cu	Fe	Pb	Mn	Hg	Ni
Units		uS/cm	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(mg/L)
ANZECC (2000) FAE 95%	**6.5-8.5**	**500**	**325**	**0.055**	**0.013**	**0.37**	**0.0002**	**0.074**	**0.0014**	**0.3**	**0.0034**	**1.900**	**0.0006**	**0.0110**
Tails 1 liquor	8.30	779	414	0.020	0.004	0.40	<0.0001		0.0030	<0.05	<0.001	0.040	<0.0001	<0.001
Tails 1 E1	8.60	226	123	0.700	0.010	0.20	<0.0001		0.0050	0.400	0.0030	0.006	<0.0001	<0.001
Tails 1 E2	8.80	126	65	0.400	0.008	0.10	<0.0001		0.0030	0.200	0.0020	0.005	<0.0001	<0.001
Tails 1 E3	8.90	86	52	0.200	0.007	0.08	<0.0001		0.0020	0.100	0.0020	0.003	<0.0001	<0.001
Tails 1 E4	8.90	56	45	0.090	0.005	0.07	<0.0001		0.0030	<0.05	0.0010	0.007	<0.0001	<0.001
Tails 1 E5	9.00	39	29	0.120	0.004	0.05	<0.0001		0.0020	<0.05	0.0010	0.004	<0.0001	<0.001
14-5788-1	7.70	780	335	0.200			<0.002		<0.01	0.190	<0.01			<0.01
Tails TCLP	5.04			0.464	0.008	0.312	0.00044	0.00367	0.0061	0.120	0.0028	0.141	< 0.00001	0.0219
Tails DI Water	10.20			2.220	0.002	0.105	0.00015	0.00409	0.0023	1.120	0.0142	0.014	< 0.00001	0.0022
Tails pH5.3 CO2 buffer	10.24			2.330	0.002	0.041	0.000033	0.00326	0.0019	1.020	0.0078	0.0045	< 0.00001	0.0016
110362	8.42	860		<0.03	<0.003		<0.003	<0.003	<0.003	<0.02	<0.003	0.021	<0.0001	<0.003
110363	8.50	1100		<0.05	0.005		<0.005	<0.005	<0.005	<0.03	<0.005	0.016	<0.0001	<0.005
110364	8.51	1200		<0.05	0.008		<0.005	<0.005	<0.005	<0.03	<0.005	0.035	<0.0001	<0.005
Tap water	7.35	140	74	0.018	0.0003		<0.0001	<0.0001	0.0091	0.119	<0.0001	0.0037	<0.0001	0.0002

1-10 x Guideline

10-100 x Guideline

Sample ID	Se	Ag	Zn	Hardness - Cor Cd	Hardness-Cor Cr	Hardness - Cor Cu	Hardness-Cor Pb	Hardness - Cor Ni	Hardness-Cor Zn	NO_2 as N	Total NH_3 as N (@pH 6.0 to 9.0)	Total N	Total Kel N	Reactive P	Total P
Units	(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)
ANZECC (2000) FAE 95%	**0.011**	**0.00005**	**0.008**	**0.0002**	**0.074**	**0.0014**	**0.0034**	**0.011**	**0.008**	**0.700**	**0.900**	**0.15**	**0.15**	**0.005**	**0.01**
Tails 1 liquor	<0.01	<0.001	<0.005	<LOR	0.000	0.0022	<LOR	<LOR	<LOR	<0.01	<0.01	0.1	0.1	0.030	0.03
Tails 1 E1	<0.01	<0.001	0.015	<LOR	0.000	0.0248	0.0329	<LOR	0.074	0.010	0.010	0.1	0.1	0.100	0.35
Tails 1 E2	<0.01	<0.001	0.009	<LOR	0.000	0.0196	0.0329	<LOR	0.059	0.020	0.050	0.2	0.2	0.190	0.43
Tails 1 E3	<0.01	<0.001	0.005	<LOR	0.000	0.0130	0.0329	<LOR	0.033	<0.01	0.020	<0.1	<0.1	0.240	0.43
Tails 1 E4	<0.01	<0.001	0.005	<LOR	0.000	0.0196	0.0165	<LOR	0.033	<0.01	0.020	<0.1	<0.1	0.300	0.59
Tails 1 E5	<0.01	<0.001	0.006	<LOR	0.000	0.0130	0.0165	<LOR	0.039	<0.01	0.020	<0.1	<0.1	0.330	0.53
14-5788-1			<0.01	<LOR	0.000	<LOR	<LOR	<LOR	<LOR	0.010					
Tails TCLP	0.00053	< 0.0005	0.021	0.0001	0.001	0.0012	0.0002	0.004	0.004						5.83
Tails DI Water	0.00009	< 0.0005	0.010	0.0002	0.005	0.0030	0.0220	0.003	0.013						2.46
Tails pH5.3 CO2 buffer	0.00006	< 0.0005	0.006	0.0001	0.007	0.0042	0.0257	0.004	0.013						0.698
110362	<0.5	<0.003	<0.02	<LOR	<LOR	<LOR	<LOR	<LOR	<LOR	<0.20	<0.4	<0.020	0.42	0.011	1.4
110363	<1	<0.005	<0.03	<LOR	<LOR	<LOR	<LOR	<LOR	<LOR	<0.20	<0.4	<0.020	<0.40	0.012	2
110364	<1	<0.005	<0.03	<LOR	<LOR	<LOR	<LOR	<LOR	<LOR	<0.20	<0.4	<0.020	0.43	0.036	0.68
Tap water	<0.02	<0.0001	0.012		<0.0001					<0.20	<0.4	<0.020	<0.4	0.025	0.040

1-10 x Guideline

10-100 x Guideline

100-1000 x Guideline

>1000 x Guideline

Table 3-6 Tailings leachate and liquor compared to Average groundwater guidelines

Sample ID	Method	Lab pH	EC	TDI Calc from	Na	K	Ca	Mg	Bi-carbonate as Ca(HC	Carbonate as $CaCO_3$	Cl	SO_4	Calc Hardness	Al	Sb	As	Ba	Be	B	Cd	Cr	Co
Units			uS/cm	(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)	(mg/L)	(mg/L)	(mg/L)
Average GW		**7.93**	**1530**	**655**	**124**	**23**	**93**	**53**	**358**	**0.5**	**188**	**206**	**450**	**0.041**	**0.001**	**0.002**	**0.028**	**0.0005**	**0.38**	**0.000057**	**0.001**	**0.0008**
Tails 1 liquor	Tails Liquor	8.30	779	414	141	4	9	5	147		86	58	43	0.020	<0.001	0.004	0.008	<0.001	0.40	<0.0001		<0.001
Tails 1 E1	MEP	8.60	226	123	44	1	1	1	48		26	14	5	0.700	<0.001	0.010	0.300	<0.001	0.20	<0.0001		<0.001
Tails 1 E2	MEP	8.80	126	65	21	1	1	1	45		5	4	3	0.400	<0.001	0.008	0.070	<0.001	0.10	<0.0001		<0.001
Tails 1 E3	MEP	8.90	86	52	16	1	1	1	41		2	2	3	0.200	<0.001	0.007	0.060	<0.001	0.08	<0.0001		<0.001
Tails 1 E4	MEP	8.90	56	45	12	1	1	1	38		1	2	3	0.090	<0.001	0.005	0.040	<0.001	0.07	<0.0001		<0.001
Tails 1 E5	MEP	9.00	39	29	10	1	1	1	20		1	2	3	0.120	<0.001	0.004	0.050	<0.001	0.05	<0.0001		<0.001
14-5788-1	Concentrate filtrate	7.70	780	335	110	7	18	12	240		5	3	94	0.200						<0.002		
Tails TCLP	TCLP	5.04			1050	3	62.9	12.7	1300	< 2		< 2	209	0.464	< 0.002	0.008	0.300	0.00096	0.312	0.000439	0.0037	0.00098
Tails DI Water	TCLP	10.20			14.8	1	7.25	0.767	18	26		< 2	21	2.220	0.0004	0.002	0.013	0.00041	0.105	0.000151	0.0041	0.00035
Tails pH5.3 CO2 buffer	TCLP	10.24			16.8	1	3.53	0.699	16	29		< 2	12	2.330	0.0003	0.002	0.011	0.00026	0.041	0.000033	0.0033	0.00029
110362	Tails Liquor	8.42	860	565	230	1	3.2	1.65	390	9.2	2	28	15	<0.03	<0.003	<0.003	0.005	<0.03		<0.003	<0.003	<0.003
110363	Tails Liquor	8.50	1100	676	274	1	5.4	2.77	450	26	3	36	25	<0.05	<0.005	0.005	0.048	<0.05		<0.005	<0.005	<0.005
110364	Tails Liquor	8.51	1200	738	300	1	3.2	1.9	460	26	3	67	16	<0.05	<0.05	0.008	0.015	<0.05		<0.005	<0.005	<0.005
Tap water	Tap water	7.35	140	74	13	0.74	12.50	1.29	17	0.1	19	15		0.018	0.0002	0.000	0.006	<0.001		<0.0001		<0.0001

1-10 x Guideline
10-100 x Guideline

Sample ID	Cu	Fe	Pb	Mn	Hg	Mo	Ni	Se	Ag	Sn	U	V	Zn	F	NO_2 as N	NO_3 as N	NO_x (NO_3 + NO_2) as N	Total N	Total P
Units	(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)	(mg/L)	(mg/L)	(mg/L)
Average GW	**0.003**	**0.544**	**0.0033**	**0.022**	**0.00005**	**0.0256**	**0.0014**	**0.005**	**0.0014**	**0.0377**	**0.014**	**0.005**	**0.024**	**1.3**	**0.009**	**7.80**	**7.80**	**6.75**	**0.215**
Tails 1 liquor	0.0030	<0.05	<0.001	0.040	<0.0001	0.0200	<0.001	<0.01	<0.001	<0.001	0.010		<0.005	3	<0.01	<0.01	<0.01	0.1	0.03
Tails 1 E1	0.0050	0.400	0.0030	0.006	<0.0001	0.0100	<0.001	<0.01	<0.001	<0.001	<0.001		0.015	4	0.010	0.01	0.020	0.1	0.35
Tails 1 E2	0.0030	0.200	0.0020	0.005	<0.0001	0.0030	<0.001	<0.01	<0.001	<0.001	<0.001		0.009	3	0.020	<0.01	0.020	0.2	0.43
Tails 1 E3	0.0020	0.100	0.0020	0.003	<0.0001	0.0010	<0.001	<0.01	<0.001	<0.001	<0.001		0.005	2	<0.01	<0.01	<0.01	<0.1	0.43
Tails 1 E4	0.0030	<0.05	0.0010	0.007	<0.0001	<0.001	<0.001	<0.01	<0.001	<0.001	<0.001		0.005	1	<0.01	<0.01	<0.01	<0.1	0.59
Tails 1 E5	0.0020	<0.05	0.0010	0.004	<0.0001	<0.001	<0.001	<0.01	<0.001	<0.001	<0.001		0.006	1	<0.01	<0.01	<0.01	<0.1	0.53
14-5788-1	<0.01	0.190	<0.01				<0.01						<0.01		0.010	0.06			
Tails TCLP	0.0061	0.120	0.0028	0.141	< 0.00001	0.0007	0.0219	0.00053	< 0.0005	0.00037	0.002070	0.00182	0.021	0.68					5.83
Tails DI Water	0.0023	1.120	0.0142	0.014	< 0.00001	0.0010	0.0022	0.00009	< 0.0005	0.00092	0.001070	0.017	0.010	0.9					2.46
Tails pH5.3 CO2 buffer	0.0019	1.020	0.0078	0.0045	< 0.00001	0.0006	0.0016	0.00006	< 0.0005	0.00034	0.000636	0.0147	0.006	0.89					0.698
110362	<0.003	<0.02	<0.003	0.021	<0.0001	0.0100	<0.003	<0.5	<0.003		<0.003	<0.003	<0.02	6.3	<0.20	<0.20	<0.4	0.42	1.4
110363	<0.005	<0.03	<0.005	0.016	<0.0001	0.0250	<0.005	<1	<0.005		<0.003	<0.005	<0.03	6.57	<0.20	<0.20	<0.4	<0.40	2
110364	<0.005	<0.03	<0.005	0.035	<0.0001	0.0240	<0.005	<1	<0.005		<0.003	<0.005	<0.03	7.12	<0.20	<0.20	<0.4	0.43	0.68
Tap water	0.009	0.119	<0.0001	0.004	<0.0001	0.0003	0.0002	<0.02	<0.0001		<0.0001	0.0002	0.012	0.06	<0.020	0.25			0.055

1-10 x Guideline
10-100 x Guideline
100-1000 x Guideline
>1000 x Guideline

Additional results from recent tailings test work

An additional tailings filter cake sample (Lot20/60/20 Final Tails) was subjected by SGS Minerals to total recoverable metals (ICP-OES/MS) NAG, NAPP, TCLP and modified TCLP (deionised water and CO_2 saturated solutions). The full report is available at Appendix 8.

Analysis of the recoverable portion of the sample determined that it was comprised primarily of silicates with moderate to minor amounts of calcium, aluminium, phosphorus, and iron.

The key findings of the analyses are:

- Standard acid base accounting demonstrated that the sample is non-acid forming due to a lack of acid generating sulfide content and an excess of acid neutralization capacity.
- The net acid generation (NAG) test, with a NAG pH of 7.66, corroborated the acid base accounting result as no acid was generated upon aggressive oxidation.
- TCLP extraction results indicated that the sample would not be considered hazardous or potentially toxic as the extract passed the Australian drinking water quality (DWQ) guidelines for all parameters except pH (prescribed by the test method) and a marginally higher nickel concentration.
- CO_2 saturated deionized water extraction results indicated that the sample would be considered to have low toxicity as the extract passed the Australian DWQ guidelines for all parameters except the alkaline pH and a marginally higher lead concentration (0.0142 mg/L compared to 0.01 mg/L).
- Deionized water extraction results also indicated low toxicity as the alkaline pH was the only parameter found to be outside the Australian DWQ guidelines.
- TCLP extract concentrations were higher than modified TCLP extracts in all cases except where a higher pH was favoured (carbonate, aluminium, iron, silicon as silica, titanium, and yttrium).

The analyses indicate that the various soluble analytes that were elevated in the ore and waste rock leachate (ASLP, MEP and TCLP) have been removed by processing and would report to the tailing liquor, confirming that the tailings present a low risk to human health and the environment, with leachate quality being within the ADWG (with minor exceptions), and higher than the underlying groundwater, in terms of potential use.

Testing of the decant liquor (see also Appendix 9) will be carried out for future tailings batches, but given the mineralogy, the liquor is likely to be similar to the ASLP water leach, subject to any influence from the source water.

3.1.2 Water Table Rise

Methodology

Mounding beneath a recharge has been calculated using the Hantush Equation (Hantush 1967). The equation requires estimates of the seepage rate and estimates of the hydraulic conductivity and specific yield of the receiving aquifer.

Tailings Seepage

Tailings Particle Size Distribution (PSD) analysis reports tailings grainsize less than 0.075 mm (75% passing 0.075mm sieve) (Coffey, 2014). Permeability of a clastic material is controlled by the finer fraction (typically finest 10% size fraction, (Domineco and Schwartz, 1990). For this tailing sample, the finest 10% is in the range of a fine silt. Hydraulic conductivity of a fine silt ranges around 0.0001 to 0.001 m/day (ibid).

Vertical seepage of a fully saturated column of tailings will then range from 0.0001 to 0.001 m/day.

Seepage is calculated for an area of 600 m x 600 m approximately equivalent to the size of the aboveground TSF or a single cell of the in-pit TSF.

Aquifer Properties

The properties of the fractured rock aquifer underlying the in-pit and surface TSF is assigned a hydraulic conductivity of 0.5 to 0.1 consistent with negligible yield of bores drilled into this formation and the overlying carbonate. Specific yield is 4% consistent with hydraulic testing of the Georgina Basin Carbonates. Aquifer thickness is assigned 50 m.

Results

The mounding that results from seepage from the TSF for 2 years to 25 years ranges from less than 1 m to a maximum 25 m from a high seepage rate into a low permeability aquifer for 25 years. These maximum heights are calculated for the centre of the mound directly beneath the recharge area and will diminish with distance away from the centre.

As stated in the Groundwater Report (Appendix H of the EIS) the depth to water at the site is approximately 60 to 80 m below ground level. Given this, no surface impacts of tailing seepage are expected for even the uppermost estimate.

Table 3-7 Estimated water table mounding beneath tailings storage facilities.

Seepage Rate (m/day)	Aquifer Hydraulic Conductivity (m/day)	Water level rise (m)	
		2 years	25 years
0.001	0.1	9	19
0.0001	0.5	1.3	3.6

3.1.3 Groundwater Quality Change

The fate of tailings seepage mixing with groundwater has been calculated as a simple mixing fraction with down-gradient dispersion. Dispersion is calculated using the method presented in Bear, (1972). The initial concentration at the point of seepage is assigned a concentration of 100% tailings leachate. Background concentration is 0% tailing leachate (pure groundwater). Parameters applied in the calculation are summarised in Table 3-8.

Table 3-8 Parameters for Dispersion Calculation.

Parameter	Value	Discussion
Dispersivity	20 m	0.1 x scale of plume (Fetter, 1993)
Initial Concentration	100 unitless	100 % leachate
Hydraulic gradient	0.001 unitless	Measured gradient across site
Effective porosity	0.01 unitless	Estimate for fractured rock aquifer (Spitz and Moreno, 1996)
Hydraulic conductivity	0.1 m/day	Estimate for fractured rock aquifer

Results

The calculated down-gradient concentration of tailings leachate is presented as Figure 3-1. The plume moves very slowly due to the low hydraulic conductivity of the basement rock and the relatively low gradient. After 100 years, the peak of the leachate plume has moved some 400 m down gradient, and the concentration is diluted to a 10% fraction of leachate in 90% natural groundwater.

The calculation is conservative in that it considers a starting concentration of 100% leachate. In reality leachate will seep vertically to initially mix with the water table beneath the tailing facilities and result in a starting concentration much less than 100% leachate.

Given that the starting water quality of each fluid is comparable (both suitable for stock use, but not potable use) the impact is negligible regardless of dilution.

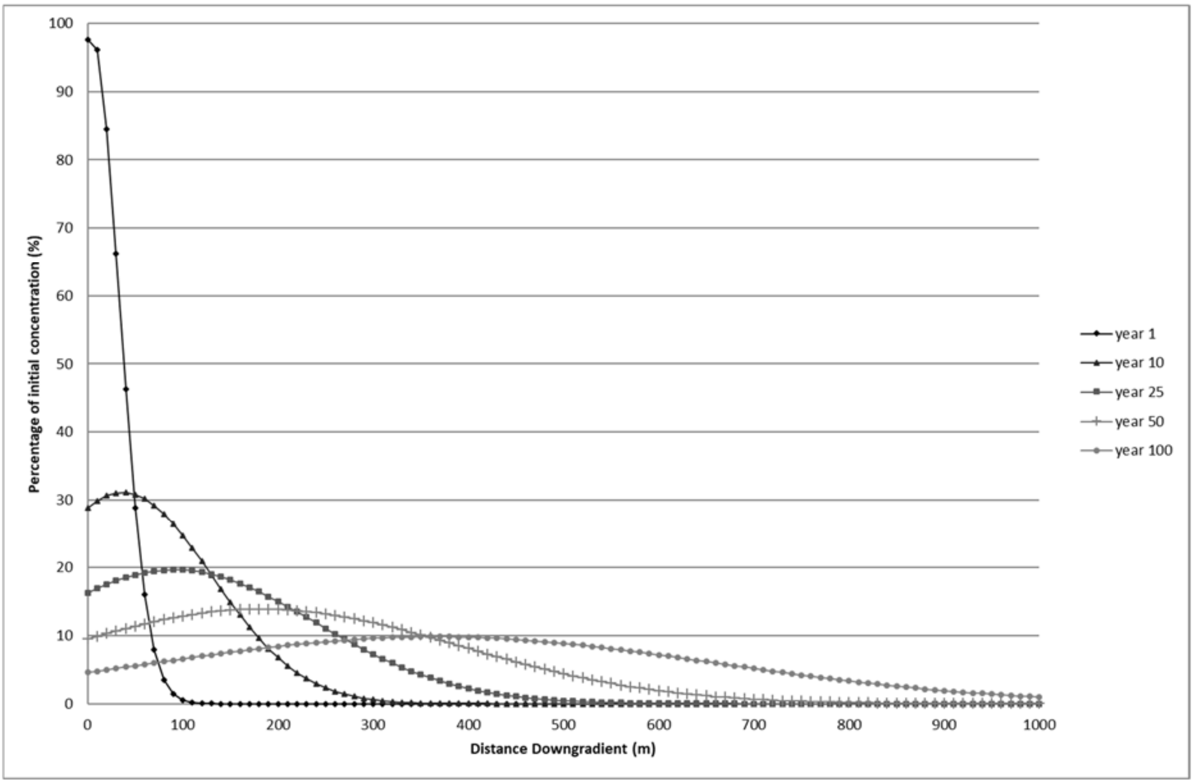


Figure 3-1 Down-gradient concentration of a plume

Table 3-9 Down-gradient concentration of a plume (percentage leachate).

Time from release (Years)					
Distance Down-gradient (metres)	1	10	25	50	100
0	98	29	16	10	5
100	0	25	20	13	7
200	0	7	15	14	8
300	0	1	7	12	10
400	0	0	2	8	10
500	0	0	0	4	9
600	0	0	0	2	7
700	0	0	0	1	5
800	0	0	0	0	3
900	0	0	0	0	2
1000	0	0	0	0	1

3.2 Tailings Design and Management

3.2.1 Design Concept

The surface TSF has been designed as a standalone facility, with perimeter embankments constructed from compacted clayey fill sourced from the overburden stripping activities, or internally within the TSF footprint. The facility is designed to have an operational life of 2 years, based on a design deposited dry density of 0.9 t/m3 (based on laboratory settling tests undertaken) and a production rate of 2.05 Mtpa.

The preliminary design has assumed 3 horizontal: 1 vertical (3H:1V) downstream batters and 2H:1V upstream batters.

The TSF will have a central decant tower, with supernatant water recovered using a submersible pump located within the tower. Water will be returned to the process plant and stored at the return water pond for re-use. The design provides the opportunity to raise the perimeter embankment crest level using the downstream method of embankment construction, with a 2.5 m raise included in the design, which would provide an additional 12 months of storage. The requirement for an embankment raise will be identified during the first 2 years of operation as the pit void is developed.

3.2.2 Tailings Deposition

Tailings will be deposited sub-aerially from multiple spigots around the perimeter of the facility. It is expected that tailings will be deposited from up to 6 spigots at any one time, with the discharging spigots changed regularly to permit the deposited tailings to dry and consolidate. Slotted offtake pipes will be installed at each spigot location, to reduce the potential for erosion of the perimeter upstream batter slope during the discharge of tailings.

During the initial stages of operation, the deposition of tailings will be focused in the southeast section of the facility where the embankment height is greatest. As the tailings beach develops, deposition will need to be undertaken predominantly from the southeast section, with intermittent deposition from the northeast corner and further to the south to enable the water pond to remain centred to the decant tower.

The tailings deposition strategy will be optimized during the detailed design phase of the project.

3.2.3 Consequence Category

A Consequence Category assessment for the surface TSF has been undertaken, to enable applicable design criteria to be identified. The hazard category assessment was undertaken in accordance with ANCOLD (2012). The assessment identifies that the surface TSF is classified as *Significant*, for both sunny day and flood failure. The dam spill Consequence Category was also assessed as *Significant.*

In line with the guidelines' requirements for a *Significant* Consequence Category TSF, the design will make provisions for the following:

- Extreme Storm Storage allowance of the 1:100 Annual Exceedance Probability (AEP), 72 hour flood event with 0.3 m additional freeboard;
- Spillway designed to pass the 1:1,000 AEP flood event, with wave run-up freeboard allowance for a 1:10 AEP wind event;
- Earthquake design for a 1:475 AEP event (Operating Basis Earthquake) and 1:1,000 AEP event (Safety Evaluation Earthquake);
- Instrumentation design (piezometers) to monitor pore pressures within the embankment, and potentially survey monuments for surface movement depending on the outcomes of detailed design.

3.2.4 Geotechnical Stability

Preliminary design has conservatively assumed 3H:1V downstream slopes. Initial stability modelling has been undertaken based on geotechnical investigations and testing of potential materials and foundations, and found to be stable under drained conditions (static) and undrained conditions (rapid loading, such as construction and drawdown).

3.2.5 Seismic Stability

Any potentially liquefiable materials (e.g. loose sands) will be removed from the embankment foundation footprint. Tailings liquefaction is likely during an earthquake event, however tailings will not form a structural element of the dam, therefore liquefaction would not impact on the stability of the embankment.

A deformation analysis will be carried out during the detailed design phase; however given the flat batter slopes, relatively low height (max height 13 m for potential Stage 2) and extreme storm freeboard allowance, deformation is considered a low risk.

3.2.6 Piping / Seepage

As the decant pond will be maintained away from the embankment walls and the embankment walls will be relatively low, it has been assumed in the preliminary design that filters / free-draining rockfill zones are not required in the design. This will be further assessed in the detailed design phase.

A cut-off trench is included in the design to minimise any potential seepage through the foundations of the embankment.

Depending on the results of seepage modelling, underdrainage may be included in the detailed design to collect seepage through the tailings body and return to the plant. This would also aid in facilitating drainage and consolidation of the tailings, as well as decreasing the time required before the tailings surface is accessible for final capping.

3.2.7 Decant System

A decant structure will be located centrally within the TSF, accessed by a traffic compacted, clay fill access causeway. The decant structure will comprise a concrete tower constructed from stacked, internal flush jointed, slotted concreted well liner pipe sections. A solid wall section is to be located at the base to form a shallow sump.

A rock filter ring will be placed around the stacked tower to prevent the deposited tailings from flowing into the decant structure.

3.2.8 Spillway

The spillway will be located in the northeast section of the facility, where the embankment height is limited. Runoff from any discharge will be directed away from the facility, towards the southeast. The spillway has been located to minimise the spillway height and to direct any discharge away from the process plant and pits. The material, which is expected to be water run-off, will flow into the naturally draining south east corner of the site.

The spillway will be a broad-crested weir, overtopping the embankment. The inlet and discharge chute will be lined with competent rockfill sourced locally from a dolerite borrow source. The required thickness of rockfill, freeboard requirements, inlet / chute dimensions and slope, and retention basin design will be determined in detailed design, following final flood modelling.

A layer of non-woven geotextile is to be installed beneath the rockfill to reduce the potential for erosion of the perimeter embankment fill during times of discharge.

In-pit tailings spill ways will be directed into adjoining pits, which will contain the overflow for later recovery.

3.2.9 Monitoring and inspection

Monitoring and inspection will be carried out for both surface and in-pit tailings facilities.

A series of standpipe piezometers will be installed within the perimeter embankment to enable monitoring of the phreatic surface within the embankment. A series of monitoring bores will be installed downstream of the perimeter embankment to enable monitoring of the groundwater level downstream of the facility, thus enabling any deep-seated seepage beneath the perimeter embankment to be identified.

The TSF will be inspected on a daily basis by operations personnel as part of their routine operating activities for:

- cracking or deformation of the perimeter embankment;
- evidence of seepage from the downstream side of the perimeter embankment;
- effective operation of the decant pump;
- effective operation of the underdrainage system;
- sufficient freeboard allowance;
- effective development of the tailings beach; and
- holes/damage to the tailings delivery or return water pipelines.

In addition to daily monitoring of the facility, bi-monthly inspection of the facility will focus on:

- estimated remaining life within the facility;
- review of monitoring data (groundwater level and quality); and
- operating efficiency of the facility.

In accordance with the ANCOLD Guidelines (2012), in addition to the above inspections, TSF will be audited on an annual basis by a suitably qualified and experienced engineer.

3.3 Tailings Water Management and Recovery

3.3.1 Water Recovery

The key strategy to minimise water consumption in the beneficiation plant and mine has been the process water design. This has optimised the use of water by recycling 85% of the water within the process plant and storage ponds, with the overall make-up water representing 14% of the water used in the process and associated mine activities. Of this 14% of make-up water:

- about 2% is consumed in the mine or lost to evaporation,
- about 1% is lost to drying the product and within the final product.
- 11% is retained in the tailings long term or evaporated from the tailings facility

The recovery of water from the tailings and the tailings facility will vary throughout the life of the mine. The greatest recovery of water will be possible when the facility is well established and the beaching and decant system operating efficiently. Over the life of the facility it is expected that average recoveries in the region of 17% of the deposited slurry water will be achievable (ranging from 9% to 33%), depending upon the maturity of the beaching/decanting process, the tailings composition and weather conditions.

The design of the surface tailing facility has been optimised to aid water recovery and will use a circumferential distribution system of spigots around the TFS, with a central decant tower with a submersible pump located within the tower to recover water. The management of spigot distributors will aid the formation of segment beaches within the TSF and enhance earlier water recovery from the decant tower. In-pit TSF design will also use a spigot distribution system along the walls of the TSF to enhance local beach formation at the toe of the pit wall and hence water recovery using a floating pontoon pump. The recovered water will be pumped from the TSF to the water storage ponds and used within the process plant.

The only other option to reduce the loss of water through the deposition of tailings is the potential drying of the tailings slurry through a combination of additional mechanical and pressurised filters. Such arrangements are capital and energy intensive and also suffer from significant operational and reliability issues and also require the availability of a wet tailings facility for commissioning and operational upsets. Such a combination of process equipment may reduce the moisture in the tailings from the nominal 40 to 50% moisture to 20 to 30% moisture, thereby reducing water sent to the TSF by 2 to 3 ML per day, but without any further water recovery. The net gain from this significant investment in complex mechanical plant, increased operational complexity and increased energy consumption and hence cost, would therefore be in the region of 1 to 2 ML per day of additional water recovery or a reduction of less than 5% of the make-up water demand.

A wet tailings approach has been adopted with a design to recover as much available water as possible given the operational stage, climatic conditions and the tailings composition over the life of mine. This option is commonly adopted in the phosphate industry.

3.3.2 Slurry Density

Geotechnical testing of tailings samples was undertaken in 2014 as part of the Pre-Feasibility Study. The tests were undertaken on a sample of tailings at a slurry density of 50% solids (by weight).The testing included:

- 1 x Drained settling test;

- 1 x Undrained settling test;
- 1 x Particle size distribution test; and
- 1 x Atterberg Limits test.

The results of the laboratory testing indicates that the tailings can be classified a sandy silt (ML/CL) in accordance with the Unified Soil Classification system, with a particle size distribution of 99% passing 0.3 mm, 91% passing 0.15 mm and 75% passing 0.075 mm.

The undrained settling test, which is indicative of a location along the tailings beach where drainage from below is restricted by the low permeable nature of the existing deposited tailings, indicates that the deposited dry density of the tailings is likely to be in the order of 0.9 t/m3 after 24 hours of deposition, with marginal increase in the time thereafter. The water available for recovery during this period is expected to be in the order of 30% of the total slurry water discharged.

A summary of the geotechnical parameters of the tailings, are summarised in Table 3-10

The relationship between the dry density of the tailings and the moisture content, for a tailings production rate of 2.1 Mtpa, is presented in Figure 3-2.

Table 3-10 Tailings Geotechnical Properties

Parameter		Tailings Property
USC		ML / CL
PSD	% passing 0.425 mm % passing 0.3 mm % passing 0.15 mm % passing .075 mm	100% 99% 91% 75%
Atterberg Limits	Plasticity Index Plastic Limit Liquid Limit	8% 23% 31%
Slurry Density (at discharge)		50% solids
Deposited Dry Density (design/planning)		0.9 t/m3

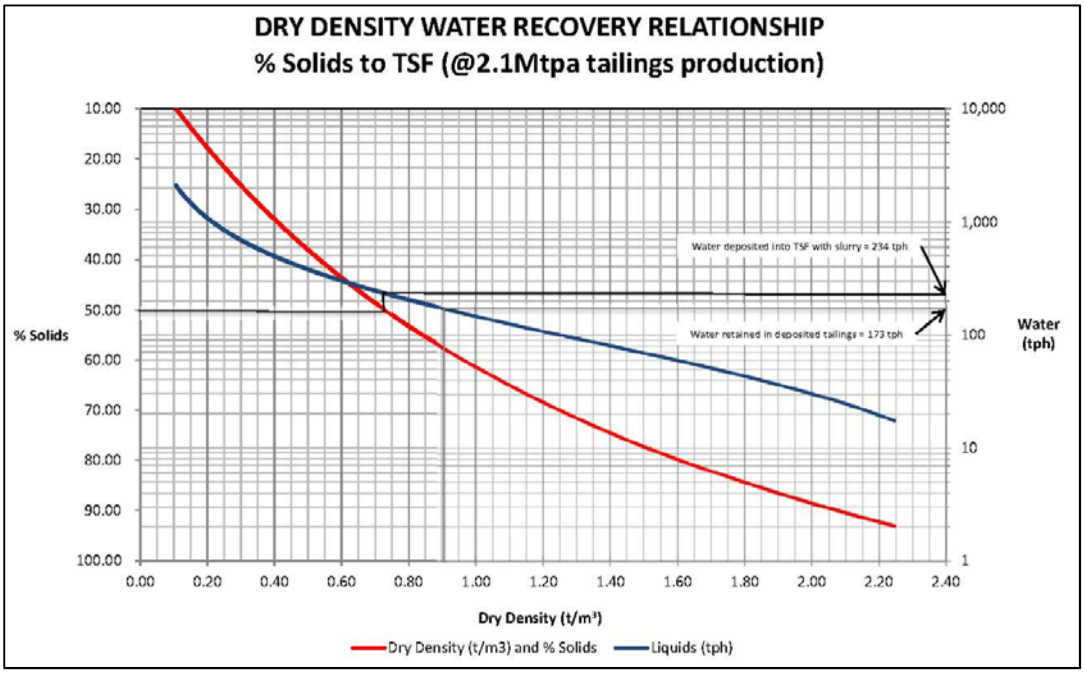


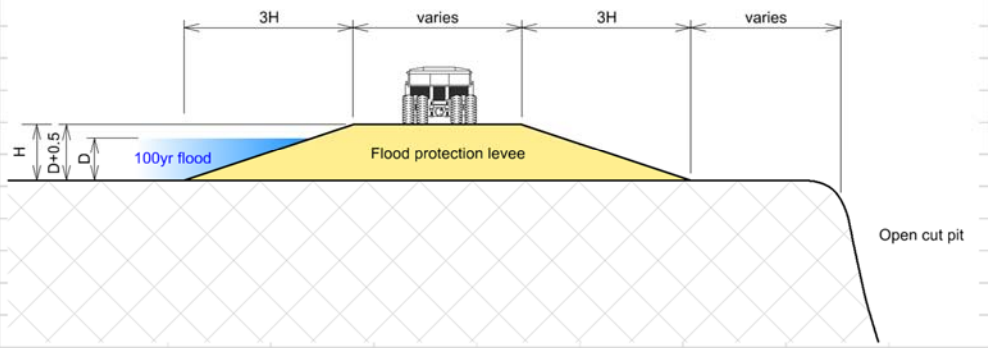
Figure 3-2 Tailings dry density – moisture content relationship

3.4 Flood Protection Berms

Two flood protection berms are proposed at the Ammaroo site - east and west. These berms are intended to protect the open cut pit from inrush during flooding, and to minimise the interception of clean water from external catchments. The conceptual design requirements of the berms are provided in Table 3-11 and Table 3-12.

Table 3-11 Summary of results – east berm

East Levee		
Freeboard:	0.5	(m)
Top width:	3	(m)
batter slope 1:	3	(h:v)
Total estimated v	58000	(m^3)



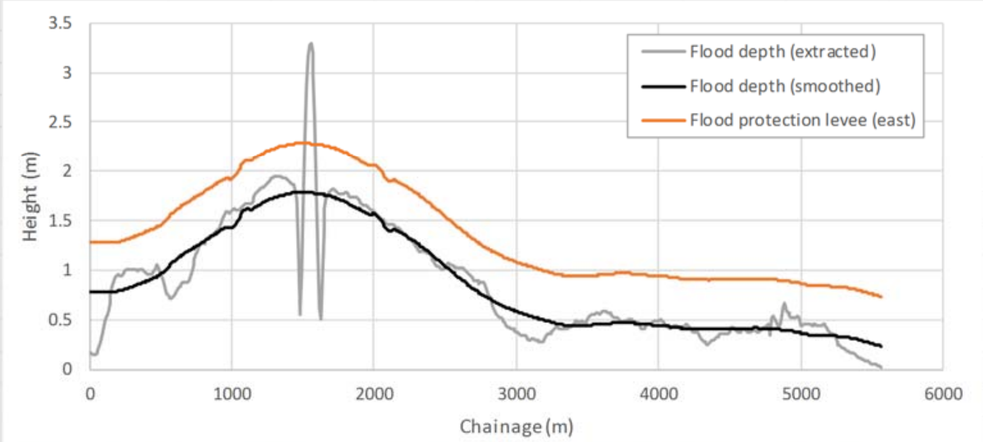
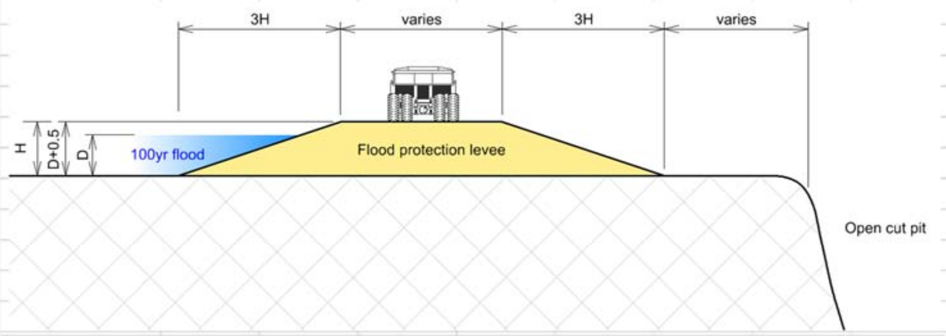
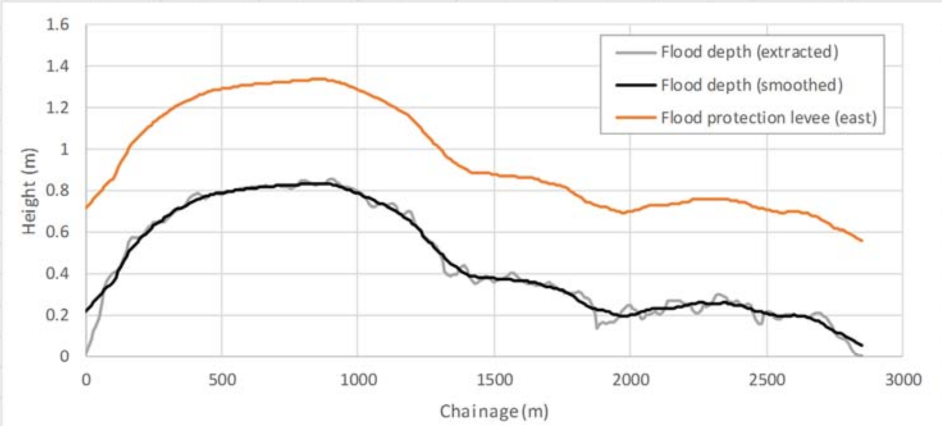
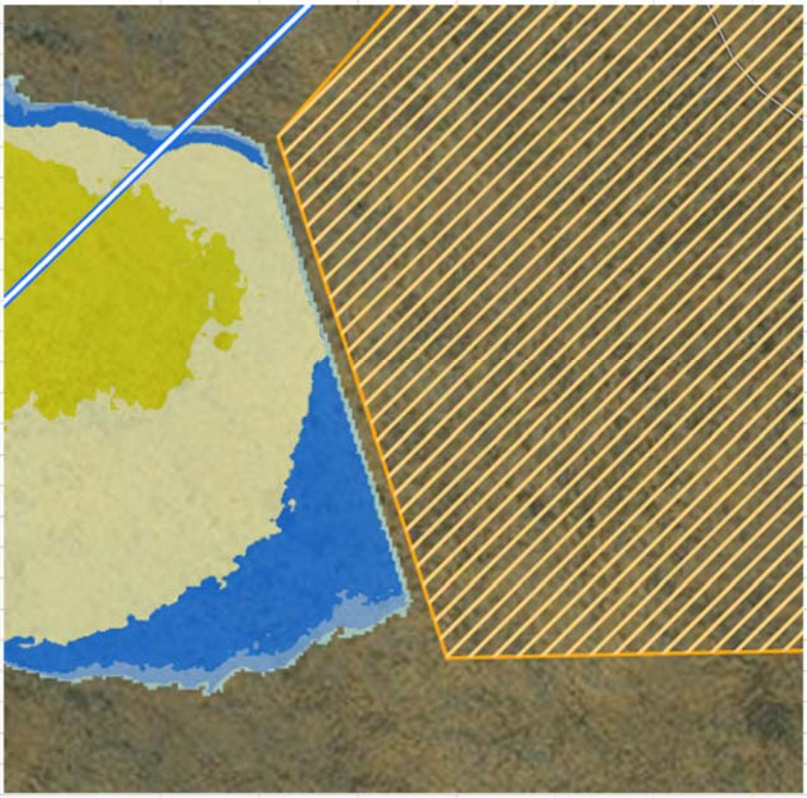


Table 3-12 Summary of results – west berm

West Levee		
Freeboard:	0.5	(m)
Top width:	3	(m)
batter slope 1:	3	(v:h)
Total estimated	17000	(m^3)







3.5 Ecologically Sustainable Development

As defined by the Commonwealth Government in 1990, Ecologically Sustainable Development (ESD) in Australia can be seen as:

> *Using, conserving and enhancing the community's resources so that ecological processes, on which life depends, are maintained, and the total quality of life, now and in the future, can be increased.*

The National Strategy for ESD (Department of the Environment, 1992) was developed to encourage the sustainable use of Australia's natural resources for economic purposes whilst simultaneously increasing the range, variety and quality of the resource.

The guiding principles of ESD development are:

- Precautionary principle: namely, that if there are threats of serious or irreversible environmental damage, lack of full scientific certainty should not be used as a reason for postponing measures to prevent environmental degradation.
- Inter-generational equity: namely, that the present generation should ensure that the health, diversity and productivity of the environment is maintained or enhanced for the benefit of future generations.
- Conservation of biological diversity and ecological integrity; namely, that conservation of biological diversity and ecological integrity should be a fundamental consideration.
- Improved valuation, pricing and incentive mechanisms: namely, that environmental factors should be included in the valuation of assets and service.

The main objectives listed in the National Strategy for mining activities include:

- To ensure mine sites are rehabilitated to sound environmental and safety standards, and to a level at least consistent with the condition of surrounding land.
- To provide appropriate community returns for using mineral resources and achieve better environmental protection and management in the mining sector.
- To improve community consultation and information, improve performance in occupational health and safety and achieve social equity objectives.

VRM has met its obligations with regard to the adoption of the guiding principles throughout this environmental impact assessment process by:

- Applying the precautionary approach in the risk assessment process through the inclusion of a certainty level for each potential impact and consideration of this uncertainty in the assessment of the risk ranking.
- Commitment to recycling process water and recovery of water from tailings for use in operations to reduce water demand from the borefield.
- Minimising waste outputs through the implementation of the waste management hierarchy including objectives to reduce, reuse and recycle waste products.
- Utilising natural gas for energy generation, rather than diesel, to minimise emissions.
- Including solar power generation, in areas of the Project that require lower base loads / are remote and/or have mobile power needs, to meet the overall energy demand and minimise power generation from fossil fuels.
- Undertaking progressive rehabilitation of the mine pit to limit cumulative impact
- Developing and/or maintaining relationships with key communities and stakeholders for the life of the project

- Implementing controls that so that no significant environmental impacts are anticipated as a result of the Project.

Rehabilitation, decommissioning and closure during and after mining operations have ceased are detailed in Chapter 17 of the EIS. The intent of mine closure and rehabilitation is to achieve a stable and functioning landform that is consistent with the surrounding landscape, and will remove potential for long term, post closure impacts.

3.6 Revised Project Water Balance

3.6.1 Introduction

Project optimisation studies have resulted in a revised water balance. The demand from the borefield has significantly reduced from the 4.4 GL/year considered in the EIS to 3.6 GL/year for 2 million tonne per annum production.

The impacts of groundwater extraction from the borefield must then be revised based on the much lower rate of water use.

3.6.2 Methodology

The magnitude of water table drawdown varies proportionally to the rate of groundwater extraction. (Hazel, 2009). For example, if the rate of pumping is halved then the magnitude of drawdown at an observation bore will be halved. This basic principle of groundwater hydraulics has been used to assess the consequence of the optimised water balance at the Ammaroo project. The range of drawdown and the extent of drawdown has been modified based on the pumping rates for the high, average, and low efficiency project water balances.

3.6.3 Results

The maximum drawdown predicted for key receptors is presented as Table 3-13. Predicted drawdown is significantly reduced.

Table 3-13 Drawdown at Key Receptors (Range show 5th and 95th percentile)

Receptor	Drawdown (m)
Ampilwatja Community borefield	0.5 – 2.2
Hagen’s Bore	1.2 – 3.0

The revised flux across the WDWCD likewise scales linearly with pumping rated. The fluxes calculated for the optimised water balance are presented as Table 3-14. The maximum flux for the 50th percentile model output is 0.4 GL/year in years 25-40 (first 15 years post mining).

Table 3-14 Flux Across WDWCD

Flux (GL/year)			
Years of Operation	5th Percentile	50th percentile	95th percentile
1-5	0.0	0.0	0.1
5-10	0.0	0.0	0.3
10-15	0.0	0.1	0.5
15-20	0.0	0.3	0.6
20-25	0.0	0.3	0.7
25-30 (post mining)	0.1	0.4	0.4
30-40	0.1	0.4	0.5
40-50	0.1	0.3	0.3
50-60	0.1	0.2	0.2
60-80	0.0	0.1	0.2
80-100	0.0	0.1	0.1

3.7 Distances to Key Communities

Sensitive community receptors for potential impacts from mining and/or transport infrastructure have been identified in Figure 3-3 and Table 3-15.

Table 3-15 Community distance to project infrastructure

Community	Distance (km) to project infrastructure
Wauchope	41.8 to rail corridor
Ali - Curung	19.2 to rail corridor
Imangara / Murray Downs	24.7 to rail corridor
Imperrenth	17.5 to rail corridor
Elkedra	40.5 to mine site
Neutral Junction	49.4 to rail corridor
Illeuwurru	42.9 to rail corridor
Ngkwarlerlanern	37 to rail corridor
Ampilatwatja	15.3 to mine site
Indaringinya	41.7
Inkawenyerre	40
Amengernterneah	47.4
Iylentye	62.3
Arlparra	68.8
Atnwengerrpe	38.9 to mine site
Ammaroo	22 to mine site

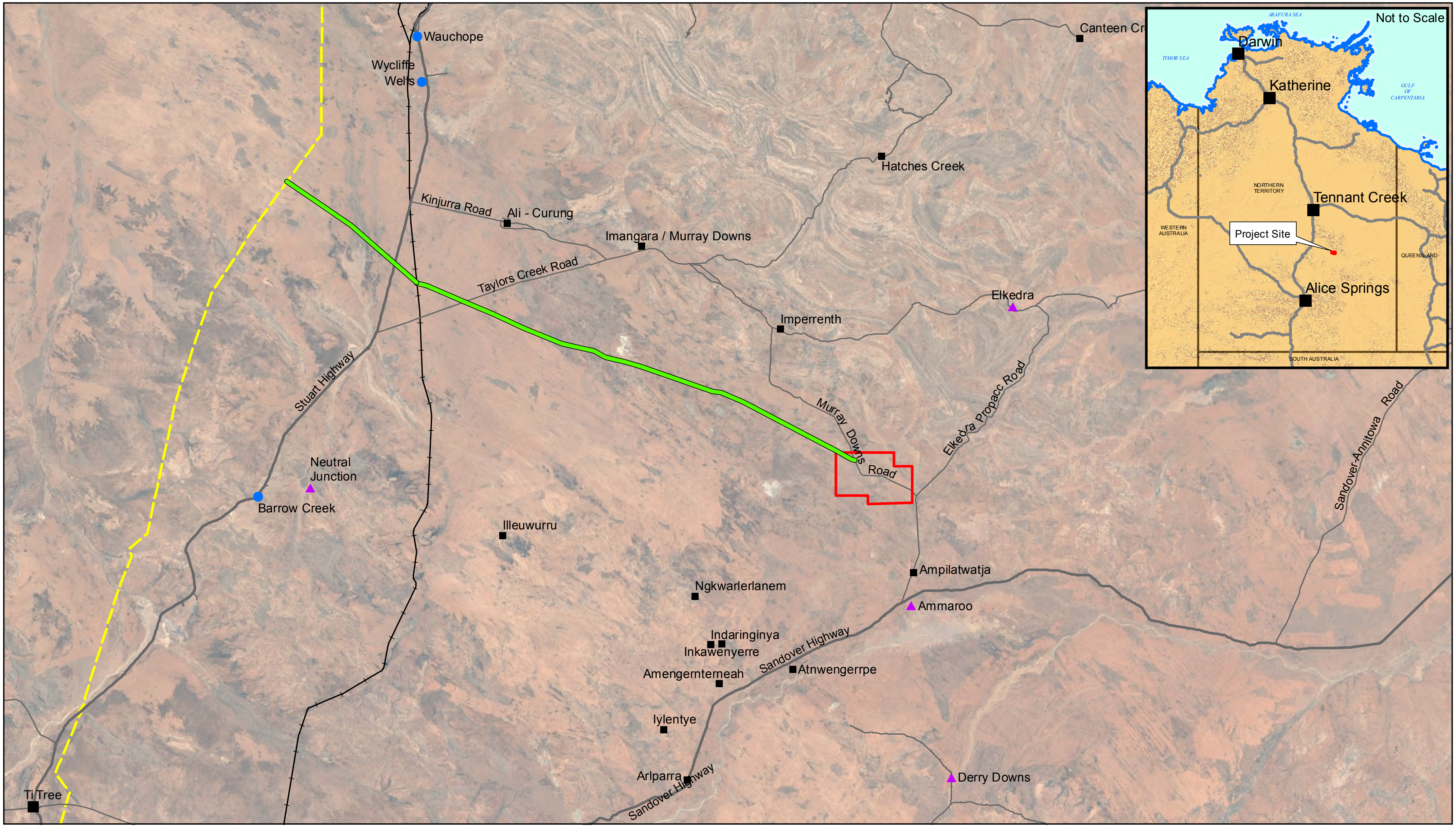
Table 3-16 Community information

Community name	Notes	Est. Population
Ampilatwatja	Located just off the Sandover Highway towards the project site, about 25 km south-east of the Ammaroo Project There are also three outstations Irrultja (60 km south east), Atnwengerrp (40 km away) and Welere (Derry Downs) (60 km south), with considerable mobility between Ampilatwatja, Arlparra and other outstations.	Population: 406. The heart of Alyawarre, or Aherrenge country.
Ali Curung	151 km south of Tennant Creek by sealed road and 95 km north-west of the Ammaroo Project	Population: 537.
Imangara (Murray Downs)	A small community living area excised from Murray Downs Station about 205 km south of Tennant Creek	Population: 50.
Imperrenth (Elkedra) Outstation	About 70 km from Ali Curung off the Ammaroo Road.	Imperrenth (also known as the Dinnie Excision) is a family outstation between Imangara and Ampilatwatja, 29 km from the project site.
Tara (Neutral Junction)	About 230 km south of Tennant Creek, 10 km off the Stuart Highway and 2 km past the Neutral Junction homestead.	Population: 50. It is the closest community to the proposed railway siding for the Project.
Pastoral properties	Various	Ammaroo Station; Murray Downs Station; Elkedra Station; Neutral Junction Station; and Ooratippra Station.

3.8 Residual Risk to the Community

Table 3-17 Residual risk to the community

	Environmental factor					
Community receptor	Groundwater drawdown	Amenity (dust, visual, noise, light)	Reduced pastoral productivity	Local content not achieved	Reduced community cohesion	Pressure on community services
Murray Downs Station	✓	✓	✓		✓	✓
Ammaroo Station			✓		✓	✓
Other Pastoral Stations					✓	✓
Ampilatwatja	✓	✓		✓	✓	✓
Imperrenth		✓		✓	✓	✓
Ali Curung				✓	✓	✓
Other communities and outstations				✓	✓	✓
Wider regional community					✓	✓



1:1,100,000 @ A4

0 10 20 30 40
Kilometres

Map Projection: Universal Transverse Mercator
Horizontal Datum: GDA 1994
Grid: GDA 1994 MGA Zone 53

N

LEGEND

Airport
Towns
Communities
Homesteads
Roadhouses
Major road
Local road
Rail
Amadeus gas pipeline
Access corridor
Mineral lease

Verdant Minerals Ltd
Ammaroo Phosphate Project

Job Number	43-22544
Revision	0
Date	18 Jul 2018

Sensitive community receptors **Figure 3-3**

G:\43\22544\GIS\Maps\4322544_202.mxd

Level 5, 66 Smith Street Darwin NT 0800 Australia T 61 8 8982 0100 F 61 8 8981 1075 E drwmail@ghd.com W www.ghd.com

Data source: GA - Roads, Places, Rail, Pipeline (2015) Google Earth Pro - Imagery (Date extracted: 07/09/2017). VML - Proposed Corridor, Project Site (2017). Created by: CM

3.9 Surface Water Sampling

There is no natural, standing surface water on the Mineral Leases. The only semi-permanent surface water is a shallow man-made stock-watering dam called Woodys Dam, which is located to the northeast of the site. The water quality in this dam is currently being monitored. In addition, temporarily ponded water has been opportunistically sampled from two locations along drainage lines adjacent to road causeways and culverts after significant rainfall. These two locations (EC1 and EC2) have been the only easily accessible concentrations of water within a 20 km radius of the mine site, less than 24 hours after significant rainfall.

All samples have been analysed by a NATA accredited laboratory.

Refer to the Water Management Plan for further information on ongoing surface water quality monitoring (Appendix 6).

3.9.1 Woodys Dam

Location

Centred on GDA94 MGA 519,262mE 7,624,026mN.

Description

Woodys Dam is a shallow unlined 70 m x 70 m surface water dam located on a local drainage line north-east (upstream) of the project site (Figure 3-4) and outside the ML. This dam is used by Ammaroo Station for stockwater. The dam is dug into semi-consolidated dolomitic siltstone rock, which locally contains up to 13% P2O5.

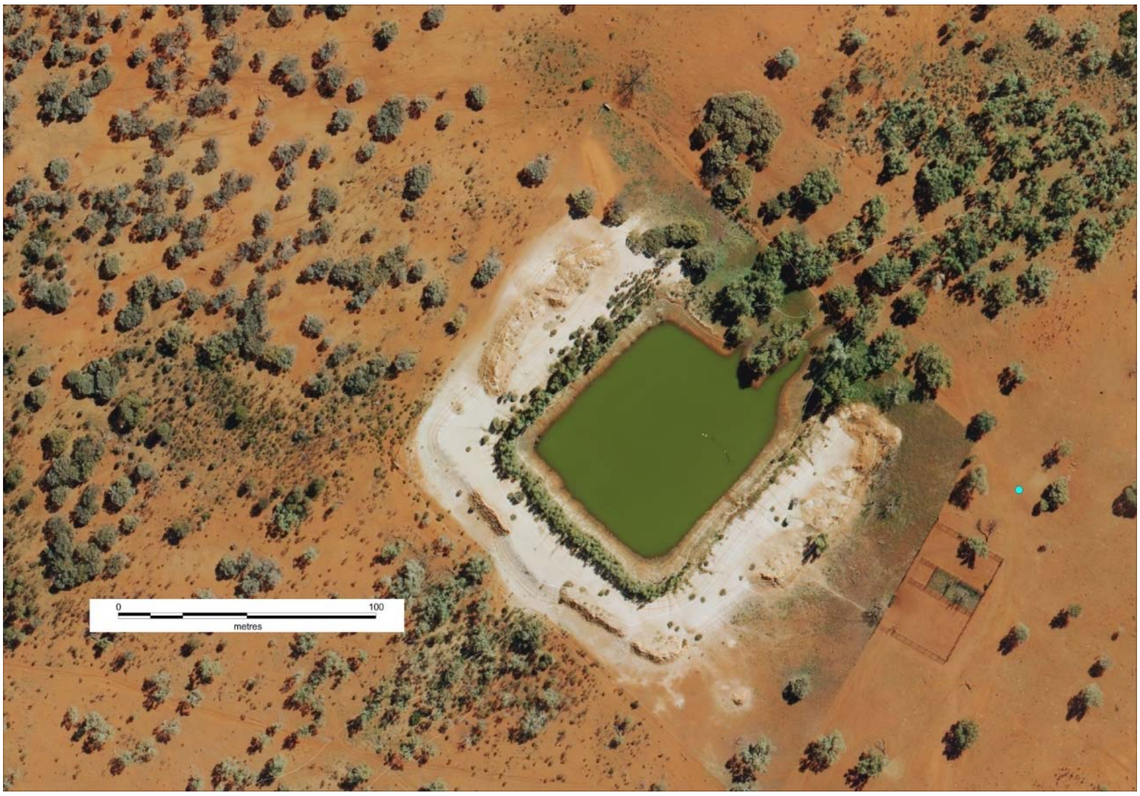


Figure 3-4 Woodys Dam aerial photo taken 16/07/2016.

3.9.2 Site EC1

Location

GDA94 MGA 503,631mE 7,638.172mN. Sample taken from 10 m south of the causeway.

Description

Adjacent to a causeway with flood markers over an ephemeral creek on Murray Downs Road, 17 straight line kilometres northwest of the proposed mine site (Figure 3-5).

A photo of the site is provided in Figure 3-6 and was taken one day after heavy rainfall. No official rainfall figures are yet available.

The site was characterised by standing, shallow and moderately clear water in a modified road drain that approximates the natural dry creek bed.

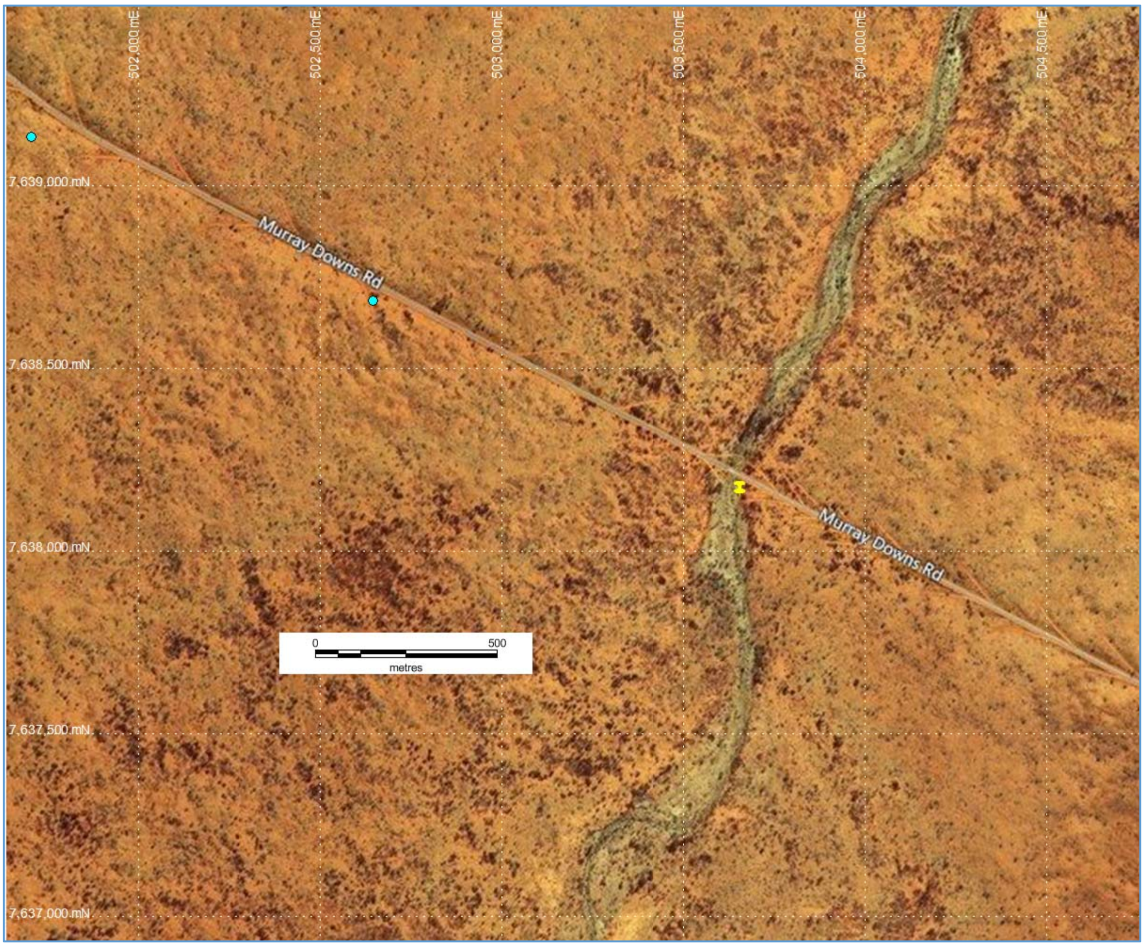


Figure 3-5 Location of sampling site EC1.

Figure 3-6 Site EC1, one day after heavy rain on 13 November 2017.

3.9.3 Site EC2

Location

GDA94 MGA 500,450mE 7,639,870mN. Sample from 5 m north of the causeway.

Description

Adjacent to a concrete causeway with flood markers on Murray Downs Road, 20 km straight line distance northwest of the proposed mine (Figure 3-7).

A photo of the site is provided in Figure 3-8 and was taken one day after heavy rainfall. No official rainfall figures are yet available. The site was characterised by standing, shallow and moderately turbid water in a modified road drain that approximates the natural, ephemeral creek bed.

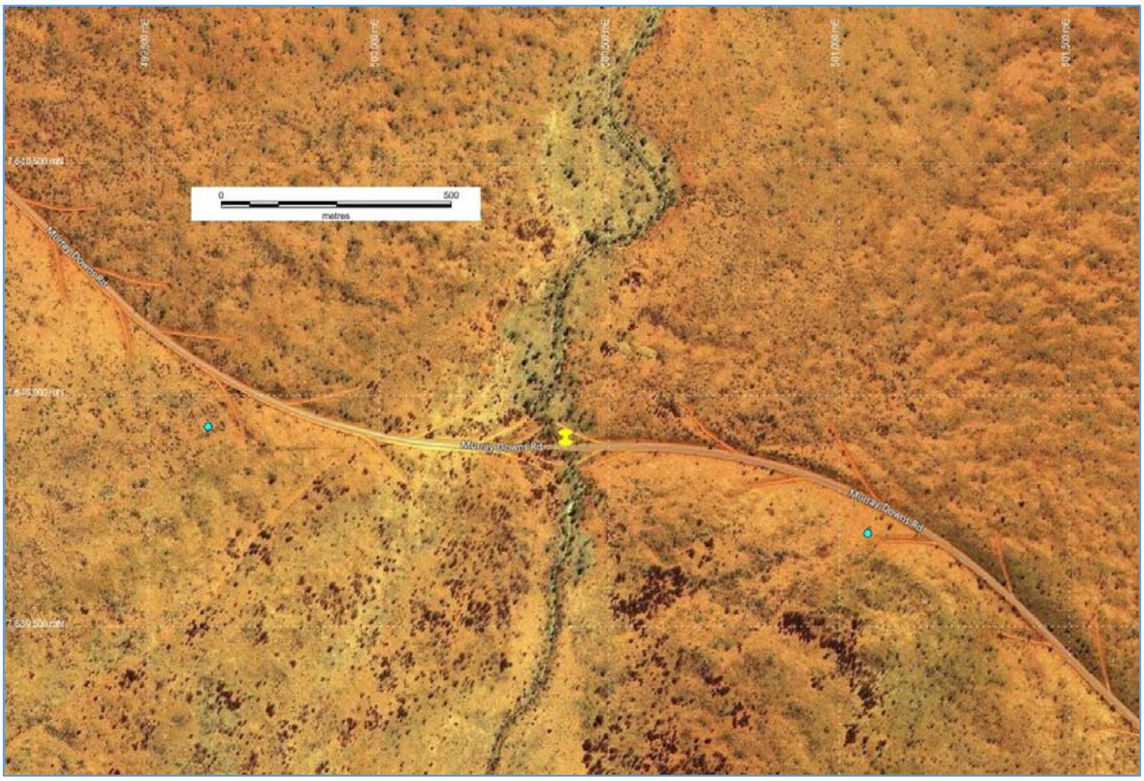


Figure 3-7 Location of sampling site EC2.

Figure 3-8 Site EC2 one day after heavy rain in November 2017.

3.9.4 Monitoring Results

The surface water quality monitoring results from sampling undertaken to date is provided in Table 3-18.

The limited monitoring data indicates that the existing surface water quality is generally good, being suitable for use as stock water (Table 3-18).

In particular, electroconductivity (EC) and turbidity are low (< 100 μS/cm and 14 Nephelometric Turbidity Unit (NTU)). Similarly, metal concentrations are also relatively low and are not expected to cause issue for livestock use.

Table 3-18 Surface water quality monitoring data

IDENT	UNITS	SCHEME	ANZECC guideline trigger	WOODYS DAM 11/11/16	WOODYS DAM 01/11/17	EC1 13/11/17	EC2 13/11/17
Job number				NT46536	NT48124	NT48206	NT48206
Project code				Woody's Dam 11/11/2016	Ammaroo Surface Water 01/11/2017	Ammaroo Surface Water 13/11/2017	Ammaroo Surface Water 13/11/2017
pH	units	WWM07		7			
EC	µS/cm	WWM12	6000 [A]	53	90	16	27
Alkalinity	mg/L	WWM08		27			
CO_3	mg/L	WWM08		<1			
HCO_3	mg/L	WWM08		27			
OH	mg/L	WWM08		<1			
Turbidity	NTU	WWM15		14			
True Colour	PCU	WWM16		15			
TSS	mg/L	WWM14		10	40	270	60
TDS	mg/L	WWM14	4000 [A]	40			
NO_2_N	mg/L	WWM22	30 [B]	<0.005			
NO_2	mg/L	WWM22	30 [B]	<0.02			
NO_3_N	mg/L	WWM22	400 [B]	<0.005			
NO_3	mg/L	WWM22	400 [B]	<0.02			
Cl	mg/L	WWM19		3.3			
PO_4_P	mg/L	WWM25		0.005			
NH_3_N	mg/L	WWM22		0.225	0.185	0.065	0.095
Total N	mg/L	WWM22			2.62	1.01	0.55
Total P	mg/L	WWM25			0.21	0.7	0.055
DF	--				--		

IDENT	UNITS	SCHEME	ANZECC guideline trigger	WOODYS DAM 11/11/16	WOODYS DAM 01/11/17	EC1 13/11/17	EC2 13/11/17
F	mg/L	WWM20		<0.1			
Hardness	mg/L	WWM11		15.6			
Ca_F	mg/L	W108	1000 [B]	4.6			
K_F	mg/L	W108		7.1			
Mg_F	mg/L	W108	2000 [B]	1			
Na_F	mg/L	W108		0.1			
SiO2	mg/L	W108		2.6			
SO4_F	mg/L	W108		0.2			
Ag_T	µg/L	W200		<10			
Al_T	µg/L	W200	5000 [C]	680			
As_F	µg/L	W100			0.95	0.25	0.2
As_T	µg/L	W200	500 [C]	0.5	1.5	1.5	0.35
B_T	µg/L	W200	5000 [C]	<20			
Ba_F	µg/L	W100			91.8	6.5	17
Ba_T	µg/L	W200		<50	110	89.8	23.8
Be_F	µg/L	W100			<0.05	<0.05	<0.05
Be_T	µg/L	W200		<1	<0.05	0.95	0.05
Br_T	µg/L	W200		16			
Cd_F	µg/L	W100			<0.02	<0.02	0.02
Cd_T	µg/L	W200	10 [C]	<0.2	<0.02	0.02	0.04
Co_F	µg/L	W100			0.35	0.03	0.25
Co_T	µg/L	W200	1000 [C]		1.49	9.57	0.99
Cr_F	µg/L	W100			<0.1	<0.1	0.1
Cr_T	µg/L	W200	1000 [C]	<5	0.5	26.3	1.5
Cu_F	µg/L	W100			0.27	0.36	1.25

IDENT	UNITS	SCHEME	ANZECC guideline trigger	WOODYS DAM 11/11/16	WOODYS DAM 01/11/17	EC1 13/11/17	EC2 13/11/17
Cu_T	µg/L	W200	1000 [C]	<10	1.45	13.4	2.3
Fe_T	µg/L	W200		740			
Hg	µg/L	W200		<0.1			
Hg_F	µg/L	W100			<0.02	<0.02	<0.02
Hg_T	µg/L	W200	2 [C]		<0.02	0.04	<0.02
I_T	µg/L	W200		<10			
Mn_F	µg/L	W100			0.98	0.38	32.3
Mn_T	µg/L	W200		10	98.5	268	59.5
Mo_T	µg/L	W200	150 [C]	<5			
Ni_F	µg/L	W100			0.54	0.1	0.43
Ni_T	µg/L	W200	1000 [C]	<2	0.94	11	1.22
Pb_F	µg/L	W100			0.03	0.02	0.16
Pb_T	µg/L	W200	100 [c]	<1	0.44	12.1	0.79
Sb_T	µg/L	W200		<0.2			
Se_T	µg/L	W200	20 [C]	<1			
Sn_T	µg/L	W200		<10			
U_T	µg/L	W200	200 [C]	0.04			
V_F	µg/L	W100			0.45	0.2	0.55
V_T	µg/L	W200			4.9	56.5	3.6
Zn_F	µg/L	W100			1.5	0.3	2.5
Zn_T	µg/L	W200	20000 [C]	<10	6.4	26.5	6.1

[A] Table 4.3.1 of ANZECC (2000), beef cattle “No adverse effects”, assuming TDS = 0.67 x EC

[B] Section 4.3.3 of ANZECC (2000)

[C] Table 4.3.2 of ANZECC (2000)

3.10 Assessment Criteria for ASLP Data

The Australian Standard Leaching Procedure (ASLP) (AS4439-1996) is commonly used to assess the risk of metalliferous leachate from non-reactive (usually non-sulfidic) waste rock and tailings. There are, however, no guidelines for acceptable concentrations of metals or major ions from ASLP testing in waste rock and tailings.

Simple direct comparison of ASLP results with ambient groundwater quality, Australian Drinking Water Guidelines (ADWG) (NHMRC, NRMMC, 2011) or local aquatic ecosystem guidelines (ANZECC & ARMCANZ, 2000) may act as a very conservative screening tool, but in practice, it is rare for any ASLP analyses not to exceed the guidelines for one or more elements. This is because the test involves fine grinding (<2.4 mm) far below the grainsize of waste rock dumps (although similar to tailings), and constant agitation (18 hours) further abrading the sample in the test solution, which releases metals and other weakly soluble components at a far higher rate than would simple passive leaching. The results are also likely to overestimate long-term leachate production as most soluble components are removed in the initial first flush, although other components may increase over time as salinity decreases (ANZECC & ARMCANZ, 2000).

To allow for these limitations in landfill and on-site containment settings, most Regulators have developed leachate guidelines based on the target water quality guidelines multiplied by a dilution-attenuation factor (DAF). These guidelines are based on the assumption that the landfill overlies a sensitive drinking water aquifer, albeit with minimum separation distances. Consequently, the guidelines are based on the ADWG, but substitution aquatic ecosystem (ANZECC & ARMCANZ, 2000) guidelines with the appropriate dilution factor, may be more appropriate.

3.10.1 Waste Classification by Liner Type

Unlined Disposal

Western Australia has developed unlined landfill acceptance criteria (WADEC, 2009) for Class I and Class II materials, which include inert materials and clean fill. These guidelines are based on the 2004 ADWG multiplied by a factor of 10.

The Brisbane City Council (BCC, 1994) guidelines for unlined industrial fill used the then current drinking water guidelines multiplied by a factor of 10 and are identical to the QLD (QDEHP, 2015) guidelines for clay-lined systems, both of which tend to be slightly higher than the WA equivalent.

NSW (NSWEPA 2014) has guidelines for inert waste, including “virgin excavated material” suitable for Class 1 landfills. The classification is based on total concentrations and leachable Concentration Threshold based on TCLP (or ASLP) multiplied by a factor 10 or higher.

Based on these guidelines, an appropriate screening ASLP upper limit for unlined WRDs or TSFs is 10 times ADWG (NHMRC, NRMMC, 2011).

Composite Liner

WA Class III waste (WADEC, 2009) is based on the 2004 ADWG times 100. The Northern Territory Listed Waste Criteria (NTEPA, 2013) and the Victoria EPA (EPAVIC, 2009) Category C limits are based on ADWG 1996 multiplied by 100. These criteria are similar to, although in some cases higher than, the QLD (QDEHP, 2015) guidelines for double lined systems and the NSW EPA (NSWEPA, 2014) limits for General Solid Waste which are based on 100 times a combination of ADWG and freshwater aquatic ecosystem guidelines (ANZECC & ARMCANZ, 2000).

Based on these guidelines, an appropriate current ASLP upper limit for clay or composite-lined WRDs or TSFs is 100 times ADWG 2011 (NHMRC, NRMMC, 2011).

Double Liner

WA (WADEC, 2009) Class IV is based on ADWG x 1000. The Victorian (EPAVIC, 2009) and NT (NTEPA, 2013) Double liner limits are equivalent to 4 times the USEPA Category C limits or 400 times ADWG 1996.

Based on these guidelines, an appropriate current ASLP upper limit for double-lined WRDs or TSFs is 400 to 100 times ADWG 2011 (NHMRC, NRMMC, 2011).

3.10.2 Summary of Assessment Criteria and Containment Systems

Based on the above, a reasonably conservative guide to appropriate base liner systems, with appropriately matched capping systems, for non-sulfidic waste rock and tailings, whether raw or treated to reduce metal mobility, is:

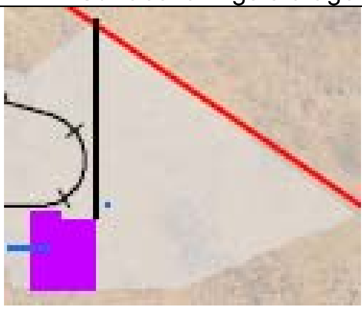
- Material with an ALSP concentration less than or equal 10 times the 2011 ADWG (or other more appropriate receptor guideline) is suitable for containment in un-lined waste rock dumps and tailings ponds, subject to normal sediment and erosion control and retention and testing of runoff. The base of the facility should, as a minimum, be cleared of vegetation, grubbed and traffic compacted.
- Material with ASLP concentrations between 10 and 100 times the selected guideline is suitable for containment within an engineered compacted clay or composite-lined dumps.
- Material with an ASLP concentration between 100 and 400 (or possibly up to 1000) times the selected guideline is suitable for containment within double lined systems.

If sulfidic material is present, or site-specific guidelines are required, then long-term kinetic testing such as column or barrel leach testing is carried out to provide a more realistic indication of long-term leachate quality. An initial indication can be obtained by leaching the material with a deionised water/sulfuric acid solution with acidity and pH similar to the corresponding NAG solution (Smart et al., 2002).

Numerical modelling of groundwater flow and solute transport modelling may indicate higher leachate concentrations are acceptable; if prior to reaching groundwater users or groundwater dependant ecosystems groundwater is of poor quality and or significant attenuation within the aquifer is likely.

3.11 Administration and Plant Area Closure

The Task Register for the administration and plant area (Table 3-1 from the Closure Report – Appendix Q of the EIS) is detailed below in all completeness.

Administration and Plant Area – Closure Task Register	
1.1 Description of Domain of Feature	
Plant, administration, beneficiation plant, maintenance facilities, infrastructure and services, including: • Administration building (typical office type construction and finish); • Power plant; • Warehouse/workshop (steel frame building with concrete floors); • Change room and amenities; • Canteen (dry); • Security and emergency services; • Waste water treatment plant for utility oily water; • Sewerage services; • Run of Mine stockpile and reclaim system; • Primary and secondary crushers; • Crushed ore stockpile and reclaim system; • Conveyor and blending system; • Beneficiation plant; • Waste tails thickener; and • Surface tailings storage facility	
 see figure 3-1	
Location	Adjacent to Murray Downs Road realignment.
Tenements	ML 29463 & ML 29854
Status	Not yet constructed.
Current Disturbance	Exploration 50 x 50m spaced drillholes and 200 x 200m spaced drillholes Pastoral Lease and Cattle Grazing
Life of Asset Disturbance	25 years Life of Mine (LOM)
Estimated Closure Start Date	2045
Estimated Closure End Date	2046
Closure Works Duration	1 year
1.2 Land-Use Information	
Post-Mining Land Use	Natural habitat compatible with pastoral use
Rehabilitated Landform Objective	Reinstate natural (unmanaged) ecosystem(s) similar to the pre-mining state that does not preclude pastoral use or inhibit surrounding pastoral use. Rehabilitation will achieve a stable and functioning landform that is consistent with the surrounding landscapes and other environmental values and will remove potential for long term, post closure impacts on downstream water quality, beneficial uses and environmental values.
Post-Mining Landform Design	Flat area rehabilitation with gently sloping south to north surface drainage.

Closure Completion Criteria and Performance Indicators	Certification that no contamination remains in place that would prevent the closure objectives being met. Certification that adequate topsoil is in place. Certification that adequate vegetation has been reinstated to meet the closure objectives.	
1.3 Closure Work Tasks		
Activity	**Closure Work Tasks**	**Approx. Duration**
Decommission	1. Decommission all services prior to demolition. 2. Disconnect all High Voltage (HV) and Low Voltage (LV) electrical power supply cables and isolate all equipment. 3. Disconnect water supply and sewerage services. 4. Drain down and flush all pipelines and tanks. 5. Remove residue and/or sludge from ponds to in-pit TSF. 6. Remove and if necessary clean any infrastructure / plant before transporting off site for reuse/sale. 7. Transport all unused reagents off-site.	1 to 2 months
Demolish	1. Remove any hazardous materials for disposal in hazardous waste landfill off-site. 2. Demolish all infrastructure and services to at least 0.5m below closed ground surface level, including plant, offices, communications tower, power station, fuel tanks, roads, water ponds. 3. Cut and/or break up demolition debris to suitable size for safe transport and disposal.	3 to 5 months
Clean-up and dispose	1. Investigate extent of soil contamination around fuel storage, plant area (spills), and mining maintenance facilities. 2. Excavate all contaminated soils down to extent of contamination. 3. Transport contaminated soil material off-site for disposal. 4. Transport all oil and oily wastes off-site (from maintenance facilities). 5. Transport any hazardous materials to off-site hazardous waste licensed landfill or designated facility. 6. Clean and dispose pond liners into agreed facility (i.e. placed and capped in-pit if appropriate). 7. Transport all other inert demolition debris and dispose in existing excavations (where possible), base of pit or excavated on-site landfill.	2 to 4 months
Site landform and drainage reconstruction	1. Backfill structural voids and residual excavations (tanks, ponds, landfills) with inert mine waste. 2. Remove culverts and drain crossings but leave main diversion drains in place to protect landforms. 3. Reshape/re-contour area to generally return pre-mining east west surface drainage and to remove any erosion prone features. Provide fill to areas where contaminated soil has been removed if necessary to recreate appropriate surface drainage.	2 to 3 months
Rehabilitation and re-vegetation	1. Spread available topsoil at >100mm and rip on contour. 2. Seed with local pioneer species and mulch with any available vegetation detritus.	1 to 2 months

Security and Signage	The site will be safe for public access post-closure. No security fencing or signage is required.	Not applicable
1.4 Schedule of Work for Research, Investigation and Trials Tasks		
Aspect	**Research, Investigations and/or Trial**	**Schedule**
Demolition and Waste Disposal	Investigate the potential for sale and/or transfer of plant and associated equipment (e.g. tanks, sheds, demountable offices and piping) to a third party, thereby reducing the waste to landfill.	Not applicable
Contaminated soils	Maintain a contaminated spills register during operations to assist identification of areas with known contamination for removal on closure.	Not applicable
1.5 Schedule of Work for Progressive Rehabilitation		
Aspect	**Progressive Rehabilitation Works**	**Schedule**
Plant and administration areas	No progressive rehabilitation works are envisaged for the plant and administration area	Not applicable
1.6 Availability and Management of Closure Material Sources		
Requirement	**Resource**	**Volume/Area**
Excavate and Backfill	Estimated based on soil removal (to 1000mm if required) from potentially contaminated areas. Some will also be required to backfill concrete footings areas. Backfill with additional material sourced from ROM pad, removal of roads, ponds and landfill excavations.	See Table 12
Earthworks Area	Area requiring grading and contouring (based on areas of infrastructure and potential excavation).	See Table 12
Topsoil	Spread to areas as required at >100mm. Available topsoil stockpiled adjacent to plant areas.	See Table 12
Seeding	Seed areas disturbed and topsoiled. Purchase local pioneer species seed from local supplier (or establish local supply).	See Table 12
1.7 Key Tasks for Unexpected (Early) Closure and/or Temporary Closure		
Scenario	**Key Tasks**	**Schedule**
Early Closure	Decommission all services, power and water supply and isolate all equipment. Drain down and flush all pipelines, pumps, tanks to surface TSF or in-pit TSF and remove residue and/or sludge from ponds to surface TSF or in-pit TSF.	On announcement of early/ sudden closure
Temporary Closure	Flush residual solids from lines to prevent blockage on restart, and grease, oil and pack all mechanical equipment and vehicles appropriately. Develop a care and maintenance plan to maintain a minimum but active security and maintenance presence.	On announcement of temporary closure
1.8 Information Gaps		
Aspect	**Information Gap/Uncertainty**	**Schedule**
Contaminated soil sampling and assessment	Sampling and assessment will be required at the time of closure to determine the extent of soil contamination and remediation required. This risk will be reduced through maintaining a spill register during operations phase.	Closure
1.9 Performance Monitoring and Maintenance Schedule		
Aspect	**Performance Monitoring and Maintenance Task**	**Schedule**
Post-Closure Monitoring	Implement agreed post-closure monitoring program.	Relinquishment
Post-closure Maintenance	Undertake regular inspections as per monitoring requirements to assess the need for maintenance activities.	Annually
	Implement post-closure maintenance activities as required.	As required to relinquishment

3.12 ASLP 1:20 Water Leach Results

The summary statistics of the ASLP analyses are presented below in Table 3-19 with comparisons to the applicable guidelines. The analyses are presented in subsequent tables in comparison with the applicable site water quality guidelines.

3.12.1 Freshwater Aquatic Ecosystems 95% protection

ASLP results were compared with the ANZECC and ARMCANZ (2000) guidelines for moderately disturbed freshwater aquatic ecosystems (FAE95%) and analytes for which one or more samples exceeded a guideline are presented in Table 3-20.

In the absence of a reliable freshwater guideline for chromium III, the USEPA (1995) freshwater chronic exposure guideline of 0.074 mg/L was used. To enable calculation of statistics, all <LOR results were set to 0.5 x LOR. In some cases, such as for total phosphorus, this gives the impression that the results exceeded the guideline, however this is due to the LOR being more than twice the guideline.

The guidelines were exceeded by aluminium, iron and hardness-corrected copper, chromium, lead and zinc. Although aluminium exceeds the guidelines, given the circum-neutral pH, this is likely to be due to colloidal clays not filtered out by the standard 0.45um filter (MAMD, 2007).

Several analyses exceed the guideline for hardness-corrected copper, lead or zinc, but only 6 samples exceeded the guideline by more than a factor of 10 for one or more metal. The median hardness corrected concentrations were all less than FAE95%. The 99% upper confidence interval (99% UCL) and third quartile for all metals other than aluminium were all less than 10 times FAE95%.

The nitrate and total phosphorus concentrations were elevated relative to the nuisance algal growth guidelines but do not present a toxicity risk.

Based on these concentrations, leachate from the waste rock dumps does not present a significant risk to surface freshwater aquatic ecosystems, provided direct discharge of runoff or leachate to surface water is prevented.

3.12.2 Average Groundwater

ASLP results are compared in Table 3-21 with average of 8 groundwater concentrations recorded in bores in or around the mine from 2011 to 2016. The results are summarised in Table 3-21. As with the FAE95% comparison, there are some anomalously high results due to the high LOR, including chromium, manganese, uranium and vanadium. Arsenic, copper, lead and zinc exceeded average groundwater concentrations in some samples, some by a factor of between 10 and 100. Of these, the mean, median, 99%UCL and 3rd quartile are all less than 10 times the average groundwater concentration. Cobalt concentrations were highly variable ranged from less than the average groundwater concentration to between 100 and 1000 times the average, which is based on only 2 groundwater samples.

Fluoride was above the average groundwater concentration in most samples although the 99%UCL was below the average and all were less than 10 times the average groundwater concentration. Nitrite was higher but nitrate was lower in all of the samples and the nitrate plus nitrite (NOx) was lower than the average groundwater in all but 2 samples and total N in all but 3. All statistics other than the maximum leachate concentration were below the average groundwater concertation for NOx and total nitrogen. Total phosphorus was above the average groundwater concertation in all samples but by less than a factor of 10, however the LOR was 5 times the groundwater concentration. Despite this, the 99% UCL was less than the average groundwater total phosphorus concentration.

Table 3-19 ASLP statistical summary

	LAB PHYS.			MAJOR IONS								
Sample ID	Lab pH	EC	TDI Calc from Major Ions	Na	K	Ca	Mg	Bi-carbonate as $Ca(HCO_3)_2$ (0.5 = <LOR)	Carbonate as $CaCO_3$ (0.5 = <LOR)	Cl	SO_4	Cation/Anion Balance
Units		mS/cm	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(mg/L)	%
Average Groundwater	**7.93**	**1530**	**655**	**124**	**23**	**93**	**53**	**358**	**<0.5**	**188**	**206**	
ANZECC (2000) FAE 95%												
ANZECC (2000) Livestock	**6 to 8.5**					**1,000**					**1,000**	
ANZECC (2000) Irrigation LTV	**6 to 8.5**			**<115-460**						**<175-700**		
ANZECC (2000) Irrigation STV	**6 to 8.5**		**5,000**							**700**		
ADWG(2011) Health											**500**	
ADWG(2011) Aesthetic				**180**						**250**	**250**	
Min	7.10	52	62	3	5	1	1	26	0.5	4	4	-47.67
1st Quartile	7.60	239	135	10	10	6	4	52	0.5	19	18	-38.67
Mean	7.79	309	231	24	12	9	6	73	0.5	81	44	-30.64
Median	7.89	280	185	20	10	8	6	52	0.5	59	29	-32.68
99%UCL	0.10	56	55	7	2	2	1	11	#NUM!	31	28	3.90
3rd Quartile	8.03	374	269	36	15	13	8	100	0.5	120	44	-25.29
Max	8.15	746	859	85	30	46	24	150	0.5	400	570	0.27

	CALCULATED INDICES				METALS										
Sample ID	SAR	$Cl:SO_4$ Ratio (Seawater = 7.2)	Calc Hardness	Log Cl/CO_3	Al	As	Cr	Co	Cu	Fe	Pb	Mn	U	V	Zn
Units			(mg/L)		(mg/L)	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(mg/L)	mg/L	(mg/L)	(mg/L)
Average Groundwater	**3**	**1**	**450**		0.041	**0.002**	**0.001**	**0.0008**	**0.003**	**0.544**	**0.003**	**0.022**	**0.014**	**0.005**	**0.024**
ANZECC (2000) FAE 95%					**0.06**	**0.013**			**0.001**		**0.003**	**1.900**			**0.008**
ANZECC (2000) Livestock				**2**	**5.00**	**0.500**	**1.000**	**1.0000**	**0.500**			**0.100**	**0.200**		**20.000**
ANZECC (2000) Irrigation LTV	**<2-102**		**60-350**	**2**	**5.00**	**0.100**	**0.1**	**0.05**	**0.200**		**2.000**	**0.200**	**0.010**	**0.1**	**2.000**
ANZECC (2000) Irrigation STV			**60-350**	**2**	**20.00**	**2.000**	**1.0**	**0.10**	**5.000**	**10**	**5.000**	**10.000**	**0.100**	**0.5**	**5.000**
ADWG(2011) Health					**NA**	**0.010**	**0.05**		**2.000**	**NA**	**0.010**	**0.500**	**0.017**		**NA**
ADWG(2011) Aesthetic			**200**		**0.20**	**NA**	**NA**		**1.000**	**0.3**	**NA**	**0.100**	**NA**		**3.000**
Min	0	0	7	1	2.50	0.001	0.1	0.00	0.001	2.5	0.001	0.500	0.500	0.5	0.006
1st Quartile	1	1	34	2	2.50	0.001	0.1	0.00	0.001	2.5	0.001	0.500	0.500	0.5	0.009
Mean	2	3	48	2	8.22	0.002	0.1	0.01	0.003	4.2	0.009	0.500	0.500	0.5	0.023
Median	1	2	48	2	2.50	0.002	0.1	0.00	0.002	2.5	0.004	0.500	0.500	0.5	0.012
99%UCL	0	1	11	0	3.44	0.000	0.0	0.01	0.002	1.5	0.004	#NUM!	#NUM!	#NUM!	0.014
3rd Quartile	2	3	58	2	10.00	0.003	0.1	0.00	0.003	2.5	0.012	0.500	0.500	0.5	0.017
Max	4	12	214	3	40.00	0.005	0.1	0.15	0.028	20.0	0.052	0.500	0.500	0.5	0.214

	HARDNESS CORRECTED METALS				NON-METALLIC INORGANICS					
Sample ID	Cr	Cu	Pb	Zn	F	NO_2 as N	NO_3 as N	NO_x (NO_3 + NO_2) as N	Total N	Total P
Units	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(mg/L)
Average Groundwater	**0.0001**	**0.0004**	**0.0001**	**0.0023**	**1.28**	**0.009**	**7.8**	**7.80**	**0.25**	**0.02**
ANZECC (2000) FAE 95%	**0.001**	**0.0014**	**0.003**	**0.008**		**0.700**				
ANZECC (2000) Livestock					**2**	#####	**30**			
ANZECC (2000) Irrigation LTV					**1**				**5**	**0.05**
ANZECC (2000) Irrigation STV					**4**				**25**	**0.8**
ADWG(2011) Health		**2.0000**	**0.010**		**1.500**	**0.910**	**11.3**			
ADWG(2011) Aesthetic		**1.0000**		**3.000**						
Min	0.010	0.0002	0.000	0.002	0.1	0.050	0.4	0.45	0.45	0.5
1st Quartile	0.029	0.0005	0.000	0.006	1	0.050	1	1.05	1.05	0.5
Mean	0.044	0.0024	0.009	0.018	2.69	0.472	1.94	2.41	2.4087	0.56863
Median	0.034	0.0012	0.003	0.008	2	0.050	1	2.00	2	0.5
99%UCL	0.010	0.0012	0.010	0.009	0.77	0.250	0.52	0.66	0.6554	0.08849
3rd Quartile	0.045	0.0026	0.008	0.021	3	0.800	2	3.01	3.0125	0.5
Max	0.173	0.0150	0.192	0.107	12	4.000	7	9.00	9	2

Table 3-20 ASLP FAE95% Summary

	Phys	Disolved Metals								Hardness-Corrected Metals				Nutrients			
Sample ID	**Lab pH**	**Al**	**As**	**Cr 3+**	**Cu**	**Fe**	**Pb**	**Mn**	**Zn**	**Cr**	**Cu**	**Pb**	**Zn**	**NO_2 as N**	**NO_3 as N**	**NO_x (NO_3 + NO_2) as N**	**Total P**
Units		(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)
ANZECC (2000) FAE 95%	**6.5-8.5**	**0.06**	**0.0130**	**0.0033**	**0.001**	**0.3**	**0.003**	**1.900**	**0.008**	**0.003**	**0.0014**	**0.003**	**0.008**	**0.700**		**0.004**	**0.01**
Min	7.10	2.50	0.0005	0.050	0.001	2.5	0.001	0.500	0.006	0.010	0.0002	0.000	0.002	0.050	0.4	0.45	0.5
1st Quartile	7.60	2.50	0.0009	0.050	0.001	2.5	0.001	0.500	0.009	0.029	0.0005	0.000	0.006	0.050	1	1.05	0.5
Mean	7.79	8.22	0.0018	0.050	0.003	4.2	0.009	0.500	0.023	0.044	0.0024	0.009	0.018	0.472	1.94	2.41	0.56863
Median	7.89	2.50	0.0020	0.050	0.002	2.5	0.004	0.500	0.012	0.034	0.0012	0.003	0.008	0.050	1	2.00	0.5
99%UCL	NA	3.44	0.0004	0.000	0.002	1.5	0.004	#NUM!	0.014	0.010	0.0012	0.010	0.009	0.250	0.52	0.66	0.08849
3rd Quartile	8.03	10.00	0.0030	0.050	0.003	2.5	0.012	0.500	0.017	0.045	0.0026	0.008	0.021	0.800	2	3.01	0.5
Max	8.15	40.00	0.0050	0.050	0.028	20.0	0.052	0.500	0.214	0.173	0.0150	0.192	0.107	4.000	7	9.00	2
110684	7.62	2.50	0.0030	0.050	0.002	2.5	0.001	0.5	0.008	0.029	0.0011	0.000	0.005	1	2	3.00	0.5
110807	7.70	5.00	0.0005	0.050	0.002	2.5	0.006	0.5	0.012	0.030	0.0012	0.003	0.007	4	5	9.00	0.5
110905	7.97	5.00	0.0030	0.050	0.002	2.5	0.011	0.5	0.015	0.029	0.0012	0.005	0.009	0.05	2	2.05	1
111089	8.05	2.50	0.0020	0.050	0.0005	2.5	0.001	0.5	0.008	0.040	0.0004	0.000	0.006	0.9	5	5.90	0.5
111188	7.83	2.50	0.0010	0.050	0.001	2.5	0.001	0.5	0.008	0.029	0.0006	0.000	0.005	0.05	2	2.05	0.5
111419	7.94	2.50	0.0005	0.050	0.002	2.5	0.001	0.5	0.013	0.028	0.0011	0.000	0.007	0.05	1	1.05	0.5
111356	7.70	2.50	0.0030	0.050	0.002	2.5	0.002	0.5	0.011	0.026	0.0010	0.001	0.006	1	3	4.00	0.5
111767	7.58	2.50	0.0020	0.050	0.001	2.5	0.001	0.5	0.010	0.060	0.0012	0.001	0.012	0.05	1	1.05	0.5
111726	8.07	2.50	0.0020	0.050	0.003	2.5	0.007	0.5	0.012	0.025	0.0015	0.002	0.006	0.05	1	1.05	0.5
111684	8.06	40.00	0.0030	0.050	0.028	15.0	0.038	0.5	0.214	0.026	0.0140	0.013	0.107	0.05	2	2.05	2
111571	7.82	5.00	0.0030	0.050	0.003	2.5	0.008	0.5	0.013	0.033	0.0020	0.004	0.008	0.05	1	1.05	1
111517	7.64	5.00	0.0020	0.050	0.004	2.5	0.011	0.5	0.011	0.036	0.0028	0.006	0.008	0.05	1	1.05	0.5
111471	7.87	10.00	0.0020	0.050	0.002	2.5	0.027	0.500	0.008	0.026	0.0010	0.010	0.004	0.05	1	1.05	0.5
111820	7.95	2.50	0.0005	0.050	0.0005	2.5	0.003	0.500	0.009	0.035	0.0003	0.002	0.006	1	7	8.00	0.5
111888	7.84	2.50	0.0040	0.050	0.006	2.5	0.016	0.500	0.025	0.030	0.0035	0.007	0.015	0.9	1	1.90	0.5
111926	7.95	2.50	0.0020	0.050	0.0005	2.5	0.001	0.500	0.010	0.033	0.0003	0.000	0.007	0.8	1	1.80	0.5
112691	7.98	2.50	0.0005	0.050	0.001	2.5	0.001	0.500	0.009	0.026	0.0005	0.000	0.005	0.05	3	3.05	0.5
112650	8.04	2.50	0.0010	0.050	0.0005	2.5	0.001	0.500	0.010	0.038	0.0004	0.000	0.007	0.05	1	1.05	0.5
112584	8.04	2.50	0.0020	0.050	0.001	2.5	0.001	0.500	0.008	0.034	0.0007	0.000	0.005	0.7	2	2.70	0.5
112712	8.08	5.00	0.0010	0.050	0.002	2.5	0.009	0.500	0.008	0.042	0.0017	0.007	0.007	0.05	1	1.05	0.5
112758	8.07	5.00	0.0020	0.050	0.001	2.5	0.006	0.500	0.012	0.028	0.0006	0.003	0.007	1	1	2.00	0.5
113035	8.14	2.50	0.0010	0.050	0.003	2.5	0.003	0.500	0.013	0.085	0.0052	0.007	0.023	0.05	1	1.05	0.5
112968	8.02	5.00	0.0010	0.050	0.001	2.5	0.005	0.500	0.009	0.048	0.0010	0.005	0.009	0.7	2	2.70	0.5
112909	7.86	10.00	0.0030	0.050	0.003	2.5	0.015	0.500	0.017	0.038	0.0022	0.010	0.013	0.05	1	1.05	0.5
113101	7.91	30.00	0.0030	0.050	0.004	5.0	0.013	0.500	0.021	0.031	0.0025	0.006	0.013	2	2	4.00	0.5
113109	7.51	2.50	0.0020	0.050	0.0005	2.5	0.002	0.500	0.012	0.098	0.0010	0.006	0.024	0.05	1	1.05	0.5
113182	7.38	2.50	0.0005	0.050	0.0005	2.5	0.002	0.500	0.007	0.173	0.0018	0.014	0.025	0.05	1	1.05	0.5
113247	7.92	2.50	0.0020	0.050	0.0005	2.5	0.003	0.500	0.007	0.038	0.0004	0.002	0.005	0.05	3	3.05	0.5
113301	8.03	2.50	0.0010	0.050	0.0005	2.5	0.001	0.500	0.009	0.045	0.0005	0.000	0.008	1	1	2.00	0.5
113407	7.50	25.00	0.0040	0.050	0.005	20.0	0.017	0.500	0.031	0.030	0.0030	0.008	0.018	0.9	0.9	1.80	0.5
113455	7.36	20.00	0.0020	0.050	0.008	10.0	0.020	0.500	0.032	0.085	0.0139	0.045	0.055	0.7	1	1.70	0.5
113535	7.80	2.50	0.0005	0.050	0.001	2.5	0.001	0.500	0.007	0.023	0.0004	0.000	0.003	0.05	0.4	0.45	0.5
113654	7.83	25.00	0.0030	0.050	0.002	10.0	0.031	0.500	0.041	0.029	0.0011	0.013	0.023	2	3	5.00	1
114215	7.18	20.00	0.0020	0.050	0.003	2.5	0.024	0.500	0.042	0.042	0.0025	0.018	0.035	0.05	2	2.05	0.5
114130	7.96	25.00	0.0050	0.050	0.008	10.0	0.044	0.500	0.108	0.038	0.0060	0.029	0.081	0.05	1	1.05	0.5
113753	7.56	30.00	0.0040	0.050	0.002	15.0	0.052	0.500	0.034	0.116	0.0048	0.192	0.081	0.05	2	2.05	1
113951	7.30	5.00	0.0010	0.050	0.0005	2.5	0.017	0.500	0.012	0.032	0.0003	0.008	0.007	0.5	0.8	1.30	0.5
114108	7.43	30.00	0.0040	0.050	0.011	15.0	0.019	0.500	0.183	0.027	0.0058	0.007	0.097	0.4	1	1.40	0.5
114810	7.48	5.00	0.0005	0.050	0.002	2.5	0.004	0.500	0.016	0.045	0.0018	0.003	0.014	1	4	5.00	0.5
114358	7.60	2.50	0.0005	0.050	0.0005	2.5	0.001	0.500	0.013	0.048	0.0005	0.001	0.012	0.05	0.7	0.75	0.5
114273	7.10	15.00	0.0005	0.050	0.003	5.0	0.004	0.500	0.017	0.085	0.0052	0.009	0.029	0.4	1	1.40	0.5
114469	7.31	2.50	0.0010	0.050	0.0005	2.5	0.001	0.500	0.008	0.038	0.0004	0.000	0.006	0.05	0.9	0.95	0.5
114656	8.06	2.50	0.0005	0.050	0.001	2.5	0.004	0.500	0.012	0.085	0.0017	0.009	0.021	0.05	3	3.05	0.5
114934	7.14	15.00	0.0040	0.050	0.002	10.0	0.008	0.500	0.019	0.098	0.0040	0.023	0.038	0.3	2	2.30	0.5
115023	7.91	2.50	0.0005	0.050	0.0005	2.5	0.001	0.500	0.010	0.038	0.0004	0.001	0.008	0.5	3	3.50	0.5
115110	8.07	2.50	0.0005	0.050	0.001	2.5	0.001	0.500	0.012	0.031	0.0006	0.000	0.007	0.05	2	2.05	0.5
115229	8.10	15.00	0.0010	0.050	0.022	2.5	0.009	0.500	0.033	0.035	0.0150	0.005	0.022	0.6	1	1.60	0.5
115345	8.09	2.50	0.0005	0.050	0.003	2.5	0.002	0.500	0.010	0.033	0.0020	0.001	0.007	0.8	2	2.80	0.5
115590	7.87	2.50	0.0010	0.050	0.003	2.5	0.001	0.500	0.014	0.051	0.0031	0.001	0.014	0.05	7	7.05	N.A.
115705	8.15	2.50	0.0010	0.050	0.001	2.5	0.001	0.500	0.006	0.020	0.0004	0.000	0.002	0.05	1	1.05	0.5
115642	7.97	2.50	0.0020	0.050	0.0005	2.5	0.002	0.500	0.012	0.030	0.0003	0.001	0.007	0.05	3	3.05	0.5
115937	7.92	2.50	0.0020	0.050	0.001	2.5	0.001	0.500	0.011	0.010	0.0002	0.000	0.002	0.05	2	2.05	0.5
1-10 x Guideline																	
10-100 x Guideine																	
100-1000 x Guideline																	
>1000 x Guideline																	

Table 3-21 ASLP Average groundwater summary

	LAB PHYS.			MAJOR IONS								METALS											NON-METALLIC INORGANICS					
Sample ID	Lab pH	EC	TDI Calc from Major Ions	Na	K	Ca	Mg	Bi-carbonate as $Ca(HCO_3)_2$ (0.5 = <LOR)	Carbonate as $CaCO_3$ (0.5 = <LOR)	Cl	SO_4	Al	As	Cr	Co	Cu	Fe	Pb	Mn	U	V	Zn	F	NO_2 as N	NO_3 as N	NO_x (NO_3 + NO_2) as N	Total N	Total P
Units		mS/cm	(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)	(mg/L)	mg/L	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(mg/L)
Average Groundwater	**7.93**	**1530**	**655**	**124**	**23**	**93**	**53**	**358**	**<0.5**	**188**	**206**	**0.041**	**0.0018**	**0.001**	**0.0008**	**0.003**	**0.544**	**0.003**	**0.022**	**0.014**	**0.005**	**0.024**	**1.28**	**0.009**	**7.8**	**7.80**	**6.75**	**0.215**
Min	7.10	52	62	3	5	1	1	26	0.5	4	4	2.50	0.0005	0.050	0.00	0.001	2.5	0.001	0.500	0.500	0.5	0.006	0.1	0.050	0.4	0.45	0.45	0.5
1st Quartile	7.60	239	135	10	10	6	4	52	0.5	19	18	2.50	0.0009	0.050	0.00	0.001	2.5	0.001	0.500	0.500	0.5	0.009	1	0.050	1	1.05	1.05	0.5
Mean	7.79	309	231	24	12	9	6	73	0.5	81	44	8.22	0.0018	0.050	0.01	0.003	4.2	0.009	0.500	0.500	0.5	0.023	2.69	0.472	1.94	2.41	2.4087	0.56863
Median	7.89	280	185	20	10	8	6	52	0.5	59	29	2.50	0.0020	0.050	0.00	0.002	2.5	0.004	0.500	0.500	0.5	0.012	2	0.050	1	2.00	2	0.5
99%UCL	NA	56	55	7	2	2	1	11	#NUM!	31	28	3.44	0.0004	0.000	0.01	0.002	1.5	0.004	#NUM!	#NUM!	#NUM!	0.014	0.77	0.250	0.52	0.66	0.6554	0.08849
3rd Quartile	8.03	374	269	36	15	13	8	100	0.5	120	44	10.00	0.0030	0.050	0.00	0.003	2.5	0.012	0.500	0.500	0.5	0.017	3	0.800	2	3.01	3.0125	0.5
Max	8.15	746	859	85	30	46	24	150	0.5	400	570	40.00	0.0050	0.050	0.15	0.028	20.0	0.052	0.500	0.500	0.5	0.214	12	4.000	7	9.00	9	2
110684	7.62	296	158	10	10	17	4	52	0.5	32	46	2.50	0.0030	0.050	0.002	0.002	3	0.001	0.5	0.50	0.50	0.008	2	1	2	3.00	3	0.5
110807	7.70	281	185	10	10	16	4	100	0.5	36	33	5.00	0.0005	0.050	0.001	0.002	3	0.006	0.5	0.50	0.50	0.012	1	4	5	9.00	9	0.5
110905	7.97	318	186	25	10	13	6	52	0.5	58	35	5.00	0.0030	0.050	0.002	0.002	3	0.011	0.5	0.50	0.50	0.015	5	0.05	2	2.05	2.05	1
111089	8.05	241	145	10	10	6	6	100	0.5	18	19	2.50	0.0020	0.050	0.001	0.0005	3	0.001	0.5	0.50	0.50	0.008	3	0.9	5	5.90	5.9	0.5
111188	7.83	392	275	35	10	10	8	52	0.5	130	43	2.50	0.0010	0.050	0.003	0.001	3	0.001	0.5	0.50	0.50	0.008	1	0.05	2	2.05	2.05	0.5
111419	7.94	293	521	60	25	8	10	52	0.5	310	69	2.50	0.0005	0.050	0.004	0.002	3	0.001	0.5	0.50	0.50	0.013	1	0.05	1	1.05	1.05	0.5
111356	7.70	590	144	10	5	17	6	52	0.5	34	33	2.50	0.0030	0.050	0.001	0.002	3	0.002	0.5	0.50	0.50	0.011	2	1	3	4.00	4	0.5
111767	7.58	521	291	40	15	3	4	52	0.5	160	30	2.50	0.0020	0.050	0.001	0.001	3	0.001	0.5	0.50	0.50	0.010	1	0.05	1	1.05	1.05	0.5
111726	8.07	504	638	85	20	11	10	100	0.5	400	36	2.50	0.0020	0.050	0.001	0.003	3	0.007	0.5	0.50	0.50	0.012	1	0.05	1	1.05	1.05	0.5
111684	8.06	499	257	40	10	14	8	52	0.5	60	86	40.00	0.0030	0.050	0.038	0.028	15	0.038	0.5	0.50	0.50	0.214	5	0.05	2	2.05	2.05	2
111571	7.82	370	376	55	10	10	6	100	0.5	120	99	5.00	0.0030	0.050	0.002	0.003	3	0.008	0.5	0.50	0.50	0.013	12	0.05	1	1.05	1.05	1
111517	7.64	711	372	55	10	5	8	100	0.5	200	18	5.00	0.0020	0.050	0.001	0.004	3	0.011	0.5	0.5	0.50	0.011	5	0.05	1	1.05	1.05	0.5
111471	7.87	341	485	50	25	7	12	26	0.5	300	71	10.00	0.0020	0.050	0.005	0.002	3	0.027	0.500	0.5	0.5	0.008	0.8	0.05	1	1.05	1.05	0.5
111820	7.95	267	131	10	10	9	6	100	0.5	16	4	2.50	0.0005	0.050	0.001	0.0005	3	0.003	0.500	0.5	0.5	0.009	2	1	7	8.00	8	0.5
111888	7.84	271	153	5	10	16	4	100	0.5	20	22	2.50	0.0040	0.050	0.007	0.006	3	0.016	0.500	0.5	0.5	0.025	0.9	0.9	1	1.90	1.9	0.5
111926	7.95	242	113	10	5	13	4	52	0.5	20	22	2.50	0.0020	0.050	0.001	0.0005	3	0.001	0.500	0.5	0.5	0.010	3	0.8	1	1.80	1.8	0.5
112691	7.98	232	395	45	15	13	8	100	0.5	180	58	2.50	0.0005	0.050	0.001	0.001	3	0.001	0.500	0.5	0.5	0.009	2	0.05	3	3.05	3.05	0.5
112650	8.04	386	267	40	15	7	6	52	0.5	140	20	2.50	0.0010	0.050	0.001	0.0005	3	0.001	0.500	0.5	0.5	0.010	2	0.05	1	1.05	1.05	0.5
112584	8.04	513	188	5	10	16	2	150	0.5	23	19	2.50	0.0020	0.050	0.001	0.001	3	0.001	0.500	0.5	0.5	0.008	2	0.7	2	2.70	2.7	0.5
112712	8.08	454	317	55	20	5	6	52	0.5	150	42	5.00	0.0010	0.050	0.003	0.002	3	0.009	0.500	0.5	0.5	0.008	2	0.05	1	1.05	1.05	0.5
112758	8.07	323	150	5	10	14	6	100	0.5	10	29	5.00	0.0020	0.050	0.003	0.001	3	0.006	0.500	0.5	0.5	0.012	4	1	1	2.00	2	0.5
113035	8.14	339	135	15	10	3	2	52	0.5	61	5	2.50	0.0010	0.050	0.001	0.003	3	0.003	0.500	0.5	0.5	0.013	3	0.05	1	1.05	1.05	0.5
112968	8.02	319	178	20	15	6	4	100	0.5	44	13	5.00	0.0010	0.050	0.001	0.001	3	0.005	0.500	0.5	0.5	0.009	2	0.7	2	2.70	2.7	0.5
112909	7.86	160	245	30	15	7	6	100	0.5	90	21	10.00	0.0030	0.050	0.002	0.003	3	0.015	0.500	0.5	0.5	0.017	7	0.05	1	1.05	1.05	0.5
113101	7.91	291	250	40	10	8	8	100	0.5	59	49	30.00	0.0030	0.050	0.032	0.004	5	0.013	0.500	0.5	0.5	0.021	5	2	2	4.00	4	0.5
113109	7.51	222	181	25	10	2	2	26	0.5	84	38	2.50	0.0020	0.050	0.001	0.0005	3	0.002	0.500	0.5	0.5	0.012	1	0.05	1	1.05	1.05	0.5
113182	7.38	177	157	20	10	1	1	26	0.5	95	10	2.50	0.0005	0.050	0.002	0.0005	3	0.002	0.500	0.5	0.5	0.007	3	0.05	1	1.05	1.05	0.5
113247	7.92	346	224	25	15	7	6	100	0.5	78	17	2.50	0.0020	0.050	0.001	0.0005	3	0.003	0.500	0.5	0.5	0.007	3	0.05	3	3.05	3.05	0.5
113301	8.03	269	161	10	15	7	4	100	0.5	19	30	2.50	0.0010	0.050	0.001	0.0005	3	0.001	0.500	0.5	0.5	0.009	5	1	1	2.00	2	0.5
113407	7.50	104	109	10	10	9	8	52	0.5	7	26	25.00	0.0040	0.050	0.045	0.005	20	0.017	0.500	0.5	0.5	0.031	1	0.9	0.9	1.80	1.8	0.5
113455	7.36	52	74	3	10	3	2	52	0.5	5	12	20.00	0.0020	0.050	0.111	0.008	10	0.020	0.500	0.5	0.5	0.032	0.1	0.7	1	1.70	1.7	0.5
113535	7.80	541	416	55	10	15	10	100	0.5	190	60	2.50	0.0005	0.050	0.001	0.001	3	0.001	0.500	0.5	0.5	0.007	2	0.05	0.4	0.45	0.45	0.5
113654	7.83	321	212	25	15	10	8	100	0.5	45	33	25.00	0.0030	0.050	0.008	0.002	10	0.031	0.500	0.5	0.5	0.041	6	2	3	5.00	5	1
114215	7.18	80	184	20	10	5	6	52	0.5	66	38	20.00	0.0020	0.050	0.015	0.003	3	0.024	0.500	0.5	0.5	0.042	5	0.05	2	2.05	2.05	0.5
114130	7.96	274	98	10	10	7	6	52	0.5	8	18	25.00	0.0050	0.050	0.134	0.008	10	0.044	0.500	0.5	0.5	0.108	2	0.05	1	1.05	1.05	0.5
113753	7.56	89	69	10	5	1	2	26	0.5	21	10	30.00	0.0040	0.050	0.008	0.002	15	0.052	0.500	0.5	0.5	0.034	2	0.05	2	2.05	2.05	1
113951	7.30	72	151	10	10	11	6	100	0.5	23	15	5.00	0.0010	0.050	0.004	0.0005	3	0.017	0.500	0.5	0.5	0.012	3	0.5	0.8	1.30	1.3	0.5
114108	7.43	191	155	5	20	9	10	100	0.5	5	30	30.00	0.0040	0.050	0.148	0.011	15	0.019	0.500	0.5	0.5	0.183	0.3	0.4	1	1.40	1.4	0.5
114810	7.48	114	112	15	10	7	4	52	0.5	8	29	5.00	0.0005	0.050	0.006	0.002	3	0.004	0.500	0.5	0.5	0.016	3	1	4	5.00	5	0.5
114358	7.60	243	249	25	10	6	4	52	0.5	91	74	2.50	0.0005	0.050	0.003	0.0005	3	0.001	0.500	0.5	0.5	0.013	2	0.05	0.7	0.75	0.75	0.5
114273	7.10	246	80	10	5	3	2	52	0.5	4	17	15.00	0.0005	0.050	0.003	0.003	5	0.004	0.500	0.5	0.5	0.017	0.6	0.4	1	1.40	1.4	0.5
114469	7.31	142	221	20	10	7	6	26	0.5	140	18	2.50	0.0010	0.050	0.004	0.0005	3	0.001	0.500	0.5	0.5	0.008	1	0.05	0.9	0.95	0.95	0.5
114656	8.06	254	116	15	5	3	2	52	0.5	38	14	2.50	0.0005	0.050	0.001	0.001	3	0.004	0.500	0.5	0.5	0.012	2	0.05	3	3.05	3.05	0.5
114934	7.14	86	62	5	5	2	2	26	0.5	4	24	15.00	0.0040	0.050	0.008	0.002	10	0.008	0.500	0.5	0.5	0.019	0.5	0.3	2	2.30	2.3	0.5
115023	7.91	246	129	3	10	10	4	100	0.5	6	21	2.50	0.0005	0.050	0.001	0.0005	3	0.001	0.500	0.5	0.5	0.010	2	0.5	3	3.50	3.5	0.5
115110	8.07	406	285	30	15	8	8	100	0.5	100	48	2.50	0.0005	0.050	0.001	0.001	3	0.001	0.500	0.5	0.5	0.012	7	0.05	2	2.05	2.05	0.5
115229	8.10	245	134	5	15	9	6	100	0.5	7	16	15.00	0.0010	0.050	0.002	0.022	3	0.009	0.500	0.5	0.5	0.033	3	0.6	1	1.60	1.6	0.5
115345	8.09	278	135	3	15	13	4	100	0.5	6	19	2.50	0.0005	0.050	0.001	0.003	3	0.002	0.500	0.5	0.5	0.010	0.6	0.8	2	2.80	2.8	0.5
115590	7.87	255	210	25	10	5	4	52	0.5	79	48	2.50	0.0010	0.050	0.001	0.003	3	0.001	0.500	0.5	0.5	0.014	1	0.05	7	7.05	7.05	N.A.
115705	8.15	334	495	50	20	14	14	100	0.5	240	81	2.50	0.0010	0.050	0.001	0.001	3	0.001	0.500	0.5	0.5	0.006	3	0.05	1	1.05	1.05	0.5
115642	7.97	600	205	15	10	9	8	100	0.5	60	27	2.50	0.0020	0.050	0.001	0.0005	3	0.002	0.500	0.5	0.5	0.012	3	0.05	3	3.05	3.05	0.5
115937	7.92	746	859	30	30	46	24	52	0.5	120	570	2.50	0.0020	0.050	0.002	0.001	3	0.001	0.500	0.5	0.5	0.011	3	0.05	2	2.05	2.05	0.5
1-10 x Guideline																												
10-100 x Guideine																												
100-1000 x Guideline																												
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3.13 Livestock Drinking Water

In the waste rock, only aluminium and fluoride exceeded stock drinking water guidelines (Table 3-19) and the LOR for uranium was above the guideline. No concentrations (or LORs) were more than 10 times the stock drinking water guidelines. The median for fluoride, of 3 mg/L exceeded the guideline of 2 mg/L. The 99%UCL for all analytes were within the guidelines. This indicates that leachate from waste rock is unlikely to result in either runoff or deep-drainage exceeding stock drinking water guidelines.

Table 3-22 Livestock drinking water summary

		LAB PHYS.		MAJOR IONS		METALS								NON-METALLIC INORGANICS		
Sample ID		Lab pH	TDI Calc from Major Ions	Ca	SO_4	Al	As	Cr	Co	Cu	Pb	U	Zn	F	NO_2 as N	NO_3 as N
Units			(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)
ANZECC (2000) Livestock		**6 to 8.5**	**2,000**	**1,000**	**1,000**	**5.0**	**0.5000**	**1.00**	**1.0000**	**0.500**	**0.100**	**0.2**	**20.000**	**2**	**30.00**	**400**
Min		7.10	62	1	4	2.5	0.0005	0.05	0.00	0.001	0.001	0.5	0.006	0	0.05	0.4
1st Quartile		7.60	135	6	18	2.5	0.0009	0.05	0.00	0.001	0.001	0.5	0.009	1	0.05	1.0
Mean		7.79	231	9	44	8.2	0.0018	0.05	0.01	0.003	0.009	0.5	0.023	3	0.47	1.9
Median		7.89	185	8	29	2.5	0.0020	0.05	0.00	0.002	0.004	0.5	0.012	2	0.05	1.0
99%UCL		NA	55	2	28	3.4	0.0004	0.00	0.01	0.002	0.004	NA	0.014	1	0.25	0.5
3rd Quartile		8.03	269	13	44	10.0	0.0030	0.05	0.00	0.003	0.012	0.5	0.017	3	0.80	2.0
Max		8.15	859	46	570	40.0	0.0050	0.05	0.15	0.028	0.052	0.5	0.214	12	4.00	7.0
110684	Sand	7.62	158	17	46	2.5	0.0030	0.05	0.002	0.002	0.001	0.5	0.008	2	1.00	2.0
110807	Sandstone	7.70	185	16	33	5.0	0.0005	0.05	0.001	0.002	0.006	0.5	0.012	1	4.00	5.0
110905	Sandstone	7.97	186	13	35	5.0	0.0030	0.05	0.002	0.002	0.011	0.5	0.015	5	0.05	2.0
111089	Sandstone	8.05	145	6	19	2.5	0.0020	0.05	0.001	0.0005	0.001	0.5	0.008	3	0.90	5.0
111188	Phosphatic Siltstone	7.83	275	10	43	2.5	0.0010	0.05	0.003	0.001	0.001	0.5	0.008	1	0.05	2.0
111356	Phosphatic Siltstone	7.70	144	17	33	2.5	0.0030	0.05	0.001	0.002	0.002	0.5	0.011	2	1.00	3.0
111419	Sandstone	7.94	521	8	69	2.5	0.0005	0.05	0.004	0.002	0.001	0.5	0.013	1	0.05	1.0
111471	Sandstone	7.87	485	7	71	10.0	0.0020	0.05	0.005	0.002	0.027	0.5	0.008	1	0.05	1.0
111517	Phosphatic Siltstone	7.64	372	5	18	5.0	0.0020	0.05	0.001	0.004	0.011	0.5	0.011	5	0.05	1.0
111571	Sandstone	7.82	376	10	99	5.0	0.0030	0.05	0.002	0.003	0.008	0.5	0.013	12	0.05	1.0
111684	Sand	8.06	257	14	86	40.0	0.0030	0.05	0.038	0.028	0.038	0.5	0.214	5	0.05	2.0
111726	Clay	8.07	638	11	36	2.5	0.0020	0.05	0.001	0.003	0.007	0.5	0.012	1	0.05	1.0
111767	Clay	7.58	291	3	30	2.5	0.0020	0.05	0.001	0.001	0.001	0.5	0.010	1	0.05	1.0
111820	Sandstone	7.95	131	9	4	2.5	0.0005	0.05	0.001	0.0005	0.003	0.5	0.009	2	1.00	7.0
111888	Sand	7.84	153	16	22	2.5	0.0040	0.05	0.007	0.006	0.016	0.5	0.025	1	0.90	1.0
111926	Sand	7.95	113	13	22	2.5	0.0020	0.05	0.001	0.0005	0.001	0.5	0.010	3	0.80	1.0
112584	Sand	8.04	188	16	19	2.5	0.0020	0.05	0.001	0.001	0.001	0.5	0.008	2	0.70	2.0
112650	Clay	8.04	267	7	20	2.5	0.0010	0.05	0.001	0.0005	0.001	0.5	0.010	2	0.05	1.0
112691	Clay	7.98	395	13	58	2.5	0.0005	0.05	0.001	0.001	0.001	0.5	0.009	2	0.05	3.0
112712	Sandstone	8.08	317	5	42	5.0	0.0010	0.05	0.003	0.002	0.009	0.5	0.008	2	0.05	1.0
112758	Clay	8.07	150	14	29	5.0	0.0020	0.05	0.003	0.001	0.006	0.5	0.012	4	1.00	1.0
112909	Sandstone	7.86	245	7	21	10.0	0.0030	0.05	0.002	0.003	0.015	0.5	0.017	7	0.05	1.0
112968	Clay	8.02	178	6	13	5.0	0.0010	0.05	0.001	0.001	0.005	0.5	0.009	2	0.70	2.0
113035	Sandstone	8.14	135	3	5	2.5	0.0010	0.05	0.001	0.003	0.003	0.5	0.013	3	0.05	1.0
113101	Sandstone	7.91	250	8	49	30.0	0.0030	0.05	0.032	0.004	0.013	0.5	0.021	5	2.00	2.0
113109	Sandstone	7.51	181	2	38	2.5	0.0020	0.05	0.001	0.0005	0.002	0.5	0.012	1	0.05	1.0
113182	Sandstone	7.38	157	1	10	2.5	0.0005	0.05	0.002	0.0005	0.002	0.5	0.007	3	0.05	1.0
113247	Sandstone	7.92	224	7	17	2.5	0.0020	0.05	0.001	0.0005	0.003	0.5	0.007	3	0.05	3.0
113301	Sandstone	8.03	161	7	30	2.5	0.0010	0.05	0.001	0.0005	0.001	0.5	0.009	5	1.00	1.0
113407	Clay	7.50	109	9	26	25.0	0.0040	0.05	0.045	0.005	0.017	0.5	0.031	1	0.90	0.9
113455	Sand	7.36	74	3	12	20.0	0.0020	0.05	0.111	0.008	0.020	0.5	0.032	0	0.70	1.0
113535	Siltstone	7.80	416	15	60	2.5	0.0005	0.05	0.001	0.001	0.001	0.5	0.007	2	0.05	0.4
113654	Clay	7.83	212	10	33	25.0	0.0030	0.05	0.008	0.002	0.031	0.5	0.041	6	2.00	3.0
113753	Sandstone	7.56	69	1	10	30.0	0.0040	0.05	0.008	0.002	0.052	0.5	0.034	2	0.05	2.0
113951	Siltstone	7.30	151	11	15	5.0	0.0010	0.05	0.004	0.0005	0.017	0.5	0.012	3	0.50	0.8
114108	Sandstone	7.43	155	9	30	30.0	0.0040	0.05	0.148	0.011	0.019	0.5	0.183	0	0.40	1.0
114130	Clay	7.96	98	7	18	25.0	0.0050	0.05	0.134	0.008	0.044	0.5	0.108	2	0.05	1.0
114215	Sandstone	7.18	184	5	38	20.0	0.0020	0.05	0.015	0.003	0.024	0.5	0.042	5	0.05	2.0
114273	Sandstone	7.10	80	3	17	15.0	0.0005	0.05	0.003	0.003	0.004	0.5	0.017	1	0.40	1.0
114358	Sandstone	7.60	249	6	74	2.5	0.0005	0.05	0.003	0.0005	0.001	0.5	0.013	2	0.05	0.7
114469	Sandstone	7.31	221	7	18	2.5	0.0010	0.05	0.004	0.0005	0.001	0.5	0.008	1	0.05	0.9
114656	Sandstone	8.06	116	3	14	2.5	0.0005	0.05	0.001	0.001	0.004	0.5	0.012	2	0.05	3.0
114810	Siltstone	7.48	112	7	29	5.0	0.0005	0.05	0.006	0.002	0.004	0.5	0.016	3	1.00	4.0
114934	Sandstone	7.14	62	2	24	15.0	0.0040	0.05	0.008	0.002	0.008	0.5	0.019	1	0.30	2.0
115023	Sandstone	7.91	129	10	21	2.5	0.0005	0.05	0.001	0.0005	0.001	0.5	0.010	2	0.50	3.0
115110	Sandstone	8.07	285	8	48	2.5	0.0005	0.05	0.001	0.001	0.001	0.5	0.012	7	0.05	2.0
115229	Sandstone	8.10	134	9	16	15.0	0.0010	0.05	0.002	0.022	0.009	0.5	0.033	3	0.60	1.0
115345	Sand	8.09	135	13	19	2.5	0.0005	0.05	0.001	0.003	0.002	0.5	0.010	1	0.80	2.0
115590	Sandstone	7.87	210	5	48	2.5	0.0010	0.05	0.001	0.003	0.001	0.5	0.014	1	0.05	7.0
115642	Sandstone	7.97	205	9	27	2.5	0.0020	0.05	0.001	0.0005	0.002	0.5	0.012	3	0.05	3.0
115705	Sandstone	8.15	495	14	81	2.5	0.0010	0.05	0.001	0.001	0.001	0.5	0.006	3	0.05	1.0
115937	Sandstone	7.92	859	46	570	2.5	0.0020	0.05	0.002	0.001	0.001	0.5	0.011	3	0.05	2.0
1-10 x Guideline																
10-100 x Guideine																
100-1000 x Guideline																
>1000 x Guideline																

3.14 Irrigation LTV water

In the waste rock aluminium, chlorine, total nitrogen, cobalt and fluoride exceeded irrigation LTV water guidelines (Table 3-20). There are some anomalously high results due to the high LOR, including manganese, vanadium, uranium, iron and Total phosphorus. The 99%UCL for all analytes were within the guidelines except iron and total phosphorus, which were not more than 10 times the guidelines. Manganese and vanadium concentrations (or LORs) do not exceed 10 times the irrigation LTV water guidelines, iron, uranium and total phosphorus do not exceed 100 times the guidelines. Aluminium, chlorine and total nitrogen exceed irrigation LTV concentrations in some samples, by a factor of between 10 and 100. Of these, the median and 99%UCL are all less than 10 times the average groundwater concentration. Cobalt concentrations were highly variable and ranged from less than the irrigation LTV guidelines to between 1 and 10 times the average, which is based on only 4 groundwater samples. The mean, median, 3rd quartile and 99%UCL are all less than 10 times the average groundwater concentration. Fluoride was above the average groundwater concentration in most samples although the 99%UCL was below the average and all were less than 10 times the average groundwater concentration except for one sample. The median for fluoride, of 2 mg/L exceeded the guideline of 1 mg/L. Total phosphorus was above the average groundwater concertation in all samples but by less than a factor of 100; however the LOR was 10 times the irrigation LTV guideline. Despite this, the 99% UCL was greater than the guidelines concentration by a factor no more than 10. This indicates that leachate from waste rock is unlikely to result in runoff exceeding irrigation LTV water guidelines.

Table 3-23 Irrigation LTV summary

	PHYS.			ALCULATED INDICE						METALS							NON-METALLIC INORGANICS		
Sample ID	Lab pH	Na	Cl	SAR	Calc Hardness	Al	As	Cr	Co	Cu	Fe	Pb	Mn	U	V	Zn	F	Total N	Total P
Units		(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)	(mg/L)
ANZECC (2000) Irrigation LTV	**6 to 8.5**	**115**	**175**	**<2-102**	**60-350**	**5.00**	**0.1000**	**0.10**	**0.05**	**0.200**	**0.2**	**2.000**	**0.2**	**0.01**	**0.1**	**2.000**	**1**	**5**	**0.05**
Min	7.10	3	4	0	7	2.50	0.0005	0.05	0.00	0.001	2.5	0.001	0.5	0.50	0.5	0.006	0.1	0.45	0.5
1st Quartile	7.60	10	19	1	34	2.50	0.0009	0.05	0.00	0.001	2.5	0.001	0.5	0.50	0.5	0.009	1	1.05	0.5
Mean	7.79	24	81	2	48	8.22	0.0018	0.05	0.01	0.003	4.2	0.009	0.5	0.50	0.5	0.023	2.6885	2.4087	0.56863
Median	7.89	20	59	1	48	2.50	0.0020	0.05	0.00	0.002	2.5	0.004	0.5	0.50	0.5	0.012	2	2	0.5
99%UCL	NA	7	31	0	11	3.44	0.0004	0.00	0.01	0.002	1.5	0.004	#NUM!	#NUM!	#NUM!	0.014	0.7662	0.6554	0.08849
3rd Quartile	8.03	36	120	2	58	10.00	0.0030	0.05	0.00	0.003	2.5	0.012	0.5	0.50	0.5	0.017	3	3.0125	0.5
Max	8.15	85	400	4	214	40.00	0.0050	0.05	0.15	0.028	20.0	0.052	0.5	0.50	0.5	0.214	12	9	2
110684	7.62	10	32	1	59	2.50	0.0030	0.05	0.002	0.002	2.5	0.001	0.5	0.50	0.5	0.008	2	3	0.5
110807	7.70	10	36	1	56	5.00	0.0005	0.05	0.001	0.002	2.5	0.006	0.5	0.50	0.5	0.012	1	9	0.5
110905	7.97	25	58	1	57	5.00	0.0030	0.05	0.002	0.002	2.5	0.011	0.5	0.50	0.5	0.015	5	2.05	1
111089	8.05	10	18	1	40	2.50	0.0020	0.05	0.001	0.0005	2.5	0.001	0.5	0.50	0.5	0.008	3	5.9	0.5
111188	7.83	35	130	2	58	2.50	0.0010	0.05	0.003	0.001	2.5	0.001	0.5	0.50	0.5	0.008	1	2.05	0.5
111419	7.94	60	310	3	61	2.50	0.0005	0.05	0.004	0.002	2.5	0.001	0.5	0.50	0.5	0.013	1	1.05	0.5
111356	7.70	10	34	1	67	2.50	0.0030	0.05	0.001	0.002	2.5	0.002	0.5	0.50	0.5	0.011	2	4	0.5
111767	7.58	40	160	4	24	2.50	0.0020	0.05	0.001	0.001	2.5	0.001	0.5	0.50	0.5	0.010	1	1.05	0.5
111726	8.07	85	400	4	69	2.50	0.0020	0.05	0.001	0.003	2.5	0.007	0.5	0.50	0.5	0.012	1	1.05	0.5
111684	8.06	40	60	2	68	40.00	0.0030	0.05	0.038	0.028	15.0	0.038	0.5	0.50	0.5	0.214	5	2.05	2
111571	7.82	55	120	3	50	5.00	0.0030	0.05	0.002	0.003	2.5	0.008	0.5	0.50	0.5	0.013	12	1.05	1
111517	7.64	55	200	4	45	5.00	0.0020	0.05	0.001	0.004	2.5	0.011	0.5	0.50	0.5	0.011	5	1.05	0.5
111471	7.87	50	300	3	67	10.00	0.0020	0.05	0.005	0.002	2.5	0.027	0.5	0.50	0.5	0.008	0.8	1.05	0.5
111820	7.95	10	16	1	47	2.50	0.0005	0.05	0.001	0.0005	2.5	0.003	0.5	0.50	0.5	0.009	2	8	0.5
111888	7.84	5	20	0	56	2.50	0.0040	0.05	0.007	0.006	2.5	0.016	0.5	0.50	0.5	0.025	0.9	1.9	0.5
111926	7.95	10	20	1	49	2.50	0.0020	0.05	0.001	0.0005	2.5	0.001	0.5	0.50	0.5	0.010	3	1.8	0.5
112691	7.98	45	180	2	65	2.50	0.0005	0.05	0.001	0.001	2.5	0.001	0.5	0.50	0.5	0.009	2	3.05	0.5
112650	8.04	40	140	3	42	2.50	0.0010	0.05	0.001	0.0005	2.5	0.001	0.5	0.50	0.5	0.010	2	1.05	0.5
112584	8.04	5	23	0	48	2.50	0.0020	0.05	0.001	0.001	2.5	0.001	0.5	0.50	0.5	0.008	2	2.7	0.5
112712	8.08	55	150	4	37	5.00	0.0010	0.05	0.003	0.002	2.5	0.009	0.5	0.50	0.5	0.008	2	1.05	0.5
112758	8.07	5	10	0	60	5.00	0.0020	0.05	0.003	0.001	2.5	0.006	0.5	0.50	0.5	0.012	4	2	0.5
113035	8.14	15	61	2	16	2.50	0.0010	0.05	0.001	0.003	2.5	0.003	0.5	0.50	0.5	0.013	3	1.05	0.5
112968	8.02	20	44	2	31	5.00	0.0010	0.05	0.001	0.001	2.5	0.005	0.5	0.50	0.5	0.009	2	2.7	0.5
112909	7.86	30	90	2	42	10.00	0.0030	0.05	0.002	0.003	2.5	0.015	0.5	0.50	0.5	0.017	7	1.05	0.5
113101	7.91	40	59	2	53	30.00	0.0030	0.05	0.032	0.004	5.0	0.013	0.5	0.50	0.5	0.021	5	4	0.5
113109	7.51	25	84	3	13	2.50	0.0020	0.05	0.001	0.0005	2.5	0.002	0.5	0.50	0.5	0.012	1	1.05	0.5
113182	7.38	20	95	3	7	2.50	0.0005	0.05	0.002	0.0005	2.5	0.002	0.5	0.50	0.5	0.007	3	1.05	0.5
113247	7.92	25	78	2	42	2.50	0.0020	0.05	0.001	0.0005	2.5	0.003	0.5	0.50	0.5	0.007	3	3.05	0.5
113301	8.03	10	19	1	34	2.50	0.0010	0.05	0.001	0.0005	2.5	0.001	0.5	0.50	0.5	0.009	5	2	0.5
113407	7.50	10	7	1	55	25.00	0.0040	0.05	0.045	0.005	20.0	0.017	0.5	0.50	0.5	0.031	1	1.8	0.5
113455	7.36	3	5	0	16	20.00	0.0020	0.05	0.111	0.008	10.0	0.020	0.5	0.50	0.5	0.032	0.1	1.7	0.5
113535	7.80	55	190	3	79	2.50	0.0005	0.05	0.001	0.001	2.5	0.001	0.5	0.50	0.5	0.007	2	0.45	0.5
113654	7.83	25	45	1	58	25.00	0.0030	0.05	0.008	0.002	10.0	0.031	0.5	0.50	0.5	0.041	6	5	1
114215	7.18	20	66	1	37	20.00	0.0020	0.05	0.015	0.003	2.5	0.024	0.5	0.50	0.5	0.042	5	2.05	0.5
114130	7.96	10	8	1	42	25.00	0.0050	0.05	0.134	0.008	10.0	0.044	0.5	0.50	0.5	0.108	2	1.05	0.5
113753	7.56	10	21	1	11	30.00	0.0040	0.05	0.008	0.002	15.0	0.052	0.5	0.50	0.5	0.034	2	2.05	1
113951	7.30	10	23	1	52	5.00	0.0010	0.05	0.004	0.0005	2.5	0.017	0.5	0.50	0.5	0.012	3	1.3	0.5
114108	7.43	5	5	0	64	30.00	0.0040	0.05	0.148	0.011	15.0	0.019	0.5	0.50	0.5	0.183	0.3	1.4	0.5
114810	7.48	15	8	1	34	5.00	0.0005	0.05	0.006	0.002	2.5	0.004	0.5	0.50	0.5	0.016	3	5	0.5
114358	7.60	25	91	2	31	2.50	0.0005	0.05	0.003	0.0005	2.5	0.001	0.5	0.50	0.5	0.013	2	0.75	0.5
114273	7.10	10	4	1	16	15.00	0.0005	0.05	0.003	0.003	5.0	0.004	0.5	0.50	0.5	0.017	0.6	1.4	0.5
114469	7.31	20	140	1	42	2.50	0.0010	0.05	0.004	0.0005	2.5	0.001	0.5	0.50	0.5	0.008	1	0.95	0.5
114656	8.06	15	38	2	16	2.50	0.0005	0.05	0.001	0.001	2.5	0.004	0.5	0.50	0.5	0.012	2	3.05	0.5
114934	7.14	5	4	1	13	15.00	0.0040	0.05	0.008	0.002	10.0	0.008	0.5	0.50	0.5	0.019	0.5	2.3	0.5
115023	7.91	3	6	0	41	2.50	0.0005	0.05	0.001	0.0005	2.5	0.001	0.5	0.50	0.5	0.010	2	3.5	0.5
115110	8.07	30	100	2	53	2.50	0.0005	0.05	0.001	0.001	2.5	0.001	0.5	0.50	0.5	0.012	7	2.05	0.5
115229	8.10	5	7	0	47	15.00	0.0010	0.05	0.002	0.022	2.5	0.009	0.5	0.50	0.5	0.033	3	1.6	0.5
115345	8.09	3	6	0	49	2.50	0.0005	0.05	0.001	0.003	2.5	0.002	0.5	0.50	0.5	0.010	0.6	2.8	0.5
115590	7.87	25	79	2	29	2.50	0.0010	0.05	0.001	0.003	2.5	0.001	0.5	0.50	0.5	0.014	1	7.05	N.A
115705	8.15	50	240	2	93	2.50	0.0010	0.05	0.001	0.001	2.5	0.001	0.5	0.50	0.5	0.006	3	1.05	0.5
115642	7.97	15	60	1	55	2.50	0.0020	0.05	0.001	0.0005	2.5	0.002	0.5	0.50	0.5	0.012	3	3.05	0.5
115937	7.92	30	120	1	214	2.50	0.0020	0.05	0.002	0.001	2.5	0.001	0.5	0.50	0.5	0.011	3	2.05	0.5
1-10 x Guideline																			
10-100 x Guideine																			
100-1000 x Guideline																			
>1000 x Guideline																			

3.15 Geochemistry

3.15.1 Sample collection and storage

Samples were collected from holes drilled primarily using reverse-circulation (RC) percussion, with some water-flushed diamond core (DD) and air-core (AC). Drilling was carried out in the dry season and samples stored in the open on site for periods in the order of a few weeks until a large enough batch was produced to ship to the laboratory. Approximately 10 RC samples were wet by unseasonal rain soon after collection. ASLP analyses were carried out on samples of various ages stored dry off-site.

3.15.2 Sample Depths

The “Assay” samples for the total metal, total sulfur and acid soluble sulfate sulfur use to calculate Maximum Potential Acidity (MPA), and Acid Neutralising Capacity (ANC) subtracted from MPA to get Net Acid Producing Potential (NAPP), were taken over the full depth profile from surface to below the ore zone. The secondary sub-samples for leachate analysis and Net Acid Generation (NAG) testing were selected randomly from the available holes, to provide representative chemical characterisation.

The sample depth distribution for the 71 secondary samples, for which depth information were available, is summarised in Figure 3-9, showing a relatively uniform distribution, other than a higher number of samples in the upper 1.5 metres. The samples were collected over 3-4 m intervals.

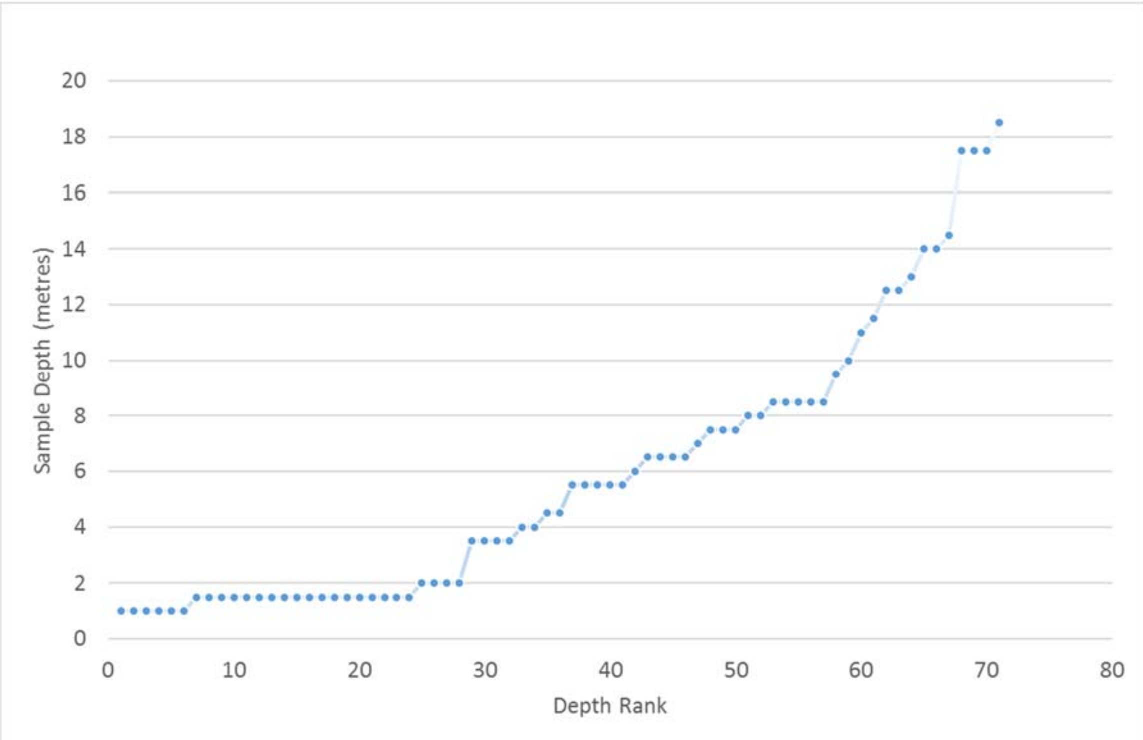


Figure 3-9 Secondary AMD sample depth distribution

Primary (assay) and secondary (ABA and leachate) samples represent the full volume of material to be excavated. The apparent over-representation of shallower samples is due to the sampling in areas where the ore is near surface. Key ABA results are summarised in Table 3-24 below.

Table 3-24 ABA results summary

Count		202	202	66	52	66	202	202	202	202	202	202	202	202	66	66	202
Minimum		6.3	52	3.98	0.1	0.0	2	0.01	0.005	-0.390	0.15	-409.4	-409.9	8.7	0.00	0	0.08
Median		7.7	389	7.11	0.1	0.1	17	0.01	0.025	-0.020	0.15	-17.7	-16.9	113.3	0.00	1	0.56
Mean		7.6	472	7.57	0.1	1.5	33	0.02	0.045	-0.024	0.16	-32.2	-32.5	216.3	0.05	30	1.07
Maximum		8.9	2940	11.00	0.1	23.3	410	0.21	0.600	0.045	1.38	0.5	-2.3	2733.3	0.76	475	13.40
99%UCL (assume norm. dist.)		7.7	516	7.94	0.1	2.3	39	0.02	0.054	-0.019	0.18	-25.7	-25.9	259.8	0.07	46	1.28
99%ile		8.6	1282	11.00	0.1	12.1	192	0.10	0.290	0.025	0.76	0.0	-3.1	1282.1	0.39	246	6.28
Sample ID	Lithology	Initial pH	EC (μS/cm)	NAG pH/ pH_{ox}	NAG pH4.5 (kg/t H_2SO_4)	NAG pH7 (kg/t H_2SO_4)	ANC (kg/t H_2SO_4)	Total Sulfur (%S)	Sulfate Sulfur (%S)	Sulfide Sulfur (%S)	Sulfide MPA (kg/t H_2SO_4) (%S*30.6)	Total S (Lab) NAPP (kg/t H2SO4)	Sulfide NAPP (kg/t H_2SO_4)	NPR (ANC/ MPA)	NAG pH7as %S Equiv	NAG pH7 as Mol H^+/t	ANC (%H_2SO_4 or %$CaCO_3$)
95001	Siltstone	7.0	136				14	0.01	0.025	-0.020	0.15	-13.8	-13.9	93.3			0.46
95002	Soil	8.0	348				14	0.01	0.050	-0.045	0.15	-13.8	-13.9	93.3			0.46
95003	Siltstone	8.0	835				24	0.02	0.050	-0.030	0.15	-23.4	-23.9	160.0			0.78
95004	Siltstone	7.5	950				14	0.02	0.100	-0.080	0.15	-13.4	-13.9	93.3			0.46
95005	Siltstone	7.2	1099				10	0.03	0.100	-0.070	0.15	-9.1	-9.9	66.7			0.33
95006	Siltstone	7.1	932				10	0.03	0.100	-0.070	0.15	-9.1	-9.9	66.7			0.33
95007	Siltstone	7.0	650				10	0.02	0.025	-0.005	0.15	-9.4	-9.9	66.7			0.33
95008	Siltstone	7.0	769				10	0.01	0.025	-0.020	0.15	-9.8	-9.9	66.7			0.33
95009	Siltstone	6.8	591				10	0.01	0.025	-0.020	0.15	-9.8	-9.9	66.7			0.33
95011	Siltstone	6.8	1025				10	0.01	0.025	-0.020	0.15	-9.8	-9.9	66.7			0.33
95012	Siltstone	6.8	540				14	0.01	0.025	-0.015	0.15	-13.7	-13.9	93.3			0.46
95013	Siltstone	6.8	905				14	0.01	0.025	-0.020	0.15	-13.8	-13.9	93.3			0.46
95014	Siltstone	8.0	805				14	0.02	0.025	-0.005	0.15	-13.4	-13.9	93.3			0.46
95015	Siltstone	8.0	821				19	0.02	0.050	-0.030	0.15	-18.4	-18.9	126.7			0.62
95016	Siltstone	6.9	682				24	0.01	0.025	-0.015	0.15	-23.7	-23.9	160.0			0.78
95017	Siltstone	7.1	641				43	0.03	0.100	-0.070	0.15	-42.1	-42.9	286.7			1.41
95018	Siltstone	6.7	120				10	0.01	0.025	-0.015	0.15	-9.7	-9.9	66.7			0.33
95019	Soil	7.8	167				12	0.01	0.050	-0.045	0.15	-11.8	-11.9	80.0			0.39
95021	Soil	8.4	368				17	0.01	0.025	-0.020	0.15	-16.8	-16.9	113.3			0.56
95022	Siltstone	8.2	607				24	0.02	0.025	-0.005	0.15	-23.4	-23.9	160.0			0.78
95023	Siltstone	7.9	802				12	0.01	0.050	-0.040	0.15	-11.7	-11.9	80.0			0.39
95024	Siltstone	8.1	826				19	0.02	0.050	-0.030	0.15	-18.4	-18.9	126.7			0.62
95025A	Siltstone	8.1	750				12	0.07	0.025	0.045	1.38	-9.9	-10.6	8.7			0.39
95025B	Siltstone	8.1	738				14	0.01	0.025	-0.020	0.15	-13.8	-13.9	93.3			0.46
95026	Siltstone	7.2	1004				10	0.01	0.025	-0.020	0.15	-9.8	-9.9	66.7			0.33
95027	Siltstone	6.9	844				7	0.01	0.025	-0.020	0.15	-6.8	-6.9	46.7			0.23
95028	Siltstone	7.2	1283				7	0.01	0.025	-0.020	0.15	-6.8	-6.9	46.7			0.23
95029	Siltstone	6.9	707				10	0.01	0.025	-0.020	0.15	-9.8	-9.9	66.7			0.33
95031	Siltstone	6.9	580				10	0.01	0.025	-0.015	0.15	-9.7	-9.9	66.7			0.33
95032	Siltstone	7.0	851				7	0.01	0.025	-0.015	0.15	-6.7	-6.9	46.7			0.23
95033	Siltstone	8.0	936				10	0.01	0.025	-0.020	0.15	-9.8	-9.9	66.7			0.33
95034	Siltstone	7.9	871				10	0.01	0.025	-0.020	0.15	-9.8	-9.9	66.7			0.33
95035	Siltstone	7.0	438				10	0.01	0.025	-0.020	0.15	-9.8	-9.9	66.7			0.33
95036	Siltstone	6.6	55				10	0.01	0.025	-0.020	0.15	-9.8	-9.9	66.7			0.33
95037	Siltstone	8.7	204				22	0.01	0.025	-0.020	0.15	-21.8	-21.9	146.7			0.72
95038	Siltstone	8.9	200				24	0.01	0.025	-0.020	0.15	-23.8	-23.9	160.0			0.78
95039	Sandstone	7.9	272				65	0.01	0.025	-0.015	0.15	-64.7	-64.9	433.3			2.12
95041	Siltstone	8.5	786				22	0.02	0.050	-0.030	0.15	-21.4	-21.9	146.7			0.72
95042	Siltstone	7.4	498				5	0.01	0.025	-0.020	0.15	-4.8	-4.9	33.3			0.16
95043	Siltstone	7.4	579				7	0.01	0.025	-0.020	0.15	-6.8	-6.9	46.7			0.23
95044	Siltstone	8.1	662				7	0.01	0.025	-0.020	0.15	-6.8	-6.9	46.7			0.23
95045	Siltstone	7.8	780				65	0.02	0.050	-0.030	0.15	-64.4	-64.9	433.3			2.12
95046	Siltstone	8.8	457				120	0.05	0.150	-0.100	0.15	-118.5	-119.9	800.0			3.92
95047	Siltstone	7.8	2940				17	0.21	0.600	-0.390	0.15	-10.6	-16.9	113.3			0.56
95048	Siltstone	7.7	813				12	0.01	0.050	-0.040	0.15	-11.7	-11.9	80.0			0.39
95049	Siltstone	7.2	642				10	0.02	0.025	-0.005	0.15	-9.4	-9.9	66.7			0.33
95051	Siltstone	7.0	1078				10	0.02	0.050	-0.030	0.15	-9.4	-9.9	66.7			0.33
95052	Siltstone	7.1	825				7	0.01	0.025	-0.015	0.15	-6.7	-6.9	46.7			0.23
95053	Siltstone	7.1	751				10	0.06	0.025	0.035	1.07	-8.2	-8.9	9.3			0.33
95054	Siltstone	8.3	705				10	0.01	0.025	-0.020	0.15	-9.8	-9.9	66.7			0.33
95055	Siltstone	7.4	730				5	0.01	0.025	-0.015	0.15	-4.7	-4.9	33.3			0.16
95056	Siltstone	7.4	788				7	0.02	0.025	-0.005	0.15	-6.4	-6.9	46.7			0.23
95057	Siltstone	8.3	701				12	0.01	0.025	-0.020	0.15	-11.8	-11.9	80.0			0.39
95058	Siltstone	6.6	92				7	0.01	0.025	-0.015	0.15	-6.7	-6.9	46.7			0.23
95059	Siltstone	7.6	155				12	0.03	0.050	-0.020	0.15	-11.1	-11.9	80.0			0.39
95061	Siltstone	7.3	127				7	0.03	0.100	-0.070	0.15	-6.1	-6.9	46.7			0.23
95062	Siltstone	7.4	153				7	0.02	0.100	-0.080	0.15	-6.4	-6.9	46.7			0.23
95063	Siltstone	7.6	185				7	0.02	0.050	-0.030	0.15	-6.4	-6.9	46.7			0.23
95064	Siltstone	7.0	193				14	0.01	0.025	-0.020	0.15	-13.8	-13.9	93.3			0.46
95065	Siltstone	6.9	328				10	0.01	0.025	-0.020	0.15	-9.8	-9.9	66.7			0.33
95066	Siltstone	7.3	429				10	0.02	0.025	-0.005	0.15	-9.4	-9.9	66.7			0.33
95067	Siltstone	8.3	446				12	0.01	0.025	-0.015	0.15	-11.7	-11.9	80.0			0.39
95068	Siltstone	7.9	542				14	0.01	0.025	-0.015	0.15	-13.7	-13.9	93.3			0.46
95069	Siltstone	7.4	440				7	0.01	0.025	-0.020	0.15	-6.8	-6.9	46.7			0.23
95071	Siltstone	7.4	79				7	0.01	0.025	-0.020	0.15	-6.8	-6.9	46.7			0.23
95072	Siltstone	8.1	205				72	0.01	0.050	-0.040	0.15	-71.7	-71.9	480.0			2.35
95073	Siltstone	7.9	326				24	0.01	0.025	-0.020	0.15	-23.8	-23.9	160.0			0.78
95074	Siltstone	8.6	357				41	0.02	0.050	-0.030	0.15	-40.4	-40.9	273.3			1.34
95075	Siltstone	8.3	467				19	0.01	0.025	-0.020	0.15	-18.8	-18.9	126.7			0.62
95076	Siltstone	8.4	386				46	0.01	0.025	-0.020	0.15	-45.8	-45.9	306.7			1.50
95077	Siltstone	7.7	256				10	0.01	0.025	-0.015	0.15	-9.7	-9.9	66.7			0.33
95078	Siltstone	6.7	123				10	0.01	0.025	-0.020	0.15	-9.8	-9.9	66.7			0.33
95079	Siltstone	7.3	211				24	0.01	0.025	-0.020	0.15	-23.8	-23.9	160.0			0.78
95081	Siltstone	6.9	641				12	0.02	0.025	-0.005	0.15	-11.4	-11.9	80.0			0.39
95082	Siltstone	7.1	534				17	0.01	0.025	-0.015	0.15	-16.7	-16.9	113.3			0.56
95083	Siltstone	7.0	385				24	0.02	0.025	-0.005	0.15	-23.4	-23.9	160.0			0.78
95084	Siltstone	7.1	298				17	0.01	0.025	-0.020	0.15	-16.8	-16.9	113.3			0.56
95085	Siltstone	7.0	455				10	0.01	0.025	-0.015	0.15	-9.7	-9.9	66.7			0.33
95086	Sandstone	7.4	765				24	0.02	0.050	-0.030	0.15	-23.4	-23.9	160.0			0.78

Sample ID	Lithology	Initial pH	EC (µS/cm)	NAG pH/ pH_{ox}	NAG pH4.5 (kg/t H_2SO_4)	NAG pH7 (kg/t H_2SO_4)	ANC (kg/t H_2SO_4)	Total Sulfur (%S)	Sulfate Sulfur (%S)	Sulfide Sulfur (%S)	Sulfide MPA (kg/t H_2SO_4) (%S*30.6)	Total S (Lab) NAPP (kg/t H2SO4)	Sulfide NAPP (kg/t H_2SO_4)	NPR (ANC/ MPA)	NAG pH7as %S Equiv	NAG pH7 as Mol H^+/t	ANC (% H_2SO_4 or % $CaCO_3$)
95087	Sandstone	7.2	1334				14	0.05	0.100	-0.050	0.15	-12.5	-13.9	93.3			0.46
95088	Siltstone	6.3	910				12	0.01	0.050	-0.040	0.15	-11.7	-11.9	80.0			0.39
95089	Siltstone	6.5	909				14	0.01	0.050	-0.040	0.15	-13.7	-13.9	93.3			0.46
95091	Siltstone	6.9	776				31	0.01	0.025	-0.015	0.15	-30.7	-30.9	206.7			1.01
95092	Siltstone	6.8	826				14	0.01	0.025	-0.015	0.15	-13.7	-13.9	93.3			0.46
95093	Siltstone	7.9	227				34	0.01	0.025	-0.020	0.15	-33.8	-33.9	226.7			1.11
95094	Siltstone	8.4	359				24	0.01	0.025	-0.020	0.15	-23.8	-23.9	160.0			0.78
95095	Siltstone	7.9	170				19	0.05	0.025	0.025	0.77	-17.5	-18.2	24.8			0.62
95096	Siltstone	7.6	176				17	0.01	0.025	-0.020	0.15	-16.8	-16.9	113.3			0.56
95097	Sand	8.1	232				51	0.05	0.150	-0.100	0.15	-49.5	-50.9	340.0			1.67
95098	Sand	8.6	279				63	0.01	0.050	-0.040	0.15	-62.7	-62.9	420.0			2.06
95099	Siltstone	8.0	635				46	0.01	0.050	-0.045	0.15	-45.8	-45.9	306.7			1.50
95101	Material 1	8.4	561				87	0.01	0.050	-0.045	0.15	-86.8	-86.9	580.0			2.84
95102	Material 1	7.9	305				41	0.01	0.025	-0.020	0.15	-40.8	-40.9	273.3			1.34
95103	Material 1	8.0	302				34	0.01	0.025	-0.015	0.15	-33.7	-33.9	226.7			1.11
95104	Material 1	7.5	316				67	0.01	0.025	-0.020	0.15	-66.8	-66.9	446.7			2.19
95105	Material 1	7.5	426				72	0.02	0.050	-0.030	0.15	-71.4	-71.9	480.0			2.35
95106	Siltstone	7.9	244				96	0.03	0.025	0.005	0.15	-95.1	-95.8	627.5			3.14
95107	Siltstone	8.2	248				65	0.01	0.025	-0.020	0.15	-64.8	-64.9	433.3			2.12
95108	Siltstone	7.7	189				31	0.01	0.050	-0.040	0.15	-30.7	-30.9	206.7			1.01
95109	Siltstone	7.5	302				26	0.02	0.050	-0.030	0.15	-25.4	-25.9	173.3			0.85
95111	Siltstone	7.0	736				72	0.08	0.250	-0.170	0.15	-69.6	-71.9	480.0			2.35
95112	Siltstone	7.2	749				111	0.13	0.350	-0.220	0.15	-107.0	-110.9	740.0			3.63
95113	Siltstone	8.1	226				96	0.01	0.025	-0.020	0.15	-95.8	-95.9	640.0			3.14
95114	Siltstone	8.4	188				48	0.01	0.025	-0.020	0.15	-47.8	-47.9	320.0			1.57
95115	Siltstone	8.3	211				53	0.01	0.025	-0.020	0.15	-52.8	-52.9	353.3			1.73
95116	Siltstone	8.3	405				58	0.01	0.025	-0.020	0.15	-57.8	-57.9	386.7			1.90
95117	Material 1	7.9	247				63	0.01	0.025	-0.020	0.15	-62.8	-62.9	420.0			2.06
95118	Material 1	8.3	596				193	0.04	0.150	-0.110	0.15	-191.8	-192.9	1286.7			6.31
95119	Material 1	8.1	220				410	0.02	0.050	-0.030	0.15	-409.4	-409.9	2733.3			13.40
95121	Siltstone	8.0	260				82	0.01	0.025	-0.020	0.15	-81.8	-81.9	546.7			2.68
95122	Siltstone	8.6	651				396	0.02	0.050	-0.030	0.15	-395.4	-395.9	2640.0			12.94
95123	Siltstone	7.6	240				29	0.01	0.025	-0.015	0.15	-28.7	-28.9	193.3			0.95
95124	Siltstone	8.5	242				63	0.01	0.025	-0.020	0.15	-62.8	-62.9	420.0			2.06
95125	Siltstone	8.3	237				29	0.01	0.025	-0.020	0.15	-28.8	-28.9	193.3			0.95
95126	Siltstone	7.7	186				29	0.01	0.025	-0.020	0.15	-28.8	-28.9	193.3			0.95
95127	Siltstone	7.4	153				19	0.01	0.025	-0.020	0.15	-18.8	-18.9	126.7			0.62
95128	Siltstone	7.0	270				29	0.01	0.025	-0.015	0.15	-28.7	-28.9	193.3			0.95
95129	Siltstone	7.0	255				125	0.02	0.025	-0.005	0.15	-124.4	-124.9	833.3			4.08
95131	Siltstone	7.0	503				24	0.01	0.025	-0.020	0.15	-23.8	-23.9	160.0			0.78
95132	Sandstone	8.0	247				34	0.01	0.050	-0.040	0.15	-33.7	-33.9	226.7			1.11
95133	Siltstone	8.3	316				87	0.01	0.050	-0.040	0.15	-86.7	-86.9	580.0			2.84
95134	Siltstone	8.2	661				53	0.01	0.025	-0.020	0.15	-52.8	-52.9	353.3			1.73
95135	Siltstone	7.3	793				39	0.01	0.025	-0.020	0.15	-38.8	-38.9	260.0			1.27
95136	Siltstone	7.3	431				125	0.02	0.100	-0.080	0.15	-124.4	-124.9	833.3			4.08
95137	Siltstone	8.0	227				92	0.01	0.050	-0.045	0.15	-91.8	-91.9	613.3			3.01
95138	Siltstone	8.4	569				97	0.01	0.050	-0.045	0.15	-96.8	-96.9	646.7			3.17
95139	Siltstone	8.3	723				34	0.01	0.050	-0.040	0.15	-33.7	-33.9	226.7			1.11
95141	Siltsone	8.1	500				53	0.01	0.050	-0.045	0.15	-52.8	-52.9	353.3			1.73
95142	Siltstone	8.1	580				43	0.01	0.025	-0.020	0.15	-42.8	-42.9	286.7			1.41
95143	Siltstone	7.5	473				48	0.01	0.025	-0.020	0.15	-47.8	-47.9	320.0			1.57
95144	Siltstone	7.2	430				125	0.01	0.025	-0.020	0.15	-124.8	-124.9	833.3			4.08
95145	Siltstone	7.1	445				82	0.01	0.025	-0.020	0.15	-81.8	-81.9	546.7			2.68
95146	Siltstone	6.8	701				43	0.01	0.025	-0.020	0.15	-42.8	-42.9	286.7			1.41
95147	Siltstone	7.0	752				29	0.02	0.025	-0.005	0.15	-28.4	-28.9	193.3			0.95
95148	Siltstone	7.0	715				24	0.01	0.025	-0.015	0.15	-23.7	-23.9	160.0			0.78
95149	Siltstone	7.0	640				19	0.03	0.025	0.005	0.15	-18.1	-18.8	124.2			0.62
95010	Siltstone	6.8	808	7.04		0.0	19	0.01	0.025	-0.020	0.15	-18.8	-18.9	126.7	0.00	0	0.62
95020	Siltstone	8.6	288	9.60		0.0	48	0.01	0.025	-0.020	0.15	-47.8	-47.9	320.0	0.00	0	1.57
95030	Siltstone	7.0	810	7.09		0.0	14	0.01	0.025	-0.015	0.15	-13.7	-13.9	93.3	0.00	0	0.46
95040	Siltstone	8.3	618	7.26		0.0	19	0.02	0.050	-0.030	0.15	-18.4	-18.9	126.7	0.00	0	0.62
95050	Siltstone	7.2	1170	3.98		23.3	14	0.03	0.100	-0.070	0.15	-13.1	-13.9	93.3	0.76	475	0.46
95060	Siltstone	8.2	207	7.12		0.0	14	0.03	0.100	-0.070	0.15	-13.1	-13.9	93.3	0.00	0	0.46
95070	Siltstone	7.7	474	7.02		0.0	10	0.01	0.025	-0.015	0.15	-9.7	-9.9	66.7	0.00	0	0.33
95080	Siltstone	7.0	224	7.13		0.0	19	0.01	0.025	-0.015	0.15	-18.7	-18.9	126.7	0.00	0	0.62
95090	Siltstone	6.7	866	7.06		0.0	19	0.02	0.025	-0.005	0.15	-18.4	-18.9	126.7	0.00	0	0.62
95100	Material 1	8.0	470	8.01		0.0	67	0.02	0.100	-0.080	0.15	-66.4	-66.9	446.7	0.00	0	2.19
95110	Siltstone	7.0	415	7.09		0.0	19	0.03	0.100	-0.070	0.15	-18.1	-18.9	126.7	0.00	0	0.62
95120	Siltstone	8.6	246	7.87		0.0	62	0.03	0.100	-0.070	0.15	-61.1	-61.9	413.3	0.00	0	2.03
95130	Siltstone	7.1	245	7.28		0.0	14	0.01	0.025	-0.015	0.15	-13.7	-13.9	93.3	0.00	0	0.46
95140	Siltstone	8.0	217	7.95		0.0	43	0.02	0.025	-0.005	0.15	-42.4	-42.9	286.7	0.00	0	1.41
110684	Sand	7.6	296	11.00	0.1	0.1	34	0.02	0.040	-0.005	0.15	-33.0	-33.9	226.7	0.00	1	1.11
110807	Sandstone	7.7	281	11.00	0.1	0.1	41	0.02	0.040	-0.005	0.15	-38.0	-40.9	273.3	0.00	1	1.34
110905	Sandstone	8.0	318	9.10	0.1	0.1	47	0.05	0.150	-0.005	0.15	-46.0	-46.9	313.3	0.00	1	1.54
111089	Sandstone	8.1	241	8.60	0.1	0.1	55	0.01	0.020	-0.005	0.15	-48.0	-54.9	366.7	0.00	1	1.80
111188	Phosphatic Siltstone	7.8	392	6.40	0.1	2.4	8	0.05	0.150	-0.005	0.15	-3.0	-8.3	56.0	0.08	49	0.27
111356	Phosphatic Siltstone	7.9	293	10.00	0.1	0.1	47	0.04	0.110	-0.005	0.15	-42.0	-46.9	313.3	0.00	1	1.54
111419	Sandstone	7.7	590	6.10	0.1	4.3	23	0.02	0.020	-0.005	0.15	-23.0	-22.9	153.3	0.14	88	0.75
111471	Sandstone	7.6	521	6.30	0.1	3.3	4	0.04	0.050	-0.005	0.15	-4.0	-4.0	27.3	0.11	67	0.13
111517	Phosphatic Siltstone	8.1	504	7.30	0.1	0.1	15	0.01	0.005	-0.005	0.15	-10.0	-14.9	100.0	0.00	1	0.49
111571	Sandstone	8.1	499	10.00	0.1	0.1	60	0.04	0.090	-0.005	0.15	-52.0	-59.9	400.0	0.00	1	1.96
111684	Sand	7.8	370	9.30	0.1	0.1	34	0.02	0.050	-0.005	0.15	-28.0	-33.9	226.7	0.00	1	1.11
111726	Clay	7.6	711	6.20	0.1	5.4	8	0.09	0.290	-0.005	0.15	-11.0	-8.1	54.7	0.18	110	0.27
111767	Clay	7.9	341	6.10	0.1	5.3	4	0.02	0.070	-0.005	0.15	0.5	-4.0	27.3	0.17	108	0.13
111820	Sandstone	8.0	267	6.50	0.1	4.4	6	0.02	0.005	-0.005	0.15	-18.0	-5.9	40.0	0.14	90	0.20
111888	Sand	7.8	271	9.30	0.1	0.1	36	0.02	0.005	-0.005	0.15	-37.0	-35.9	240.0	0.00	1	1.18

Sample ID	Lithology	Initial pH	EC (µS/cm)	NAG pH/ pH_{ox}	NAG pH4.5 (kg/t H_2SO_4)	NAG pH7 (kg/t H_2SO_4)	ANC (kg/t H_2SO_4)	Total Sulfur (%S)	Sulfate Sulfur (%S)	Sulfide Sulfur (%S)	Sulfide MPA (kg/t H_2SO_4) (%S*30.6)	Total S (Lab) NAPP (kg/t H2SO4)	Sulfide NAPP (kg/t H_2SO_4)	NPR (ANC/ MPA)	NAG pH7as %S Equiv	NAG pH7 as Mol H^+/t	ANC (%H_2SO_4 or %$CaCO_3$)
111926	Sand	8.0	242	8.30	0.1	0.1	29	0.02	0.060	-0.005	0.15	-28.0	-28.9	193.3	0.00	1	0.95
112584	Sand	8.0	232	11.00	0.1	0.1	74	0.01	0.010	-0.005	0.15	-71.0	-73.9	493.3	0.00	1	2.42
112650	Clay	8.0	386	6.90	0.1	1.0	6	0.02	0.005	-0.005	0.15	-4.0	-6.0	40.7	0.03	20	0.20
112691	Clay	8.0	513	7.70	0.1	0.1	21	0.01	0.005	-0.005	0.15	-19.0	-20.9	140.0	0.00	1	0.69
112712	Sandstone	8.1	454	6.50	0.1	3.3	6	0.01	0.005	-0.005	0.15	-5.0	-5.8	39.3	0.11	67	0.19
112758	Clay	8.1	323	11.00	0.1	0.1	91	0.05	0.110	-0.005	0.15	-79.0	-90.9	606.7	0.00	1	2.97
112909	Sandstone	8.1	339	9.90	0.1	0.1	54	0.02	0.020	-0.005	0.15	-51.0	-53.9	360.0	0.00	1	1.76
112968	Clay	8.0	319	7.40	0.1	0.1	7	0.01	0.005	-0.005	0.15	-14.0	-6.5	44.0	0.00	1	0.22
113035	Sandstone	7.9	160	6.50	0.1	1.5	6	0.01	0.005	-0.005	0.15	-10.0	-5.5	37.3	0.05	31	0.18
113101	Sandstone	7.9	291	7.50	0.1	0.1	7	0.01	0.005	-0.005	0.15	-5.0	-6.6	44.7	0.00	1	0.22
113109	Sandstone	7.5	222	6.70	0.1	0.8	4	0.02	0.060	-0.005	0.15	-4.0	-3.8	26.0	0.03	16	0.13
113182	Sandstone	7.4	177	6.30	0.1	1.0	3	0.01	0.005	-0.005	0.15	-5.0	-3.1	21.3	0.03	20	0.10
113247	Sandstone	7.9	346	7.70	0.1	0.1	9	0.01	0.005	-0.005	0.15	-10.0	-8.6	58.0	0.00	1	0.28
113301	Sandstone	8.0	269	11.00	0.1	0.1	37	0.02	0.040	-0.005	0.15	-42.0	-36.9	246.7	0.00	1	1.21
113407	Clay	7.5	104	7.30	0.1	0.1	6	0.02	0.005	-0.005	0.15	-9.0	-6.3	42.7	0.00	1	0.21
113455	Sand	7.4	52	6.50	0.1	0.5	4	0.01	0.005	-0.005	0.15	-10.0	-4.0	27.3	0.02	10	0.13
113535	Siltstone	7.8	541	6.80	0.1	1.3	9	0.01	0.005	-0.005	0.15	-10.0	-8.5	57.3	0.04	27	0.28
113654	Clay	7.8	321	7.50	0.1	0.1	7	0.02	0.010	-0.005	0.15	-9.0	-6.7	45.3	0.00	1	0.22
113753	Sandstone	7.2	80	5.70	0.1	6.0	5	0.01	0.005	-0.005	0.15	-5.0	-4.4	30.0	0.20	122	0.15
113951	Siltstone	8.0	274	6.80	0.1	1.4	25	0.01	0.005	-0.005	0.15	-48.0	-24.9	166.7	0.05	29	0.82
114108	Sandstone	7.6	89	6.50	0.1	1.0	3	0.01	0.005	-0.005	0.15	-10.0	-3.1	21.3	0.03	20	0.10
114130	Clay	7.3	72	6.20	0.1	1.0	4	0.01	0.005	-0.005	0.15	-10.0	-3.5	24.0	0.03	20	0.12
114215	Sandstone	7.4	191	6.00	0.1	5.2	7	0.01	0.005	-0.005	0.15	-5.0	-7.3	49.3	0.17	106	0.24
114273	Sandstone	7.5	114	7.30	0.1	0.1	5	0.01	0.005	-0.005	0.15	-5.0	-5.1	34.7	0.00	1	0.17
114358	Sandstone	7.6	243	5.90	0.1	4.6	3	0.01	0.005	-0.005	0.15	0.0	-2.6	18.0	0.15	94	0.09
114469	Sandstone	7.1	246	6.20	0.1	2.4	4	0.01	0.005	-0.005	0.15	-5.0	-4.2	28.7	0.08	49	0.14
114656	Sandstone	7.3	142	6.30	0.1	2.1	4	0.01	0.005	-0.005	0.15	0.0	-3.4	23.3	0.07	43	0.11
114810	Siltstone	8.1	254	10.00	0.1	0.1	30	0.01	0.010	-0.005	0.15	-24.0	-29.9	200.0	0.00	1	0.98
114934	Sandstone	7.1	86	6.70	0.1	0.2	4	0.04	0.100	-0.005	0.15	-4.0	-3.7	25.3	0.01	4	0.12
115023	Sandstone	7.9	246	10.00	0.1	0.1	39	0.02	0.030	-0.005	0.15	-28.0	-38.9	260.0	0.00	1	1.27
115110	Sandstone	8.1	406	6.90	0.1	0.8	8	0.01	0.005	-0.005	0.15	-5.0	-7.8	52.7	0.03	16	0.26
115229	Sandstone	8.1	245	6.80	0.1	1.8	7	0.02	0.040	-0.005	0.15	-13.0	-7.2	48.7	0.06	37	0.24
115345	Sand	8.1	278	7.90	0.1	0.1	14	0.01	0.005	-0.005	0.15	-19.0	-13.9	93.3	0.00	1	0.46
115590	Sandstone	7.9	255	5.80	0.1	5.9	2	0.10	0.270	-0.005	0.15	-2.0	-2.3	16.0	0.19	120	0.08
115642	Sandstone	8.2	334	6.70	0.1	3.2	8	0.01	0.005	-0.005	0.15	-14.0	-7.6	51.3	0.10	65	0.25
115705	Sandstone	8.0	600	6.50	0.1	3.7	9	0.04	0.060	-0.005	0.15	-13.0	-9.1	61.3	0.12	75	0.30
115937	Sandstone	7.9	746	8.30	0.1	0.1	48	0.04	0.120	-0.005	0.15	-32.0	-47.9	320.0	0.00	1	1.57

NAPP testing and NAG and ASLP testing is summarised by lithology in Table 3-25 below. The secondary (NAG and ASLP) samples are more from sandstone and less than siltstone than the primary (NAPP) samples, but still have a broad range of coverage of the major lithologies. As the lithologies are not correlatable between drill holes, it is not possible to estimate the volumes of individual lithologies, other than to assume they will be proportional to their occurrence in drill holes. As the primary samples were collected over the full profile, all lithologies are proportionally represented by analyses.

Table 3-25 AMD testing lithology summary

Lithology	Number of NAPP tests	Number of NAG and ASLP tests
Soil	3	
Siltstone	134	16
Sandstone	34	30
Phosphatic siltstone	3	3
Sand	9	7
Clay	9	9
Unknown	9	1

3.15.3 Secondary Sample Locations

Secondary samples for NAG and ASLP testing were selected to cover a wide extent of the deposit. Samples were taken over 3 m lengths and the midpoint depth of samples runs (Figure 3-9) ranged from 1.5 m to 18.5 m. This corresponds to heights from 3.88 m below the top of the ore to 71 m above the top of the ore (Figure 3-10). The elevations of the samples ranged from 380.80 to 411.21 mAHD and are shown along with ore base (approximating the pit shell) contours in Figure 3-11.

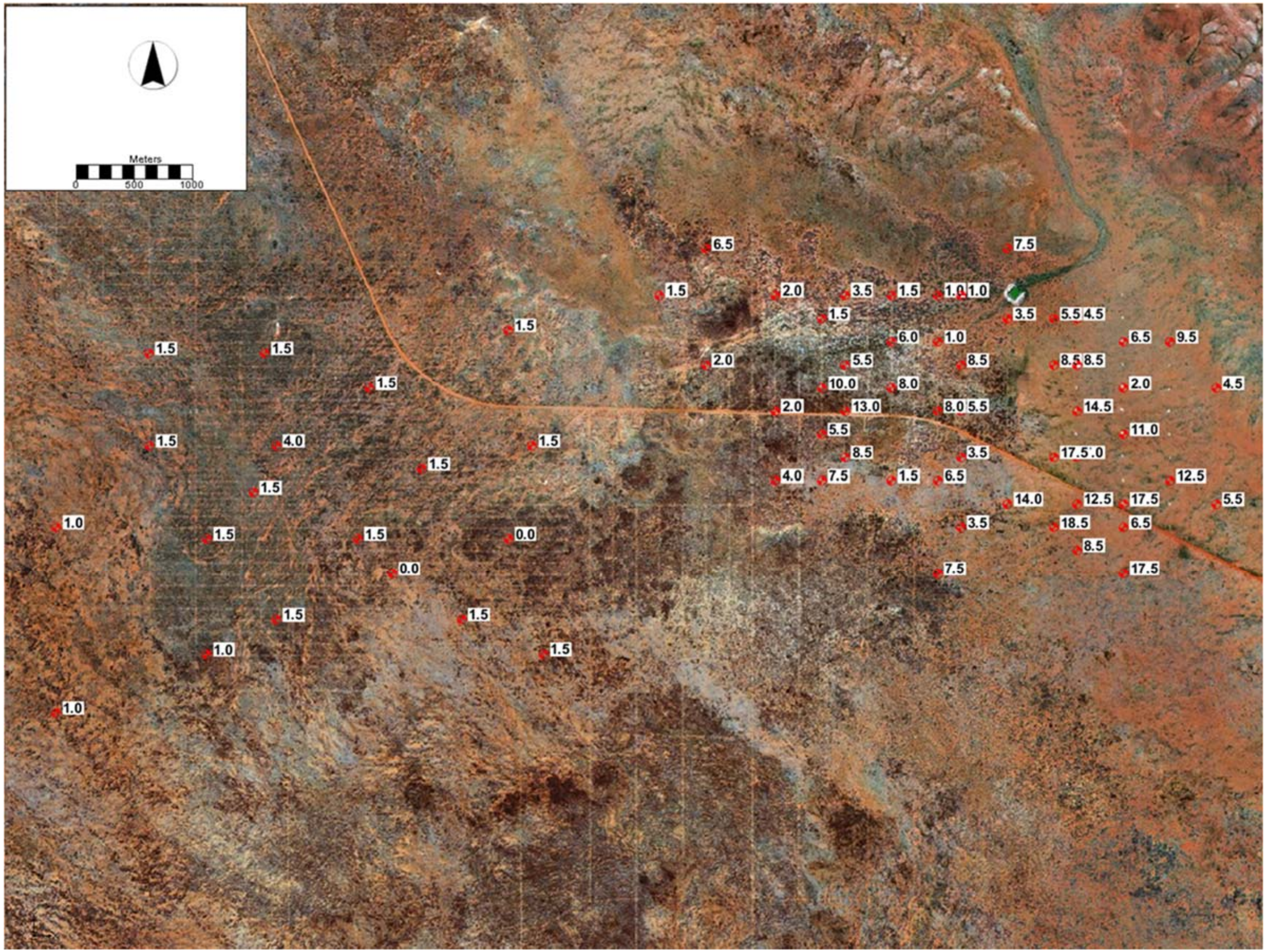


Figure 3-10 Sample depth below surface (m)

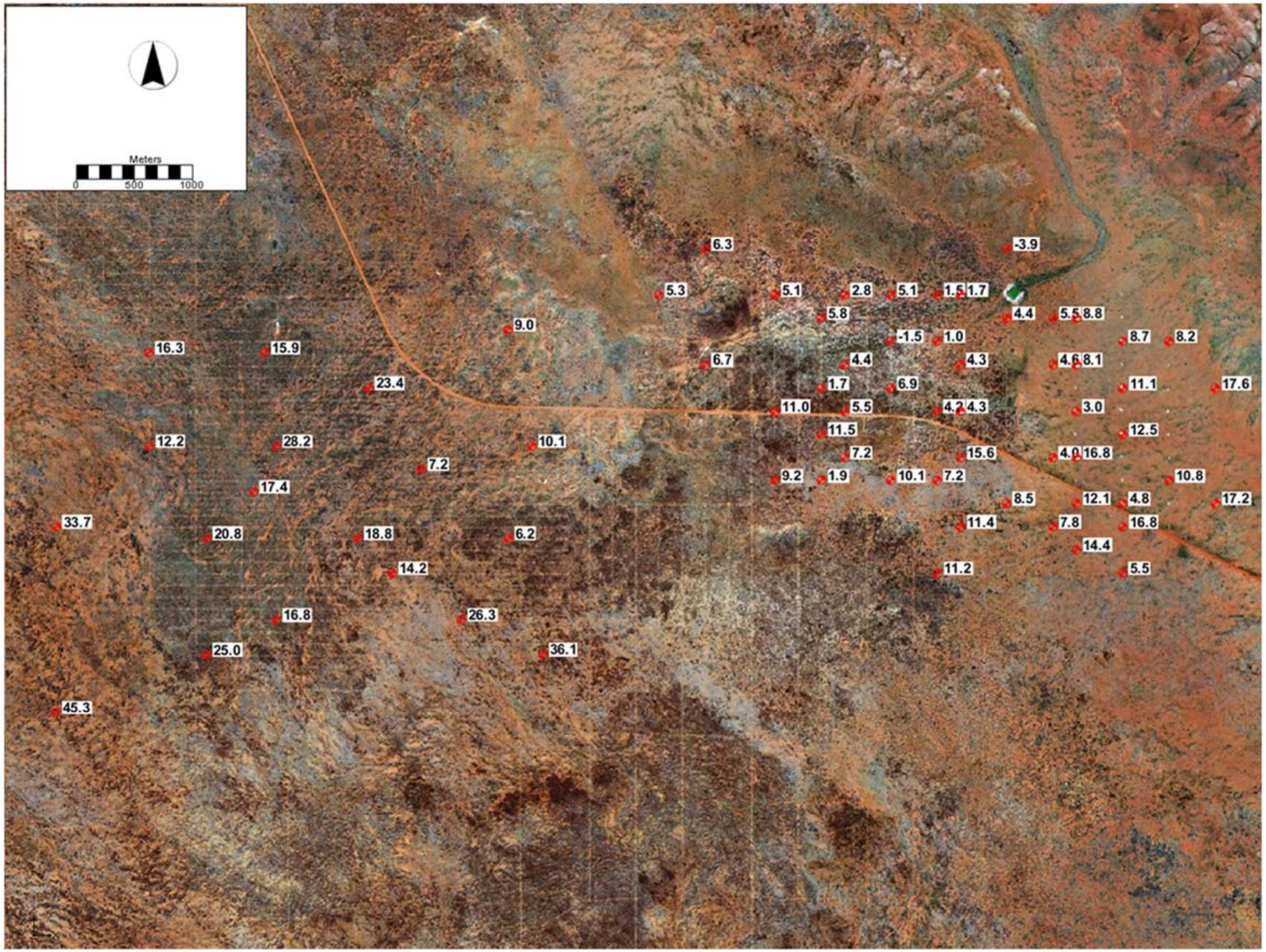


Figure 3-11 Sample height above top of ore (m)

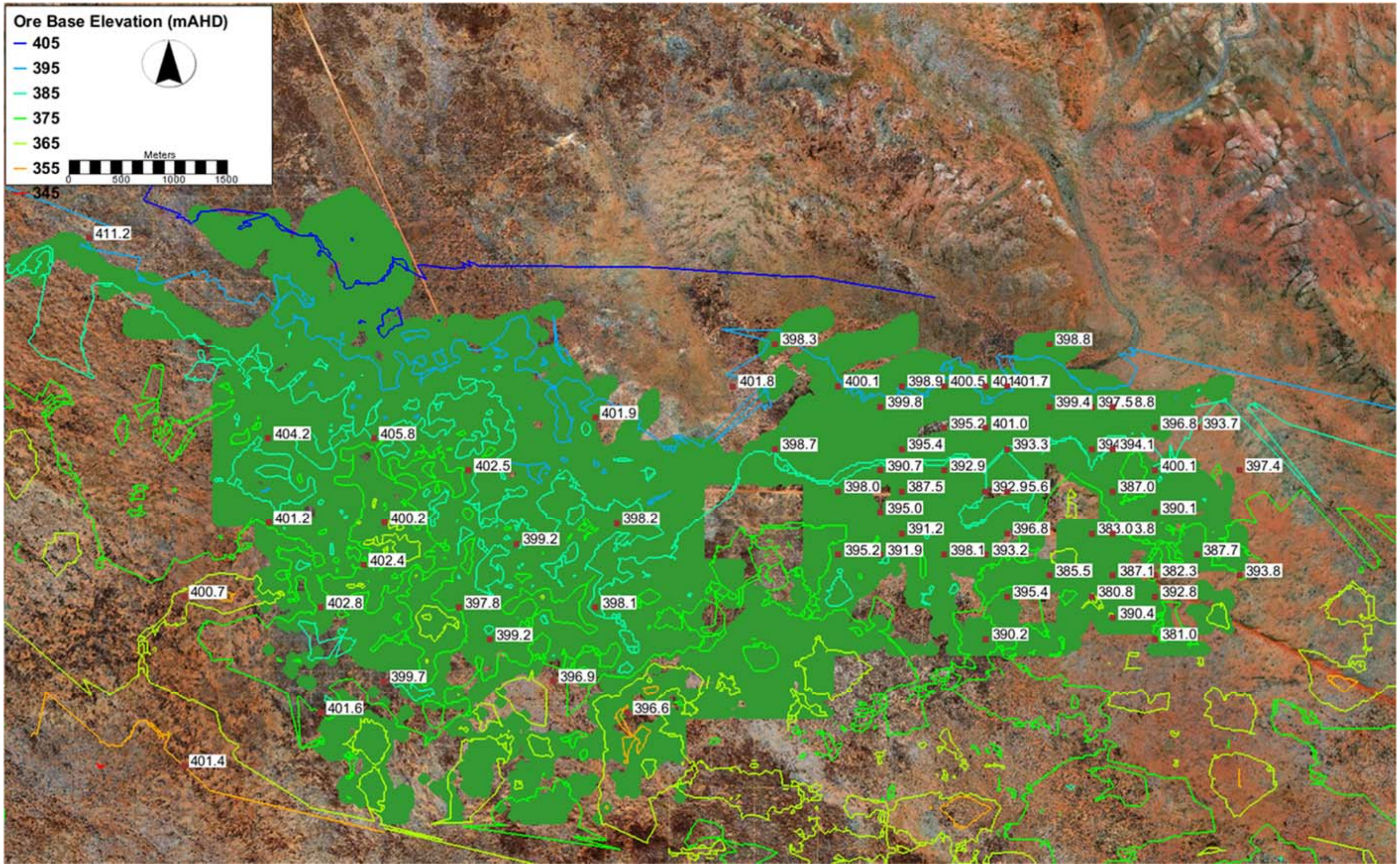


Figure 3-12 Sample elevation and ore base elevation contours (mAHD) showing approximate life of mine pit limits.

3.15.4 Total Element (Assay) Statistics

The summary statistics for the assay data for 54 elements are summarised below in Table 3-26. To provide an indication of relative abundance, elements that exceed the average crustal abundance are in bold and to provide an indication of potential environmental risk, those that exceed the NT Clean Fill Guidelines are highlighted in yellow.

The NT clean fill guidelines were exceeded by the maximum value for arsenic, cadmium, copper, nickel lead and zinc. Other than zinc, the 99% upper confidence intervals (99%UCL), means, medians and third quartiles were all below NT clean fill guidelines. The mean (201 ppm), third quartile (214 ppm) and 99%UCL (237 ppm) values for Zinc slightly exceeded the clean fill guideline of 200 ppm. Multiple elements exceeded average crustal abundance for various statistical parameters and hence are discussed below with reference to Geochemical Abundance Indices (GAI). The maximum combined uranium and thorium activity was 0.63 Bq/g, which is well below the trigger value of 1Bq/g.

Table 3-27 provides the statistics of the GAI, where a GAI of greater than 3, considered to be significantly elevated, is highlighted. The maximum value exceeded a GAI of three for silver, bismuth, cadmium, carbon, cobalt, dysprosium, erbium, holmium, lutetium, manganese, neodymium, phosphorus, lead, thallium, thulium, ytterbium and zinc. Only carbon and neodymium had 3rd quartiles above 3 and all other summary statistics for GAIs were less than 3.

Based on the above statistics, other than some minor spikes the overall waste rock does not contain significantly elevated elements of concern, other than zinc, which is not elevated in terms of comparison to crustal average, but its mean and 99%UCL is slightly above the NT clean fill guideline for total zinc.

Table 3-26 Assay data statistical summary compared with average crustal abundance and NT clean fill guidelines

Metal	Units	NT Clean Fill	Avg Crustal Abundance	Count	Min	1st Quartile	Median	Mean	3rd Quartile	Max	99% UCL
Ag	ppm	10	**0.07**	229	0.03	**0.12**	**0.23**	**0.33**	**0.44**	**1.57**	**0.37**
Al	%		**8.23**	431	0.17	3.49	5.87	5.41	7.20	**12.20**	5.64
As	ppm	20	**15**	431	1.2	4.2	6.8	10.0	10.8	**168.0**	11.1
Be	ppm		**3**	229	0.27	2.10	**3.48**	**4.79**	**6.69**	**23.50**	**5.29**
Bi	ppm		**0.18**	229	0.02	0.11	**0.19**	**0.23**	**0.25**	**3.00**	**0.26**
Ca	%		**4.2**	431	0.05	0.19	0.77	3.71	3.53	**29.90**	**4.31**
Cd	ppm	3	**0.2**	229	0.01	0.11	**0.80**	**1.60**	**2.28**	**12.00**	**1.87**
C	%		**0.02**	202	0.01	**0.04**	**0.10**	**0.20**	**0.27**	**1.50**	**0.23**
Ce	ppm		**50**	229	2.82	35.30	**56.50**	**72.33**	**92.00**	**283.00**	**79.25**
Co	ppm		**20**	431	1	8	8	17	17	**437**	**21**
Cr	ppm		**100**	229	4	27	46	49	66	**178**	53
Cs	ppm		**5**	229	0.47	2.92	3.83	4.61	4.90	**17.75**	**5.00**
Cu	ppm	100	**50**	431	2.1	10.0	16.0	31.1	29.8	**576.0**	36.1
Dy	ppb		**5000**	229	220	2760	4430	**7165**	**7710**	**79700**	**8324**
Er	ppb		**2000**	229	160	1830	**2660**	**4719**	**4940**	**67000**	**5636**
Eu	ppb		**1000**	229	50	560	900	**1332**	**1730**	**7120**	**1479**
Fe	%		**20**	431	0.24	0.57	1.24	2.55	2.74	**44.53**	2.96
Ga	ppm		**20**	229	0.56	5.31	9.80	10.53	15.95	**22.20**	11.27
Gd	ppb		**6000**	229	230	2910	4550	**7127**	**9130**	**46400**	**8013**
Hf	ppm		**3**	229	0.1	1.2	**3.1**	2.9	**4.3**	**8.0**	**3.2**
Ho	ppb		**1000**	229	50	620	900	**1550**	**1700**	**20100**	**1832**
K	%		**2.1**	431	0.06	0.65	0.97	1.12	1.35	**4.97**	1.19
La	ppm		**20**	229	0.00006	0.00082	0.00140	0.00164	0.00211	0.00612	0.00179
Lu	ppb		**500**	229	30	260	390	**648**	**630**	**8840**	**773**

Mg	%		**2.3**	202	0.125	0.310	0.388	0.418	0.508	1.270	0.440
Mn	ppm		**850**	431	0.0025	25.0000	100.0000	395.8533	363.9800	**18121.5565**	503.5952
Mo	ppm	40	**3**	431	0.21	0.96	1.00	1.38	1.26	**20.00**	1.52
Nb	ppm		**20**	229	0.3	3.2	5.6	6.8	10.1	19.4	7.3
Nd	ppb		**2400**	229	1200	**14200**	**23800**	**32255**	**43100**	**136500**	**35523**
Ni	ppm	60	**70**	229	5.1	14.8	23.5	43.8	48.1	**428.0**	51.0
P	ppm		**1050**	431	50	569	**1144**	**7612**	**6689**	**73425**	**8983**
Pb	ppm	300	**20**	431	5	18	**55**	**93**	**110**	**1180**	**104**
Pr	ppb		**6000**	229	310	3730	**6260**	**8084**	**10650**	**32100**	**8871**
Rb	ppm		**140**	229	3.3	39.6	62.5	64.7	83.3	**168.0**	69.4
Re	ppm		**0.0005**	229	**0.001**	**0.001**	**0.001**	**0.001**	**0.001**	**0.004**	**0.001**
S	%		**0.035**	431	0.005	0.010	0.020	0.029	**0.035**	**0.240**	0.033
Sb	ppm	50	**1**	229	0.08	0.31	0.51	0.60	0.67	**4.05**	0.66
Si	%		**28**	431	5.0	**30.0**	**34.2**	**31.9**	**36.7**	**43.4**	**32.6**
Sm	ppb		**6000**	229	250	2880	4880	**6768**	**9040**	**27800**	**7482**
Sn	ppm	50	**4**	229	0.1	1.2	2.0	2.4	3.4	**6.3**	2.6
Sr	ppm		**300**	229	11.7	41.5	76.0	175.3	183.5	**1665.0**	209.2
Ta	ppm		**2**	229	0.025	0.200	0.470	0.553	0.860	1.500	0.606
Tb	ppb		**1000**	229	40	440	690	**1113**	**1350**	**8580**	**1270**
Th	ppm	240	**12**	229	0.5	6.6	10.7	11.8	**16.3**	**30.2**	**12.6**
Ti	%		**0.46**	431	0.009	0.160	0.356	0.345	**0.515**	**1.205**	0.364
Tl	ppm		**0.3**	229	0.1	**0.3**	**0.4**	**0.6**	**0.7**	**7.4**	**0.7**
Tm	ppb		**200**	229	20	**270**	**380**	**669**	**660**	**9330**	**800**
U	ppm	80	**4**	431	1	**4**	**7**	**9**	**11**	**45**	**10**
V	ppm		**130**	281	0.5	20.0	59.0	63.7	92.0	**403.0**	70.4
W	ppm		**2**	229	0.3	1.0	1.5	1.6	**2.1**	**4.6**	1.7
Y	ppm		**25**	229	2.2	20.7	**32.1**	**93.8**	**60.6**	**4444.0**	**147.5**
Yb	ppb		**6000**	229	150	1710	2520	4204	4210	**56000**	5009
Zn	ppm	200	**100**	431	6	22	47	**201**	**214**	**4160**	**237**
Zr	ppm		**160**	229	1.4	46.2	109.5	107.0	**164.0**	**288.0**	116.3
U+Th Rad	Bq/g	1	**0.1**	229	0.01	0.09	**0.15**	**0.17**	**0.22**	**0.63**	**0.19**

Table 3-27 Geochemical Abundance Index (GAI) statistical summary

Element	Count	Min	1st Quartile	Median	Mean	3rd Quartile	Max	99%UCL
Ag	229	-1.9	0.1	1.1	1.1	2.0	3.8	1.3
Al	431	-6.3	-1.9	-1.1	-1.5	-0.9	-0.1	-1.4
As	431	-4.3	-2.5	-1.8	-1.7	-1.1	2.8	-1.6
Be	229	-4.1	-1.2	-0.4	-0.4	0.5	2.3	-0.2
Bi	229	-3.8	-1.4	-0.6	-0.8	-0.2	3.4	-0.6
Ca	431	-7.1	-5.1	-3.1	-2.9	-0.9	2.2	-2.5
Cd	229	-5.0	-1.5	1.3	0.6	2.9	5.2	1.0
C	202	-1.7	0.3	1.7	1.8	3.1	5.6	2.1
Ce	229	-4.8	-1.2	-0.5	-0.5	0.2	1.8	-0.3
Co	431	-5.0	-2.1	-2.1	-1.7	-0.9	3.8	-1.5
Cr	229	-5.3	-2.5	-1.8	-1.9	-1.3	0.2	-1.8
Cs	229	-4.1	-1.4	-1.0	-1.1	-0.7	1.2	-0.9
Cu	431	-5.2	-3.0	-2.3	-2.1	-1.4	2.9	-1.9
Dy	229	-5.2	-1.5	-0.8	-0.7	0.0	3.3	-0.5
Er	229	-4.3	-0.8	-0.2	-0.1	0.6	4.4	0.1
Eu	229	-5.0	-1.5	-0.8	-0.7	0.1	2.2	-0.5
Fe	431	-7.0	-5.8	-4.7	-4.5	-3.5	0.5	-4.4
Ga	229	-5.8	-2.6	-1.7	-1.9	-1.0	-0.5	-1.7
Gd	229	-5.4	-1.7	-1.1	-0.9	-0.1	2.3	-0.7
Hf	229	-5.6	-2.0	-0.6	-1.4	-0.1	0.8	-1.1
Ho	229	-5.0	-1.3	-0.8	-0.6	0.1	3.7	-0.4
K	431	-5.8	-2.4	-1.8	-1.9	-1.3	0.6	-1.7
La	229	-19.0	-15.2	-14.5	-14.6	-13.9	-12.3	-14.4
Lu	229	-4.7	-1.6	-1.0	-0.9	-0.3	3.5	-0.7
Mg	202	-4.9	-3.6	-3.2	-3.2	-2.8	-1.5	-3.1
Mn	431	-19.0	-5.7	-3.7	-4.0	-1.9	3.8	-3.6
Mo	431	-4.5	-2.3	-2.2	-2.1	-1.9	2.1	-2.0
Nb	229	-6.7	-3.3	-2.5	-2.6	-1.6	-0.7	-2.4
Nd	229	-1.7	1.9	2.6	2.7	3.5	5.2	2.9
Ni	229	-4.4	-2.9	-2.2	-2.0	-1.2	2.0	-1.8
P	431	-5.1	-1.5	-0.5	0.2	2.0	5.5	0.5
Pb	431	-2.7	-0.8	0.8	0.7	1.8	5.2	0.9
Pr	229	-4.9	-1.3	-0.6	-0.6	0.2	1.8	-0.4
Rb	229	-6.1	-2.5	-1.8	-2.0	-1.4	-0.4	-1.9
Re	229	0.3	0.3	0.3	0.6	0.3	2.3	0.6
S	431	-3.5	-2.5	-1.5	-1.6	-0.7	2.1	-1.5
Sb	229	-4.3	-2.3	-1.6	-1.8	-1.2	1.4	-1.6
Se	202	2.4	2.4	2.4	2.4	2.4	2.4	2.4
Si	431	-3.1	-0.6	-0.4	-0.5	-0.3	0.0	-0.5
Sm	229	-5.2	-1.7	-1.0	-0.9	-0.1	1.6	-0.7
Sn	229	-6.0	-2.4	-1.7	-1.7	-0.9	0.0	-1.5
Sr	229	-5.3	-3.5	-2.6	-2.4	-1.4	1.8	-2.1
Ta	229	-7.0	-4.0	-2.7	-3.1	-1.9	-1.1	-2.9
Tb	229	-5.3	-1.8	-1.2	-1.0	-0.2	2.4	-0.8
Th	229	-5.2	-1.5	-0.8	-1.0	-0.2	0.7	-0.8
Ti	431	-6.3	-2.2	-1.0	-1.4	-0.5	0.7	-1.3
Tl	229	-2.2	-0.7	-0.2	0.0	0.5	4.0	0.1
Tm	229	-4.0	-0.2	0.3	0.4	1.1	4.9	0.6
U	431	-2.7	-0.6	0.1	0.1	0.7	2.8	0.3
V	281	-8.7	-3.4	-1.8	-3.0	-1.2	1.0	-2.6
W	229	-3.4	-1.7	-1.1	-1.2	-0.6	0.5	-1.0
Y	229	-4.2	-0.9	-0.3	-0.1	0.6	6.8	0.2
Yb	229	-6.0	-2.5	-1.9	-1.8	-1.2	2.6	-1.6
Zn	431	-4.7	-2.8	-1.7	-1.2	0.4	4.7	-0.9
Zr	229	-7.5	-2.5	-1.2	-2.0	-0.6	0.2	-1.6

3.16 Radiological considerations

The following is a summary of all work done on the uranium and thorium contents of the Ammaroo Phosphate deposit. All results cited are presented as elements/compounds and in units exactly as in the analytical files from the laboratories. For the purposes of this document, mg/kg, ppm and ug/g can be considered to be equivalent. . Those results reported as U_3O_8 need to be multiplied by 0.85 to convert them to the pure elemental radionuclides used by the International Atomic Energy Agency (IAEA). The IAEA 2006 guidelines are based on average concentrations of radionuclides and the discussion below reflects that. However, where applicable, full statistics are presented in tables. Where values are below the detection limit, a value equivalent to that limit has been used is statistical analysis.

The discussion ranges from detailed half-metre sampling of diamond drill core to global averages of almost three billion tonnes based on tens of thousands of assays and the processed concentrate of a 30 t bulk sample.

The following empirical relationships were used to relate elemental concentrations to radioactivity:

- 80 ppm uranium is equivalent to 1 Bq/g (natural uranium)
- 246 ppm thorium is equivalent to 1 Bq/g (natural thorium)
- 1 Bq/g (Becquerel per gram) is the IAEA threshold above which material is potentially subject to regulation for the purposes of radiological control.

3.16.1 ASLP testwork

Uranuim and thorium analysis as part of the ASLP test work undertaken for the EIS provide an indication of radiation risk.

Uranium analyses are available over the full depth profile for 28 boreholes, and thorium from the ARC-series holes (6 boreholes). The maximum concentrations of uranium (44.9 ppm) and thorium (30.2 ppm) were below the concentrations equivalent to the activity threshold of 1 Bq/g of 80 ppm and 246 ppm respectively (DME QLD, 2008). The highest combined equivalent, for the 229 samples where both uranium and thorium were analysed, was 0.63 Bq/g, hence the materials are not classified as NORM. The summary statistics for the uranium and thorium analyses are presented in Table 3-28 below.

Table 3-28 Uranium, thorium and calculated activity summary statistics

	Th (ppm)	U (ppm)	U+Th activity (Bq/g)
U+Th Count	229	431	229
1st Quartile (ppm)	6.6	4	0.09
3rd Quartile (ppm)	16.3	11	0.22
Min (ppm)	0.5	1	0.01
Median (ppm)	10.7	7	0.15
mean (ppm)	11.8	9	0.17
Max (ppm)	30.2	45	0.63
99%UCL (ppm) (assume norm. dist.)	12.6	10	0.19

3.16.2 Ore

Uranium

Metallurgical test-work done on half-metre and metre-by-metre diamond drillhole samples in 2013 analysed 318 “ore” samples by ICP4 with a lower detection limit (LDL) of 0.5 ppm U3O8. This half-metre sampling is the most closely-spaced undertaken. This study returned an average of 12.45% P_2O_5 and a corresponding average of 15.7 ppm U (Table 3-29).

Table 3-29 Uranium statistics of 318 samples from the “MET” diamond core holes

Number	Units	LDL	Average	Max	Min	St Dev
318	ppm	0.5	15.7	50.0	0.5	8.4

Uranium concentration statistics were generated and analysed as part of the March 2017 JORC Resource estimation independently undertaken by MPR Geological Consulting. That study was based on greater than 19,000 uranium assays, including routine ICP analysis with a lower detection limit of 10 ppm and higher-precision XRF checks with a lower detection limit of 1 ppm. The MPR Consulting study presented a summary of the U_3O_8 ppm concentrations for various P_2O_5 cut-offs within the different JORC resource categories (Table 3-30). The global resource and associated exploration target with no P_2O_5 cut-off is almost three billion tonnes. This three billion tonnes averages 21.0 ppm U_3O_8, identical to just the Measured Resource at 212 Mt, and testifying to the overall geological homogeneity of the uranium grades at mine-scale.

Table 3-30 Uranium statistics for the global resource and exploration target with no P_2O_5 cut-off

JORC Category	Mt	P_2O_5%	U_3O_8 ppm
with no P2O5 cut-off			
Measured	212	12.4	21.0
Indicated	368	10.3	18.1
Inferred	2,249	9.23	21.2
Total Resource	2,829	9.61	20.7
Exploration Target	84	7.87	28.3
Grand Total	2,913	9.56	21.0
at a 10% P2O5 cut-off			
Measured	136	15.4	22.7
Indicated	165	15.5	21.0
Inferred	843	13.5	25.8
Total Res	1,144	14.0	24.7
at a 15% P2O5 cut-off			
Measured	61	18.5	24.3
Indicated	72	19.0	22.1
Inferred	205	17.4	31.0
Total Res	338	18.0	27.9

MPR Consulting also undertook a detailed statistical analysis of the uranium concentration in the JORC resource further sub-divided into multiple Zones. Only a brief excerpt, taken to be most representative of the 30 year mine plan, is presented here.

Table 3-31 MPR Consulting's Model A "Zone C" which most closely approximates the highest grade ore.

	P2O5 %	U3O8 ppm
Number	19,806	19,801
Average	14.4	22.8
Variance	49.6	189
Coef. Var.	0.49	0.6
Minimum	0.04	0.59
1st Quartile	9.91	13.6
Median	13.6	20
3rd Quartile	18.4	27.1
Maximum	40.9	236

MPR Consulting's Model A "Zone C" which contains the highest grade ore, has an average of 14.4% P2O5 from 19,806 assays and a corresponding average uranium concentration of 22.8 ppm U3O8 from 19,801 assays (Table 3-31). This population contains a maximum outlier of 236 ppm, which should be seen in context of the histogram (Figure 3-13) and the fact that it represents a single metre sample in 19,801 samples. Should it be mined, it would be diluted during the normal mining process.

As reported in the Draft EIS, 35,834 samples geologically representative of the entire 40 km long deposit (including a large volume of material from outside the 30 year mine plan) gave a mean content of 22.7 ppm U3O8 (for material >10% P2O5 which could approximate the economic cut-off of "ore"). This is equivalent to 0.24 Bq/g of natural uranium, less than one quarter of the 1 Bq/g IAEA threshold.

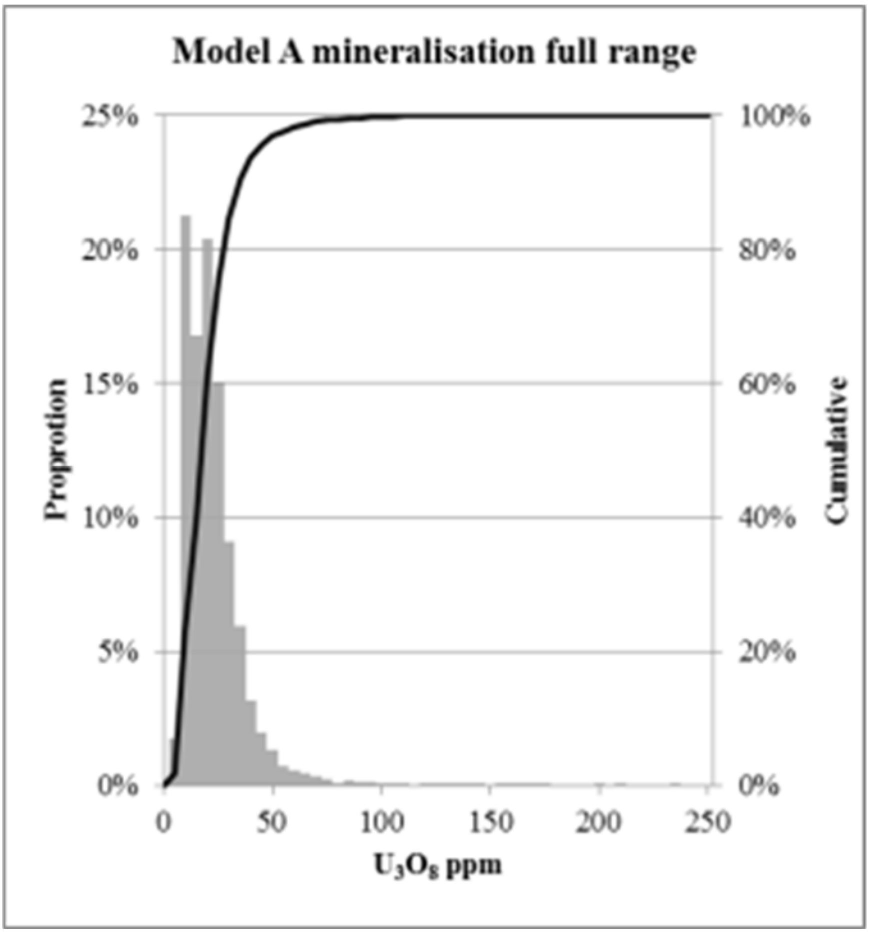


Figure 3-13 Histogram of uranium concentration in ore. There is a maximum outlier of 236 ppm U

Thorium

Of the 229 samples analysed for thorium and reported in the Draft EIS, 47 have >10% P_2O_5. These "ore" grade samples have an average concentration of 8.8 ppm thorium (Table 3-32). It takes 246 ppm of thorium to produce 1 Bq/g, so any contribution to radioactivity from Th in ore is negligible.

Table 3-32 Thorium concentrations in ore

Number	Units	LDL	Average	Max	Min	St Dev
47	ppm	0.5	8.8	16.6	2.5	3.6

3.16.3 Overburden and waste rock

Based on the study by MPR Geological Consulting, 15,987 samples of overburden from the above the "ore" had a mean of 16.9 ppm U_3O_8 (Table 3-33). As reported in the Draft EIS, this is equivalent to 0.18 Bq/g of natural uranium.

Table 3-33 Univariate uranium statistics for overburden

	P2O5 %	U3O8 ppm
Number	15,988	15,987
Average	2.25	16.9
Variance	6.8	144
Coef. Var.	1.16	0.71
Minimum	0.01	0.59
1st Quartile	0.33	10.6
Median	1.05	11.8
3rd Quartile	3.44	21.2
Maximum	27.7	242

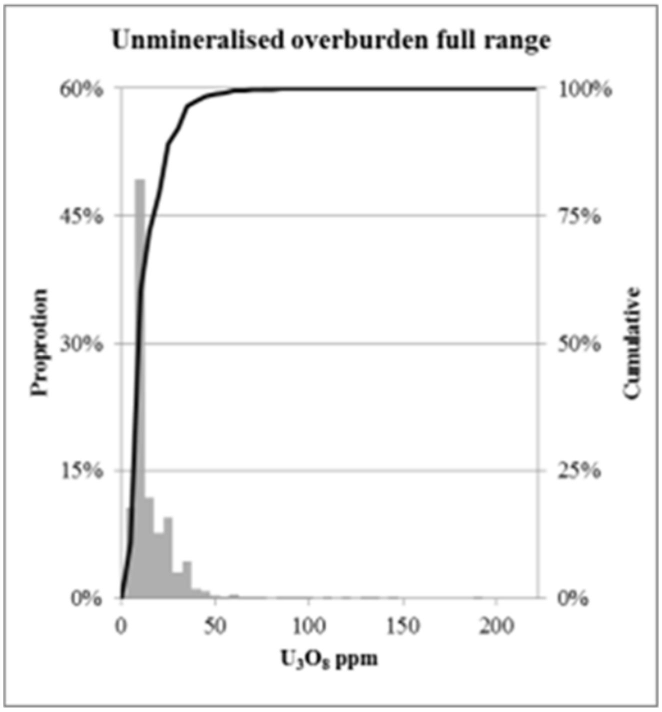


Figure 3-14 Histogram of uranium concentration in overburden.

Of the 229 samples analysed for thorium and reported in the Draft EIS, 182 were <10% P_2O_5 and considered representative of overburden and waste rock (Table 3-34). These 182 samples had an average concentration of 12.5 ppm thorium. A single sample was at or below the LDL of 0.5 ppm.

Table 3-34 Thorium concentrations in overburden and waste rock

Number	Units	LDL	Average	Max	Min	St Dev
182	ppm	0.5	12.5	30.2	0.5	6.8

3.16.4 Tailings and leachate

Test 1

In July 2014, Environmental Geochemistry International Pty Ltd reported assays of synthetic tailings at 16 mg/kg U. They also gave sequential leach results of both elemental U and Th in composite tailings liquor, all of which were below the <0.001 mg/l detection limit.

Test 2

An SGS Laboratories report of synthetic tailings dated 23 October 2017 and presented in a Worley Parsons report dated 15 December 2017 gave 7.1 ug/g uranium and 8.0 ug/g thorium in tailings. These results were received after submission of the Draft EIS.

Barrel leach tests are still underway. See Appendix 12 for more information.

3.16.5 Export Rock Concentrate

Test 1

Test work on a 32.8% P_2O_5 dry rock concentrate was reported by Prayon Technologies as part of the original Scoping Study. It had 22 ppm U_3O_8.

Test 2

A sample of Ammaroo export phosphate rock concentrate (14.47 %w/w Total Phosphorous) was analysed by ARL Laboratories and reported in early December 2017, after the submission of the Draft EIS. This new analysis gave 14 mg/kg uranium.

Test 3 and Check Repeat

SGS Canada Inc undertook independent assays of the export phosphate rock concentrate produced by COREM in Quebec from 30 t of Ammaroo rock. Their results reported on 06 December 2017, received after submission of the Draft EIS, gave 18.9 ppm U with a check repeat of 18.6 ppm and a detection limit of 0.05 ppm.

This sample was also analysed for thorium with a 0.2 ppm detection limit. It gave 6.8 ppm Th with a check repeat of 7.4 ppm.

3.17 Stygofauna

3.17.1 Scope

This section provides a desktop review of Stygofauna at the Ammaroo site. The review is not intended as a stand-alone report and should be read in conjunction with the Ammaroo Project EIS and Groundwater Study (EIS Appendix H) to provide project and hydrogeological context.

3.17.2 Background

Stygofauna are subterranean fauna occurring below the surface of the earth. Micro-habitats are provided by geology, water and spaces, ranging from small pores to aquifers. Subterranean fauna are known from karst (such as limestones and calcretes) and non-karst (banded iron formations, alluvial deposits and fractured rock aquifers) geologies. Species now occupying subterranean habitats have evolved from the fauna that lived at the surface before the aridification of the Australian continent (WA-EPA, 2007).

The Western Australian EPA released two guidance statements regarding subterranean fauna dealing with consideration during environmental impact assessment in WA-EPA, (2003) and sampling and survey in WA-EPA, (2007) and these have now been superseded by the Environmental Assessment Guideline No. 12 (WA-EPA, 2016).

The Queensland Department of Science, Information Technology, and Innovation, (QDSIT, 2015) also provides a Guideline for the Environmental Assessment of Subterranean Aquatic Fauna.

Both guidelines detail a staged investigation approach commencing with desktop study to determine the likelihood of stygofauna within the area of the proposal, and a determination of the likely degree of impacts. The aim of the desktop study is to determine if stygofauna are likely to be an environmental factor, and if so, guide subsequent survey to characterise the stygofauna population.

The guidelines describe the structure and aims of the desktop survey to:

- Assess the suitability of local habitat for subterranean aquatic fauna (based on local geological, hydrological and other information, including the distribution of any alluvium present in the project area and likely hydrological connectivity with geological formations targeted for development);
- Determine the presence and composition of subterranean aquatic fauna in the region and project area (based on previous published and/or unpublished studies); and
- Assess the likely degree of impact on any subterranean aquatic fauna including direct (e.g. drawdown of groundwater, compaction of habitat) and indirect impacts (e.g. siltation, groundwater contamination).

This approach has been implemented for the Ammaroo Project.

3.17.3 Literature Review

There is very little information available regarding stygofauna in the arid NT and specifically the Georgina Basin.

The most extensive groundwater studies in the area have been undertaken to support the Western Davenport Water Control District Water Allocation Plan (current plan dated 2011, and draft revised plan dated 2017). The revised draft plan allocates some 50 GL/year of groundwater from the Wiso Basin and Southern Georgina Basin to agriculture and strategic indigenous reserve. In that plan stygofauna are assumed not to exist as follows:

> *In some parts of central Australia, small aquatic invertebrate animals called 'stygofauna' have been found in water that has just been pumped from aquifers. The presence of these subterranean aquatic animals means that an aquifer is a GDE. As stygofauna have not been found in the District, for the purposes of this draft Plan, it is assumed that they are not present.*

As part of the Western Davenport Water Control District studies the NT Government's Department of Environment and Natural Resources (then NRETAS, 2009) undertook a survey of wetlands and groundwater dependant ecosystems within the Western Davenport Water Control District. That study, provided the following detail on stygofauna:

> *Australian government policy and the international wetland treaty (Ramsar Treaty) both recognise that small aquatic animals can occur in wet caves and in some aquifers. Macroscopic (visible without magnification) stygofauna (underground animals) have been found in calcrete and unconsolidated aquifers in the southern NT. Although stygofauna have not been recorded for the Western Davenport Water Control District, they may occur.*

A Department of Environment and Natural Resources, (2005) study into wetlands in the arid NT reports that sampling of two bores in Proterozoic Limestone near Alice Springs yielded no stygofauna. Sampling in calcrete aquifers in the Ngalia Basin did identify some species.

In August 2010, a stygofauna pilot survey was undertaken by GHD as part of the Nolan's Bore Phosphate and Rare Earth Elements Mine located approximately 300 km west-southwest of the Ammaroo Phosphate Mine site (GHD, 2011). The hydrogeological system sampled was the fractured rock aquifer of the Arunta Block and local carbonates (calcrete). Seven bores were sampled in accordance with the Western Australian EPA Guidance Statement 54 and 54a (EPA 2003, 2007). No stygofauna were found.

TNG's Mount Peake Project Titanium-Vanadium Project is located 190 km west of the Ammaroo Project on the Arunta Block and plans to extract groundwater from Quaternary sediments. Stygofauna are not considered in the 2016 EIS. The Biodiversity Management Plan submitted as part of the Supplementary information does discuss stygofauna and concludes that a suitable habitat in the Quaternary aquifer accessed by the project borefield is unlikely.

The Wonarah Phosphate Project is located on the Barkly Tableland 230 km north-east of the Ammaroo Project and plans to extract water from the Georgina Basin. Stygofauna are not considered in the 2009 EIS.

WA-EPA, (2016) reports that:

- The types of geology unlikely to support stygofauna include
  - deep sands or clays (especially over solid rock) or
  - hyper-saline (exceeding marine concentration) groundwater.
- The types of geology known to support stygofauna include
  - calcretes;
  - alluvial formations particularly when associated with alluvial or palaeochannel aquifers;
  - fractured rock aquifers, and
  - karst limestone

3.17.4 Ammaroo Project

Habitat suitability

At the mine site the habitat suitability is poor. The lithology of sedimentary rock is fine grained, and it is unsaturated. This overlies solid rock that did not yield measurable water to drilling. These rocks will not provide the pore spaces required to support stygofauna.

At the bore field and infrastructure corridor sites, the habitable suitability is higher. The aquifer comprises limestone with low salinity groundwater. The extent of the potential habitat is immense. The Georgina Basin is an intra-cratonic sedimentary basin extending approximately 330,000 km^2 within the NT and Queensland with a thickness exceeding 1000 m at the basin centre and thinning at the margins.

Presence and composition of stygofauna

There have been no stygofauna identified in the Georgina Basin due to negligible sampling effort. Studies by the NT government to support water allocation have concluded that stygofauna are assumed not to be present. Limited survey in similar rock in the NT (but not in the Georgina Basin) did not find stygofauna. The only recorded occurrence of stygofauna in the arid NT is in shallow calcrete in the Ngalia Basin.

3.17.5 Impact Assessment

The impact on potential stygofauna for this project is dewatering of the aquifer habitat in proximity to the borefield and at construction water supply bores along the infrastructure corridor.

The impact must be assessed in the context of habitat reduction, which is as follows:

- The mine water supply will result in water table drawdown of less than 10 m over an area of less than 1,250 km^2. The area of drawdown represents less than 0.5% of the total Georgina Basin extent, and the depth of drawdown is a small fraction of the more than 100 m thickness of the aquifer within the basin. The impact is temporary since water levels will recover once mining is complete and the borefield ceases to pump.
- Water supply bores along the construction corridor induce negligible drawdown. Drawdown will be less than 3.4 m at the pumping bores and the radius of drawdown will be less than 850 m from each pumping bore. Details of the drawdown calculation are provided in Section 5.3.5 of EIS Appendix H.

Given that there is no evidence of stygofauna at the project site (though their presence is possible) and the level of expected reduction in habitat, in the context of the size of the possible habitat, the potential impact is considered possible and insignificant. The impact to stygofauna from groundwater drawdown is low.

3.17.6 Tailings liquor and leachate chemistry

An additional tailings filter cake sample (Lot20/60/20 Final Tails) was subjected by SGS Minerals to total recoverable metals ((ICP-OES/MS) NAG, NAPP TCLP and modified TCLP (deionised water and CO_2 saturated solutions). The full report is available at Appendix 8.

Analysis of the recoverable portion of the sample determined that it was comprised primarily of silicates with moderate to minor amounts of calcium, aluminium, phosphorus, and iron.

The key findings of the analyses are:

- Standard acid base accounting demonstrated that the sample is not potentially acid generating due to a lack of acid generating sulphur content and an excess of acid neutralization capacity.
- The net acid generation test corroborated the acid base accounting result as no acid was generated upon aggressive oxidation.
- TCLP extraction results indicated that the sample would not be considered hazardous or potentially toxic as the extract passed the Australian drinking water quality (DWQ) guidelines for all parameters except pH (prescribed by the test method) and a marginally higher nickel concentration.
- CO_2 saturated deionized water extraction results indicated that the sample would be considered to have low toxicity as the extract passed the Australian DWQ guidelines for all parameters except the alkaline pH and a marginally higher lead concentration (0.0142 mg/L compared to 0.01 mg/L).
- Deionized water extraction results also indicated lox toxicity as the alkaline pH was the only parameter found to be outside the Australian DWQ guidelines.
- TCLP extract concentrations were higher than modified TCLP extracts in all cases except where a higher pH was favoured (carbonate, aluminium, iron, silicon as silica, titanium, and yttrium).

The analyses indicate that the various analytes that were elevated in the ore and waste rock leachate (ASLP) have been removed by the tailing liquor with leachate quality being higher than the ADWG (with minor exceptions), and higher than the underlying groundwater. Testing of the decant liquor should be carried out for future tailings batches, but given the mineralogy the liquor is likely to be similar to the ASLP water leach, subject to any influence from the source water.

3.18 Impacts on Overlying Aquifers

The extent of overlying aquifers is presented on Figure 3-15.

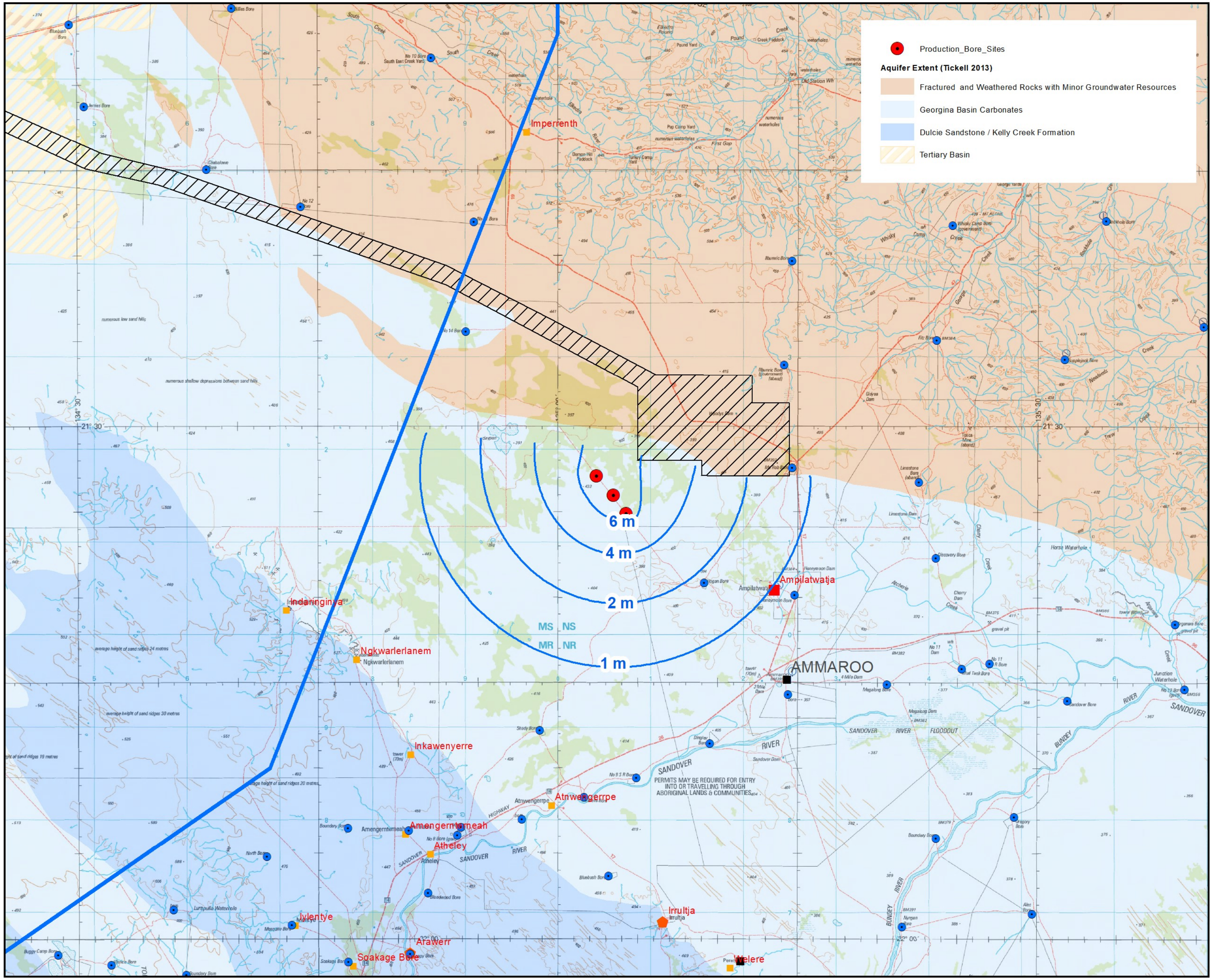
The closest margin of the Tertiary aquifers are located approximately 65 km to the northwest of the borefield.

The closest margin of the Dulcie Sandstone aquifer is located 25km to the southwest of the borefield.

Drawdown from borefield pumping at the end of mining is also presented on Figure 3-15.

The distance to the overlying Tertiary aquifer and the Dulcie Sandstone aquifer is greater than the radius of drawdown from borefield pumping and no impacts on these aquifers are expected.

Water levels in the Dulcie Sandstone will be monitored at a bore twinned on “Shady Bore”. Monitoring bores will also be placed between the borefield and the Tertiary Aquifer to the Northwest (refer section 3.19.3).



Production_Bore_Sites

Water Table Drawdown (m)

Third Party Water Bores

Western Davenport Water Control District

NT_Aboriginal_Communities

MAJOR

MINOR

TOWN CAMP

FAMILY

Stations

Project Infrastructure

GROUNDWATER SCIENCE

Job Number: RJR-16-3

Client: Verdant Minerals

Version: 1 Date: 11/03/2018

Drawn by: BJ

N

0 5 10 20
Kilometers

Coordinate System: GDA 1994 MGA Zone 53

Borefield Drawdown
End of Mining

Figure xx.xx

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Document Name: RJR-16-3 Drawdown

3.19 Groundwater Monitoring

The groundwater Monitoring plan for the project is detailed in Section 4.5 of the Water management Plan attached to this report as an appendix. An overview is presented here.

3.19.1 Design

Borefield

Groundwater monitoring to measure the impact of borefield pumping is detailed in Table 3-35 and Figure 3-16. The monitoring network comprises 14 observation bores extending out from the borefield in all directions.

Observation bores located adjacent pastoral bores will be located approximately 200 m from the pastoral bore to assess drawdown without being overly impacted by intermittent low rate pumping from the pastoral bore.

Additional observation bores will be installed beyond the current predicted zone of drawdown if measured drawdown exceeds predicted drawdown.

Tailings

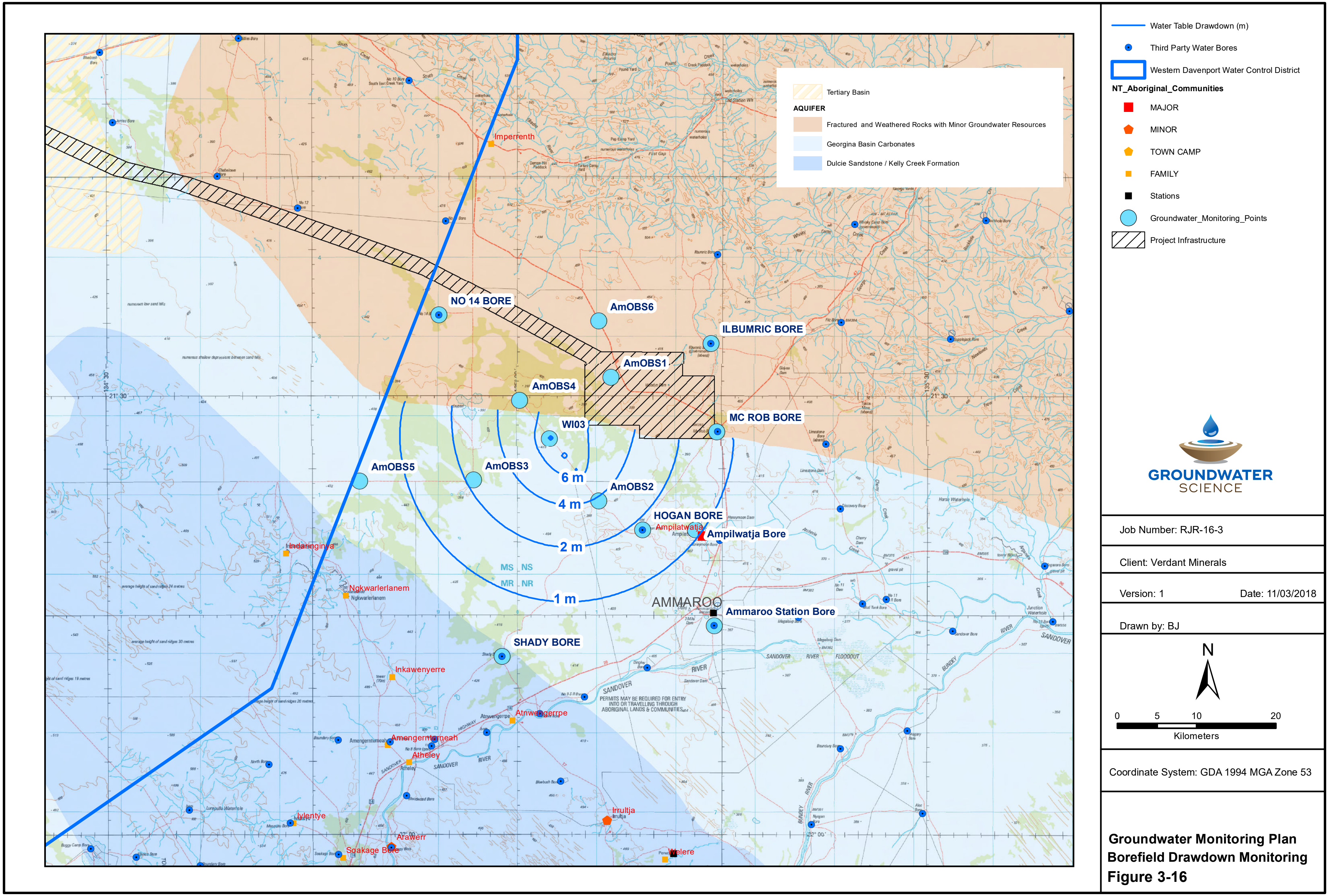
Groundwater Monitoring to measure the impact of tailings seepage is detailed in Table 3-35 and Figure 3-17. Two bores will be located down-gradient of the Ex-pit TSF, and two bores will be located down-gradient of the in-pit tailing storage. The existing bore AMObs1 is located upgradient of the pits and provides baseline data.

Bore Design

Bores will be constructed in accordance with the Minimum Construction Requirements for Water Bores in Australia. The nominal bore design comprises 100mmDN Class18 UPVC Bore casing with slotted production zone. Bores will be drilled to approximately 30m below the first water yielding interval. The bore casing will be slotted against water producing intervals. The screen annulus will be gravel packed, and the casing annulus grout sealed to prevent surface water ingress. A steel lockable cover will be installed to protect the PVC from damage and to secure logging equipment.

Bores will be survey to measure elevation and allow relative standing water level to be determined.

All bores will be registered with DENR and allocated an RN number



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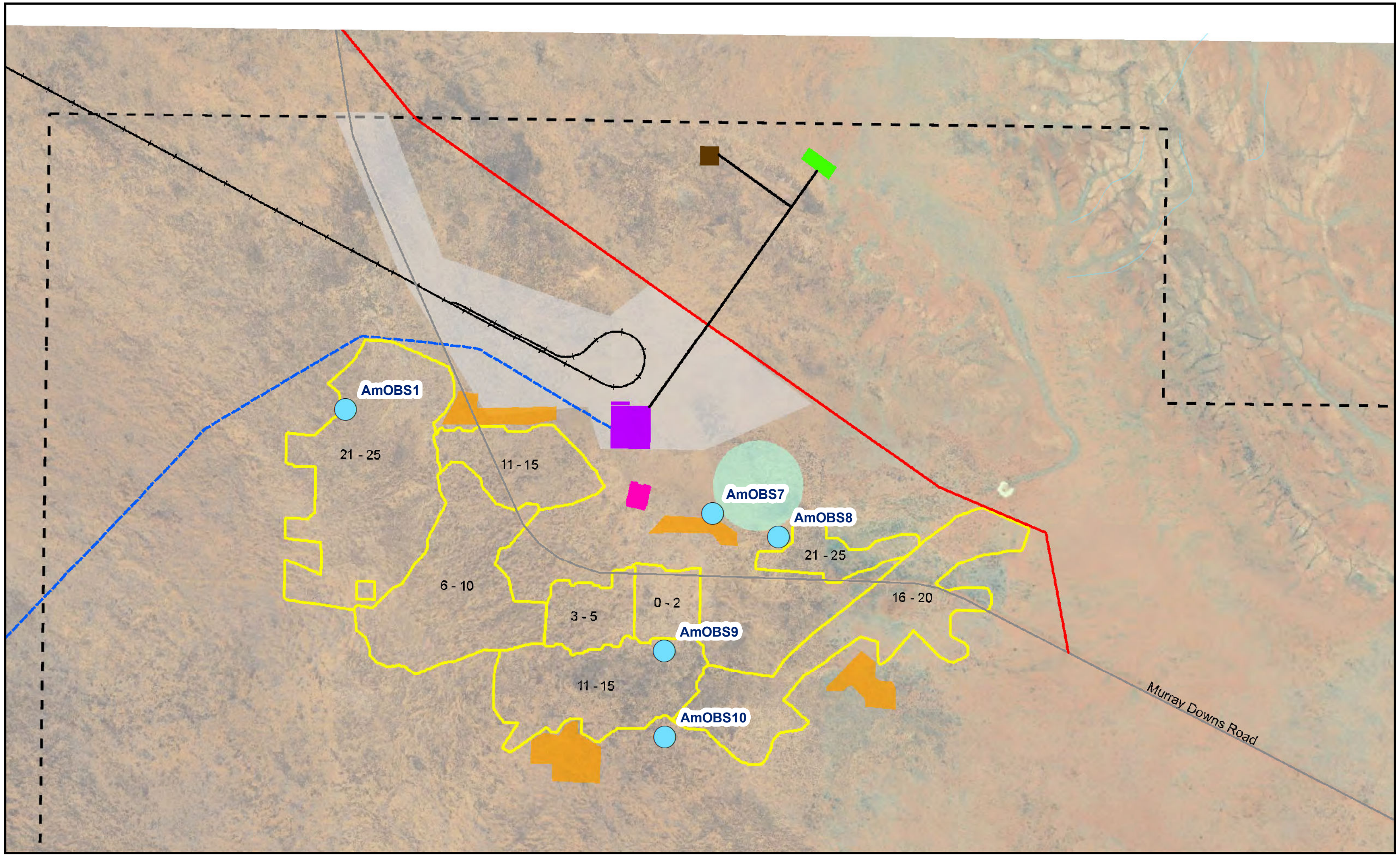

LEGEND

Existing roads	Accommodation camp	Construction area
Road realignment	Landfill	Beneficiation plant
Access road	ROM	Surface tailings storage facility
Water supply pipeline	Mineral lease	Temporary waste stockpiles
Access corridor	Pit extent (years)	

Groundwater_Monitoring_Points

GROUNDWATER SCIENCE

Job Number: RJR-16-3

Client: Verdant Minerals

Version: 4 Date: 17/04/2018

Drawn by: BJ

N

0 0.5 1 2
Kilometers

Coordinate System: GDA 1994 MGA Zone 53

Groundwater Monitoring Plan Mine Site Monitoring Figure 3-17

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Document Name: RJR-16-3 Minesite Monitoring

Table 3-35 Groundwater Monitoring Well Network

Bore NAME	X	Y	Aquifer Monitored	Purpose	Monitoring		
					Water Level Measurement	Water Quality Analysis	Volume Pumped
ILBUMRIC BORE (Twinned Obs)	524424	7629115	Tenant Creek Block	Third Party Impact Assessment	Monthly	Annually	N/A
HOGAN BORE (Twinned Obs)	515779	7605608	Georgina Basin Carbonate	Third Party Impact Assessment	Monthly	Annually	N/A
SHADY BORE (Twinned Obs)	498094	7589676	Dulcie Sandstone	Third Party Impact Assessment	Monthly	Annually	N/A
MC ROB BORE (Twinned Obs)	525285	7617999	Tenant Creek Block	Third Party Impact Assessment	Monthly	Annually	N/A
NO 14 BORE (Twinned Obs)	490114	7632728	Tenant Creek Block	Third Party Impact Assessment	Monthly	Annually	N/A
Ammaroo Station Bore (Twinned Obs)	524859	7593518	Georgina Basin Carbonate	Third Party Impact Assessment	Monthly	Annually	N/A
Ampilwatja Bore (Twinned Obs)	522447	7605625	Georgina Basin Carbonate	Third Party Impact Assessment	Monthly	Annually	From PWC
AmOBS2	510258	7609283	Georgina Basin Carbonate	Drawdown Validation – Ampilwatja and Ammaroo Leading Indicator	Monthly	Annually	N/A
AmOBS3	494479	7611928	Georgina Basin Carbonate	Drawdown Validation - WCD leading indicator	Monthly	Annually	N/A
AmOBS4	500431	7621943	Tenant Creek Block	Drawdown Validation	Monthly	Annually	N/A
AmOBS5	480118	7611739	Tenant Creek Block	Drawdown Validation - WCD boundary	Monthly	Annually	N/A
AmOBS6	510258	7631959	Tenant Creek Block	Drawdown Validation – Tenant Creek Block	Monthly	Annually	N/A
AmOBS1	511958	7624872	Tenant Creek Block	Tailing Seepage Assessment	Monthly	Quarterly	N/A
AmOBS7	515965	7623742	Tenant Creek Block	Ex-Pit TSF Seepage	Monthly	Quarterly	N/A
AmOBS8	516685	7623488	Tenant Creek Block	Ex-Pit TSF Seepage	Monthly	Quarterly	N/A

AmOBS9	513236	7621714	Tenant Creek Block	In-Pit TSF Seepage	Monthly	Quarterly	N/A
AmOBS10	515413	7621163	Tenant Creek Block	In-Pit TSF Seepage	Monthly	Quarterly	N/A
WI03	504179	7617158	Georgina Basin Carbonate	Bore field Performance	Monthly	Annually	N/A
Production Bores			Georgina Basin Carbonate	Bore field Performance	Monthly	Quarterly	Monthly
Additional bores beyond the predicted radius of drawdown.	Not defined		Georgina Basin Carbonate	Contingency if drawdown exceeds prediction	Monthly	Annually	N/A

3.19.2 Implementation Schedule

Currently 3 observation bores are in place. One at the borefield site (WI03), one at the mine site (AMObs1) and a third upgradient of the mine site (AMObs6). Monitoring of these bores has commenced in order to provide an ongoing baseline data set.

The remaining 15 observation bores will be installed at the beginning of the construction phase. This will enable collection of one year of pre-mining baseline data.

Additional observation bores will be installed beyond the current predicted zone of drawdown if measured drawdown exceeds predicted drawdown. The timing of these bores will be dependent on monitoring results. The implementation schedule is outlined in Table 3-36.

Table 3-36 Groundwater Monitoring Schedule

Mine Stage	Bores
Pre-construction (Baseline) Currently In progress	WI03, AMObs1, AMObs6
Construction (pre-mining baseline)	ILBUMRIC BORE (Twinned Obs) HOGAN BORE (Twinned Obs) SHADY BORE (Twinned Obs) MC ROB BORE (Twinned Obs) NO 14 BORE (Twinned Obs) Ammaroo Station Bore (Twinned Obs) Ampilwatja Bore (Twinned Obs) AmOBS2 AmOBS3 AmOBS4 AmOBS5 AmOBS7 AmOBS8 AmOBS9 AmOBS10
Contingency	Additional bores beyond the predicted radius of drawdown.

3.19.3 Monitoring Suite and Frequency

Water levels at all bores will be measured daily by data logger, downloaded quarterly.

Water quality will be monitored annually at all observation bores, and quarterly at pumping bores and TSF Seepage monitoring bores. A full suite of analytes per Table 3-37 will be analyses at all bores. The monitoring suite and frequency will be reviewed and optimised following two years data collection. Water quality sampling and analysis and QA/QC will be undertaken in accordance with guidelines (GA, 2009).

Volumes pumped will be recorded monthly for VRM production bores. Flow meters will comply with DENR Requirements. Groundwater use data from Ampilwatja Water supply will be requested from Power Water Corporation at the frequency that is available.

Water level observations from Shady bore, Ammaroo Station Bore and AMOBS5 will be used to identify natural recharge processes.

Pastoral bore extraction rates/volumes are estimated on an annual basis to assist with interpretation of potential variations in water level responses and to comply with the requirement to monitor discharge process.

3.19.4 Monitoring Program Review and Optimisation

The monitoring suite and frequency will be reviewed and optimised following two years data collection and every two years thereafter.

The monitoring plan will be reviewed after establishing local groundwater flow directions to ensure the bores are adequately located to fulfil their monitoring objective. If stated objective is not met additional bores will be installed.

Table 3-37 Groundwater Monitoring Analytical Suite

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

3.20 Groundwater Trigger Levels and Mitigation Measures

3.20.1 Water Table Drawdown from Borefield Pumping

Water table drawdown from borefield pumping will be measured at observation bores 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 borefield.

A trigger value is defined as: measured drawdown at observation bores exceeds the range of drawdown predicted by modelling.

Mitigation measures will be implemented sequentially as follows:

Stage 1. Development of a Class 2 Groundwater flow model will be undertaken in accordance with the Australian Groundwater Modelling Guidelines (NWI, 2012). Volumes pumped from the bore field and Ampilwatja community water supply will be used to define hydraulic stress for the model. Water level drawdown measured at the monitoring bores will be used to provide a calibration data set. Aquifer parameters applied in the model will be adjusted such that the model drawdown matches the measured drawdown. The Approach is illustrated in Figure 3-18.

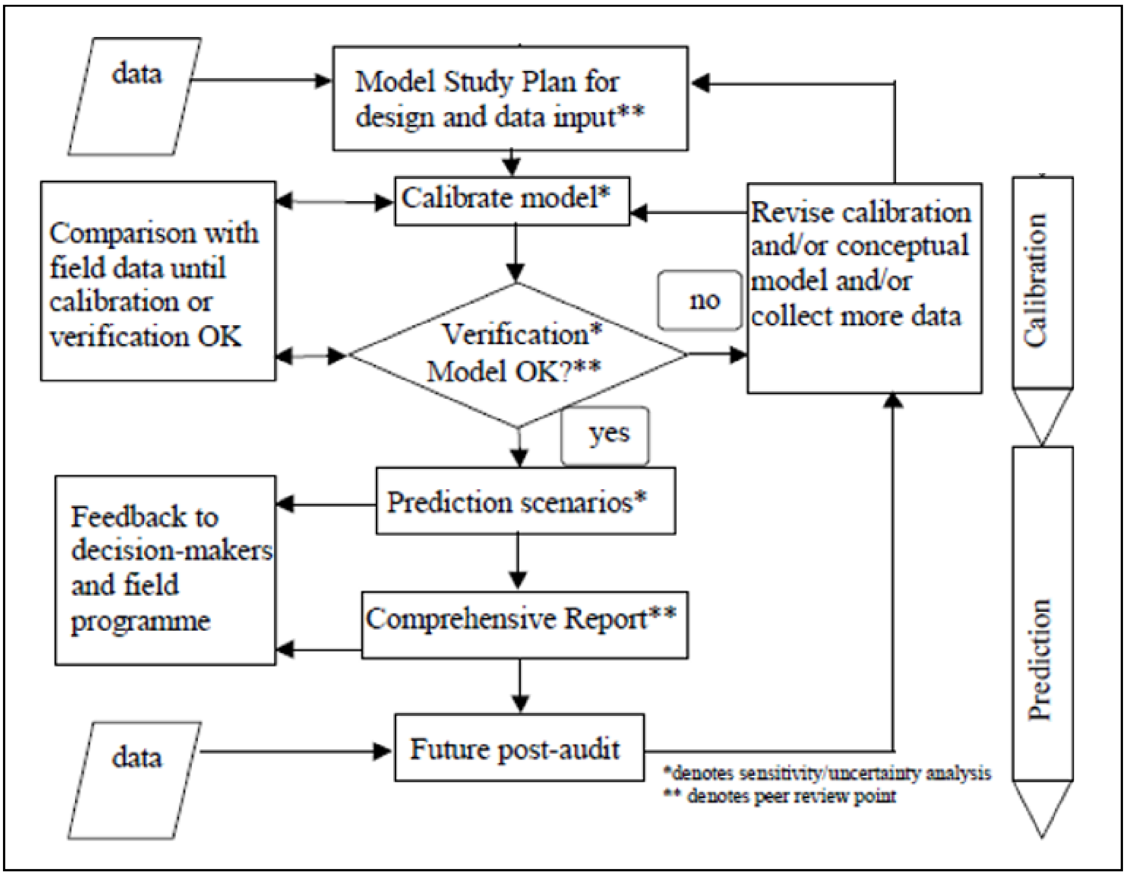


Figure 3-18 Model Revision Methodology (After MDBC, 2000)

The recalibrated model will be run to predict drawdown impacts on other users. If these impacts will reduce water availability to other users, then subsequent mitigation will be implemented.

The model set-up may require modification to better meet the model objective which is to predict the aquifer response to borefield pumping and borefield closure. Possible changes include: model development in 3 dimensions, definition of parameters zones to simulate varied geology, and modification of boundary conditions and the storage depletion approach.

Future models will be assessed as part of ongoing authorisation under the MM Act.

A recalibrated model will be delivered within one year of the trigger value being exceeded.

Stage 2. Make-good measures at other users to ensure water availability. For example, deepening bores and upgrading pumps.

Stage 3. Increased process water efficiency to be studied and implemented if practicable.

Stage 4. Modified pumping regimes to be implemented if significant impacts associated with groundwater drawdown are identified.

3.20.2 Water Table Drawdown from Construction Bore Pumping

No monitoring, trigger levels or mitigation measures are proposed for this negligible impact activity.

3.20.3 Tailing Leachate Seepage from ex-pit and in-pit Tailings

Groundwater levels and water quality downgradient of tailing storage will be monitored at 4 observation bores to detect seepage if it occurs.

Trigger Levels comprise:

- Water level rise beyond seasonal variation.
- Water quality declining from baseline.

Mitigation measures will be implemented sequentially as follows:

Stage 1: Assess the impact of water table rise. Water level rise can impact the environment if water levels rise to the root zones of plants, nominally higher than 15m below ground surface. Or if water tables rise to ground surface and cause soil waterlogging and/or salinization.

Assess the impact of water quality decline. The current beneficial use of groundwater beneath the mine is pastoral use. The impact of tailings leachate seepage if detected should be assessed to determine if the beneficial use category of groundwater will change. i.e. tailing seepage causes the groundwater to longer be suitable for pastoral use.

Stage 2: If tailing seepage causes unacceptable impacts (Water table rise to near surface or change in beneficial use) then design and implement seepage management measures:

- Pump and treat seepage from beneath the TSFs for subsequent re-use in the process plant.
- Implement underdrainage in subsequent in-pit storage cells to reduce seepage.

3.21 Bore Construction

Bores will be constructed with Inert Casing. Either PVC or FRP. Casing will be grouted from the top of the aquifer to ground surface in order to seal the annulus and prevent vertical movement of water.

Bores will be decommissioned by grouting from the end of hole back to surface in order to fully seal the borehole.

Casing at surface will be removed and the site rehabilitation to allow revegetation.

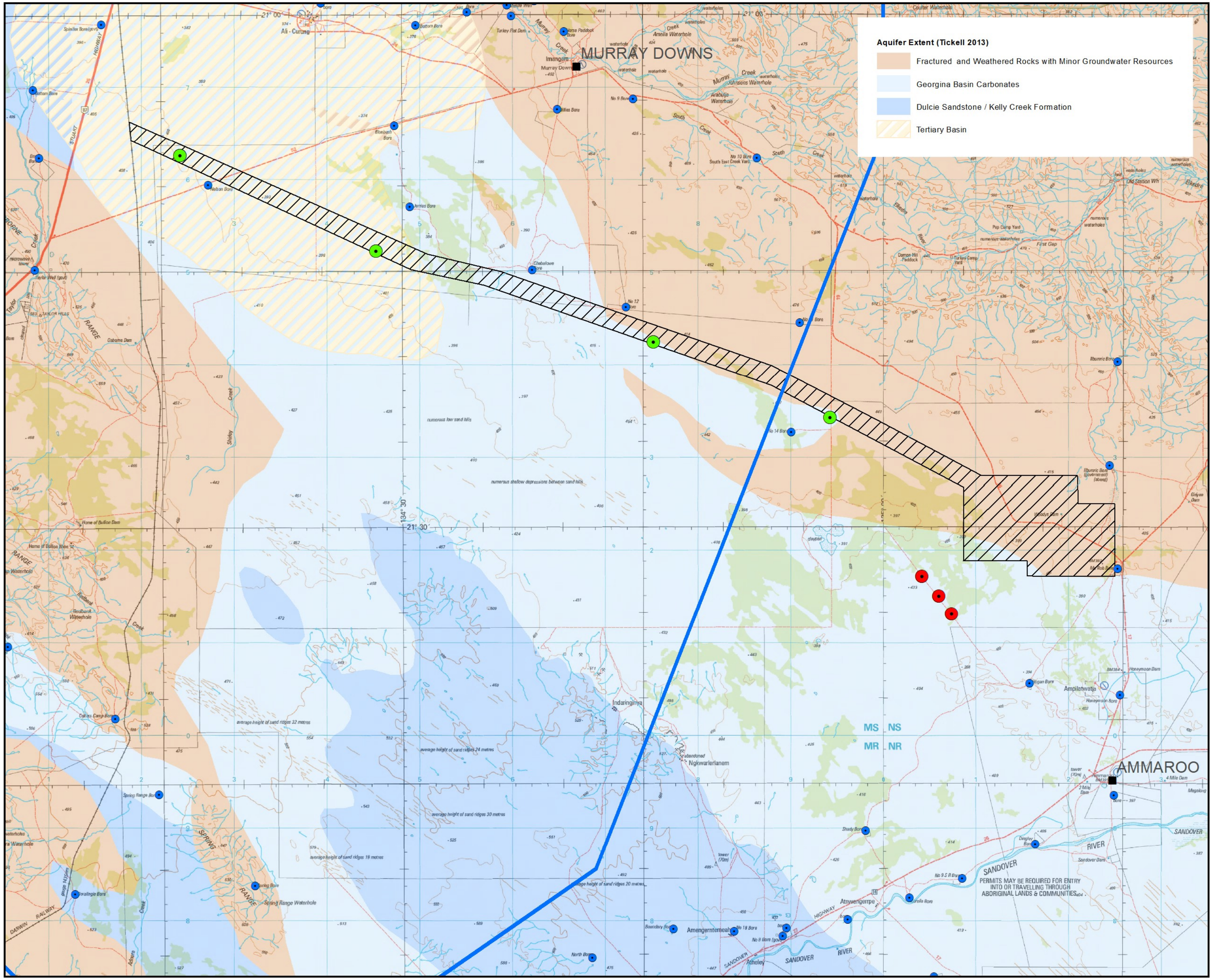
All bore construction and decommissioning will be undertaken by licensed drillers in accordance with the National Uniform Drillers Licensing Committee, 2011, Minimum Standards for Water Bore Construction in Australia, Third Edition, 2012.

3.22 Location of Temporary Bores along the Corridor

The nominal location of temporary bores used for construction of the corridor is presented as Figure 3-19 .

The bores are spaced at approximate 20 km intervals to allow efficient water supply from dust suppression and material placement.

The locations may require adjustment to site specific conditions.



Temporary Construction Bores
Production_Bore_Sites
Third Party Water Bores
Western Davenport Water Control District
Stations
Project Infrastructure

GROUNDWATER SCIENCE

Job Number: RJR-16-3

Client: Verdant Minerals

Version: 1 Date: 11/03/2018

Drawn by: BJ

N

0 5 10 20
Kilometers

Coordinate System: GDA 1994 MGA Zone 53

Temporary Construction Bores

Figure xx.xx

Document Path: C:\Users\Ben Jeuken\Dropbox (Groundwater Science)\Groundwater Science Team Folder\Project Files\RJR\RJR-16-3 Ammaroo EIS_BFS\EIS\GIS\Supplementary\RJR-16-3 Corridor Bores.mxd
Document Name: RJR-16-3 Corridor Bores

4. Commitments

A summary of commitments made in the Supplementary Report are provided in Table 4-1 Commitment RegisterTable 4-1.

Table 4-1 Commitment Register

Aspect	Commitment	Timeframe
Risk assessment	All mitigation measures proposed in the risk register will inform the Mine Closure Plan	Prior to mining
TSF	An appropriately qualified Certifying Engineer will oversee the design, construction, operation and decommissioning of the surface TSF.	Ongoing
Tailings	Tailing samples will be added to the bulk leach test work when sufficient quantities of tailings are available. Future tailings samples will be subjected to bench-scale testing to compare with previous testing.	Operation
Infrastructure Corridor	Construction of the corridor will be timed to occur during the dry season in order to minimise the need to divert water around active works areas.	Construction
Erosion	Upon completion of final design, an ESCP will be prepared by a suitably qualified professional and experienced; and included in the Mine Management Plan	Prior to mining
Heritage	The CHMP will be updated to include an unexpected heritage finds procedure. The CHMP will be submitted to the Heritage Branch for endorsement.	Prior to construction
	Verdant will seek an Authority Certificate from AAPA and all works will be conducted in accordance with the conditions of the Authority Certificate.	
	The risk register and Cultural Heritage Management Plan will be updated on receipt of the Authority Certificate.	
	Verdant will seek all necessary approvals required under NT and Commonwealth legislation.	
	Verdant will further discuss possible crossings for continued access to important hunting grounds with the Native Title Holders during future discussions.	Ongoing
Flora and fauna	Should Greater Bilby be found on or near the site the Biodiversity Management Plan will be reviewed and updated to provide additional traffic management protocols to minimise traffic impacts to the species.	Ongoing
	During the installation of the gas pipeline, where applicable (i.e. where trenches are open for distances greater than): • Trench plugs and ramps will be installed at maximum intervals of 500 m. • Fauna shelters will be installed with one per 500 m interval between trench plugs • Funnel traps may be installed to help trap and subsequently remove animals between trench plugs. • Daily trench inspections of entire length of trench.	Construction

Aspect	Commitment	Timeframe
	These controls will be included in the Biodiversity Management Plan.	
	The identification, control and monitoring of *Cenchrus ciliaris* will be explicitly included in the Weeds Management Plan	Prior to construction
	If a bat roost is discovered within the project area, Verdant will liaise with DENR regarding the significance of the roost and whether any mitigation is required.	Ongoing
	Training will be provided to all staff as part of the site induction for the purpose of reporting encounters to identify threatened flora and fauna, as well as reporting encounters with flora and predators.	Ongoing
Water	Verdant will seek water extraction licences as required under the amended Water Act.	When Water Act amended
Waste Water	Process water ponds (also referred to as Water Collection Ponds) will be lined. The ponds will be designed to prevent spilling in events where dilution by surface water flows would be less than a factor of 5.	Construction Prior to construction
Groundwater	Implementation of an independently peer reviewed and Regulator-approved Water Management Plan Verdant commit to ensuring no reduction in water availability to other users because of mining. Mitigation measures include deepening bores and upgrading pumps.	Ongoing Ongoing
Closure	Conduct pre-closure trials and investigations that will inform the success or otherwise of seeding in an arid zone.	Prior to closure
	Provision of a detailed Rehabilitation Plan within with completion criteria, including appropriate monitoring and management of flora, fauna and environmental values, for progressive rehabilitation in the Mine Closure Plan.	Prior to mining
	A conceptual design for tailings cover will be provided in the Mine Closure Plan.	Prior to mining
Compliance	Verdant will seek all necessary approvals required under NT and Commonwealth legislation	Ongoing

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Appendices

Appendix 1 – Updated Ammaroo Closure Report

Appendix 2 – Tailings Storage Facility Drawings (WSP 2018)

Appendix 3 – Peer Review of AMD Assessment

Appendix 4 – Water Balance (WSP 2018)

Appendix 5 – Historical Rehabilitation Time Series

Appendix 6 – Water Management Plan

Appendix 7 – Peer Review of the Groundwater Monitoring Program

Appendix 8 – Tailings Characterisation Report (SGS Minerals Services, 2017)

Appendix 9 – Process Water Test Work

Appendix 10 – Geochemical Assessment of Phosphate Flotation Tailings (EGI 2014)

Appendix 11 - Declaration – Peer review of AMD Report and Management Plan

Appendix 12 - Barrel leachate results, July 2018

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Document Status

Revision	Author	Reviewer		Approved for Issue		
		Name	Signature	Name	Signature	Date
0	L. Kneen K. Marmion B. Jeuken R. Virtue T. Ewers-Reilly A. Wyatt D. Craggs	N. Conroy		N. Conroy	[signature]	30/07/2018
1	L. Kneen K. Marmion B. Jeuken R. Virtue T. Ewers-Reilly A. Wyatt D. Craggs	N. Conroy		N. Conroy	[signature]	02/08/2018

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Appendix 1 – Updated Ammaroo Closure Report

Verdant Minerals Ltd

Ammaroo Phosphate Project
Closure Report

July 2018

Executive summary

The purpose of this report is to succinctly document key closure concepts, risks and tasks for the Ammaroo Phosphate Project.

The project site is divided into the following key areas including:

- Construction area (including administration, plant and permanent camp areas)
- Open pits (in-pit tailings / waste backfill)
- Starter tailings storage facility (TSF) or surface TSF
- Production borefield
- Waste rock piles
- Temporary soil stockpiles
- Access corridor and pipeline
- Borrow pits and their access roads
- Murray Downs Road realignment area

The proposed closure concept is to progressively backfill pits with tailings and waste rock. All other areas (other than the Murray Downs Road realignment area) will be rehabilitated to reflect the current predominantly flat area geometry. These areas will be re-covered with stockpiled soil cover (from their own or nearby footprints) and revegetated to enable a natural habitat compatible with the proposed post closure pastoral use.

Based on areas of disturbance during operations and the proposed closure concepts, a materials balance has been developed to ensure sufficient closure materials are available and stockpiled in suitable proximity to efficiently execute rehabilitation of landforms.

A risk assessment was undertaken to identify the key environmental risks associated with mine closure, these include management of potentially contaminated sites, surface and groundwater quality and long term final landform stability for which mitigation strategies have been proposed.

This report is subject to, and must be read in conjunction with, the limitations set out in section 1 and the assumptions and qualifications contained throughout the Report.

Table of contents

Table index

Figure index

1. Introduction

1.1 Purpose of this report

The purpose of this report is to succinctly document key closure concepts, risks and tasks for the Ammaroo Phosphate Project. Verdant Minerals Ltd commits to a the production and provision of a detailed Rehabilitation Plan within with completion criteria, including appropriate monitoring and management of flora, fauna and environmental values, for progressive rehabilitation in the Mine Closure Plan (MCP). Content from this document will eventually be incorporated into the MCP, which will be incorporated into the broader Mine Management Plan (MMP).

1.2 Scope and limitations

This report is subject to, and must be read in conjunction with, the limitations set out in main Draft Environmental Impact Statement (EIS) document and the assumptions and qualifications contained in that Report.

Where practicable, this document refers to information contained within other sections of the draft EIS to avoid reproducing generic or detailed information.

No field investigations have been undertaken as part of the preparation of this report. GHD has prepared this report on the basis of information provided by Verdant Minerals Ltd and others who provided information to GHD, which GHD has not independently verified or checked beyond the agreed scope of work. GHD does not accept liability in connection with such unverified information, including errors and omissions in the report which were caused by errors or omissions in that information. Likewise, GHD has not undertaken any mining engineering, closure designs or works that demonstrate the effectiveness of the closure tasks or strategies proposed in this specific location or with the material specific to this location.

2. Closure context

2.1 Project description

2.1.1 Location

The Ammaroo Phosphate Mine Site is located 270 km north east of Alice Springs, 125 km east of Barrow Creek (latitude 21° 39’ 52” longitude 135° 16’ 48”). The project is located on the western side of the Georgina Basin, north of the Sandover Highway (Figure 2-1).

2.1.2 Mining

The project is currently being designed to produce up to 2 million tonnes per annum (Mtpa) of phosphate concentrate over an operational period of 25 years, which will result in waste rock and tailings production of approximately 4 -18 Mtpa and 2-5 Mtpa (dry) respectively. The operation will mine and concentrate phosphate rock, which will be transported from the Ammaroo site to the Port of Darwin for export.

The larger Ammaroo deposit, including areas outside the ML, comprises an area of some 40 km in length, extending approximately 6 km North-South (across). It is overlain by overburden with an average depth to mineralisation of around 23 m, to a maximum 56 m. The overburden consists of a layer of top soil (red sandy silt fine and gravel), underlain by weathered siltstone and low grade (<10% P_2O_5) phosphatic siltstone. The phosphate resource is underlain by dolomitic limestone.

The open pit is currently designed to an average depth of between 20-30 m and a maximum depth of 60 m below ground level, and as it is above the water table, where measured, it will not require dewatering other than for surface water inputs.

Progressively, the pit will be advanced typically at one strip at a time. After the initial strip is exhausted, waste rock from the subsequent cut will be stored in the pit void, negating the need for an expanding waste rock dump. As the mine is advanced, the prior strip will be progressively rehabilitated. The mine will utilise bench heights of 8 m. The benches will be mined in two passes (flitches) of 4 m in height where required. The mining process will be the same for both ore and overburden (waste rock).

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0 25 50 75 100

Kilometres

Map Projection: Universal Transverse Mercator
Horizontal Datum: GDA 1994
Grid: GDA 1994 MGA Zone 53

N

LEGEND

- Towns
- Communities
- Homesteads
- Roadhouses
- Major Road
- Local Road
- Rail
- Amadeus gas pipeline
- Access corridor
- Mineral lease

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Verdant Minerals Ltd
Ammaroo Phosphate Project

Job Number	43-22544
Revision	0
Date	06 Oct 2017

Site Overview

Figure 2-1

G:\43\22544\GIS\Maps\4322544_101.mxd

Level 5, 66 Smith Street Darwin NT 0800 Australia T 61 8 8982 0100 F 61 8 8981 1075 E drwmail@ghd.com W www.ghd.com

Data source: GA - Roads, Places, Rail, Pipeline (2015) Google Earth Pro - Imagery (Date extracted: 07/09/2017). VML - Proposed Corridor, Project Site (2017). Created by: CM

2.1.3 Soil and waste rock dumps

Before mining, topsoil is stripped and stored for subsequent placement during rehabilitation. The mine will operate on a strip mining method with the overburden in the first year being used for construction purposes or stored in a waste rock dump. After the first year of mining, the waste rock will be returned to the mine to fill the void created by previously mined strip.

2.1.4 Tailings

Ore will be processed at the beneficiation plant to produce the phosphate rock concentrate product. The key inputs into the beneficiation process include:

- The mined phosphate ore
- Sodium silicate (n-Grade) as a silica depressant
- Sodium carbonate as a pH modifier
- Flocculant
- Emulsified collector
- Process water

The key outputs of the beneficiation process are:

- Concentrated dried phosphate rock (75% input phosphate) for export.
- Wet tailings (25% of input phosphate) and recycle process water stored in engineered ponds.

2.2 Land use and tenure

Verdant Minerals Ltd holds secure title over the deposit under ML 29463 and ML 29854. The subject area is located on perpetual pastoral lease within the traditional country of the Anmatyerr people. The predominant land use is cattle grazing. Mineral exploration (including that associated with the Ammaroo Phosphate Project) has also taken place as far back as the 1960s.

2.3 Physical environment

The following is a brief description of the physical environment. A more detailed description of the physical features of the project site is available in other parts of the draft EIS and related technical appendices.

2.3.1 Topography

The regional topography surrounding the project area is described as generally flat to undulating sand plains with some rounded ridges or broad rises. The Project site lies in the low point of a relatively flat area at an elevation of about 400 metres AHD with a wide area of low sand hills to the west.

2.3.2 Climate and surface water

The mean monthly maximum and minimum temperature over a 30 year period (1988 – 2016) indicate that the mean summer maximum temperatures are between 37 and 38 degrees Celsius, with mean summer minimum temperatures between 23 and 24 degrees Celsius. The mean winter maximum temperatures are between 24 and 27 degrees Celsius and the mean winter minimum temperatures are between 7 and approximately 9 degrees Celsius (BOM 2017).

Rainfall figures over a 30 year period (1988 – 2016) indicate an annual average rainfall of 315 mm (BOM 2017).

Surface water features in this climate are all ephemeral. Surface water features are presented and discussed in more detail in the surface water impact assessment in the draft EIS.

2.3.3 Geology and hydrogeology

The Ammaroo Project is located in the Cambrian sequence of the Georgina Basin. The simplified composite Cambrian stratigraphy is shown in Figure 2-2. The phosphate occurs in the Arthur Creek Formation.

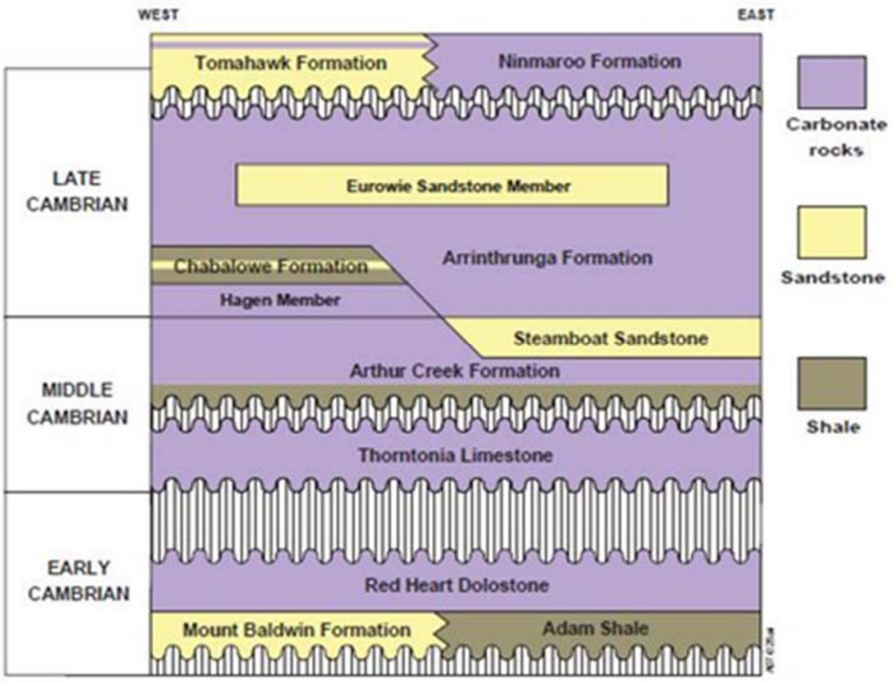


Figure 2-2 Simplified Cambrian lithostratigraphy of the southern Georgina Basin, from NTGS

Most of the successful water bores drilled in the project area and surrounds are located within the Georgina Basin sedimentary rocks. The sandstone, limestone and dolostone units exhibit reasonable primary porosity, whilst fault structures and solution joints provide secondary porosity to facilitate well yields (Groundwater Science, 2012).

Groundwater flows from the margins of the Georgina Basin from north-east, north-west and south-west and converges towards the centre, to an area south of a centre point within the project boundary, and then towards the east. Standing water levels in this area are some 60 to 100 m below ground surface (Groundwater Science, 2012).

2.3.4 Geochemistry

The geochemistry of the deposit is summarised in the acid, metalliferous and saline drainage (AMD) Assessment and Management Plan (Appendix I of the draft EIS). This report states that based on the overall geochemistry of the waste rock and ore, the risk of acid, metalliferous or saline drainage is very low and the material can be managed as non-acid-forming, non-saline, non-metalliferous and non-radioactive waste.

2.4 Landscape condition

The project site lies within the pastoral stations of Ammaroo, Murray Downs and Neutral Junction, which have a moderate level of habitat degradation typical of that associated with cattle grazing in central Australia (i.e. increased weeds, erosion development, changes to soil surface structure/infiltration, water source degradation and altered fire regimes).

2.4.1 Habitat areas

Mine site and water supply infrastructure

The mine site and water supply infrastructure areas constitute red earth plains and shallow sandplains, which support a mixture of low woodlands and low open woodlands (Mulga, Gidgee, Coolabah and Bloodwood) over short-lived tussock grass.

There is a moderate level of pastoral activity within the mine site area and water supply infrastructure corridor, with the highest activity occurring in red earth plain (due to the presence of palatable species).

Weed occurrences are typically associated with station tracks and watering points such as Woody's Dam. Overall, a low weed presence was observed during surveys, with only a few isolated Rubber Bush (*Calotropis procera*, Class B weed) plants observed, and several other non-declared grass species.

Access corridor and gas pipeline

The access corridor is 137 km in length, and spans a variety of different landforms and associated vegetation communities. Broadly, the access corridor can be discussed in terms of the eastern half and western half, as these areas support distinctly different landform types.

The eastern half of the corridor supports a mixture of red earth plains, shallow red earth sandplains, low rocky rises, alluvial plains and several seasonal swamps. Vegetation varies from Mulga woodlands (over tussock grasses) on the red earths, *Acacia* spp. and Mallee (*Eucalyptus* spp.) shrublands (over Spinifex) on the shallow sandplains, and Mulga and Smooth-barked Coolabah (*Eucalyptus victrix*) woodlands (with tussocks and sedges) in drainage floors and swamps.

The western half of the corridor supports extensive areas of desert (aeolian, windblown) sandplains, small pockets of Mulga dominated red earth plains, and one floodplain associated with the Taylor Creek drainage system (which originates from ranges situated to the south). Vegetation within the sandplains is predominantly Acacia shrublands over Spinifex with the western areas supporting moderate densities of Bigfruited Bloodwood (*Corymbia sphaerica*). The floodplains support variable densities of Smooth-barked Coolabah (*Eucalyptus victrix*), Bean Tree (*Erythrina vespertilio*), Bloodwood (*Corymbia opaca*), and Sandhill Teatree (*Melaleuca lasiandra*) over a diverse range of tussocks, sedges, and forbs.

Drainage features also occur within the western half of the access corridor – drainage floors, alluvial plains and seasonal swamps; however, no watercourses have been identified.

In general, pastoral impacts are noted as low to absent within the sandplains due to the dominance of Spinifex understory (i.e. hummock grassland) which has very little grazing value. The red earth plains have moderate levels of pastoral activity, especially in areas close to water points or cattle yards.

Taylor Creek floodplain has been noted as having a moderate to high level of pastoral impact, due to the presence of several water points, yards, station tracks and bores. Buffel Grass (introduced grass species of benefit to the pastoral industry) was widespread in these floodplains, and several other weed species (including patches of Rubber Bush, *Calotropis* procera, a Class B species under the *Weeds Management Act*) were also noted.

Field surveys confirmed the only sensitive vegetation types to occur within the project area are ephemeral swamps (scattered along the central part of the access corridor).

2.5 Existing flora and fauna (and condition)

As part of the Flora and Fauna assessment (EcOz Environmental Consultants 2017), habitat mapping was undertaken to describe and map the landforms, major soil types and vegetation communities within the project area. This habitat mapping data will be used to inform the weed and erosion potential and provide baseline flora lists (and condition) for rehabilitation purposes.

2.6 Rehabilitation objectives

This report provides the rehabilitated landform objective and post-mining landform design for each of the project key areas.

The rehabilitated landform objective is to:

- Reinstate natural (unmanaged) ecosystem(s) similar to (or better than) the pre-mining state that do not preclude pastoral use or inhibit surrounding pastoral use.
- Rehabilitation will achieve a stable and functioning landform that is consistent with the surrounding landscapes and other environmental values, and will remove potential for long term, post closure impacts on downstream water quality, beneficial uses and environmental values.

The pre-mining state is typical of that associated with cattle grazing in central Australia with a moderate level of habitat degradation and the rehabilitation objective is to return the land to a moderate (or light-moderate) level of habitat degradation. The intended post-mining land use for the rehabilitated site is natural habitat compatible with pastoral use, and applies to the key project features described below.

2.7 Summary of Closure Domains

The site layout for the Ammaroo Phosphate Project is provided in Figure 2-3. The site is divided into the following key areas:

- Administration and Plant Area (including a beneficiation plant and power plant);
- Permanent Camp (including a waste management facility/ landfill, and sewage/septic facilities);
- Rail Loop.
- Open pits (including in-pit tailings / waste backfill);
- Starter TSF (or surface TSF);
- Production borefield;
- Access corridor/infrstructure corridor and pipeline (including local constructions bores every 20 km along the corridor).
- Borrow areas/pits and their access roads;
- Temporary waste and soil stockpiles #;and the
- Murray Downs Road realignment area.

Those areas assigned a # prefix (i.e. temporary waste and soil stockpiles) are not designated closure domains. They are dynamic areas, opportunistically close to their source and/or ultimate end-use location; and they will be utilised opportunistically in progressive rehabilitation throughout the mining cycle. When individual stockpile locations are completely consumed, they will be rehabilitated on an ongoing basis. These dynamic features are discussed further throughout the document.

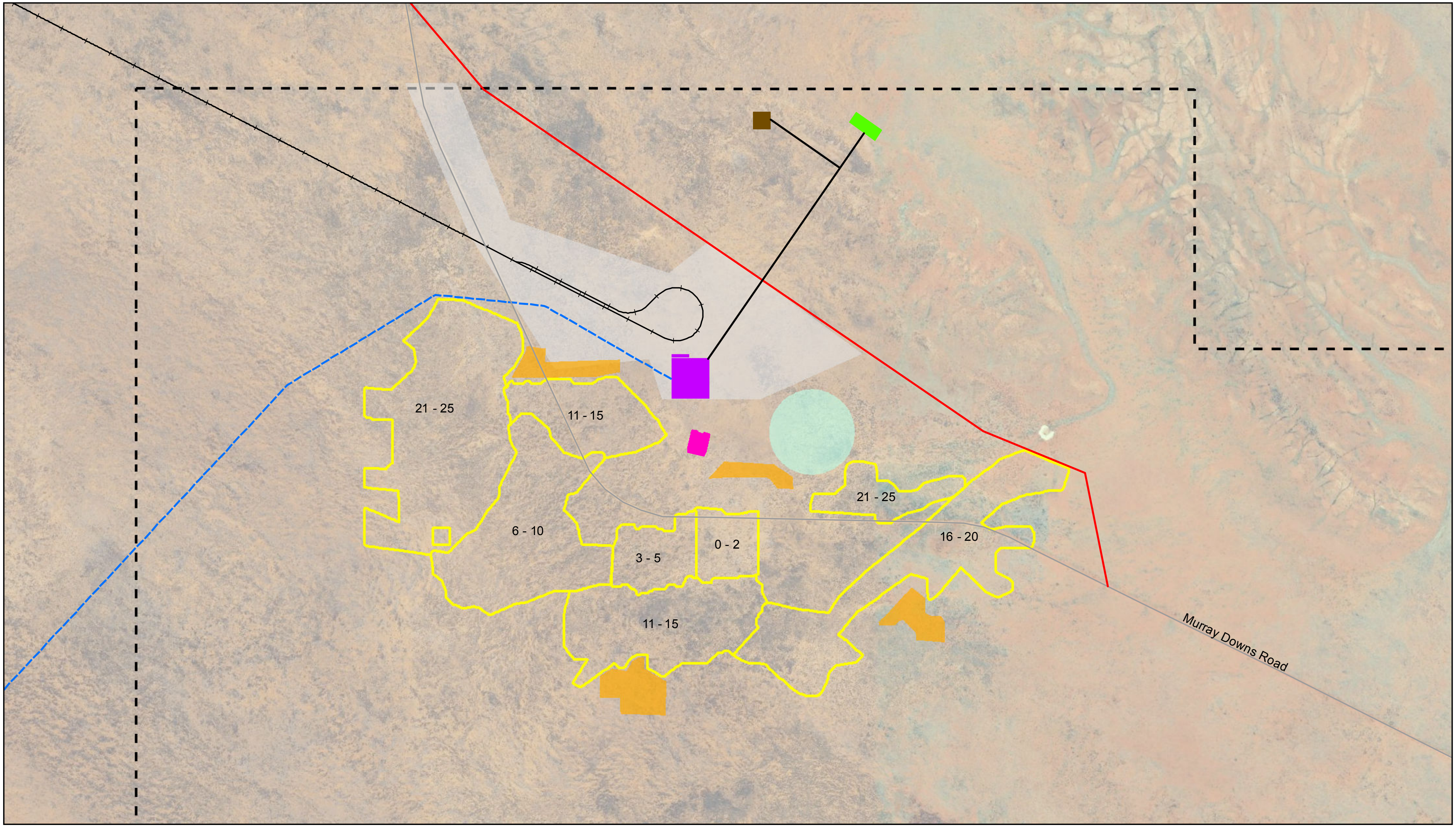
Note that, although the rail loop is physically contained within the construction/plant area, it is discussed collectively with the rest of the railway corridor in this document.

The following sections discuss the preliminary and likely closure tasks based on our current understanding of the project, and outline closure tasks by domain to form the key content of a draft Mine Closure Plan (MCP).

A summary closure schedule is presented in Table 2-1. In addition to the closure by original domain seeding, soil and landform trials will begin in 2020 and be ongoing through the LOM.

Table 2-1 Summary Closure Schedule

Domain	Nominal Closure Start Year	Nominal Closure End Year	Nominal Closure Duration (years)
Administration and Plant Area (including a beneficiation plant and power plant);	2045	2046	1
Permanent Camp (including a waste management facility/ landfill, and sewage/septic facilities);	2045	2046	0.5
Rail Loop.	2045	2047	2
Open pits (including in-pit tailings / waste backfill);	2022	2050	28
Starter TSF (or surface TSF);	2045	2047	2
Production borefield;	2049	2050	1
Access corridor/infrastructure corridor and pipeline (including local constructions bores every 20 km along the corridor).	2045	2047	2
Borrow areas/pits and their access roads;	2022	2050	28
Temporary waste stockpiles	2022	2047	25
Temporary soil stockpiles	2022	2050	28
Murray Downs Road realignment area.	N/A	N/A	N/A



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Kilometres

Map Projection: Universal Transverse Mercator
Horizontal Datum: GDA 1994
Grid: GDA 1994 MGA Zone 53

N

LEGEND

- Existing roads
- Road realignment
- Access road
- Water supply pipeline
- Access corridor
- Accommodation camp
- Landfill
- ROM
- Mineral lease
- Pit extent (years)
- Construction area
- Beneficiation plant
- Surface tailings storage facility
- Temporary waste stockpiles

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VERDANT MINERALS

Verdant Minerals Ltd
Ammaroo Phosphate Project

Job Number 43-22544
Revision 0
Date 06 Oct 2017

Mine site general arrangement **Figure 2-3**

G:\43\22544\GIS\Maps\4322544_107.mxd

Level 5, 66 Smith Street Darwin NT 0800 Australia T 61 8 8982 0100 F 61 8 8981 1075 E drwmail@ghd.com W www.ghd.com

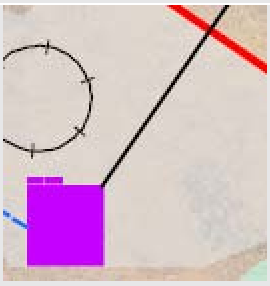
Data source: GA - Roads, Places, Rail, Pipeline (2015), Hillshade (2015). Google Earth Pro - Imagery (Date extracted: 16/08/2017). VML - Proposed Corridor, Project Site, Pit Footprint (2017). Created by: CM

3. Closure tasks

The following closure tasks by domain form the key content of a draft Mine Closure Plan (MCP).

3.1 Administration and plant area

Table 3-1 Administration and Plant Area Closure Task Register

Administration and Plant Area – Closure Task Register	
1.1 Description of Domain of Feature	
Plant, administration, beneficiation plant, maintenance facilities, infrastructure and services, including: • Administration building (typical office type construction and finish); • Power plant; • Warehouse/workshop (steel frame building with concrete floors); • Change room and amenities; • Canteen (dry); • Security and emergency services; • Waste water treatment plant for utility oily water; • Sewerage services; • Run of Mine stockpile and reclaim system; • Primary and secondary crushers; • Crushed ore stockpile and reclaim system; • Conveyor and blending system; • Beneficiation plant; • Waste tails thickener; and • Surface tailings storage facility	
	see Figure 3-1
Location	Adjacent to Murray Downs Road realignment.
Tenements	ML 29463 & ML 29854
Status	Not yet constructed.
Current Disturbance	Exploration 50 x 50m spaced drillholes and 200 x 200m spaced drillholes Pastoral Lease and Cattle Grazing
Life of Asset Disturbance	25 years Life of Mine (LOM)
Estimated Closure Start Date	2045
Estimated Closure End Date	2046
Closure Works Duration	1 year

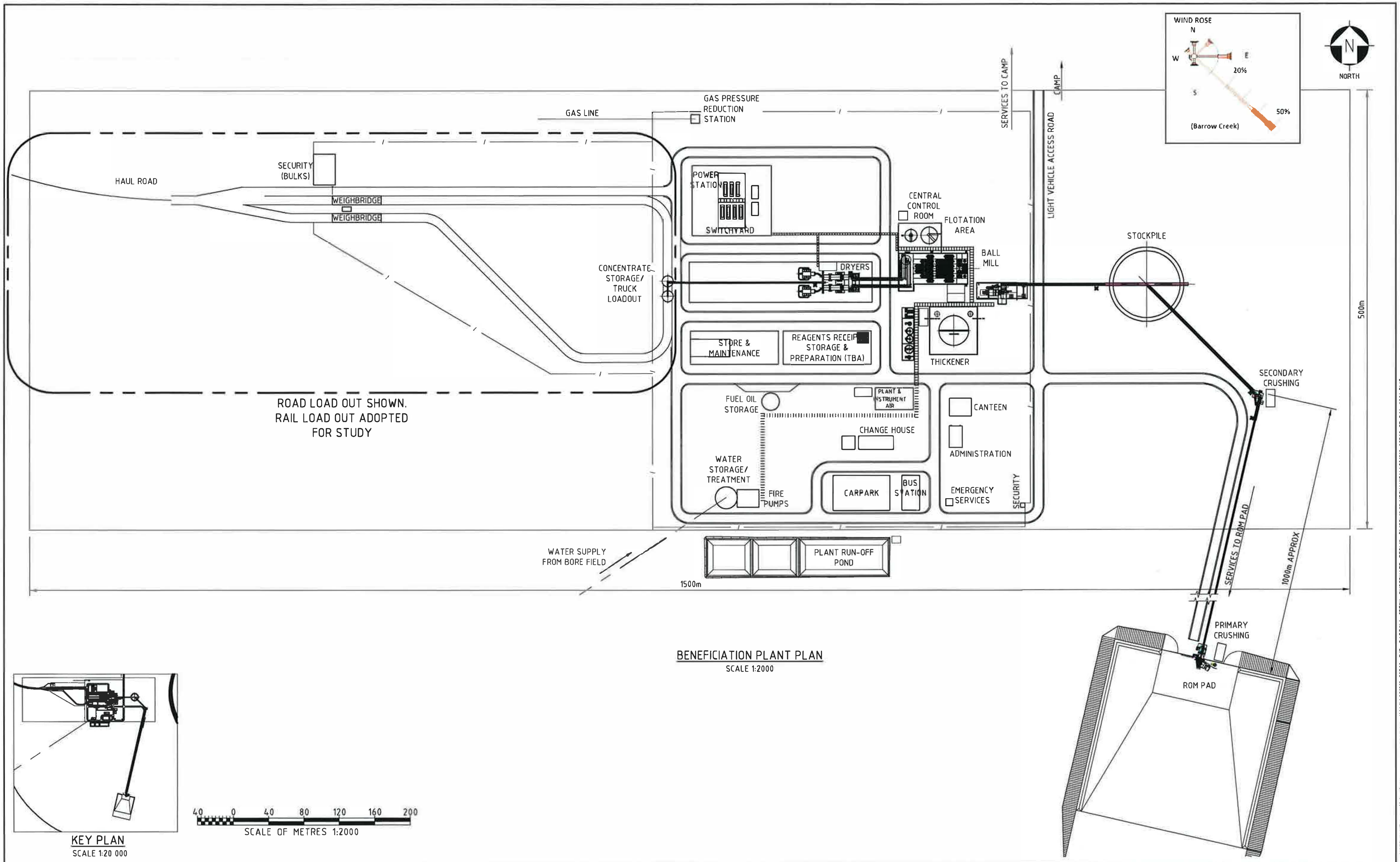
1.2 Land-Use Information	
Post-Mining Land Use	Natural habitat compatible with pastoral use
Rehabilitated Landform Objective	Reinstate natural (unmanaged) ecosystem(s) similar to the pre-mining state that does not preclude pastoral use or inhibit surrounding pastoral use. Rehabilitation will achieve a stable and functioning landform that is consistent with the surrounding landscapes and other environmental values and will remove potential for long term, post closure impacts on downstream water quality, beneficial uses and environmental values.
Post-Mining Landform Design	Flat area rehabilitation with gently sloping south to north surface drainage.
Closure Completion Criteria and Performance Indicators	Certification that no contamination remains in place that would prevent the closure objectives being met. Certification that adequate topsoil is in place. Certification that adequate vegetation has been reinstated to meet the closure objectives.

1.3 Closure Work Tasks

Activity	Closure Work Tasks	Approx. Duration
Decommission	1. Decommission all services prior to demolition. 2. Disconnect all High Voltage (HV) and Low Voltage (LV) electrical power supply cables and isolate all equipment. 3. Disconnect water supply and sewerage services. 4. Drain down and flush all pipelines and tanks. 5. Remove residue and/or sludge from ponds to in-pit TSF. 6. Remove and if necessary clean any infrastructure / plant before transporting off site for reuse/sale. 7. Transport all unused reagents off-site.	1 to 2 months
Demolish	1. Remove any hazardous materials for disposal in hazardous waste landfill off-site. 2. Demolish all infrastructure and services to at least 0.5m below closed ground surface level, including plant, offices, communications tower, power station, fuel tanks, roads, water ponds. 3. Cut and/or break up demolition debris to suitable size for safe transport and disposal.	3 to 5 months
Clean-up and dispose	1. Investigate extent of soil contamination around fuel storage, plant area (spills), and mining maintenance facilities. 2. Excavate all contaminated soils down to extent of contamination. 3. Transport contaminated soil material off-site for disposal. 4. Transport all oil and oily wastes off-site (from maintenance facilities). 5. Transport any hazardous materials to off-site hazardous waste landfill or designated facility. 6. Clean and dispose pond liners into agreed facility (i.e. placed and capped in-pit if appropriate). 7. Transport all other inert demolition debris and dispose in existing excavations (where possible), base of pit or excavated on-site landfill.	2 to 4 months
Site landform and drainage reconstruction	1. Backfill structural voids and residual excavations (tanks, ponds, landfills) with inert mine waste.	2 to 3 months

	2. Remove culverts and drain crossings but leave main diversion drains in place to protect waste rock landforms. 3. Reshape/re-contour area to generally return pre-mining surface drainage and to remove any erosion prone features. Provide fill to areas where contaminated soil has been removed if necessary to recreate appropriate surface drainage.	
Rehabilitation and re-vegetation	1. Spread available topsoil at >100mm and rip on contour. 2. Seed with local pioneer species and mulch with any available vegetation detritus.	1 to 2 months
Security and Signage	The site will be safe for public access post-closure. No security fencing or signage is required.	Not applicable
1.4 Schedule of Work for Research, Investigation and Trials Tasks		
Aspect	**Research, Investigations and/or Trial**	**Schedule**
Demolition and Waste Disposal	Investigate the potential for sale and/or transfer of plant and associated equipment (e.g. tanks, sheds, demountable offices and piping) to a third party, thereby reducing the waste to landfill.	Not applicable
Contaminated soils	Maintain a contaminated spills register during operations to assist identification of areas with known contamination for removal on closure.	Not applicable
Arid zone seeding	Conduct ongoing pre-closure trials and investigations that will inform the success of seeding in an arid zone.	Not applicable
1.5 Schedule of Work for Progressive Rehabilitation		
Aspect	**Progressive Rehabilitation Works**	**Schedule**
Plant and administration areas	No progressive rehabilitation works are envisaged for the plant and administration area.	Not applicable
1.6 Availability and Management of Closure Material Sources		
Requirement	**Resource**	**Volume/Area**
Excavate and Backfill	Estimated based on soil removal (to 1000mm if required) from potentially contaminated areas. Some will also be required to backfill concrete footings areas. Backfill with additional material sourced from ROM pad, removal of roads, ponds and landfill excavations.	See Table 4-1
Earthworks Area	Area requiring grading and contouring (based on areas of infrastructure and potential excavation).	See Table 4-1
Topsoil	Spread to areas as required at >100mm. Available topsoil stockpiled adjacent to plant areas.	See Table 4-1
Seeding	Seed areas disturbed and topsoiled. Purchase local pioneer species seed from local supplier (or establish local supply).	See Table 4-1
1.7 Key Tasks for Unexpected (Early) Closure and/or Temporary Closure		
Scenario	**Key Tasks**	**Schedule**
Early Closure	Decommission all services, power and water supply and isolate all equipment. Drain down and flush all pipelines, tanks to surface TSF or in-pit TSF and remove residue and/or sludge from ponds to surface TSF or in-pit TSF.	On announcement of early/ sudden closure

Temporary Closure	Flush residual solids from lines to prevent blockage on restart, and grease, oil and pack all mechanical equipment and vehicles appropriately. Develop a care and maintenance plan to maintain a minimum but active security and maintenance presence.	On announcement of temporary closure
1.8 Information Gaps		
Aspect	**Information Gap/Uncertainty**	**Schedule**
Contaminated soil sampling and assessment	Sampling and assessment will be required at the time of closure to determine the extent of soil contamination and remediation required. This risk will be reduced through maintaining a spill register during operations phase.	Closure
1.9 Performance Monitoring and Maintenance Schedule		
Aspect	**Performance Monitoring and Maintenance Task**	**Schedule**
Post-Closure Monitoring	Implement agreed post-closure monitoring program.	Relinquishment
Post-closure Maintenance	Undertake regular inspections as per monitoring requirements to assess the need for maintenance activities.	Annually
	Implement post-closure maintenance activities as required.	As required to relinquishment



REV	DATE	REVISION DESCRIPTION	DRAWN	DRAFT CHK	DESIGNED	ENG CHK	APPROVED	CUSTOMER	REF DRAWING No	REFERENCE DRAWING TITLE
D	19.09.14	RE-ISSUED FOR STUDY USE	SAJ	DG	BJT	EW	DG	-		
C	30.07.14	ISSUED FOR STUDY USE	SAJ	-	BJT	EW	DG	-		
B	23.07.14	ISSUED FOR INTERNAL REVIEW	SAJ	-	-	-	-	-		
A	09.07.14	ISSUED FOR INTERNAL REVIEW	SAJ	-	-	-	-	-		

A1 SHEET SCALE 1:2000

ENGINEERING AND PERMIT STAMPS (As Required)

OneWay to zero harm

WORLEYPARSONS PROJECT No 201010-00560

CUSTOMER: RUM JUNGLE RESOURCES RJR

WorleyParsons resources & energy

AMMAROO PHOSPHATE PROJECT
BENEFICIATION PLANT
Figure 3-1

DRG No 201010-00560-GE-DAL-0004 REV D

LOCATION: K:\WL\201010-00560_RJR_BARROW_CREEK_PHOSPHATE_PFS\12_DWGS\12.05 MECHANICAL\201010-00560-GE-DAL-0004.DWG

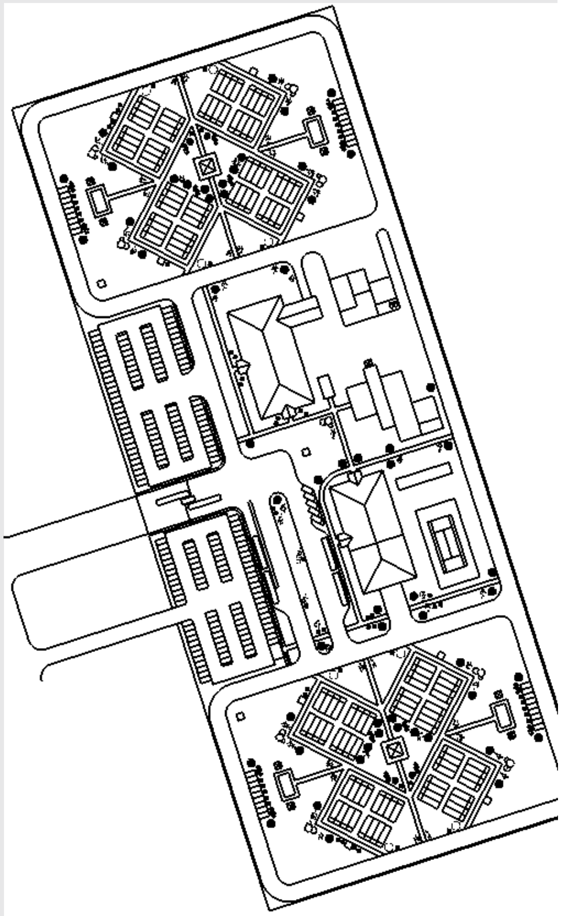
USER NAME: scott.jacobson

PLOT DATE & TIME: 19/9/2014 3:10:59 PM
SAVE DATE & TIME: 19/9/2014 3:09:01 PM

WORLEYPARSONS_A1_REV

3.2 Permanent camp

Table 3-2 Permanent Camp Closure Task Register

Permanent Camp – Closure Task Register	
1.1 Description of Domain of Feature	
Permanent camp for workforce will include: • Accommodation units; • Mess facilities; • Administration offices, shared facilities, general store and maintenance workshop; • Recreational facilities - including pool, gym; • Water purification plant for potable quality water; • Minor infrastructure - roads, car parks; • Septic and associated infrastructure; • Landfill; and • Transmission power lines.	
Location	off Murray Downs Road realignment at northern extent of ML.
Tenements	ML 29854
Status	Not yet constructed.
Current Disturbance	Exploration 600 x 900m spaced drillholes Exploration Camp Pastoral Lease and Cattle Grazing
Life of Asset Disturbance	25 years (LOM)
Estimated Closure Start Date	2045
Estimated Closure Completion Date	2046
Closure Works Duration	6 months.
1.2 Land-Use Information	
Post-Mining Land Use	Natural habitat compatible with pastoral use

Permanent Camp – Closure Task Register	
Rehabilitated Landform Objective	Reinstate natural (unmanaged) ecosystem(s) similar to the pre-mining state that does not preclude pastoral use or inhibit surrounding pastoral use. Rehabilitation will achieve a stable and functioning landform that is consistent with the surrounding landscapes and other environmental values and will remove potential for long term, post closure impacts on downstream water quality, beneficial uses and environmental values.
Post-Mining Landform Design	Flat area rehabilitation with gently sloping south to north surface drainage.
Closure Completion Criteria and Performance Indicators	Certification that no contamination remains in place that would prevent the closure objectives being met. Certification that adequate topsoil is in place. Certification that adequate vegetation has been reinstated to meet the closure objectives.

1.3 Closure Work Tasks

Activity	Closure Work Tasks	Approx. Duration
Decommission	1. Decommission all services prior to demolition. 2. Disconnect all High Voltage (HV) and Low Voltage (LV) electrical power supply cables and isolate all equipment. 3. Remove any infrastructure to be transported off site for reuse/sale. 4. Decommission landfill. 5. Decommission septic and associated infrastructure.	2 to 5 weeks
Demolish	1. Remove hazardous materials for disposal in hazardous waste landfill off-site. 2. Demolish all infrastructure and services to at least 0.5 m below closed ground surface level, including communications tower, power station, fuel tanks, and roads. 3. Crack swimming pool structure to permit infiltration. 4. Cut up demolition debris to suitable size for safe transport and disposal.	2 to 3 months
Clean-up and dispose	1. Excavate all soils where contaminated soil horizon extends deeper. 2. Transport contaminated material (including contaminated and hazardous building materials) off-site for disposal. 3. Transport all other inert demolition debris to disposal in base of pit or on-site landfill.	2 to 4 weeks
Site landform and drainage reconstruction	1. Backfill residual excavations (including landfills and septic/associated infrstructure) and swimming pool to make safe using road base and/or other suitable materials retrieved from site reshaping. 2. Reshape/re-contour area to generally return pre-mining south to north surface drainage and to remove any erosion prone features. 3. Retain locally occurring tree species where possible. 4. Remove any exotic plant species as required	4 to 6 weeks

Permanent Camp – Closure Task Register		
Rehabilitation and re-vegetation	1. Spread available topsoil at >100mm where required and rip on contour. 2. Seed with local pioneer species and mulch with any available vegetation detritus. 3. Create fauna habitats (e.g. using rocks and available vegetation detritus).	2 to 4 weeks
Security and Signage	The site will be safe for public access post-closure. No security fencing or signage is required.	Not applicable

1.4 Schedule of Work for Research, Investigation and Trials Tasks

Aspect	Research, Investigations and/or Trial	Schedule
Demolition and Waste Disposal	Investigate the potential for sale and/or transfer of camp infrastructure or assets to a third party, thereby reducing the waste to landfill.	Closure
Arid zone seeding	Conduct ongoing pre-closure trials and investigations that will inform the success of seeding in an arid zone.	Not applicable

1.5 Schedule of Work for Progressive Rehabilitation

Aspect	Progressive Rehabilitation Works	Schedule
Future progressive rehabilitation works	No future progressive rehabilitation works are proposed for the camp accommodation area.	Not applicable

1.6 Availability and Management of Closure Material Sources

Requirement	Resource	Volume/Area
Excavate and Backfill	Contaminated soil removal from potentially contaminated areas (e.g. fuel storage/gensets) to 0.5 m depth. Backfill with additional material sourced from removal of roads, landfill excavations or rock from mine area if required.	See Table 4-1
Earthworks area	Reshape and rip areas as required.	See Table 4-1
Topsoil	Spread available topsoil at >100mm where required and rip on contour. Topsoil available alongside disturbed areas.	See Table 4-1
Seeding	Seed areas disturbed and topsoiled. Purchase local pioneer species seed from local supplier (or establish local supply).	See Table 4-1

1.7 Key Tasks for Unexpected (Early) Closure and/or Temporary Closure

Scenario	Key Tasks	Schedule
Early Closure	Permanent camp may be closed temporarily while developing final closure plan, but will be kept operationally ready to house demolition and civil works crews that will carry out closure works.	On announcement of early/ unexpected closure
Temporary Closure	The majority of the accommodation facilities will be closed, and associated services curtailed. A care and maintenance accommodation plan will be developed to house the small staff contingent required to manage the care and maintenance of the camp.	On announcement of temporary closure

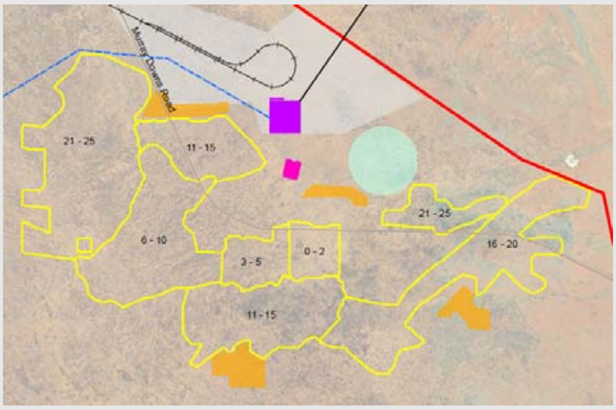
1.8 Information Gaps

Permanent Camp – Closure Task Register		
Aspect	**Information Gap/Uncertainty**	**Resolution Plan/Schedule**
Contaminated soil sampling and assessment	Sampling and assessment will be required at the time of closure to determine the extent of soil contamination and remediation required.	During closure execution

Permanent Camp – Closure Task Register		
1.9 Performance Monitoring and Maintenance Schedule		
Aspect	**Performance Monitoring and Maintenance Task**	**Schedule**
Post-Closure Monitoring	Implement agreed post-closure monitoring program.	Relinquishmen t
Post-closure Maintenance	Undertake regular inspections as per monitoring requirements to assess the need for maintenance activities.	Annually
	Implement post-closure maintenance activities as required.	As required to relinquishment

3.3 Open pits

Table 3-3 Open Pits Closure Task Register

Open Pits – Closure Task Register	
1.1 Description of Domain of Feature	
The mining area consists of: • Series of 7 discrete pits mined progressively. • The pits key elements comprise bench and batter features as well as haul roads to the ROM. • Temporary waste rock piles and temporary soil stockpiles will be placed opportunistically in close proximity to their sources and/or end-use locations adjacent to the pits (discussed later in this report). • The pit voids will be progressively filled with tailings and capped with waste rock and a soil cover. The resultant landform will form a minor mound (i.e. an excess of loose material by volume).	

Location	Adjacent to and under the current Murray Downs Road.
Tenements	ML 29463 & ML 29854.
Status	Not yet developed.
Current Disturbance	Exploration 50 x 50m spaced drillholes and 200 x 200m spaced drillholes. Pastoral Lease and Cattle Grazing.
Life of Asset Disturbance	25 years (LOM)
Estimated Closure Start Date	2022
Estimated Closure End Date	2050
Closure Works Duration	28 years.

Open Pits – Closure Task Register	
1.2 Land-Use Information	
Post-Mining Land Use	Natural habitat compatible with pastoral use
Rehabilitated Landform Objective	Reinstate natural (unmanaged) ecosystem(s) similar to the pre-mining state that does not preclude pastoral use or inhibit surrounding pastoral use. Rehabilitation will achieve a stable and functioning landform that is consistent with the surrounding landscapes and other environmental values and will remove potential for long term, post closure impacts on downstream water quality, beneficial uses and environmental values.
Post-Mining Landform Design	Flat area rehabilitation with gently sloping radial drainage (due to the excess of loose material by volume). If settlement occurs in the very long term, it is conceivable that it could take a form that mimics a depression consistent with a doline.
Closure Completion Criteria and Performance Indicators	Certification that no contamination remains in place that would prevent the closure objectives being met. Certification that adequate topsoil is in place. Certification that adequate vegetation has been reinstated to meet the closure objectives.

1.3 Closure Work Tasks

Activity	Closure Work Tasks	Approx. Duration
Development	Strip and stockpile soil from the footprint of the disturbed sections. Seed soil stockpile immediately after placement to prevent mobilization.	1 month prior to mining.
Decommission	1. Cease mining; 2. Construct in-pit TSF containment structures (where required); 3. Place tailings; 4. Allow tailings to consolidate; and 5. Place waste rock on top of tailings.	Ongoing throughout LOM. 25 years.
Demolish	Not applicable	Not applicable
Clean-up and dispose	Not applicable	Not applicable
Site landform and drainage reconstruction	1. Reshape/re-contour area to generally radially drainage and to remove any erosion prone features. 2. Retain locally occurring tree species where possible. 3. Remove any exotic plant species as required. 4. Deep rip all haul roads not required by the post-closure land user.	4 to 6 months (Ongoing throughout LOM)
Rehabilitation and re-vegetation	1. Spread available topsoil at >100mm where required and rip on contour. 2. Seed with local pioneer species and mulch with any available vegetation detritus. 3. Create fauna habitats (e.g. using rocks and available vegetation detritus).	4 to 6 months (Ongoing throughout LOM)

Open Pits – Closure Task Register		
Security and Signage	The site will be safe for public access post-closure. No security fencing or signage is required. Stock fencing put in place around the pit mounds to keep cattle off the pit mound surface, particularly during the early growth years immediately post-closure. Fencing will be maintained by post-closure landowner/pastoralist.	Not applicable
1.4 Schedule of Work for Research, Investigation and Trials Tasks		
Aspect	**Research, Investigations and/or Trial**	**Schedule**
Rehabilitation Materials Characterisation	Undertake further detailed materials characterisation of the tailings consolidation characteristics and available rehabilitation cover materials.	Ongoing
Completion Criteria	Using monitoring results, research, investigation and trials, develop criteria that are specific to the closure domains.	Ongoing
Performance Indicators	Develop specific, quantitative performance indicators for the measurement of success that are based on research and monitoring outcomes.	Ongoing
Landform and Rehabilitation Design	Continue with progressive rehabilitation and/or rehabilitation trials and subsequent vegetation performance monitoring to inform closure design.	Ongoing
Arid zone seeding	Conduct ongoing pre-closure trials and investigations that will inform the success of seeding in an arid zone.	Not applicable
1.5 Schedule of Work for Progressive Rehabilitation		
Aspect	**Progressive Rehabilitation Works**	**Schedule**
Pit mounds	As discussed above	As discussed above.
1.6 Availability and Management of Closure Material Sources		
Requirement	**Resource**	**Volume/Area**
Earthworks Area	Area requiring landforming and contouring based on surface area of pits.	See Table 4-1
	Other areas requiring minor earthworks/landscaping (i.e. exterior haul roads).	See Table 4-1
Topsoil	Spread to areas as required at >100mm. Topsoil stockpiled adjacent to pits.	See Table 4-1
	Spread topsoil to other areas.	See Table 4-1
Seeding	Seed areas disturbed and topsoiled. Purchase local pioneer species seed from local supplier (or establish local supply).	See Table 4-1
1.7 Key Tasks for Unexpected (Early) Closure and/or Temporary Closure		
Scenario	**Key Tasks**	**Schedule**
Early Closure	Anywhere where the early closure has resulted in a partially completed landforms, further earthworks will be required to meet the final design specifications. This includes, any non-competent material left exposed at the time of closure will need to be	At early closure

Open Pits – Closure Task Register		
	covered in competent rock to the minimum thickness required by the design specifications.	
	Remove and/or process any remaining ore stockpiles.	At early closure
Temporary Closure	Put in place bunding and/or fencing to prevent public access to unsafe areas.	On announcement of temporary closure.
	Develop pit water management and care and maintenance plans.	On announcement of temporary closure.
	Establish pit slope monitoring.	During the period of temporary closure
1.8 Information Gaps		
Aspect	**Information Gap/Uncertainty**	**Schedule**
Landform and Rehabilitation Design	Determine the optimum landform profile and cover design for maximum stability and vegetation establishment success.	Ongoing
1.9 Performance Monitoring and Maintenance Schedule		
Aspect	**Performance Monitoring and Maintenance Task**	**Schedule**
Post-Closure Monitoring	Implement agreed post-closure monitoring program.	Relinquishment
Post-closure Maintenance	Undertake regular inspections as per monitoring requirements to assess the need for maintenance activities.	Annually
	Implement post-closure maintenance activities as required.	As required to relinquishment

3.4 Surface TSF

Table 3-4 Starter TSF Closure Task Register

Starter Tailings Storage Facilities – Closure Task Register

1.1 Description of Domain of Feature

The starter TSF, comprises:

- A circular TSF designed to receive the mines tailings while sufficient void is created in the initial pit over years 1-3.
- The facility is then planned to remain as a contingency TSF throughout LOM.

Location	In between the current Murray Downs Road and realignment.
Tenements	ML 29854
Status	Not yet constructed.
Current Disturbance	Exploration 300 x 400m spaced drillholes. Pastoral Lease and Cattle Grazing.

Starter Tailings Storage Facilities – Closure Task Register	
Life of Asset Disturbance	25 years
Estimated Closure Start Date	2045

Starter Tailings Storage Facilities – Closure Task Register	
Estimated Closure Date	2047
Closure Works Duration	2 years
1.2 Land-Use Information	
Post-Mining Land Use	Permanent tailings facility landform compatible with surrounding natural habitat and pastoral use
Rehabilitated Landform Objective	Permanent safe, stable and non-polluting tailings landform that does not negatively impact or inhibit surrounding natural (unmanaged) ecosystems or pastoral use. Rehabilitation will achieve a stable and functioning landform that is consistent with the surrounding landscapes and other environmental values and will remove potential for long term, post closure impacts on downstream water quality, beneficial uses and environmental values.
Post-Mining Landform Design	Shallow convex shaped (gently water shedding) tailings storage landform with radial surface drainage.
Closure Completion Criteria and Performance Indicators	Certification that no contamination remains in place that would prevent the closure objectives being met. Certification that adequate topsoil is in place. Certification that adequate vegetation has been reinstated to meet the closure objectives.

1.3 Closure Work Tasks

Activity	Closure Work Tasks	Approx. Duration
Development	1. Strip and stockpile soil from the footprint of the disturbed sections. 2. Seed soil stockpile immediately after placement to prevent mobilization.	1 month prior to mining.
Decommission	1. Decommission all services at the booster, decant and return water pump stations prior to demolition. 2. Disconnect all HV and LV electrical power supply cables and isolate all equipment. 3. Remove residue and/or sludge from ponds to TSF. 4. Remove and if necessary clean any infrastructure to be transported off site for reuse/sale. 5.	1 to 2 months
Demolish	1. Demolish all infrastructure and services to at least 0.5m below closed ground surface level. 2. Remove all tailings piping and return water piping.	3 to 5 months
Clean-up and dispose	1. Cut and/or break up demolition debris, piping and liner to suitable size for safe transport and/or disposal in landfill constructed within TSF/pit or other designated disposal area. 2. Clean up surficial tailings from water storage area and decant sump and dispose in TSF. 3. Drain and clean out water ponds and sewage ponds and remove and dispose of pond liners.	2 to 6 months
Site landform and drainage reconstruction	**TSF** 1. Cover outside 1V : 3H slope perimeter embankment with 0.3m thickness (0.9m on horizontal) rock. 2. Construct roads on top of TSF on contour to provide access for haulage of cover materials.	12 to 18 months after safe access to tailings surface is available for construction equipment.

Starter Tailings Storage Facilities – Closure Task Register		
	3. Recontour landform to form radially from drainage from centre (if not already not achieved from central discharge of tailings. 4. Construct drainage lines to safely shed excess runoff to perimeter. 5. Cover tailings surface with 1 m thick capillary break layer of waste rock.	
Rehabilitation and re-vegetation	**Tailings surface** 1. Spread topsoil at >100mm and rip into rock providing around 300 mm growth medium. 2. Seed using local seed species, fertilize if soil amelioration is warranted, and lightly cover with any available vegetation detritus. **TSF perimeter embankment** 1. Spread topsoil at > 100 mm on rock cover to perimeter embankment, lightly rip on contour, seed, fertilize if necessary, and lightly cover with any available vegetation detritus.	4 to 6 months
Security and Signage	1. The site will be safe for public access post-closure. No security fencing or signage is required. 2. Stock fencing put in place around the TSF to keep cattle off the TSF surface, particularly during the early growth years immediately post-closure. Fencing will be maintained by post-closure landowner/pastoralist.	1 month

1.4 Schedule of Work for Research, Investigation and Trials Tasks

Aspect	**Research, Investigations and/or Trial**	**Schedule**
Rehabilitation Materials Characterisation	Undertake detailed materials characterisation of the tailings consolidation characteristics and available rehabilitation cover materials.	Ongoing
Completion Criteria	Using monitoring results, research, investigation and trials, develop criteria that are specific to the closure domains.	Ongoing
Performance Indicators	Develop specific, quantitative performance indicators for the measurement of success that are based on research and monitoring outcomes.	Ongoing
Arid zone seeding	Conduct ongoing pre-closure trials and investigations that will inform the success of seeding in an arid zone.	Not applicable

1.5 Schedule of Work for Progressive Rehabilitation

Aspect	**Progressive Rehabilitation Works**	**Schedule**
Not applicable		

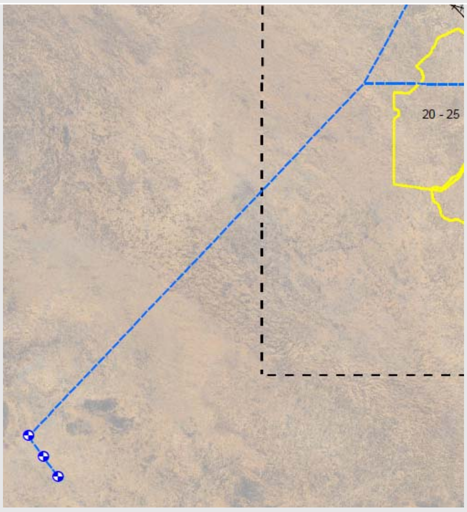
1.6 Availability and Management of Closure Material Sources

Requirement	**Resource**	**Volume/Area**
Earthworks Area	Total area of TSF top surface requiring cover treatment.	See Table 4-1
	Embankments of TSF.	See Table 4-1
Waste Rock	To be applied to the TSF top surfaces at 1000 mm. Plus additional volume for TSF embankment. Available from pits and temporary waste rock piles in the vicinity.	See Table 4-1

Starter Tailings Storage Facilities – Closure Task Register		
Topsoil	To be applied to TSF top surfaces and embankments at >100mm. Available from temporary stockpiles in the vicinity.	See Table 4-1
Seeding	Seed areas disturbed and topsoiled. Purchase from local supplier or source locally.	See Table 4-1
1.7 Key Tasks for Unexpected (Early) Closure and/or Temporary Closure		
Scenario	**Key Tasks**	**Schedule**
Early Closure	Develop interim surface water management plan to ensure that overtopping of the TSF will not occur prior to and during closure works.	On announcement of early/sudden closure
Temporary Closure	Flush residual solids from lines to prevent blockage on restart, and grease, oil and pack all mechanical equipment. Develop water management and care and maintenance plans to maintain ensure that the TSF is maintained in a safe condition including dust control on the tailings surface pending re-start or final closure decision.	On announcement of temporary closure
1.8 Information Gaps		
Aspect	**Information Gap/Uncertainty**	**Schedule**
TSF Closure Landform and Rehabilitation Design	Potential for and/or desirability of vegetative growth on the TSF at closure and potential achievable composition of vegetative cover.	At closure (2024)
TSF Closure Landform and Rehabilitation Design	Need to prove final design concept in practice and monitor performance prior to implementing large scale.	At closure (2024)
1.9 Performance Monitoring and Maintenance Schedule		
Aspect	**Performance Monitoring and Maintenance Task**	**Schedule**
Post-Closure Monitoring	Implement agreed post-closure monitoring program.	Relinquishment
Post-closure Maintenance	Undertake regular inspections as per monitoring requirements to assess the need for maintenance activities.	Annually
	Implement post-closure maintenance activities as required.	As required to relinquishment

3.5 Borefield

Table 3-5 Borefield Closure Task Register

Borefield – Closure Task Register	
1.1 Description of Domain of Feature	
The borefield comprises: • A single borefield for water supply to the mine and camp. • Associated borefield infrastructure including access roads, power lines, pipelines and pump stations. • Note that the additional bores associated with the access corridor are not considered in this section.	
	
Location	south west of Murray Downs Road
Tenements	TBA (pipeline on and to ML 29463)
Status	The borefields and all other associated infrastructure are not yet operational, nor installed.
Current Disturbance	Pastoral Lease and Cattle Grazing
Life of Asset Disturbance	30 years (LOM) and closure period
Estimated Closure Start Date	2049
Estimated Closure End Date	2050
Closure Works Duration	1 year
1.2 Land-Use Information	
Post-Mining Land Use	Natural habitat compatible with pastoral use.
Rehabilitated Landform Objective	Reinstate natural (unmanaged) ecosystem(s) similar to the pre-mining state that does not preclude pastoral use or inhibit surrounding pastoral use. Rehabilitation will achieve a stable and functioning landform that is consistent with the surrounding landscapes and other environmental values and will remove potential for long term, post closure impacts on downstream water quality, beneficial uses and environmental values.

Borefield – Closure Task Register	
Post-Mining Landform Design	**Borefield** Flat area rehabilitation or gently undulating stable landforms.
Closure Completion Criteria and Performance Indicators	Certification that adequate topsoil is in place. Certification that adequate vegetation has been reinstated to meet the closure objectives. Certification that bores have been decommissioned as per Minimum Construction Requirements for Water Bores in Australia.

1.3 Closure Work Tasks

Activity	Closure Work Tasks	Approx. Duration
Development	1. Strip and stockpile soil from the footprint of the disturbed sections. 2. Seed soil stockpile immediately after placement to prevent mobilization.	1 month prior to mining.
Decommission	1. Disconnect all HV and LV electrical power supply cables and isolate all equipment. 2. Drain down water lines. 3. Decommission pipeline. 4. Decommission bores as per Minimum Construction Requirements for Water Bores in Australia.	2 to 4 weeks
Demolition and Disposal	1. Remove bore headworks, peripheral infrastructure (<0.5m deep) and local supply powerlines. Leave pipes >0.5m deep insitu. 2. Dismantle water pipelines and store for removal off-site (e.g. potable water lines) or dispose. 3. Remove, and if necessary, clean any infrastructure to be transported off site for re-use/recycling/sale. 4. Cut and/or break up demolition debris, piping and liner to suitable size for safe transport and disposal in base of pit or onsite landfill.	2 to 5 months
Site landform and drainage reconstruction	**Borefield compounds** 1. Reshape, re-contour all disturbed areas. 2. Reestablish natural drainage system where required and/or ensure appropriate drainage. 3. Deep rip all access roads not required by the post-closure land user.	2 to 5 months
Rehabilitation and re-vegetation	1. Spread available topsoil at >100mm (pushed to side of tracks) and rip on contour. 2. Seed using local seed species, fertilize if soil amelioration is warranted, and lightly cover with any available vegetation detritus.	2 to 4 months
Security and Signage	• The borefield compound, pipeline and other areas will become part of the pastoral lease. • No security or safety signage is required.	Not applicable

1.4 Schedule of Work for Research, Investigation and Trials Tasks

Aspect	Research, Investigations and/or Trial	Schedule
Rehabilitation	No further research envisaged. Investigate potential for transfer of bore assets to pastoral lease holder.	Not applicable

Borefield – Closure Task Register		
Arid zone seeding	Conduct ongoing pre-closure trials and investigations that will inform the success of seeding in an arid zone.	Not applicable

Borefield – Closure Task Register		
1.5 Schedule of Work for Progressive Rehabilitation		
Aspect	**Progressive Rehabilitation Works**	**Schedule**
Not applicable	Not applicable	Not applicable
1.6 Availability and Management of Closure Material Sources		
Requirement	**Resource**	**Volume/Area**
Excavate and Backfill	Minor backfill required for trenches and ponds from drilling using local materials.	See Table 4-1
Earthworks area	Assumed to be minor work required.	See Table 4-1
Topsoil	Spread available topsoil to 100 mm (only where previously removed and available). Topsoil stockpiled alongside disturbed areas (only where previously.	See Table 4-1
Seeding	Seed disturbed borefields areas. Purchase from local supplier or source locally.	See Table 4-1
1.7 Key Tasks for Unexpected (Early) Closure and/or Temporary Closure		
Scenario	**Key Tasks**	**Schedule**
Early Closure	No specific key tasks are envisaged for early closure.	Not applicable.
Temporary Closure	No specific tasks are envisaged for temporary closure.	On announcement of temporary closure.
1.8 Information Gaps		
Aspect	**Information Gap/Uncertainty**	**Resolution Plan/Schedule**
	None identified.	Not applicable
1.9 Performance Monitoring and Maintenance Schedule		
Aspect	**Performance Monitoring and Maintenance Task**	**Schedule**
Post-Closure Monitoring	Implement agreed post-closure monitoring program.	Relinquishment
Post-closure Maintenance	Undertake regular inspections as per monitoring requirements to assess the need for maintenance activities.	Annually
	Implement post-closure maintenance activities as required.	As required to relinquishment

3.6 Temporary waste rock piles

Table 3-6 Temporary Waste Rock Piles Closure Task Register

Temporary Waste Rock Piles – Closure Task Register	
1.1 Description of Domain of Feature	
Temporary waste rock piles constructed out of overburden (does not include soil, which will be segregated and discussed in the following section).	
Location	Temporary waste rock piles will be dynamic areas adjacent to the pit areas. The changing areas they occupy will be opportunistically close to their source and/or ultimate end-use location and they will be utilised opportunistically throughout the mining cycle. When individual locations are completely consumed, they will be rehabilitated on an ongoing basis.
Tenements	ML 29463 & ML 29854
Status	There are currently no waste rock piles.
Current Disturbance	Exploration 50 x 50m spaced drillholes and 200 x 200m spaced drillholes Pastoral Lease and Cattle Grazing
Life of Asset Disturbance	Varied and from short term individually to 27 years in total (LOM).
Estimated Closure Start Date	2022
Estimated Closure End Date	2047
Closure Works Duration	25 years
1.2 Land-Use Information	
Post-Mining Land Use	Natural habitat compatible with pastoral use.
Rehabilitated Landform Objective	Reinstate natural (unmanaged) ecosystem(s) similar to the pre-mining state that does not preclude pastoral use or inhibit surrounding pastoral use. Rehabilitation will achieve a stable and functioning landform that is consistent with the surrounding landscapes and other environmental values and will remove potential for long term, post closure impacts on downstream water quality, beneficial uses and environmental values.
Post-Mining Landform Design	Flat area rehabilitation.
Closure Completion Criteria and Performance Indicators	Certification that adequate topsoil remains in place. Certification that adequate vegetation has been reinstated to meet the closure objectives.

1.3 Closure Work Tasks		
Activity	**Closure Work Tasks**	**Approx. Duration**
Decommission	Not applicable	Not applicable
Demolition and Disposal	Not applicable	Not applicable
Site landform and drainage reconstruction	1. When individual locations are completely consumed down to the pre-existing topsoil, they will be remediated on an ongoing basis. 2. Reshape, re-contour all disturbed areas if required. 3. Re-establish natural drainage system where required and/or ensure appropriate drainage. 4. Deep rip all access roads.	2 months

Temporary Waste Rock Piles – Closure Task Register		
Rehabilitation and re-vegetation	1. Spread available topsoil on access roads at >100mm (pushed to side of tracks) and rip on contour. 2. Seed using local seed species, fertilize if soil amelioration is warranted, and lightly cover with any available vegetation detritus.	1 month
Security and Signage	• No security or safety signage is required.	Not applicable
1.4 Schedule of Work for Research, Investigation and Trials Tasks		
Aspect	**Research, Investigations and/or Trial**	**Schedule**
Rehabilitation	No further research envisaged.	Not applicable
Arid zone seeding	Conduct ongoing pre-closure trials and investigations that will inform the success of seeding in an arid zone.	Not applicable
1.5 Schedule of Work for Progressive Rehabilitation		
Aspect	**Progressive Rehabilitation Works**	**Schedule**
Not applicable	Not applicable. May require re-working (or alternate management) if exotic species establish.	Not applicable
1.6 Availability and Management of Closure Material Sources		
Requirement	**Resource**	**Volume/Area**
Earthworks area	Assumed to be minor work required.	See Table 4-1
Topsoil	Spread available topsoil to 100 mm (only where previously removed, i.e. access roads). Topsoil stockpiled alongside disturbed areas (only where previously removed).	See Table 4-1
Seeding	Seed disturbed areas. Purchase from local supplier or source locally.	See Table 4-1
1.7 Key Tasks for Unexpected (Early) Closure and/or Temporary Closure		
Scenario	**Key Tasks**	**Schedule**
Early Closure	No specific key tasks are envisaged for early closure. May require re-working (or alternate management) if exotic species establish.	Not applicable.
Temporary Closure	No specific tasks are envisaged for temporary closure. May require re-working (or alternate management) if exotic species establish.	On announcement of temporary closure.
1.8 Information Gaps		
Aspect	**Information Gap/Uncertainty**	**Resolution Plan/Schedule**
Not applicable	None identified.	Not applicable
1.9 Performance Monitoring and Maintenance Schedule		
Aspect	**Performance Monitoring and Maintenance Task**	**Schedule**
Post-Closure Monitoring	Implement agreed post-closure monitoring program.	Relinquishment

Temporary Waste Rock Piles – Closure Task Register		
Post-closure Maintenance	Undertake regular inspections as per monitoring requirements to assess the need for maintenance activities.	Annually
	Implement post-closure maintenance activities as required.	As required to relinquishment

3.7 Temporary soil stockpiles

Table 3-7 Temporary Soil Stockpile Closure Task Register

Temporary Soil Stockpiles – Closure Task Register	
1.1 Description of Domain of Feature	
Temporary soil stockpiles will be stripped from the footprint of all features (other than temporary waste rock piles). This soil will be stripped and visually segregated from underlying waste rock.	
Location	Temporary soil stockpiles will be dynamic areas adjacent to the mine features. The changing areas they occupy will be opportunistically close to their source and/or ultimate end-use location and they will be utilised opportunistically throughout the mining cycle. When individual locations are completely consumed, they will be rehabilitated on an ongoing basis.
Tenements	ML 29463 & ML 29854
Status	There are currently no soil stockpiles.
Current Disturbance	Exploration 50 x 50m spaced drillholes and 200 x 200m spaced drillholes Pastoral Lease and Cattle Grazing
Life of Asset Disturbance	Varied and from short term to 30 years in total.
Estimated Closure Start Date	2022
Estimated Closure End Date	2050
Closure Works Duration	28 years
1.2 Land-Use Information	
Post-Mining Land Use	Natural habitat compatible with pastoral use.
Rehabilitated Landform Objective	Reinstate natural (unmanaged) ecosystem(s) similar to the pre-mining state that does not preclude pastoral use or inhibit surrounding pastoral use. Rehabilitation will achieve a stable and functioning landform that is consistent with the surrounding landscapes and other environmental values and will remove potential for long term, post closure impacts on downstream water quality, beneficial uses and environmental values.
Post-Mining Landform Design	**None.** Flat area rehabilitation.
Closure Completion Criteria and Performance Indicators	Certification that adequate topsoil remains in place. Certification that adequate vegetation has been reinstated to meet the closure objectives.
1.3 Closure Work Tasks	

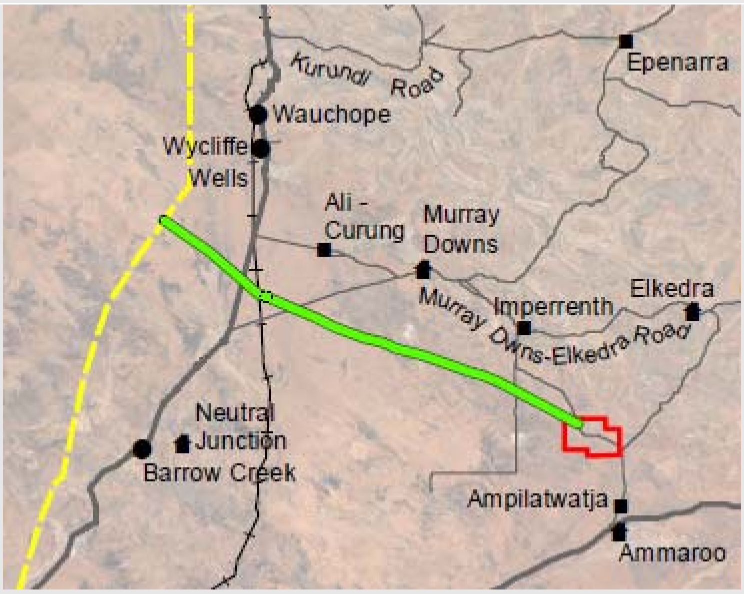
Activity	**Closure Work Tasks**	**Approx. Duration**
Development	1. Seed soil stockpile immediately after placement to prevent mobilization.	Within 1 month.

Temporary Soil Stockpiles – Closure Task Register		
Decommission	Not applicable	Not applicable
Demolition and Disposal	Not applicable	Not applicable
Site landform and drainage reconstruction	1. When individual locations are completely consumed down to the pre-existing topsoil, they will be remediated on an ongoing basis. 2. Reshape, re-contour all disturbed areas if required. 3. Reestablish natural drainage system where required and/or ensure appropriate drainage. 4. Deep rip all access roads.	1 month
Rehabilitation and re-vegetation	1. Spread remaining available topsoil on access roads at >100mm (pushed to side of tracks) and rip on contour. 2. Seed using local seed species, fertilize if soil amelioration is warranted, and lightly cover with any available vegetation detritus.	1 month
Security and Signage	• No security or safety signage is required.	Not applicable
1.4 Schedule of Work for Research, Investigation and Trials Tasks		
Aspect	**Research, Investigations and/or Trial**	**Schedule**
Rehabilitation	No further research envisaged.	Not applicable
Arid zone seeding	Conduct ongoing pre-closure trials and investigations that will inform the success of seeding in an arid zone.	Not applicable
1.5 Schedule of Work for Progressive Rehabilitation		
Aspect	**Progressive Rehabilitation Works**	**Schedule**
Not applicable	Not applicable May require re-working (or alternate management) if exotic species establish.	Not applicable
1.6 Availability and Management of Closure Material Sources		
Requirement	**Resource**	**Volume/Area**
Earthworks area	Assumed to be minor work required.	See Table 4-1
Topsoil	Spread available topsoil to 100 mm (only where previously removed, i.e. access roads). Topsoil stockpiled alongside disturbed areas (only where previously removed).	See Table 4-1
Seeding	Seed disturbed areas. Purchase from local supplier or source locally.	See Table 4-1
1.7 Key Tasks for Unexpected (Early) Closure and/or Temporary Closure		
Scenario	**Key Tasks**	**Schedule**
Early Closure	No specific key tasks are envisaged for early closure. May require re-working (or alternate management) if exotic species establish.	Not applicable.
Temporary Closure	No specific tasks are envisaged for temporary closure.	On announcement of temporary closure.

Temporary Soil Stockpiles – Closure Task Register		
	May require re-working (or alternate management) if exotic species establish.	
1.8 Information Gaps		
Aspect	**Information Gap/Uncertainty**	**Resolution Plan/Schedule**
Not applicable	None identified.	Not applicable
1.9 Performance Monitoring and Maintenance Schedule		
Aspect	**Performance Monitoring and Maintenance Task**	**Schedule**
Post-Closure Monitoring	Implement agreed post-closure monitoring program.	Relinquishment
Post-closure Maintenance	Undertake regular inspections as per monitoring requirements to assess the need for maintenance activities.	Annually
	Implement post-closure maintenance activities as required.	As required to relinquishment

3.8 Access corridor and pipeline

Table 3-8 Access Corridor and Pipeline Closure Task Register

Access Corridor and gas pipeline – Closure Task Register	
1.1 Description of Domain of Feature	
The access corridor and pipeline comprises; • A single gravel access road, rail line (including rail loop) and gas pipeline to the mine. • Associated infrastructure including 20 km spaced bores for water supply, water holding structures, bore access roads and bore power generation.	
	
Location	Ammaroo Phosphate Project to the existing Alice Springs to Darwin rail infrastructure and gas pipeline.
Tenements	TBA for most of its length, ML 29463 at the project site.
Status	The gravel access road, rail line, gas pipeline, water supply bores and all other associated infrastructure (i.e. water ponds/turkeys nests) are not yet constructed.

Access Corridor and gas pipeline – Closure Task Register	
Current Disturbance	Pastoral Lease and Cattle Grazing
Life of Asset Disturbance	25 years (LOM)
Estimated Closure Start Date	2045
Estimated Closure End Date	2047
Closure Works Duration	2 Years
1.2 Land-Use Information	
Post-Mining Land Use	Natural habitat compatible with pastoral use. Consideration to keep as major infrastructure if a beneficial use can be demonstrated at the time.
Rehabilitated Landform Objective	Reinstate natural (unmanaged) ecosystem(s) similar to the pre-mining state that does not preclude pastoral use or inhibit surrounding pastoral use. Rehabilitation will achieve a stable and functioning landform that is consistent with the surrounding landscapes and other environmental values and will remove potential for long term, post closure impacts on downstream water quality, beneficial uses and environmental values.
Post-Mining Landform Design	**Bores** Flat area rehabilitation. Hand over to pastoralists or decommission. Remove turkeys nests. **Rail line** Flat area rehabilitation. Cover with soil **Gravel access road in corridor** Where required, this may remain as a permanent feature for use by Pastoralists, and to maintain access to site for post closure monitoring. Alternatively, flat area rehabilitation or gently undulating stable landforms.
Closure Completion Criteria and Performance Indicators	Certification that adequate topsoil is in place. Certification that adequate vegetation has been reinstated to meet the closure objectives.

1.3 Closure Work Tasks

Activity	Closure Work Tasks	Approx. Duration
Development	1. Strip and stockpile soil from the footprint of the disturbed sections. As the stockpiles are relatively long term, they should mimic local longitudinal dunes in shape and orientation (which is approximately parallel to the orientation of the corridor), with adequate diversion drainage and sediment control. 2. Seed soil stockpile immediately after placement to prevent mobilisation.	1 year during construction.
Decommission	1. Disconnect all electrical power supply cables and isolate all equipment. 2. Remove ponds and evaporate. 3. Decommission and purge gas line.	2 to 4 weeks
Demolition and Disposal	1. Remove track, disperse ballast. 2. Remove any aboveground gas pipeline infrastructure. 3. Remove bore headworks, peripheral infrastructure (<0.5m deep) and local supply powerlines. Leave pipes >0.5m deep insitu.	2 to 5 months

Access Corridor and gas pipeline – Closure Task Register		
	4. Dismantle water pipelines and store for removal off-site (e.g. potable water lines) or dispose. 5. Ensuring fauna safety, remove any perimeter fencing from dams at pipe maintenance areas (consider draining dams and removing liners prior to fence removal if required). 6. Remove, and if necessary, clean any infrastructure to be transported off site for re-use/recycling/sale. 7. Cut and/or break up demolition debris, piping and liner to suitable size for safe transport and disposal in base of pit or onsite landfill. 8. Decommission bores (if not required for pastoralists) as per Minimum Construction Requirements for Water Bores in Australia.	
Site landform and drainage reconstruction	**Turkeys nests** 1. Push down embankments reshape and contour to establish sustainable drainage and blend with surrounding landscape, using suitable materials from roads and/or embankments for fill where required. **All Other Areas** 1. Reshape, re-contour all disturbed areas. 2. Re-establish natural drainage system where required and/or ensure appropriate drainage. 3. Deep rip all access roads not required by the post-closure land user.	2 to 5 months
Rehabilitation and re-vegetation	1. Spread available topsoil at >100mm (pushed to side of tracks) and rip on contour. 2. Seed using local seed species, fertilize if soil amelioration is warranted, and lightly cover with any available vegetation detritus.	2 to 4 months
Security and Signage	• The bores along corridor and other areas will become part of the pastoral lease. • No security or safety signage is required.	Not applicable

1.4 Schedule of Work for Research, Investigation and Trials Tasks

Aspect	**Research, Investigations and/or Trial**	**Schedule**
Rehabilitation	No further research envisaged.	Not applicable
Arid zone seeding	Conduct ongoing pre-closure trials and investigations that will inform the success of seeding in an arid zone.	Not applicable

1.5 Schedule of Work for Progressive Rehabilitation

Aspect	**Progressive Rehabilitation Works**	**Schedule**
Gravel and other borrow areas	Ongoing progressive rehabilitation works are planned for gravel and borrow areas if/when it has been established that these will not be required for future expansions, etc.	To be determined.

1.6 Availability and Management of Closure Material Sources

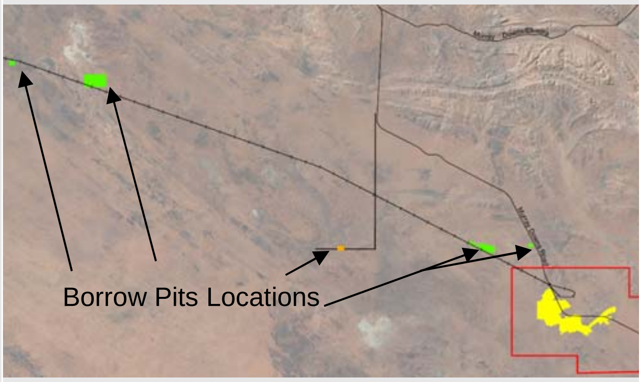
Requirement	**Resource**	**Volume/Area**
Excavate and Backfill	Minor backfill required for trenches and ponds using local materials.	See Table 4-1

Access Corridor and gas pipeline – Closure Task Register		
Earthworks area	Assumed to be minor work required.	See Table 4-1
Topsoil	Spread available topsoil to 100 mm (only where previously removed and available). Topsoil stockpiled alongside disturbed areas (only where previously.	See Table 4-1
Seeding	Seed entire areas disturbed. Purchase from local supplier or source locally.	See Table 4-1

Access Corridor and gas pipeline – Closure Task Register		
1.7 Key Tasks for Unexpected (Early) Closure and/or Temporary Closure		
Scenario	**Key Tasks**	**Schedule**
Early Closure	No specific key tasks are envisaged for early closure.	Not applicable.
Temporary Closure	No specific tasks are envisaged for temporary closure.	On announcement of temporary closure.
1.8 Information Gaps		
Aspect	**Information Gap/Uncertainty**	**Resolution Plan/Schedule**
Not applicable	None identified.	Not applicable
1.9 Performance Monitoring and Maintenance Schedule		
Aspect	**Performance Monitoring and Maintenance Task**	**Schedule**
Post-Closure Monitoring	Implement agreed post-closure monitoring program.	Relinquishment
Post-closure Maintenance	Undertake regular inspections as per monitoring requirements to assess the need for maintenance activities.	Annually
	Implement post-closure maintenance activities as required.	As required to relinquishment

3.9 Borrow pits and their access roads

Table 3-9 Borrow Pits Closure Task Register

Borrow Pits – Closure Task Register	
1.1 Description of Domain of Feature	
The borrow pits include shallow excavations to win gravel for construction of roads and rock for rail ballast.	
Location	Adjacent to Murray Downs Road, along rail alignment and outcrop to the north-west-west of the deposit.
Tenements	TBA
Status	Not yet developed.
Current Disturbance	Pastoral Lease and Cattle Grazing.
Life of Asset Disturbance	Varied, some may close immediately after construction others may be required for ongoing maintenance for up to 25 years (LOM).
Estimated Closure Start Date	2022

Borrow Pits – Closure Task Register	
Estimated Closure End Date	2050
Closure Works Duration	28 years.

1.2 Land-Use Information

Post-Mining Land Use	Natural habitat compatible with pastoral use
Rehabilitated Landform Objective	Reinstate natural (unmanaged) ecosystem(s) similar to the pre-mining state that does not preclude pastoral use or inhibit surrounding pastoral use. Rehabilitation will achieve a stable and functioning landform that is consistent with the surrounding landscapes and other environmental values and will remove potential for long term, post closure impacts on downstream water quality, beneficial uses and environmental values.
Post-Mining Landform Design	Flat area rehabilitation or gently undulating stable landforms with sloping drainage dependent on borrow pit geometry.
Closure Completion Criteria and Performance Indicators	Certification that adequate topsoil is in place. Certification that adequate vegetation has been reinstated to meet the closure objectives.

1.3 Closure Work Tasks

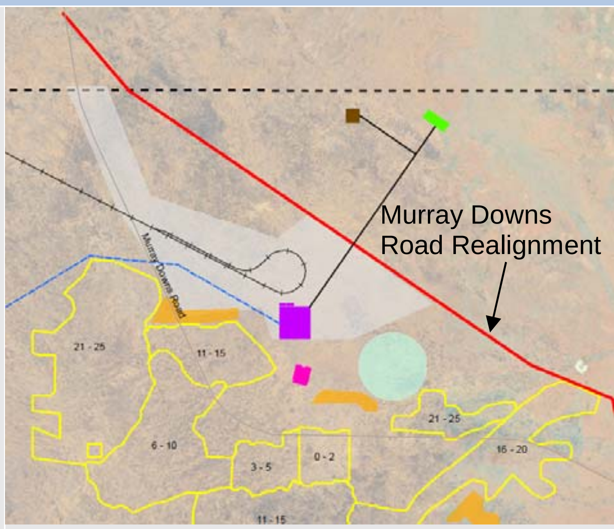
Activity	**Closure Work Tasks**	**Approx. Duration**
Development	Strip and stockpile soil from the footprint of the disturbed sections. Seed soil stockpile immediately after placement to prevent mobilization.	1 month prior to mining.
Decommission	Cease quarrying when individual borrow pits are no longer required or resource has been exhausted.	Ongoing throughout LOM. 25 years.
Demolish	Not applicable	Not applicable
Clean-up and dispose	Not applicable	Not applicable
Site landform and drainage reconstruction	1. Reshape/re-contour area to generally radially drainage and to remove any erosion prone features. 2. Retain locally occurring tree species where possible. 3. Remove any exotic plant species as required.	6 months (Ongoing throughout LOM)
Rehabilitation and re-vegetation	1. Spread available topsoil at >100mm where required and rip on contour. 2. Seed with local pioneer species and mulch with any available vegetation detritus. 3. Create fauna habitats (e.g. using rocks and available vegetation detritus).	4 to 6 months (Ongoing throughout LOM)
Security and Signage	The site will be safe for public access post-closure. No security fencing or signage is required. Stock fencing put in place around the borrow pits to keep cattle off the surface, particularly during the early growth years immediately post-closure.	Not applicable

Borrow Pits – Closure Task Register		
	Fencing will be maintained by post-closure landowner/pastoralist.	
1.4 Schedule of Work for Research, Investigation and Trials Tasks		
Aspect	**Research, Investigations and/or Trial**	**Schedule**
Arid zone seeding	Conduct ongoing pre-closure trials and investigations that will inform the success of seeding in an arid zone.	Not applicable
1.5 Schedule of Work for Progressive Rehabilitation		
Aspect	**Progressive Rehabilitation Works**	**Schedule**
Not applicable		
1.6 Availability and Management of Closure Material Sources		
Requirement	**Resource**	**Volume/Area**
Earthworks Area	Area requiring landforming and contouring based on surface area of pits.	See Table 4-1.
	Other areas requiring minor earthworks/landscaping (i.e. exterior haul roads).	See Table 4-1.
Topsoil	Spread to areas as required at >100mm. Topsoil stockpiled adjacent to pits.	See Table 4-1.
	Spread topsoil to other areas.	See Table 4-1.
Seeding	Seed areas disturbed and topsoiled. Purchase local pioneer species seed from local supplier (or establish local supply).	See Table 4-1.
1.7 Key Tasks for Unexpected (Early) Closure and/or Temporary Closure		
Scenario	**Key Tasks**	**Schedule**
Early Closure	Anywhere where the early closure has resulted in partially completed landforms, further earthworks will be required to meet the final design specifications. This includes, any non-competent material left exposed at the time of closure will need to be covered in competent rock to the minimum thickness required by the design specifications.	At early closure
	Remove and/or process any remaining ore stockpiles.	At early closure
Temporary Closure	Put in place bunding and/or fencing to prevent public access to unsafe areas.	On announcement of temporary closure.
	Develop pit water management and care and maintenance plans.	On announcement of temporary closure.
	Establish pit slope monitoring.	During the period of temporary closure
1.8 Information Gaps		
Aspect	**Information Gap/Uncertainty**	**Schedule**
Landform and Rehabilitation Design	Determine the optimum cover design for maximum stability and vegetation establishment success.	Ongoing

Borrow Pits – Closure Task Register		
1.9 Performance Monitoring and Maintenance Schedule		
Aspect	**Performance Monitoring and Maintenance Task**	**Schedule**
Post-Closure Monitoring	Implement agreed post-closure monitoring program.	Relinquishment
Post-closure Maintenance	Undertake regular inspections as per monitoring requirements to assess the need for maintenance activities.	Annually
	Implement post-closure maintenance activities as required.	As required to relinquishment

3.10 Murray Downs Road realignment area

Table 3-10 Murray Downs Road realignment area Closure Task Register

Murray Downs Road realignment area – Closure Task Register	
1.1 Description of Domain of Feature	
Murray Downs Road realignment area moves the existing road out of the footprint of the mine area. For the purpose of this report it is assumed the road will not be closed out and left as is at the end of mining.	
Location	Murray Downs Road alignment area to the north of the existing road.
Tenements	Not applicable.
Status	Not yet developed.
Current Disturbance	Pastoral Lease and Cattle Grazing.
Life of Asset Disturbance	Indefinite.
Estimated Closure Start Date	Not applicable
Estimated Closure End Date	Not applicable
Closure Works Duration	Not applicable
1.2 Land-Use Information	
Post-Mining Land Use	Road
Rehabilitated Landform Objective	Road

Murray Downs Road realignment area – Closure Task Register	
Post-Mining Landform Design	Road
Closure Completion Criteria and Performance Indicators	Not yet determined (NYD).

1.3 Closure Work Tasks

Activity	**Closure Work Tasks**	**Approx. Duration**
Development	Not applicable	Not applicable
Decommission	Not applicable	Not applicable
Demolish	Not applicable	Not applicable
Clean-up and dispose	Not applicable	Not applicable
Site landform and drainage reconstruction	Not applicable	Not applicable
Rehabilitation and re-vegetation	Not applicable	Not applicable
Security and Signage	Not applicable	Not applicable

1.4 Schedule of Work for Research, Investigation and Trials Tasks

Aspect	**Research, Investigations and/or Trial**	**Schedule**
Not applicable	Not applicable	Not applicable

1.5 Schedule of Work for Progressive Rehabilitation

Aspect	**Progressive Rehabilitation Works**	**Schedule**
Not applicable	Not applicable	Not applicable

1.6 Availability and Management of Closure Material Sources

Requirement	**Resource**	**Volume/Area**
Earthworks Area	Area requiring landforming and contouring based on existing road alignment.	See Table 4-1.
	Other areas requiring minor earthworks/landscaping (i.e. access roads).	See Table 4-1.
Topsoil	Spread to areas as required at >100mm. Topsoil stockpiled adjacent road (represents an available excess of topsoil for the project).	See Table 4-1.
	Spread topsoil to existing road area.	See Table 4-1.
Seeding	Seed existing road areas disturbed and topsoiled. Purchase local pioneer species seed from local supplier (or establish local supply).	See Table 4-1.

1.7 Key Tasks for Unexpected (Early) Closure and/or Temporary Closure

Scenario	**Key Tasks**	**Schedule**
Early Closure	Not applicable	Not applicable
Temporary Closure	Not applicable	Not applicable

Murray Downs Road realignment area – Closure Task Register		
1.8 Information Gaps		
Aspect	**Information Gap/Uncertainty**	**Schedule**
Landform and Rehabilitation Design	Not applicable	Not applicable
1.9 Performance Monitoring and Maintenance Schedule		
Aspect	**Performance Monitoring and Maintenance Task**	**Schedule**
Post-Closure Monitoring	Not applicable	Not applicable
	Not applicable	Not applicable

4. Summary of disturbance areas and required rehabilitation soils

A summary of the above disturbance areas and closure volumes (required rehabilitation soils) are presented in Table 4-1. Based on the balance there is sufficient topsoil to meet the minimum closure requirements and possibly an excess pending the actual thickness encountered at each area. Waste rock volumes required are not shown as there is an excess of waste rock due to bulking.

Table 4-1 Summary of Disturbance Areas and Required Rehabilitation Soils

Primary Areas	Length (m)	Length (km)	Width (m)	Actual Designated Area (Ha)	Actual Designated Area (m2)	Soil Resource m3 (Lower Limit 100mm)	Soil Resource m3 (Upper Limit 1000mm)	Minimum Required Rehabilitation Soil m3 (at 100mm)
Construction Area	-	-	-	675	6750000	675000	6750000	675000
Pits	-	-	-	1500	15000000	1500000	15000000	1500000
Surface TSF	-	-	-	90	900000	90000	900000	90000
Production Borefield	-	-	-	20.0	200000	20000	200000	20000
Access Corridor and Pipeline	137012	137	30 and 70	752	7520000	752000	7520000	752000
Borrow Pits	-	-	-	550	5500000	550000	5500000	550000
Murray Downs Road realignment area	11193	11	40	45	450000	45000	450000	0
Soil stockpiles	-	-	-	Varied over LOM	Varied over LOM	0	0	0
Temporary Waste Rock Piles	-	-	-	Varied over LOM	Varied over LOM	0	0	0
Breakdown of Secondary Areas	**Length (m)**	**Length (km)**	**Width (m)**	**Actual Designated Area (Ha)**	**Actual Designated Area (m2)**	**Soil Resource m3 (Lower Limit 100mm)**	**Soil Resource m3 (Upper Limit 1000mm)**	**Miniumum Required Rehabiltation Soil m3 (at 100mm)**
Ballast quarry access road	7379	7	10	7	73786	7378.64	73786.4	7378.64
Gravel pit	-	-	-	16	160000	Counted Above	Counted Above	Counted Above
Gravel pit	-	-	-	120	1203340	Counted Above	Counted Above	Counted Above
Gravel pit	-	-	-	27	269940	Counted Above	Counted Above	Counted Above
Ballast quarry	-	-	-	33	329570	Counted Above	Counted Above	Counted Above
Gravel pit	-	-	-	305	3045200	Counted Above	Counted Above	Counted Above
Gravel pit	-	-	-	26	258400	Counted Above	Counted Above	Counted Above
Rail Loop	6919	7	70	48	484322.3	Counted Above	Counted Above	Counted Above
Bene Plant	-	-	-	22	218488.07	Counted Above	Counted Above	Counted Above
Camp Carpark	-	-	-	0.4	3962.28	Counted Above	Counted Above	Counted Above
Permanent Camp	-	-	-	56	563216.9	Counted Above	Counted Above	Counted Above
Waste Management Facility	-	-	-	1	10000	Counted Above	Counted Above	Counted Above
Starter TSF	-	-	-	38	384700	Counted Above	Counted Above	Counted Above
Plant Access Road	1336	1	40	5	53440	Counted Above	Counted Above	Counted Above
Gas Only Section	37600	38	30	113	1127988	Counted Above	Counted Above	Counted Above
Rail and Gas Section	99413	99	70	696	6958895	Counted Above	Counted Above	Counted Above
Production Borefield Access Road	17634	18	10	18	176345	17634	176345	17634
Total of Primary and Secondary Soils						**3657013**	**36570131**	**3612013**
Net Excess of Soil m3 Lower Limit when re-applied at 100mm						**45000**		
Net Excess of Soil m3 Upper Limit when re-applied at 100mm							**32958118**	

5. Risk Assessment

The risks associated with closure, rehabilitation and post mining land use were examined as part of a high level risk assessment undertaken for the Project (described in more detail in the draft EIS). Following the identification of measures to eliminate or mitigate the risks, the assessment was repeated for each risk to determine the 'residual' or 'mitigated' risk. Likelihood and consequence are determined and compared using a risk matrix to determine risk scores. Key mine closure risks identified in Table 5-1. The proposed mitigation measures in Table 5-1 are considered to be commitments to further inform the MCP.

Table 5-1 Mine Closure Risks and Mitigation Measures

Hazard / event - End of life	Consequence	Mitigation Measures
Failure of post-closure surface TSF batters (not likely to be covered), leading to erosion or seepage loss of material to the environment. Or failure of in-pit TSF concept, excessive settlement or contaminated seepage discharge.	Erosion and dispersion of particulate matter via air, surface, or groundwater flows, with resultant downstream effects on dependant ecosystems.	• Reporting of spills. • Contaminated sites register. • Contaminated sites report. • Contaminated sites rehabilitation designs. • Closure plan. Operator is responsible for site until demonstrated that able to meet agreed closure objectives and criteria. • Undertake further sampling/monitoring to accurately define level and extent of any ground contamination during operations and improve volumetric estimates.
Poor management of waste materials during operations leads to closure plans being unachievable or costly.	Delays to effective rehabilitation by Project proponent, including erosion, or seepage resulting in non sustainable ecosystems and groundwater effects. Delays associated with cost overruns could be a period of years.	• Conceptual closure plan developed for the project at start-up. • Increase level of detail in closure designs during operations (detailed design level throughout mining operations and at least 5 yrs prior to closure). • Prepare decommissioning and rehabilitation plan. • Annual review of concept plans with updated estimates of disturbance with associated rehabilitation estimates. • Regular monitoring of identified key environmental aspects of operation that are potentially most problematic during operation and at closure i.e. surface/in-pit tailings, waste rock, seepage to ensure these aspects are fully understood and accounted for in all closure designs and proposals. • Strip mining methodology allows for progressive rehabilitation and review, include in mine plan showing open areas, replacement and order of fill etc. • Employ closure project manager. • Undertake inspections & monitoring.

Hazard / event - End of life	Consequence	Mitigation Measures
		• Performance monitoring of progressive rehabilitation and correction of designs/execution if required.
Contaminated sites not adequately remediated, including process plant, workshops, fuel farm or storage areas.	Delays to effective rehabilitation by Project proponent, including erosion, or contaminated seepage resulting in non sustainable ecosystems and groundwater effects. Delays associated with cost overruns could be a period of years. Inability to relinquish, leading to damage to reputation, not able to get bond, ongoing environmental damage.	• Long term offtake arrangements for clients. • Strategic long term investors. • Concept closure plan. • Commit to developing/refining closure designs through operations • Closure materials topsoils etc. stockpiles at start-up of operations. • Surface TSF design conservative and in-pit tailings/waste limited impact should they enter early closure as closure concept does not significantly change.- Progressive rehabilitation. • Bonds held by NT Government requires 110% of estimated closure cost reviewed and provided annually.
Closure designs not developed in detail to enable appropriate closure execution, including ineffective implementation of design, poor rehabilitation execution or design failure, resulting in significantly higher closure cost above closure provisioning.	Insufficient closure cost provision resulting in inability to execute closure plan. Delays or inability to achieve effective rehabilitation by Project proponent, Delays in achieving rehabilitation criterion and or relinquishment and could be a period of years, with un-remediated Project site potentially acting as source of ongoing environmental hazard.	• Reporting of spills. • Contaminated sites register. • Contaminated sites report. • Contaminated sites rehabilitation designs. • Closure plan. Operator is responsible for site until demonstrated that able to meet agreed closure objectives and criteria. • Undertake further sampling/monitoring to accurately define level and extent of any ground contamination during operations and improve volumetric estimates.
Reduction in the quality of ecosystems due to inconsistent / inadequate rehabilitation	A decrease in the abundance of flora and fauna ecosystem.	• Conceptual closure plan developed for the project at start-up. • Increase level of detail in closure designs during operations (detailed design level throughout mining operations and at least 5 yrs prior to closure). • Prepare decommissioning and rehabilitation plan.

Hazard / event - End of life	Consequence	Mitigation Measures
		• Annual review of concept plans with updated estimates of disturbance with associated rehabilitation estimates. • Regular monitoring of identified key environmental aspects of operation that are potentially most problematic during operation and at closure i.e. surface/in-pit tailings, waste rock, seepage to ensure these aspects are fully understood and accounted for in all closure designs and proposals • Strip mining methodology allows for progressive rehabilitation and review, include in mine plan showing open areas, replacement and order of fill etc. • Employ closure project manager. • Undertake inspections & monitoring. • Performance monitoring of progressive rehabilitation and correction of designs/execution if required.
Unexpected early closure of the Project, due to delays or falling commodity prices.	Delays to effective rehabilitation by Project proponent, including through erosion or seepage resulting in non sustainable ecosystems and groundwater effects. Potentially exacerbated by closure designs not yet developed in detail at time of early closure.	• Long term offtake arrangements for clients. • Strategic long term investors. • Concept closure plan. • Commit to developing/refining closure designs through operations. • Closure materials topsoils etc. stockpiles at start-up of operations. • Surface TSF design conservative and in-pit tailings/waste limited impact should they enter early closure as closure concept does not significantly change. • Progressive rehabilitation. • Bonds held by NT Government requires 110% of estimated closure cost reviewed and provided annually.
Insufficient funds / bonds for Project closure activities, due to - inadequate	Delays to effective rehabilitation, with un-remediated Project site potentially acting as source of ongoing	• Reporting of spills. • Contaminated sites register.

Hazard / event - End of life	Consequence	Mitigation Measures
closure plan designs, poor assumptions or failure to recognise impact of changes to operations on closure plans	environmental hazard. Worst credible consequence is involuntary administration, with NT Government to complete remediation with bonds shortfall and consequential budgetary impact.	• Contaminated sites report. • Contaminated sites rehabilitation designs. • Closure plan. Operator is responsible for site until demonstrated that able to meet agreed closure objectives and criteria. • Undertake further sampling/monitoring to accurately define level and extent of any ground contamination during operations and improve volumetric estimates.

6. Monitoring and maintenance

6.1 Operational monitoring

Monitoring undertaken during operations will provide data to help refine the MCP. Data gathered during the implementation of the Mine Management Plan (MMP) and its sub-plans will be retained in a manner that allows easy access for monitoring purposes.

Performance monitoring of progressively rehabilitation of pits backfilled with tailings and waste rock will be undertaken to inform and refine closure design and planning during the operational phase.

6.2 Post-operational monitoring and maintenance

The post-closure phase will include a programme to monitor the effectiveness of rehabilitation and closure and the achievement of closure criteria.

Post-closure monitoring will include assessments of public safety, geotechnical stability, physical stability, chemical stability and revegetation success.

A preliminary monitoring programme is outlined in the draft EIS. Further details of the monitoring location, frequency and parameters will be provided in later detailed revisions of the MCP which will be confirmed with Northern Territory Government prior to closure.

Following the end of operations, an agreed monitoring program will be implemented, that will span the closure and rehabilitation phases. The programme will record progress on meeting completion criteria.

7. References

Groundwater Science, 2012. Barrow Creek Project: Hydrogeological Review and Identification of Groundwater Supply Prospects.

Appendices

Appendix A – Not applicable, for Mining Engineering and Design Reports, please refer to the draft EIS.

GHD

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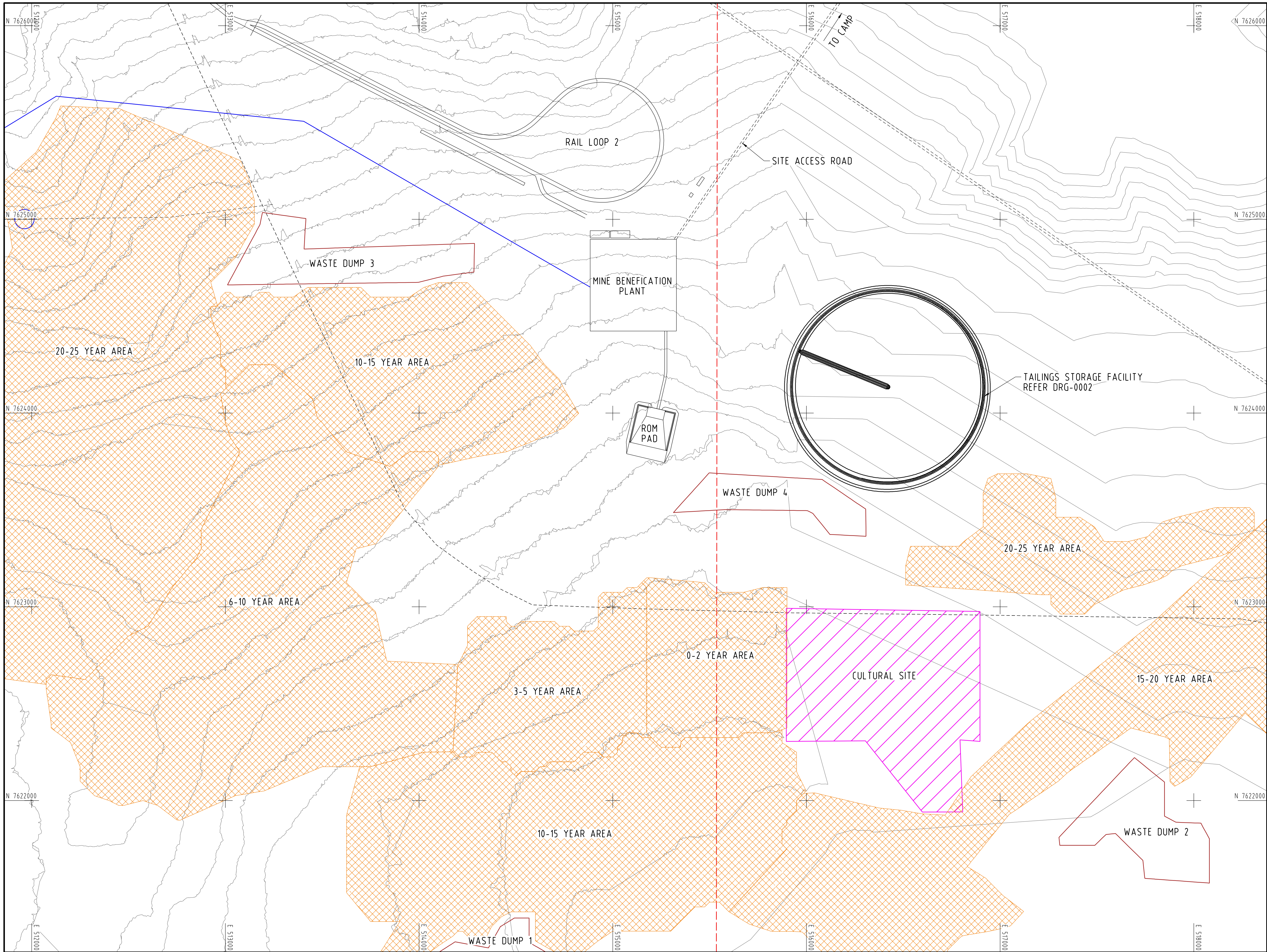
https://projects.ghd.com/oc/NorthernTerritory/rjrammaroophosphatee/Delivery/Documents/4322544_Closure_Report.docx

Document Status

Revision	Author	Reviewer		Approved for Issue		
		Name	Signature	Name	Signature	Date
0	Lee Evans	Robert Longey		Nicole Conroy		
1	Lee Evans	Robert Longey		Nicole Conroy		09/04/18

www.ghd.com

Appendix 2 – Tailings Storage Facility Drawings (WSP 2018)



NOTES

1. DIMENSIONS IN METERS UNLESS NOTED OTHERWISE
2. SURVEY CONTOURS AT 1.0m INTERVALS

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- ACCESS ROADS
- PRODUCTION BORE PIPELINE
- WASTE DUMPS
- CULTURAL SITE
- MINING AREAS

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TAILINGS STORAGE FACILITY
SITE PLAN

DRG No 201010-00710-CI-DRG-0001 REV A

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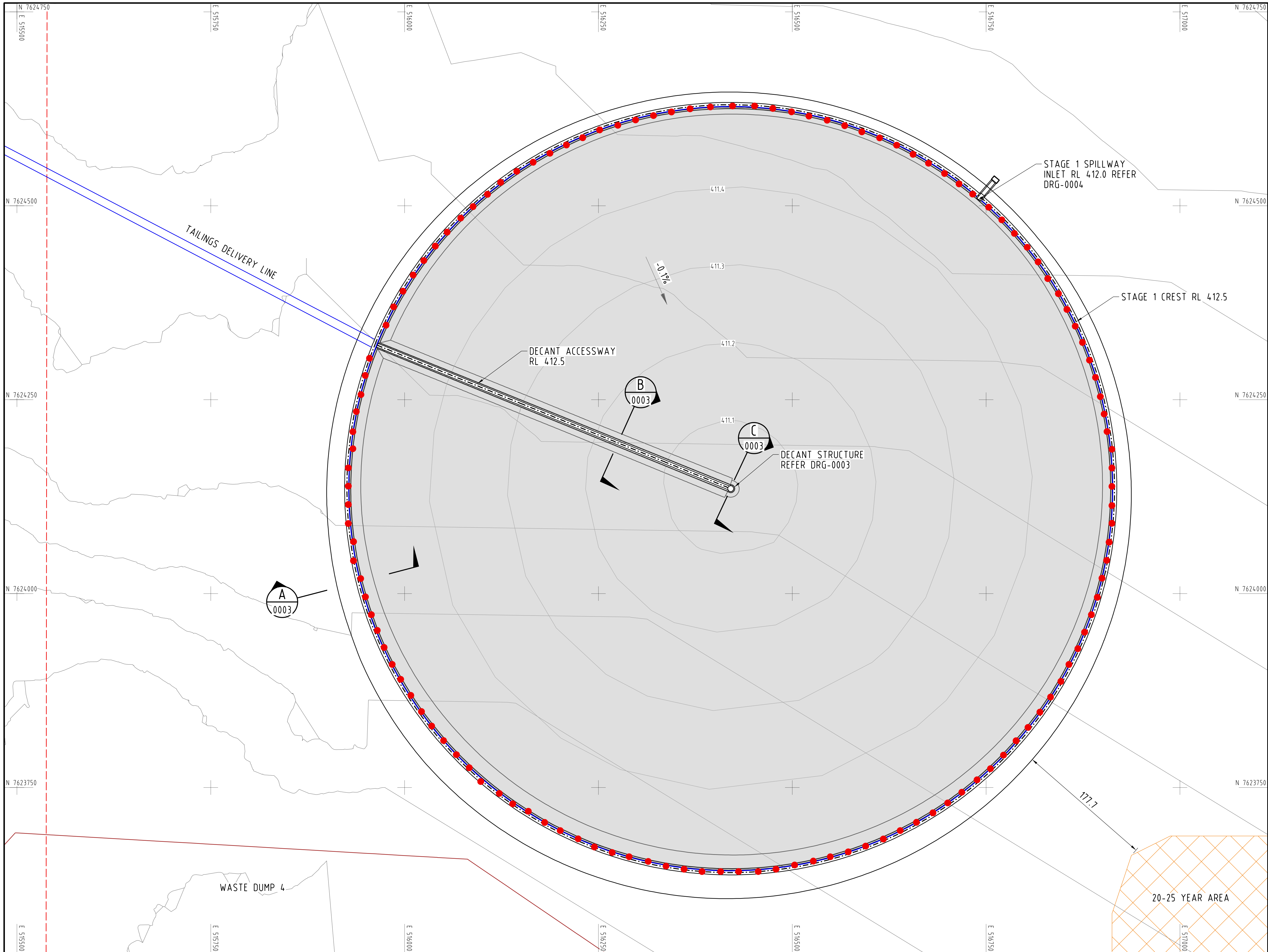

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3. DESIGN TAILINGS CONTOURS AT 0.1m INTERVALS

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- TAILINGS DELIVERY PIPELINE
- SPIGOT LOCATION
- MINE LEASE BOUNDARY
- WASTE DUMPS
- MINING AREAS
- DESIGN TAILINGS

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TAILINGS STORAGE FACILITY
STAGE 1 - GENERAL ARRANGEMENT

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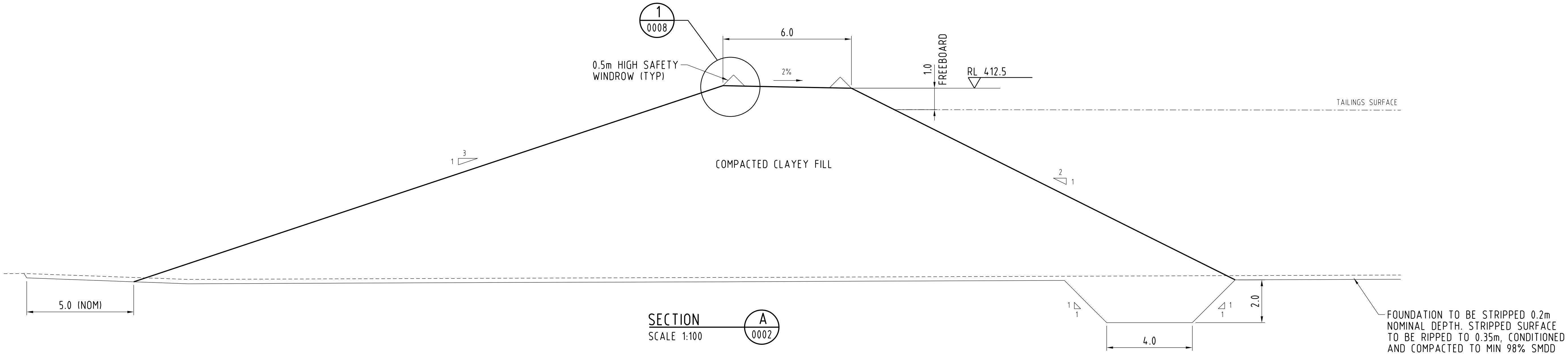

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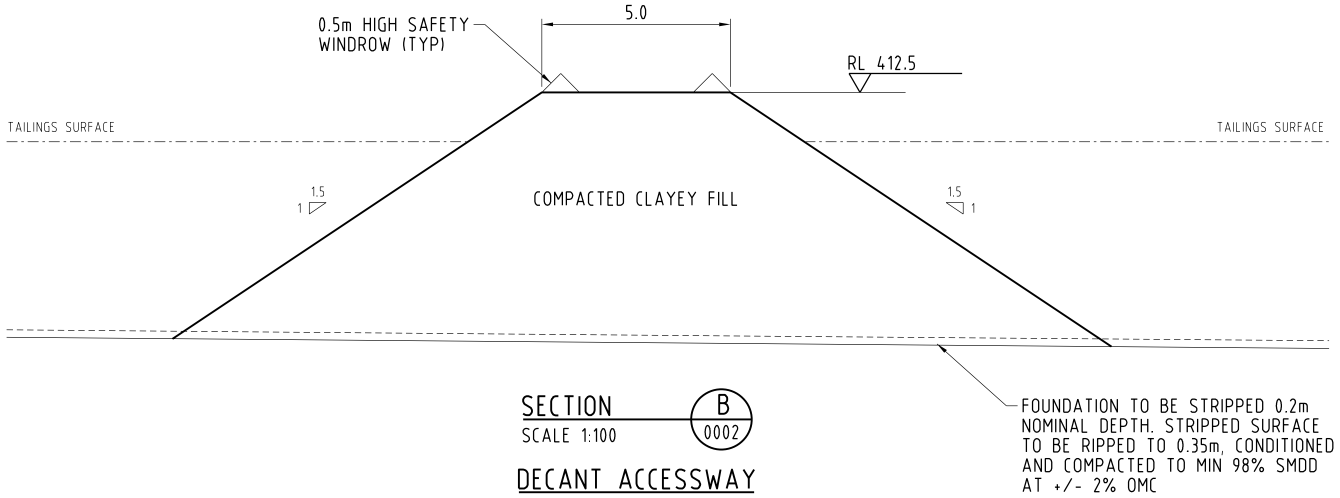

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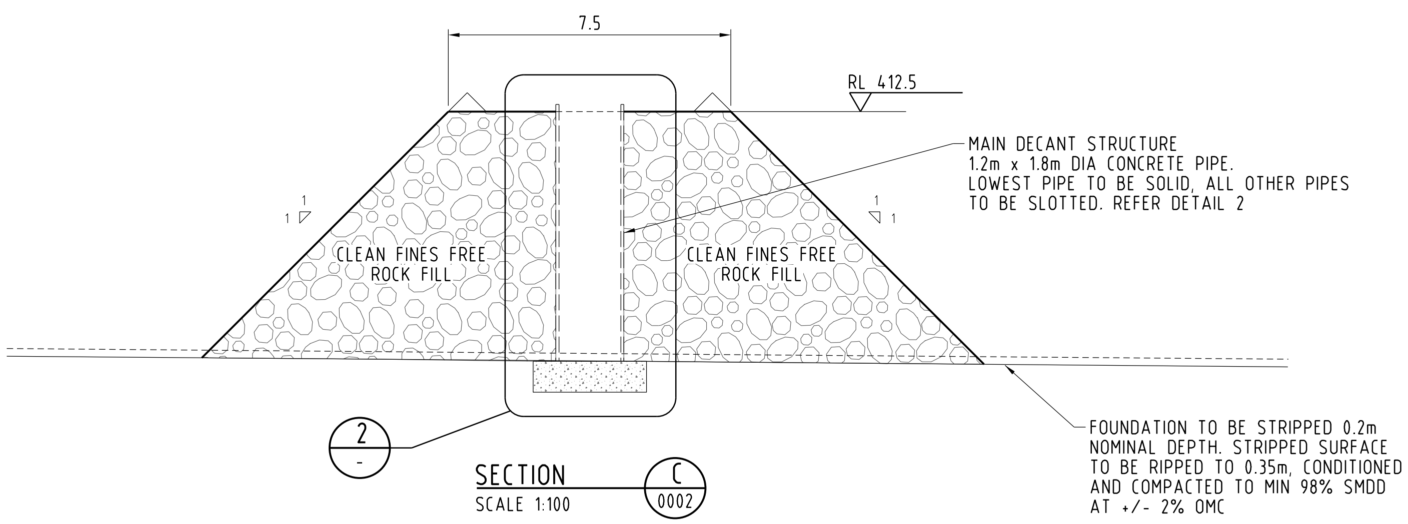

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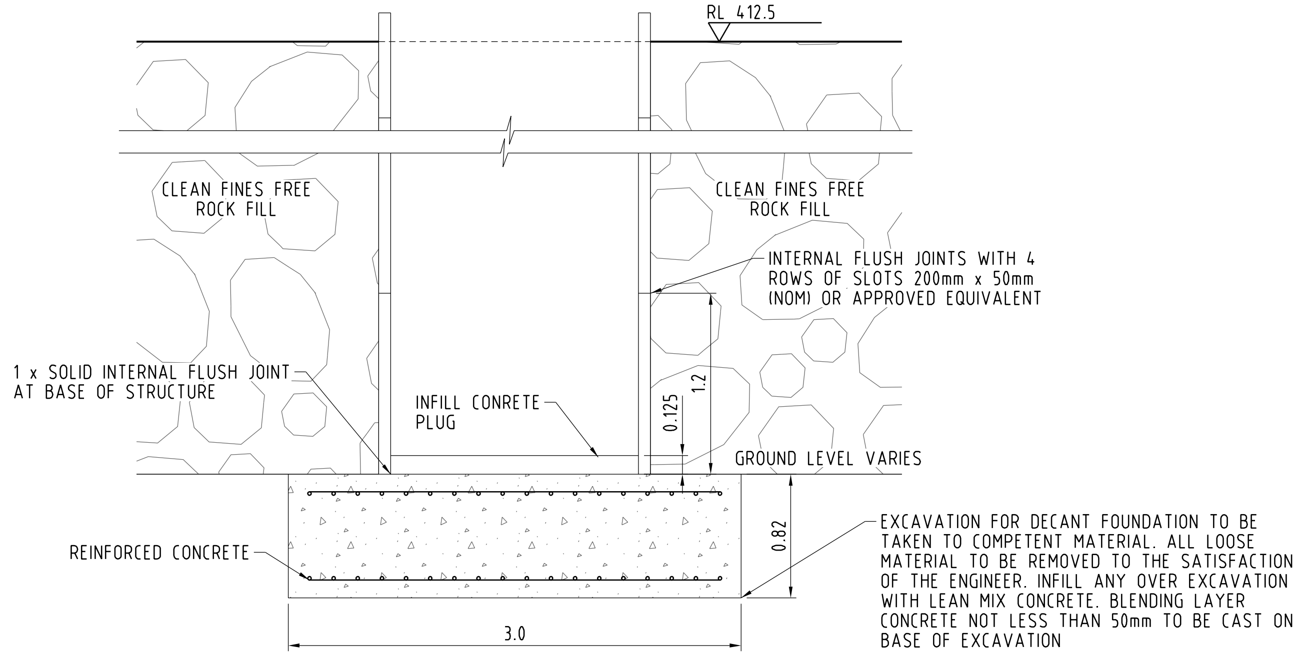

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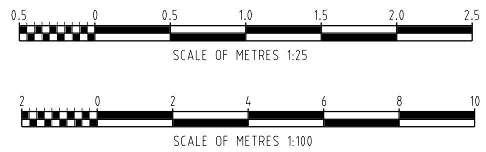

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TAILINGS STORAGE FACILITY
STAGE 1 - TYPICAL SECTIONS

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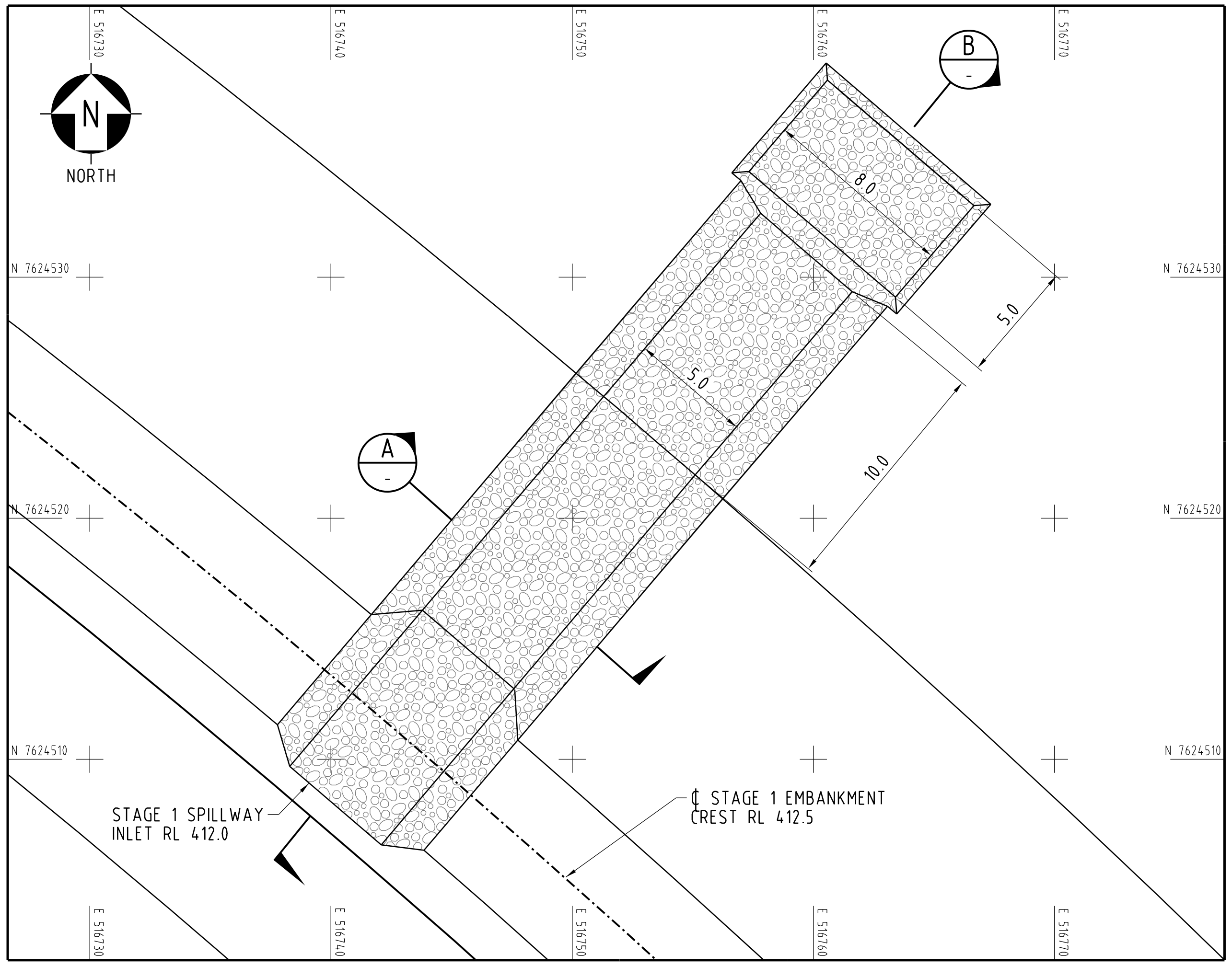

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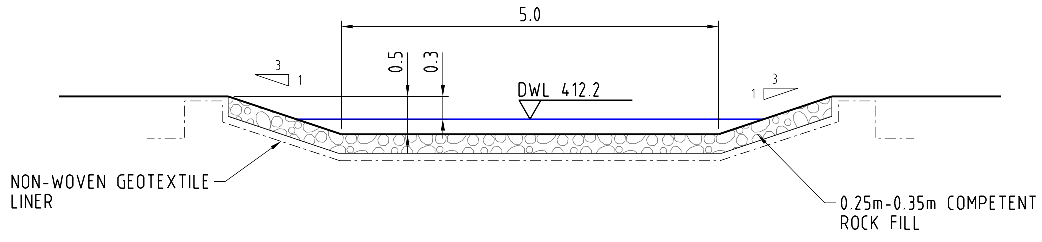

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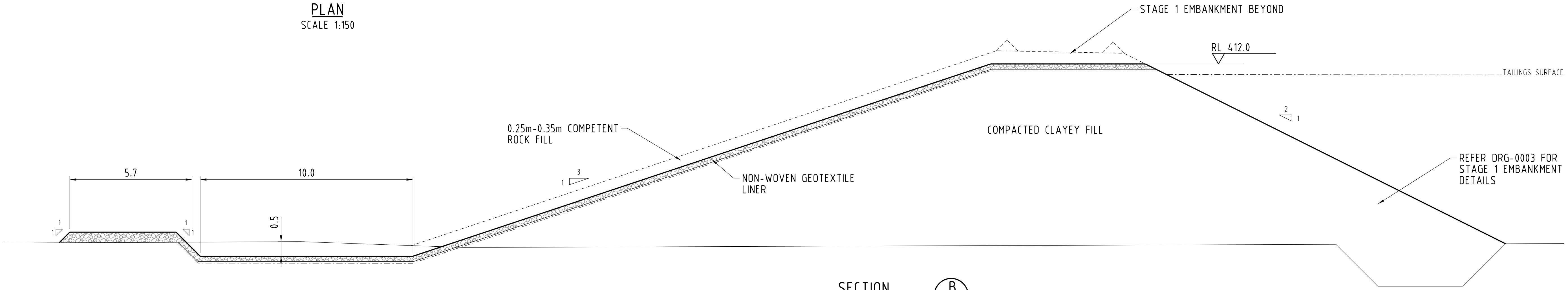

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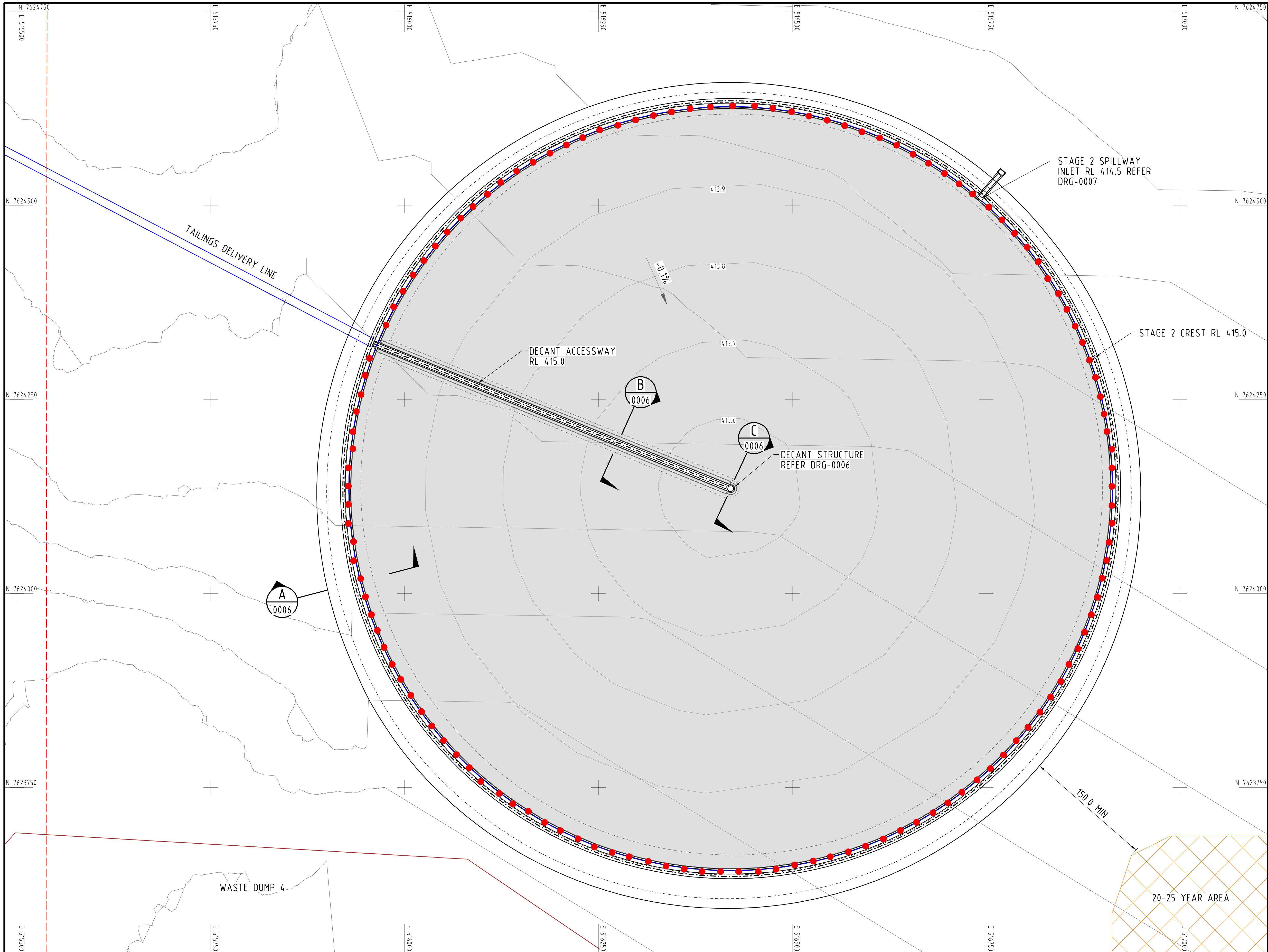

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LEGEND

- TAILINGS DELIVERY PIPELINE
- SPIGOT LOCATION
- MINE LEASE BOUNDARY
- WASTE DUMPS
- MINING AREAS
- DESIGN TAILINGS

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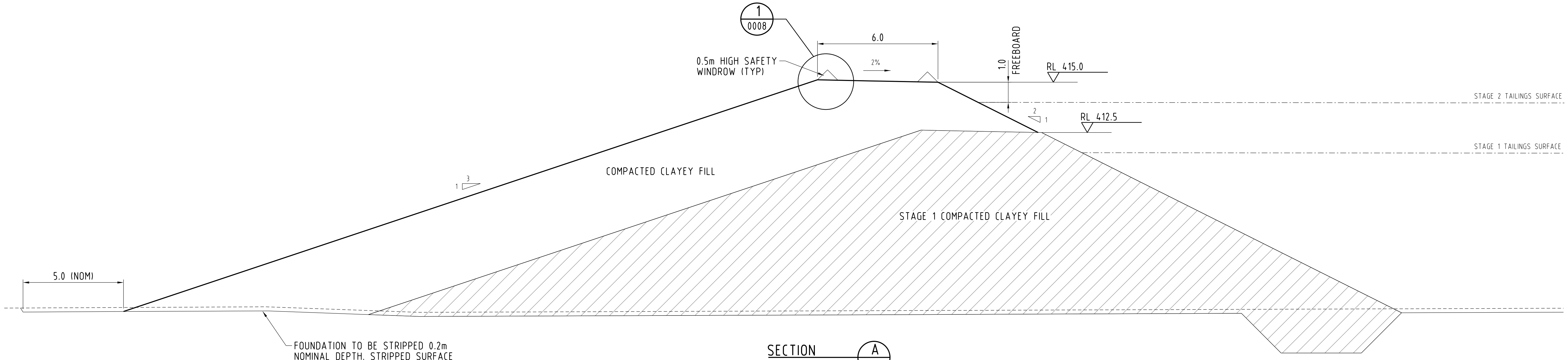

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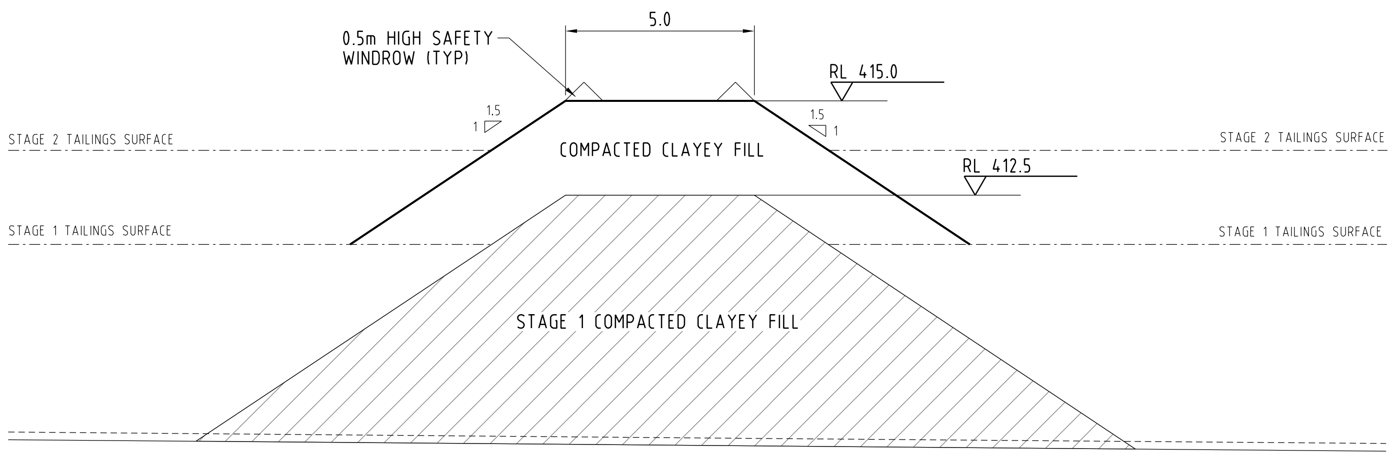

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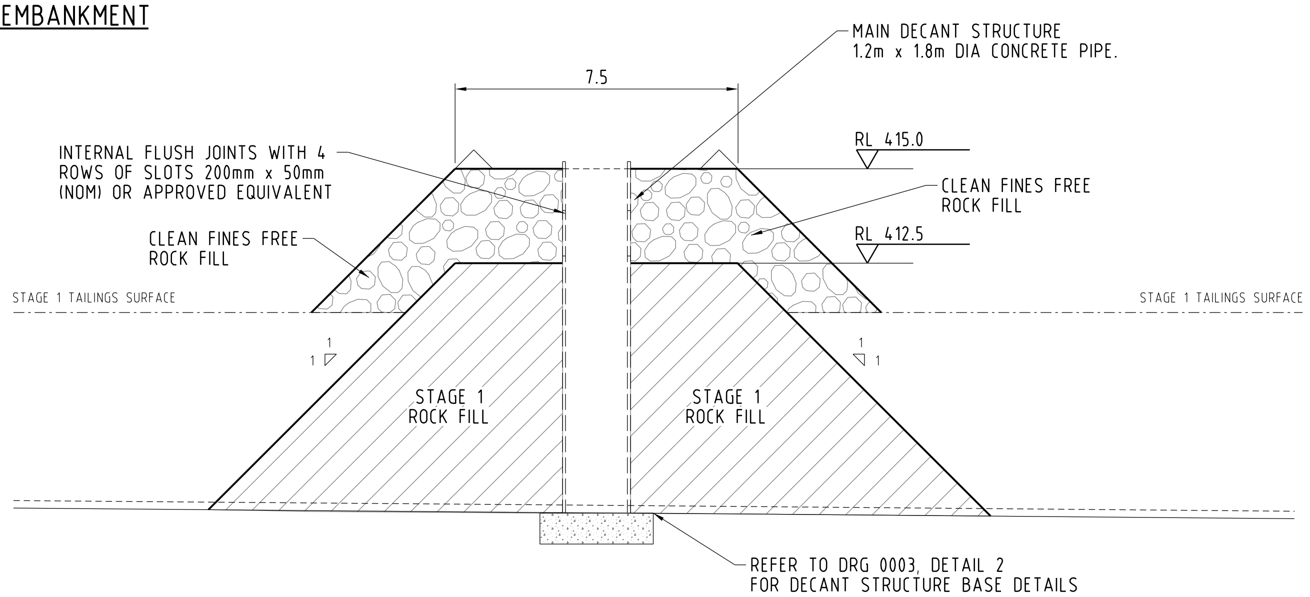

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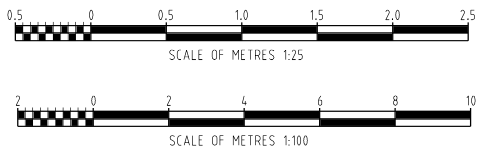

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STAGE 2 - TYPICAL SECTIONS

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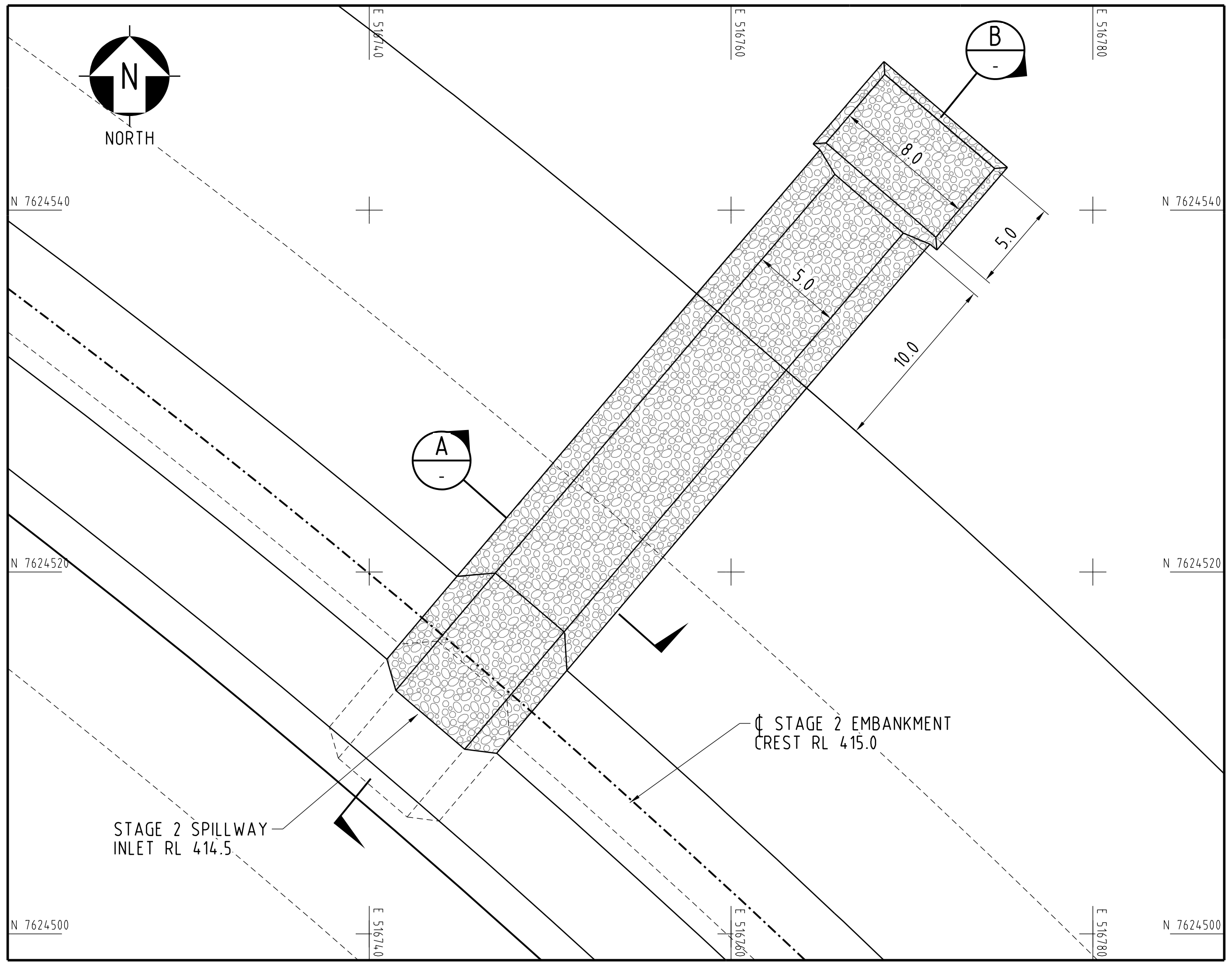

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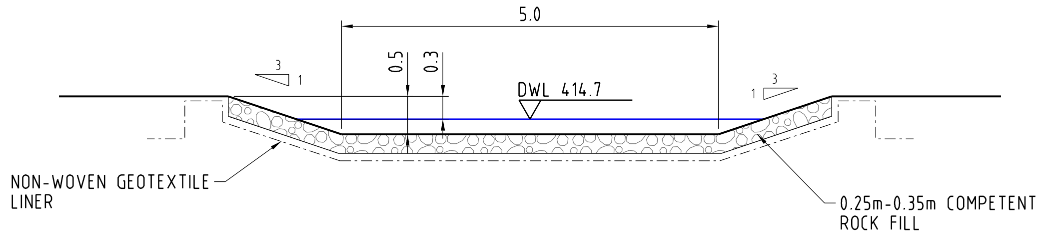

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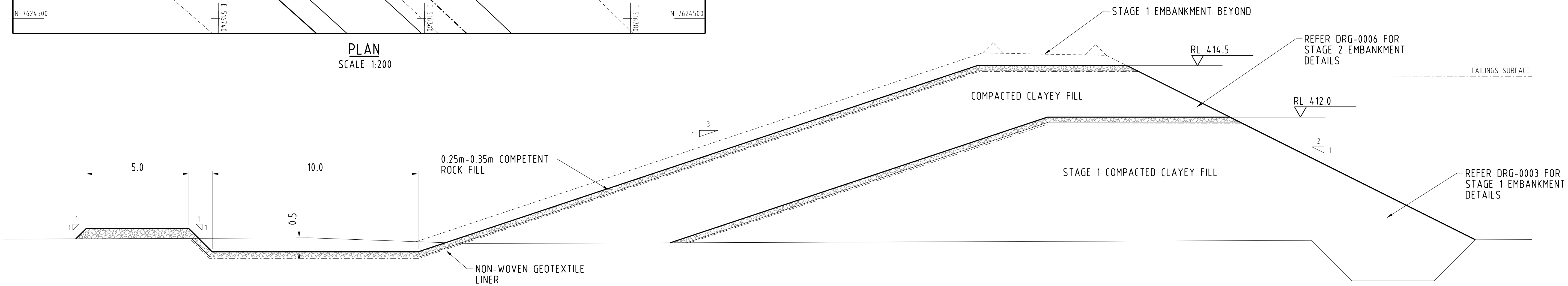

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VERDANT MINERALS

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BANKABLE FEASIBILITY STUDY
TAILINGS STORAGE FACILITY
STAGE 2 - SPILLWAY

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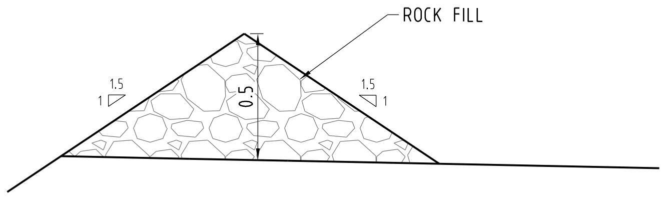
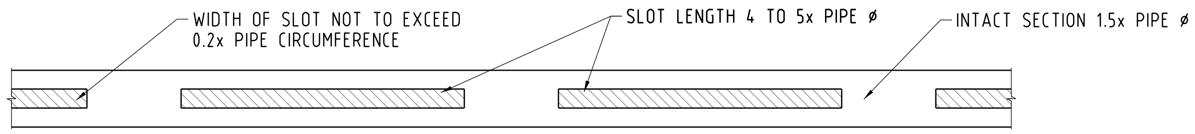


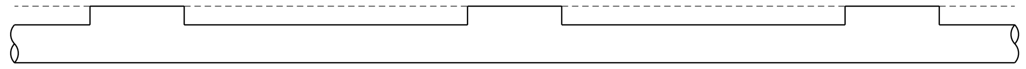
DETAIL 1 NTS 0003/0006

SAFETY WINDROW



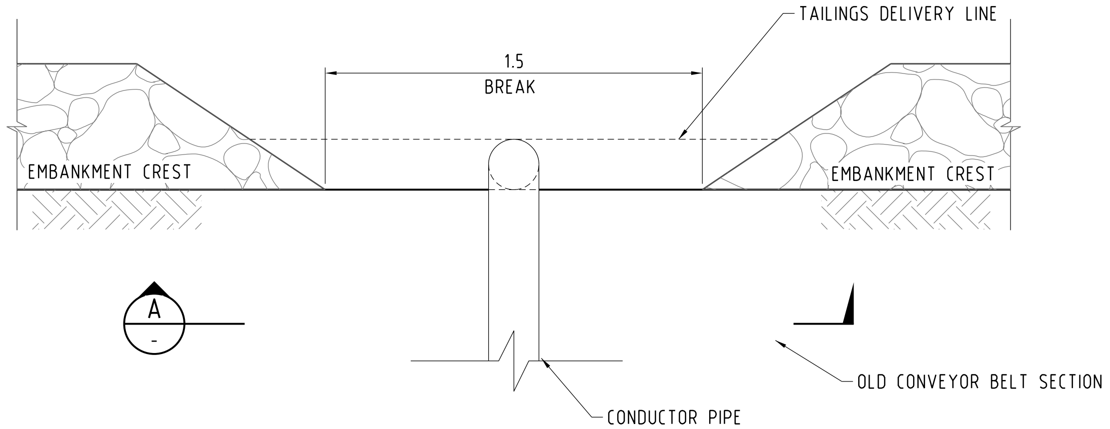
PLAN - SLOTTED PVC PIPE (CONDUCTOR PIPE)

NTS



ELEVATION - SLOTTED PVC PIPE (CONDUCTOR PIPE)

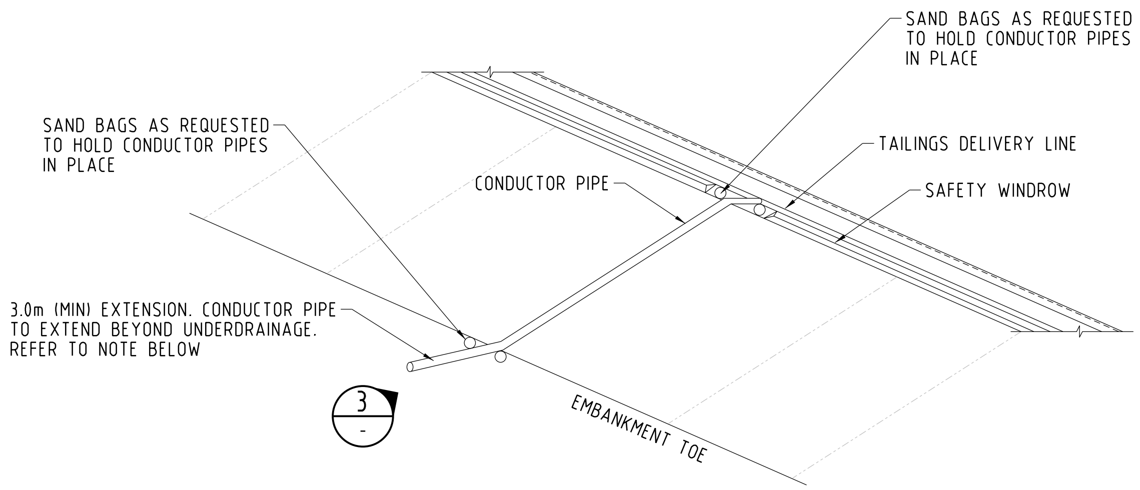
NTS



VIEW 3 NTS -

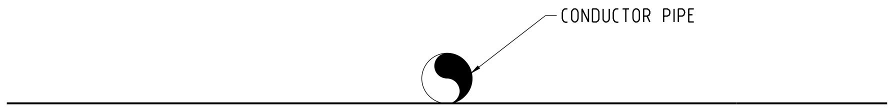
DRAINAGE/DEPOSITION PLAN

NOTE: SHOWING FRONT ON LOOK AT EMBANKMENT



PERSPECTIVE VIEW - DRAINAGE/DEPOSITION EMBANKMENT

NTS

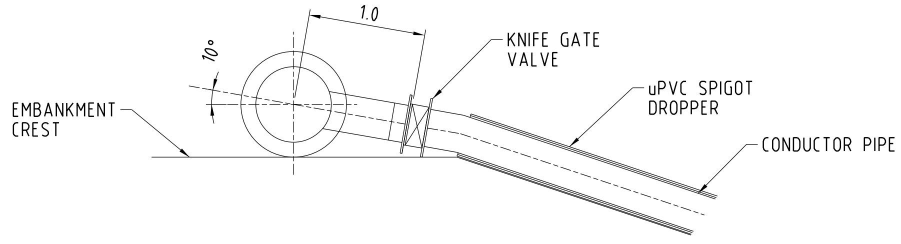


SECTION A NTS -

PRELIMINARY
UNCHECKED

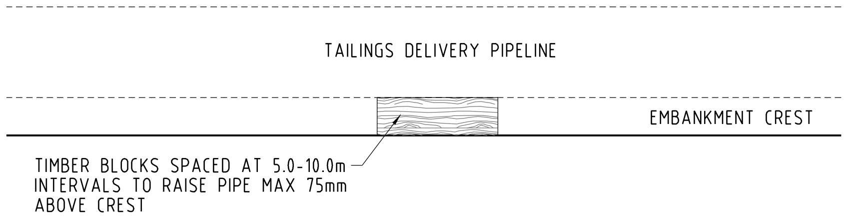
UNCONTROLLED
COPY

INFORMATION ONLY
NOT TO BE USED
FOR CONSTRUCTION



ELEVATION - SPIGOT TEE PIECE

NTS



PIPE RAISE DETAIL

NTS

NOTES

1. DIMENSIONS IN METERS UNLESS NOTED OTHERWISE

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SCALE OF METRES 1:10

REV	DATE	REVISION DESCRIPTION	DRAWN	DRAFT CHK	DESIGNED	ENG CHK	APPROVED	CLIENT	REF DRAWING No	REFERENCE DRAWING TITLE
B	25-JAN-18	ISSUED FOR REVIEW	SL							
A	10-JAN-18	ISSUED FOR REVIEW	SL							

A1 SHEET | SCALE AS SHOWN

OneWay to zero harm

ADVISIAN PROJECT No. 201010-00710

ENGINEERING AND PERMIT STAMPS (As Required)

CLIENT: VERDANT MINERALS

Advisian WorleyParsons Group

AMMAROO PHOSPHATE PROJECT
BANKABLE FEASIBILITY STUDY
TAILINGS STORAGE FACILITY
SECTIONS AND DETAILS

DRG No 201010-00710-CI-DRG-0008 | REV B

ADVISIAN_A1

PLOT DATE & TIME: 25/01/2018 12:05:34 PM SAVE DATE & TIME: $LSDATE$ $LSTIME$ USER NAME: simonie.javal LOCATION: I:\201010-00710 Ammaroo Phosphate (Perth copy)\Design\01_Drgs\DWG\201010-00710-CI-DRG-0008.dgn

Appendix 3 – Peer Review of AMD Assessment

26 April 2018
RGS Reference Number 2018016

Verdant Minerals Ltd
Unit 20, 90 Frances Bay Drive
Stuart Park NT 0820

Ammaroo Phosphate Project

Attention: Chris Tziolis (Managing Director)

Subject: Ammaroo Phosphate Project: AMD Report and Management Plan Review

1.0 INTRODUCTION

RGS Environmental Pty Ltd (RGS) was commissioned by Verdant Minerals Limited (Verdant) to undertake an independent review of the acid and metalliferous drainage (AMD) assessment and Management Plan prepared by GHD Pty Ltd (GHD) as part of a section of a draft EIS (Attachment I) for the Ammaroo Phosphate Project in the Northern Territory.

1.1 Background

The proposed Ammaroo Phosphate Mine (the "project") is owned by Verdant Minerals Limited (Verdant) and is located approximately 200 km south-east of Tennant Creek and 300 km north-east of Alice Springs in the Northern Territory. The project is designed to produce 2 million tonnes per annum (Mtpa) of phosphate concentrate over an operational period of 24 years, resulting in waste rock and tailings production of 8 - 21 Mtpa (322 Mt over mine life) and 3 to 4 Mtpa (dry), respectively. The mine will produce phosphate rock concentrate (P_2O_5) which will be transported from the Ammaroo site to the Port of Darwin for export.

The project will operate as an open cut mine with a flotation beneficiation plant and associated mine site infrastructure. The open pit is currently designed to an average depth of between 20-30 m and a maximum depth of 60 m bgl, and as it is above the water table; therefore, it will not require dewatering other than for surface water inputs.

The open pit will progressively be mined strip-by-strip, and after the initial strip becomes exhausted, waste rock from the subsequent strip will be back-filled (stored) in the mined-out void (strip), eliminating the need for permanent above ground waste rock storage. As the mine advances, the back-filled strip will be progressively rehabilitated.

Ore will be processed at the beneficiation plant to produce the phosphate rock concentrate product (75% of the input phosphate), tailings (25% of the input phosphate) and recycle process water stored in engineered ponds. For the first three years of operation, the tailings will be stored in a surface tailings storage facility (TSF) with a storage capacity of 5.3 Mt. After this period, when sufficient void space is made available, tailings will be co-disposed with waste rock and then progressively rehabilitated.

GHD was commissioned to undertake an acid and metalliferous drainage (AMD) assessment and waste rock management plan as part of the Environmental Impact Statement (EIS). The GHD scope of work included:

- Identifying the total amount of waste rock to be produced;
- Characterising the waste rock in terms of hazardous material and potential to develop acid, metalliferous and/or saline drainage; and,
- Development of an AMD Management Plan.

RGS was commissioned by Verdant to undertake an independent review of the AMD assessment and management plan prepared by GHD.

1.2 Scope of Work

The RGS scope of work for this project includes:

- Review and comment on the draft AMD Assessment/Management Plan for the Ammaroo Phosphate EIS (Appendix I) considering the associated NT EPA comments, existing risk-based technical guidelines for the geochemical assessment of mine waste in the Northern Territory (NTEPA, 2013), Australia (AMIRA, 2002; COA, 2016) and worldwide (INAP, 2009).
- Provide a short summary report of the findings of review, including recommendations; and,
- Review GHD report responding to the NT EPA comments.

The deliverable for the review of the GHD comments addressing the NT EPA comments is a marked-up (word track changes) copy of the document provided separately to this review document.

2.0 METHODOLOGY

RGS was provided with a link to a digital copy of the draft Ammaroo Phosphate EIS submission and a Word document of the NT EPA comments regarding geochemical aspects of the EIS, together with GHD's comments addressing the EPA comments.

In Australia, the regulatory and technical guidance document framework covering the geochemical characterisation of sulfidic geologic materials, to assess their AMD potential (including acidic, saline and neutral metalliferous drainage), is diverse but is generally based on the following sources:

- COA (2016). Leading Practice Sustainable Development Program for the Mining Industry. Preventing Acid and Metalliferous Drainage. Commonwealth of Australia, Canberra ACT. September.
- NT EPA Environmental Assessment Guidelines for Acid and Metalliferous Drainage (2013).
- AMIRA (2002) ARD Test Handbook - Prediction and Kinetic Control of Acid Mine Drainage; AMIRA International. Project P387A Prediction & Kinetic Control of Acid Mine Drainage, Ian Wark Research Institute and Environmental Geochemistry International Pty Ltd.
- The Global Acid Rock Drainage Guide, http://www.gardguide.com/index.php/Main_Page, International Network for Acid Prevention INAP, 2009.
- List of Potential Information Requirements in Metal Leaching/Acid Rock Drainage Assessment and Mitigation, MEND Report 5.10E, January 2005.
- Prediction Manual for Drainage Chemistry from Sulphidic Geologic Materials, MEND Report 1.20.1, December 2009.

The RGS review has been completed taking in to account information contained in the technical guideline documents cited above.

3.0 SUMMARY AND REVIEW

3.1 Sampling

GHD selected samples for waste rock is based on a risk based statistical evaluation after Price (1997), Miller (1997) and the Queensland Department of Mines and Energy (DME) (1995) according to the equation: $n = 25 \times \sqrt{y}$, where y=Mt of material per major lithological unit. GHD also referenced DITR (2007) (a previous version of the COA (2016) reference above) which suggest several hundred representative samples at the pre-feasibility stage, with a reduction in samples for uniform layered sedimentary deposits such as for the project.

Using the equation and the expected waste rock mass of **322 Mt**, GHD calculated a total of approximately 416 primary screening analyses would be required; however, given that the samples were shown to be "low risk", the overburden showed uniform geology and the deposit was positioned above the water table in the weathered/oxidised zone, there was an allowance for a lower number of samples to be selected for acid-base account (ABA) testing (ie primary screening analysis). A total of **202 waste rock samples** were selected for ABA testing; these samples proportionally reflect the lithological units intersected by the drilling campaign. A single synthetic tailings sample was analysed. The number of samples selected for each of the analysis types are summarised in **Table 1**.

Figure 4-1 and **Figure 4-2** in the GHD report show the plan view distribution of waste rock samples collected and analysed within the proposed pit shell.

RGS Comments:

- *RGS agrees with the GHD approach and number of samples selected for static geochemical testing for the waste rock samples. RGS agrees that the "low risk" nature of the waste rock, the uniform geology at the project and the fact that the waste rock is located above the water table (and has therefore been subjected to significant oxidation) allows for a reduction in the number of waste rock samples.*
- *The single tailings sample tested is less than RGS would recommended for this project, even at the pre-feasibility stage. However, RGS understands that synthetic tailings samples of sufficient volume are difficult to obtain and acknowledges that GHD has committed to additional tailings testing to substantiate the results of the test work on the single tailings sample.*
- *The plan-view distribution of samples over the proposed pit shell is adequate based on the information presented in the GHD report; however, the distribution of samples at depth and the distribution of samples within a particular lithological unit are not presented in Attachment I. RGS recommended that a table be provided within the report highlighting the number of samples collected at depth and within a particular lithological unit. In the preceding GHD response letter to the NT EPA, GHD confirmed that the samples were collected from the entire profile.*
- *RGS suggestsed adding further information on how the samples were collected (eg. drilling method), if in-field testing was undertaken and sample preservation details. Similarly, any supporting information on the samples, such as drill core logs, should be provided or referenced. Information on the drilling methods and sample preservation details were included in the GHD response letter.*
- *RGS suggests re-wording the text on page 18: "around 250 samples per 100MT of waste material", which implies that ~750 samples would be required for the project (based on 322Mt of waste rock), as it does not consider that the sample number selection equation presented earlier in this section is non-linear.*

3.3 Geochemical Test Program

A summary of the GHD static geochemical analysis suite for waste rock and tailings, including the number of samples selected for each test is summarised in **Table 1**. Static geochemical tests provide a 'snapshot' of the characteristics of a sample material at a single point in time. The ABA method was used to determine the acid-neutralising and acid-generating characteristics of the samples, while the Australian Standard Leaching Procedure (ASLP) and Multiple Extraction Procedure (MEP) were used to assess the salt and metalliferous (metals/metalloid) leaching characteristics of the materials. GHD acknowledged within the report that additional leachate and soil erodibility testing will be undertaken in future. Similarly, it was acknowledged that additional synthetic tailings samples will be produced and tested in future.

Table 1: GHD sampling and analysis suite for waste rock and tailings

Material Type	Number of Samples	Analysis Type
Waste Rock	229 - 486	B, Ba, Li
	30 - 100	SO_4, S, Ag, Al, As, Be, Bi, Cd, Ca, C, Ce, Co, Cr, Cs, Cu, Dy, Er, Eu, Fe, Ga, Gd, Hf, Ho, K, La, Lu, Mg, Mn, Mo, Na, Nb, Nd, Ni, Ru, Re, P, Pb, Se, Si, Sn, Sr, Ta, Th, Ti, Tl, Tm, U, V, W, Y, Yb,, Zn, Zr
	202	NAPP, $EC_{1:5}$ and $pH_{1:5}$
	66	Net Acid Generation (NAG) testing
	52	Chromium Reducible Sulfur (CRS)
	52	Australian Standard Leaching Procedure (ASLP) using deionised water: pH, EC, Na, Ca, K, Mg, NO_2, NO_3, SO_4, Cl, OH, CO_3, HCO_3, F, Al, As, Cr, Co, Cu, Fe, Pb, Mn, U, V and Zn
	52	Australian Standard Leaching Procedure (ASLP) using acetic acid buffered to pH 5.1: pH, EC, Na, Ca, K, Mg, NO_2, NO_3, SO_4, Cl, F, Al, Sb, As, Ba, Be, Bi, B, Cd, Cr, Co, Cu, Fe, Pb, Li, Mn, Hg, Mo, Ni, Se, Ag, Sr, Tl, Th, Sn, U, V and Zn)

Material Type	Number of Samples	Analysis Type
	10	Multiple Extraction Procedure (MEP; 10-stage): pH, EC, Na, Ca, K, Mg, NO_2, NO_3, SO_4, Cl, F, Al, Sb, As, Ba, Be, Bi, B, Cd, Cr, Co, Cu, Fe, Pb, Li, Mn, Hg, Mo, Ni, Se, Ag, Sr, Tl, Th, Sn, U, V and Zn
Tailings	1	Metals, NAF, NAPP, MEP (5-stage)

RGS Comments:

- *RGS agrees that the geochemical analysis suite utilised is acceptable for a mine that is at pre-feasibility level and testing conforms to regulatory and technical guidance documents (cited in **Section 2.0**).*
- *The commercial laboratory which undertook the ASLP incorrectly used a slightly acidic leaching fluid (acetic acid buffered to pH 5.1). RGS agrees with GHD that the leaching results for these tests are therefore considered conservative.*
- *There is no mention within the GHD report of where the laboratory testing was undertaken, although this can be determined from the laboratory certificates in Appendix 1.*

3.4 Geochemical Results and Interpretation

There are no specific guidelines and/or regulatory criteria in NT specifically related to total metal/metalloid concentrations in waste rock or tailings materials. In the absence of these and to provide relevant context, GHD has identified element enrichment in the whole rock assays by using the Geochemical abundance index (GAI) (Bowen, 1979, INAP, 2009). The extent of enrichment is reported as the Geochemical Abundance Index (GAI), which relates the actual concentration in a sample with the average (or median) crustal abundance on a $\log_{10}$ scale. The results provided by GHD indicated that some metals/metalloids (Cd, Co, Dy, Er, Ho, Lu, Mn, Nd, P, Pb, Tm, Y, Zn) were enriched relative to the average crustal abundance in some of the samples; although elements identified as enriched may not necessarily be a concern for revegetation, drainage water quality or public health, but their significance should still be evaluated. The GAI only provides an indication of metals that may be enriched relative to the global average crustal abundance, and it should be noted that:

- The average crustal abundance value varies between different literature sources, therefore affecting the calculated GAI values.
- If a sample is shown to be enriched relative to the average crustal abundance, there is no direct correlation that the sample will also leach metals/metalloids at elevated concentrations. The mobility of metals/ metalloids is dependent on mineralogy, adsorption/desorption and the environment in which it occurs.
- Although there are some element concentrations elevated relative to average crustal abundance, the nature of an ore deposit means the background levels are always expected to be elevated.

Similarly, because an element is not enriched does not mean it will never be a concern, because under some conditions (eg. low pH) the solubility of common environmentally important elements such as Al, Cu, Cd, Fe and Zn increases significantly.

The concentrations of measured Th and U in waste rock and the tailing sample was compared to threshold limits presented in DME QLD (2008) and indicated no enrichments and thus no classification as naturally occurring radioactive materials (NORM).

The ABA and Net Acid Generation (NAG) test results are only summarised in the GHD report. The results generally indicate that the waste rock and tailings samples have negligible (sulfide) sulfur content, and generally moderate to high Acid Neutralising Capacity (ANC). The average crustal abundance for total sulfur is 0.1 %S (INAP, 2009), with all presented data indicating sulfide sulfur (chromium reducible sulfur) measurements significantly below average crustal abundance. However, it needs to be highlighted that data for all the samples was not detailed within the report.

GHD have used two classification systems (COA, 2016; INAP, 2009; and, AMIRA, 2002) to classify the acid and neutralisation characteristics of the samples. The ANC:MPA ratio, referred to as the Net Potential Ratio (NPR), of the waste rock and tailings samples is presented. Generally, those samples with an NPR of greater than 2 and sulfur content <0.1 % are considered to represent material with a low to negligible risk of generating additional acidity and generally have a high factor of safety in terms of potential for AMD (COA, 2016; INAP, 2009). The presented GHD results indicate that all samples have an NPR>2; and are classified as NAF.

The AMIRA (2002) AMD classification system, which compares Net Acid Producing Potential (NAPP) versus NAG_{pH}, indicate that all the samples analysed (excluding sample 95050*)* fall within the non-acid forming (NAF) domain, with sample 95050 being classified as Uncertain.

The results from leaching tests (ASLP [deionised water and acetic acid buffered to pH 5.1] and MEP) were compared to several water quality guidelines to act as a screening tool for additional testing. The water quality guidelines included:

- ANZECC & ARMCANZ (ANZECC & ARMCANZ, 2000) guidelines for protection of 80% of freshwater aquatic ecosystem species (FAE80%) based on the ephemeral nature of the arid area streams;
- Australian Drinking Water Guidelines 2011 (ADWG) (NHMRC, NRMMC, 2011);
- Northern Territory Environment Protection Authority (NTEPA) Guidelines for the Siting, Design and Management of Solid Waste Disposal Sites in the Northern Territory (NT EPA, 2013); and
- Similar guidelines such as the WA Landfill Waste Classification and Waste Definitions 1996 (as amended December 2009) (WADEC, 2009).

The results of the leachate testing indicated some of the waste rock may produce leachate with some elevated concentrations of metals/metalloids (Al, Cu, Cr, Pb, Mn, Ni, Zn and F) relative to aquatic ecosystem or drinking water guidelines. Leached Al and Zn concentrations are more persistently elevated over the test period than other metals/metalloids. The other elevated metal/metalloid concentrations are generally only associated with anomalous spikes.

RGS Comments:

- *RGS agrees with the general GHD interpretation of results, that the samples have negligible sulfide sulfur, and moderate to high ANC, and are classified as NAF. There is therefore a high factor of safety and very low risk of acid generation from these materials. The waste rock typically has low concentrations of metal/metalloids that do not present a significant risk to the environment with respect to total metal/metalloid concentrations in solids; and, is likely to generate pH neutral surface runoff and seepage with low salinity and low/moderate concentrations of dissolved metals/metalloids and therefore poses low to negligible risk of potential impact on the quality of surface and groundwater resources. Given that the waste rock may generate some elevated dissolved metal/metalloid concentrations (eg. Al and Zn) compared to some of the applied guideline values, additional testing should focus on long-term kinetic testing (eg. column leach tests), which is currently in progress.*
- *The presentation of data in the GHD report could be improved, with most of the laboratory testing data not summarised within the report or supplied in a raw format within Appendix A (laboratory certificates). For example, there is no presentation of $pH/EC_{1:5}$, and only ABA results for 52 samples are supplied in the laboratory certificates. The ABA interpretation requires, at least, a table or similar summarising the key ABA results, for inclusion within the report or in the Appendices. It is very difficult to evaluate the data, as most is only presented in raw laboratory certificates which are also inadequately labelled.*
- *The results for sample 95050, which is the only sample to produce an acidic NAG pH, is not available in the report, but it is pertinent to know what the starting pH is before the NAG test, as this may indicate why the sample is returning an acidic NAG pH.*
- *As mentioned above, RGS agrees with the general GHD conclusions; however, it would be useful to understand if there is a link between samples with a particular lithological type and a sample's geochemical properties, for example: acid consuming properties, elevated metal/metalloid concentrations in leachate, etc. These properties may become important characteristic in later phases of mining (eg. for rehabilitation and closure).*
- *There are several samples which returned NAG pH values equal to or close to pH 11. GHD accounted for this due to the boiling stage of the NAG test, which drives of CO_2 from the carbonate-dominated samples, resulting in excess alkalinity (Charles, et al., 2015). Further interpretation of the samples and lithology types might provide more insight into this theory.*
- *The MEP results indicate that pH becomes acidic at day five for the majority of samples, and the corresponding metal/metalloid concentrations spike, particularly for elements like Al. RGS understands that the extractant solution is buffered at pH 5.1, so it is difficult to understand how these samples can produced acid leachates, given the results of the ABA testing. Additional kinetic testing which GHD has commenced may help provide a better understanding these findings.*

3.5 Management of Waste Rock and Tailings

GHD completed an AMD ecological and human health risk assessment (source-focused) following the general approach outlined in the Global Acid Rock Drainage Guide (INAP, 2009). The risk assessment recognises the limitations of the input data, including the absence of kinetic testing data. Based on the risk assessment the primary risk level was scored low.

The key components of the waste rock and tailings management plan include detailed pre-production delineation of waste material types and avoidance, blending or encapsulation of any identified PAF material, and in-pit disposal of waste rock and tailings.

Delineation of waste rock types is undertaken through routine monitoring. Surface and groundwater monitoring is captured by the Water Management Plan (not reviewed by RGS). Additionally, S, Cd, Co, Mn, P, Pb and Zn will be analysed as part of the standard AMD suite during infill or grade control drilling and sampling. Samples with a total S% content > 0.1% will undergo additional static testing (NAG and NAPP). The samples numbers will differ between pre-production and over the life of mine; however, there is some ambiguity about how this will occur.

RGS Comments:

- *Based on the geochemical data presented within the GHD report, RGS agrees that the risk assessment scoring of waste rock and tailings is low.*
- *There appears to be no samples within the static dataset representing ore materials. Whilst ore materials will only be stockpiled on site for a relatively short period of time, the geochemical characteristics of these materials will still need to be understood (eg. what will the quality of surface runoff and seepage from ore stockpiles be and will this need to be managed). RGS recommends that representative samples of ore materials be included in future geochemical testing programs.*
- *The total S% cut-off value (ie. 0.1% S), which triggers additional AMD testing and additional block modelling work, is quite low given the high ANC values and may be overly conservative.*
- *Page 49 of the GHD report mentions a table recommending the number of samples required for static testing pre-production and over the life of mine; however, this table is not present within the report. There is further a contradiction on the same page, which indicates that the need for production-phase testing will be reviewed based on the results of pre-production testing.*
- *RGS generally agrees with recommended additional testing presented in this section of the report. RGS recommends extending the analysis suite beyond the seven metal(loid)s recommended for kinetic testing to an analysis suite similar to that used in the ASLP tests.*
- *GHD has suggested reviewing the AMD management plan two years after mine closure. RGS is not sure if this is a typo but would suggest reviewing this plan one year after the commencement of production.*

3.6 General Corrections

- Change positive NAPP to negative NAPP (first page Executive Summary and in Page 41).
- Refer to metals and metalloids throughout as there is inconsistent use in the GHD report.

4.0 RGS RECOMMENDATIONS

RGS agrees with the GHD recommendations for additional testing of mine materials. Specific recommendations are made throughout the report; the following recommendations are suggested for geochemical testing only:

- Mineralogy: A qualitative and semi-quantitative analysis of the mineralogy of the various waste rock materials should be undertaken using X-ray Diffraction (XRD). The current analyses suite provides limited information on the minerals present within each lithological unit.
- Kinetic tests (column leach tests or humidity cells): Strongly recommended to supplement static testing already undertaken and based on specific knowledge gaps identified for the project. The kinetic tests are required to verify the anticipated low sulfide oxidation rates, primary neutralisation dissolution rates, changes in leachate chemistry and changes in long-term loading rates (ie., amount of solute released from a mine material over time). RGS understands that kinetic testing of waste rock has commenced.
- Tailings: GHD has committed to additional tailings testing to substantiate the results of the single tailings sample to date. RGS recommends that representative tailings samples should be tested in future for pH, EC, Total Sulfur, CRS, ANC, NAG, whole rock total analysis and leach tests (ASLP using rainwater or similar, followed by pH, EC, major ions and metal/metalloid analysis). Kinetic tests should also be considered for selected tailings samples.
- Representative samples of ore materials be included in future geochemical testing programs and be subjected to a similar geochemical testing program to that recommended for tailings above.

5 LIMITATIONS AND DISCLAIMER

This report documents the work undertaken by RGS Environmental Pty Ltd (RGS) and does not purport to give legal advice. Legal advice can only be given by qualified legal practitioners.

This report should be read in full. While the findings presented in this report are based on information that RGS considers reliable unless stated otherwise, the accuracy and completeness of source information cannot be guaranteed, although RGS has taken reasonable steps to verify the accuracy of such source data. RGS has made no independent verification of this information beyond the agreed scope of works and RGS assumes no responsibility for any inaccuracies or omissions outside of RGS's direct control. Furthermore, the information compiled in this report addresses the specific needs of the Client, so may not address the needs of third parties using this report for their own purposes. Thus, RGS and their employees accept no liability for any losses or damage for any action taken or not taken based on any part of the contents of this report. Those acting on information provided in this report do so entirely at their own risk.

Please contact Alan Robertson or Matt Landers at RGS if you have any questions regarding this report.

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Mobile: 0431 620 623, 0439 936 765

Email: alan@rgsenv.com; matt@rgsenv.com

RGS Environmental Pty Ltd

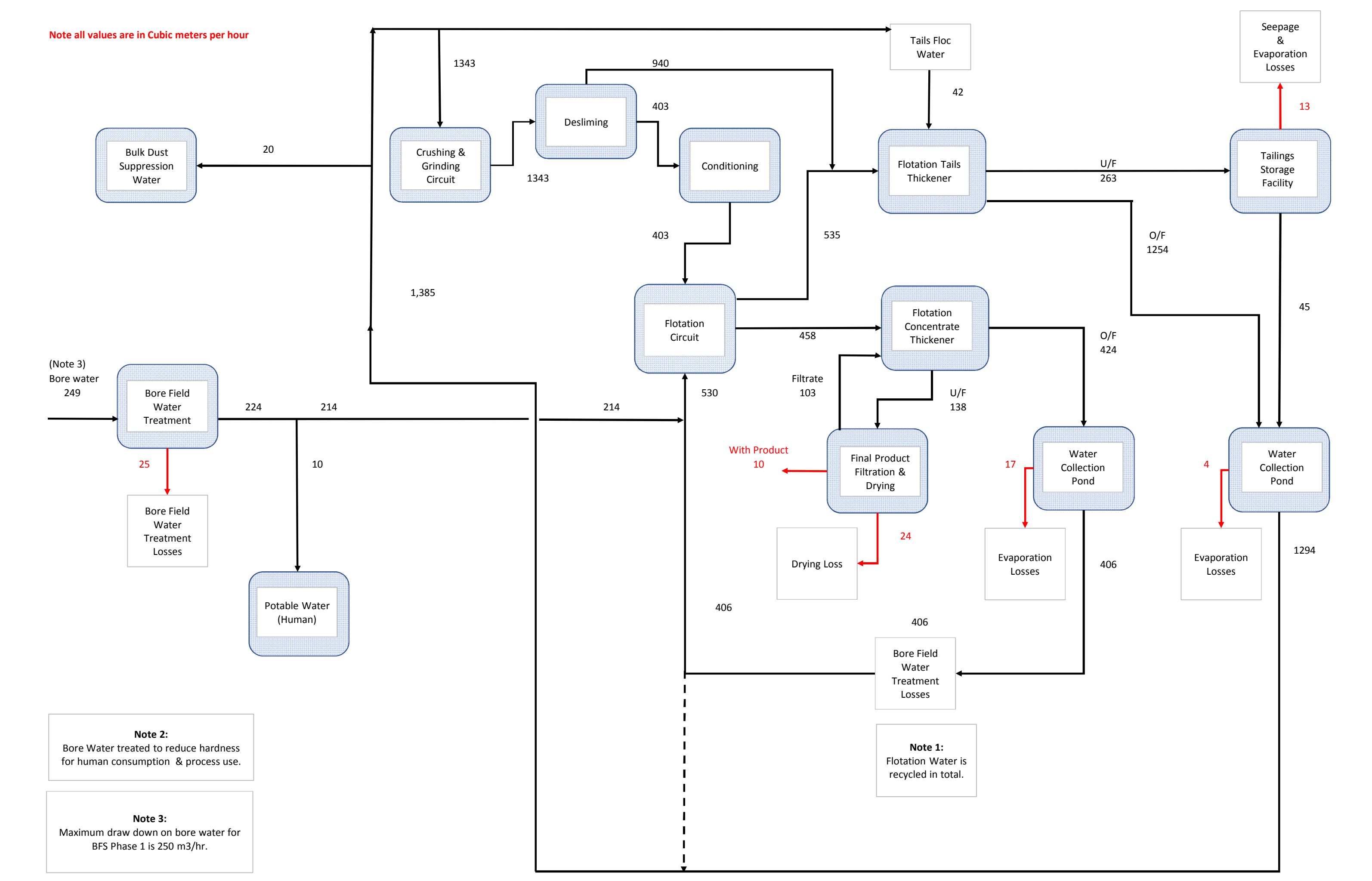
Alan M. Robertson

Dr. Alan Robertson
Principal Geochemist

RGS

LEADERS IN MINING
GEOCHEMISTRY

Appendix 4 – Water Balance (WSP 2018)



WorleyParsons
resources & energy

VERDANT MINERALS

Doc Desc:	PHASE 1 BENEFICIATION WATER BALANCE		Doc No.	201010-00710-00-PR-DSK-2001	
Project	AMMAROO PHOSPHATE PROJECT BFS	Revision	A	B	
Project No.	201010-00710	Description	For Review	Updated	
Location	Ammaroo, Australia	PREP. BY/DATE	E Wingate	E Wingate	
Client:	VERDANT MINERALS	CHKD. BY/DATE	R Atmuri	R Atmuri	
		APPD BY/DATE	M Burfield	M Burfield	

Appendix 5 – Historical Rehabilitation Time Series

Historical Rehabilitation Time Series

The photos presented below present a time series of historical rehabilitation activities undertaken to date at the Project site. The proposed rehabilitation and closure methodology of the pits will be similar to that completed for test pits dug as part of exploration activities between 2011 and 2017.

Plate 1: BCRC138 Pit 3 freshly dug in 2011

Plate 2: Rehabilitation in progress BCRC138 Pit 3 on 28/10/2016

Plate 3: Re-spreading topsoil on BCRC138 Pit 3 on 28/10/2016

Plate 4: Rehabilitation progress of BCRC138 Pit 3 on Feb 9 2107

Plate 5: Pit 4 bulk sampled to 7m depth in 2012

Plate 6: Topsoil respread on Pit 4 on 28/10/2016

Plate 7: Rehabilitation progress of Pit 4 on 09/02/2017

Plate 8: Topsoil respread on Pit 1 on 28/10/2016

Plate 9: Rehabilitation progress of Pit 1 on 09/02/2017

Appendix 6 – Water Management Plan

Verdant Minerals Ltd

Ammaroo Phosphate Project
Water Management Plan

July 2018

Table of contents

Table index

Figure index

Appendices

1. Water Management Plan

1.1 Purpose

The purpose of this Water Management Plan (WMP) is to address water management for the Ammaroo Phosphate Project (Project) which includes the mine site, beneficiation site, borefield, accommodation village and access corridor. The Project phases include construction, operations, rehabilitation and decommissioning.

The WMP has been developed to:

- Outline the management of water within the Project site
- Establish surface water, groundwater, stormwater, processing water (onsite water storage), and sediment sampling regimes and procedures
- Determine baseline conditions and operational impacts on the surrounding environment
- Implement and assess rehabilitation goals

1.2 Term of plan

The WMP will be reviewed and updated on completion of final design and prior to Project construction. The WMP will be amended regularly as a part of mining authorisation, and may be reviewed following an incident or significant change to operations.

1.3 Guidelines

This WMP has been developed with reference to the Australian and New Zealand Environment and Conservation Council (ANZECC) guidelines, including:

- Australian and New Zealand Guidelines for Fresh and Marine Water Quality (ANZECC/ARMCANZ, 2000a)
- Australian Guidelines for Water Quality Monitoring and Reporting (ANZECC/ARMCANZ, 2000b)
- Australian Drinking Water Guidelines (NHMRC/ARMCANZ) (2004)
- Guidelines for Groundwater Protection in Australia (ANZECC/ARMCANZ, 2013)

2. Project description

2.1 Water requirements

The Project has significant water requirements during operations for mining, beneficiation and other uses. The main water requirement will be:

- Treated water for general process plant use, pump gland sealing, power station, fire water and wash down requirements.
- Water for dust suppression and primary ore processing.
- Potable water for domestic use and safety showers.

Water requirements for processing will be driven by the amount of ROM feed to the processing plant. The water balance is for the first 5 years of production, at 1 million tonnes per annum, and accounts for annual water usage of 1.8 GL/year. Full production, at 2 million tonne per annum, will require a 3.6 GL/year.

2.2 Water management infrastructure

The Project proposes the following water infrastructure to address water requirements:

- Beneficiation process plant including process water storage, tailings storage facilities and reagent tank farm.
- Water supply borefield and 12 kilometre water pipeline.
- Utilities such as raw water treatment plant, reverse osmosis (RO) plant, stormwater collection and treatment.
- Waste water treatment plant for utility oily water.

Raw water will be sourced from ground water resources using a series of bores. The water supply system will have the following components:

- Borefield water supply to the process plant.
- Borefield water supply to the accommodation facilities.

3. Surface Water

3.1 Current conditions

3.1.1 Climate

Rainfall and evaporation

The mean annual rainfall is approximately 315 millimetres. Regionally, most of the rain is associated with thunderstorms during the monsoonal wet season cyclonic activity. Over some drought years there is minimal or no rainfall. Average monthly rainfall totals range from about 5 millimetres in August to about 70 millimetres in February. Average three-monthly rainfall totals range from about 22 millimetres in June/July/August to about 178 millimetres in December/January/February. However, any month can receive relatively large rainfall totals, or little or no rain at all.

Evaporation is greatest during months of higher mean rainfall with the highest average evaporation occurring in December and January at about 12 millimetres per day and 11 millimetres per day respectively. Rates of evaporation are significantly lower from May to August corresponding with lower average rainfall.

Temperature and humidity

Typical of central Australian arid climates, the Project site has high summer maximum temperatures (average of 37°C) and low minimum winter temperatures (average 6°C). The hottest months are November to March with monthly average daily maximum temperatures above 35°C, and monthly daily minimum temperatures not dropping below 20°C. The coolest months are May to August with monthly average daily maximum temperatures remaining at or below 25.4°C and monthly average daily minimum temperatures not rising above 12.9°C.

The average humidity at the Project is 39% at 9 am, and 24% at 3 pm. This is consistent across the year with monthly morning readings being higher than the afternoon readings. The highest levels of humidity are experienced in June at 53%, which coincides with lower temperatures.

Wind

The winds at the Project are mainly in a south easterly direction throughout the year. The average wind speeds range from 12.8 km/h to 19.7 km/h, with an annual average of 17.3 km/h at 9 am and 15 km/hr at 3 pm.

3.1.2 Environmental values

According to existing land system and land unit mapping and aerial imagery, only part of the Project site intersects a major seasonal watercourse and associated alluvial floodplains. This is Taylor Creek on Neutral Junction Station, which is situated on the western part of the proposed infrastructure corridor. There are no large wetlands within the Project site; however, several small seasonal swamps occur in the vicinity of the infrastructure corridor, of which none are intersected by the Project.

Watercourses within the vicinity of the Project site typically include mobile deep sand deposits about 50 metres wide with banks that show signs of active erosion. Some of these channels include a low-flow channel about one metre deep with a base width of about five metres. During infrequent, intense rainfall events out-of-bank flow can be expected leading to temporary and short-term flooding of adjacent lands.

The regional drainage system drains towards the east via the Elkedra and Sandover Rivers and their tributaries. The site area is gently undulating to flat, sloping at about 0.25 per cent southwest.

3.1.3 Water quality objectives

Given the ephemeral nature of the watercourses and drainage lines within the vicinity of the project, there has been little opportunity for surface water quality sampling. Without site water quality data, interim water quality trigger values will be adopted based on the default water quality trigger values included in ANZECC (2000) if the Project requires a Waste Discharge License from the NT EPA. However, the Project does not propose any waste water discharge.

3.2 Site water management

3.2.1 Water classification

Water onsite is classified into four types:

- **Clean water:** Runoff generated from undisturbed catchment areas. This water will be diverted around the Project using berms or diversions, or maybe captured and reused on site.
- **Raw water:** Externally sourced water used as potable water (with suitable treatment) and process water make-up.
- **Dirty water:** Runoff generated from disturbed catchment areas, excluding the process water system, including runoff from temporary waste rock dumps WRDs and some infrastructure areas. This water will be collected within sediment dams for settling and discharge, or reuse on site.
- **Process water:** Water which has been in contact with or used within the processing plant, including tailings decant water. Process water will be recycled, collected and reused within the process plant.

3.2.2 Water management system

Each water type is to be managed with a separate water management system.

Clean water management system

The clean water management system will generally include clean water diversions and flood protection berms that will be designed and constructed to safely manage the flows generated by the 100 year ARI critical duration design storm event, and include suitable bed and bank scour protection measures.

Flood protection berms

A flood assessment and modelling was undertaken for the mine site to establish potential flood related impacts. Modelling of the 100 year ARI flood event for the current conditions and with proposed infrastructure was undertaken. The maximum modelled flood extent and depths for the 100 year ARI flood event are provided in Figure 3-1 and Figure 3-2 respectively.

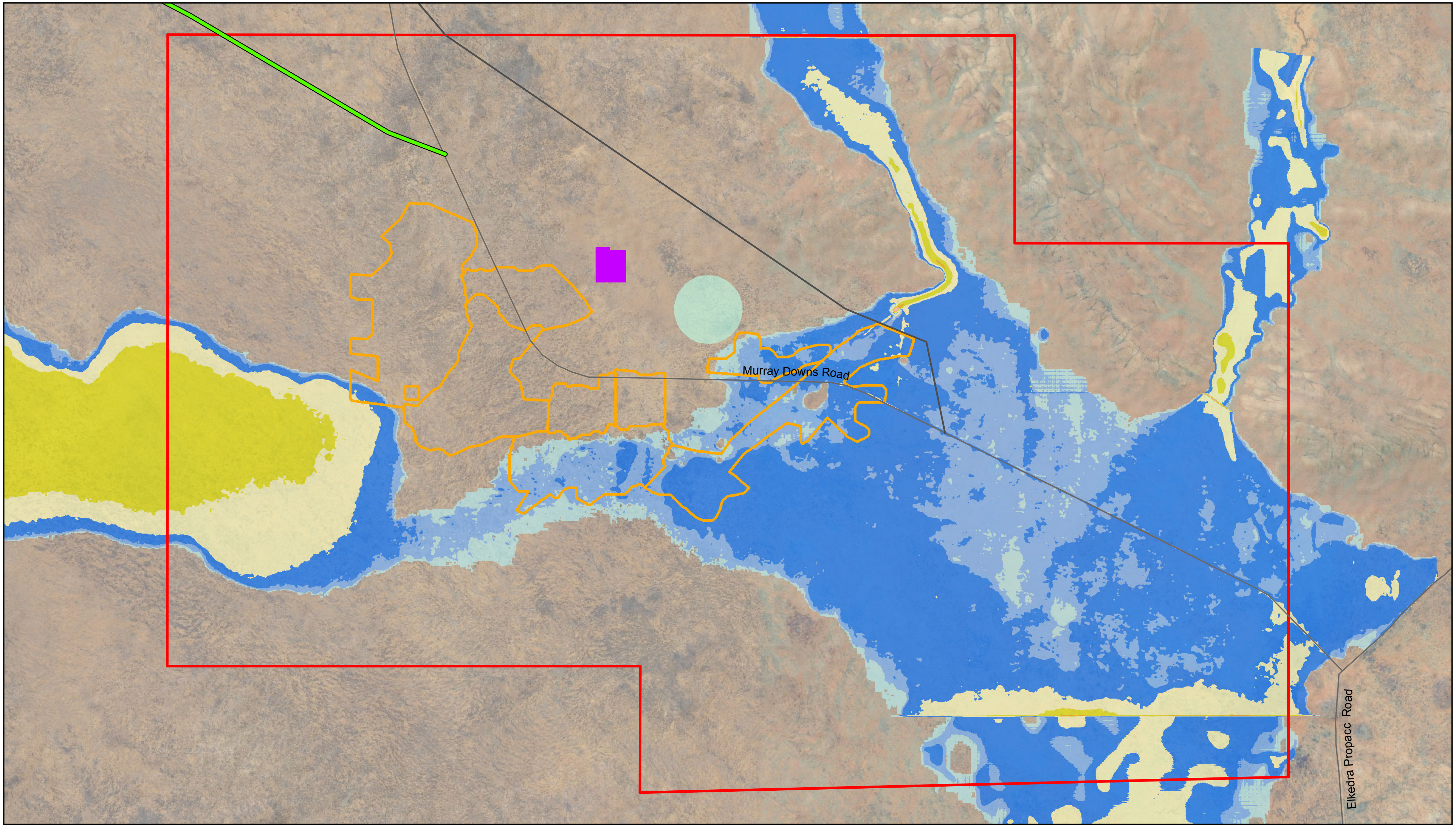
Flood protection berms will be constructed along the northern and eastern sides of the open cut pit as required, to divert clean water away and prevent inrush during flood events. Infrastructure areas, including the ROM Pad and out of pit tailings storage facility (TSF) will be constructed above the 100 year ARI flood level.

Access corridor

The access corridor will include a rail line that will be raised above the 25 year ARI flood level.

The rail line will be designed and constructed to include sufficient crossing structures (i.e. culverts) to minimise changes to flood levels within the upslope and downslope environments.

Each crossing structure will include appropriate energy dissipation downstream of the culverts.



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Kilometres

Map Projection: Universal Transverse Mercator
Horizontal Datum: GDA 1994
Grid: GDA 1994 MGA Zone 53

N

LEGEND

- Local road
- Access corridor
- Beneficiation plant
- Surface tailings storage facility
- Mineral lease
- Pit footprint

Flood Extent and Depth (m)

- 0.00 - 0.05
- 0.05 - 0.15
- 0.15 - 0.50
- 0.50 - 1.00
- 1.00 - 1.50
- 1.50 - 2.00
- 2.00 - 3.00

Verdant Minerals Ltd
Ammaroo Phosphate Project

Job Number	43-22544
Revision	0
Date	16 Feb 2018

Maximum modelled 1% AEP flood depths, existing conditions

Figure 3-1

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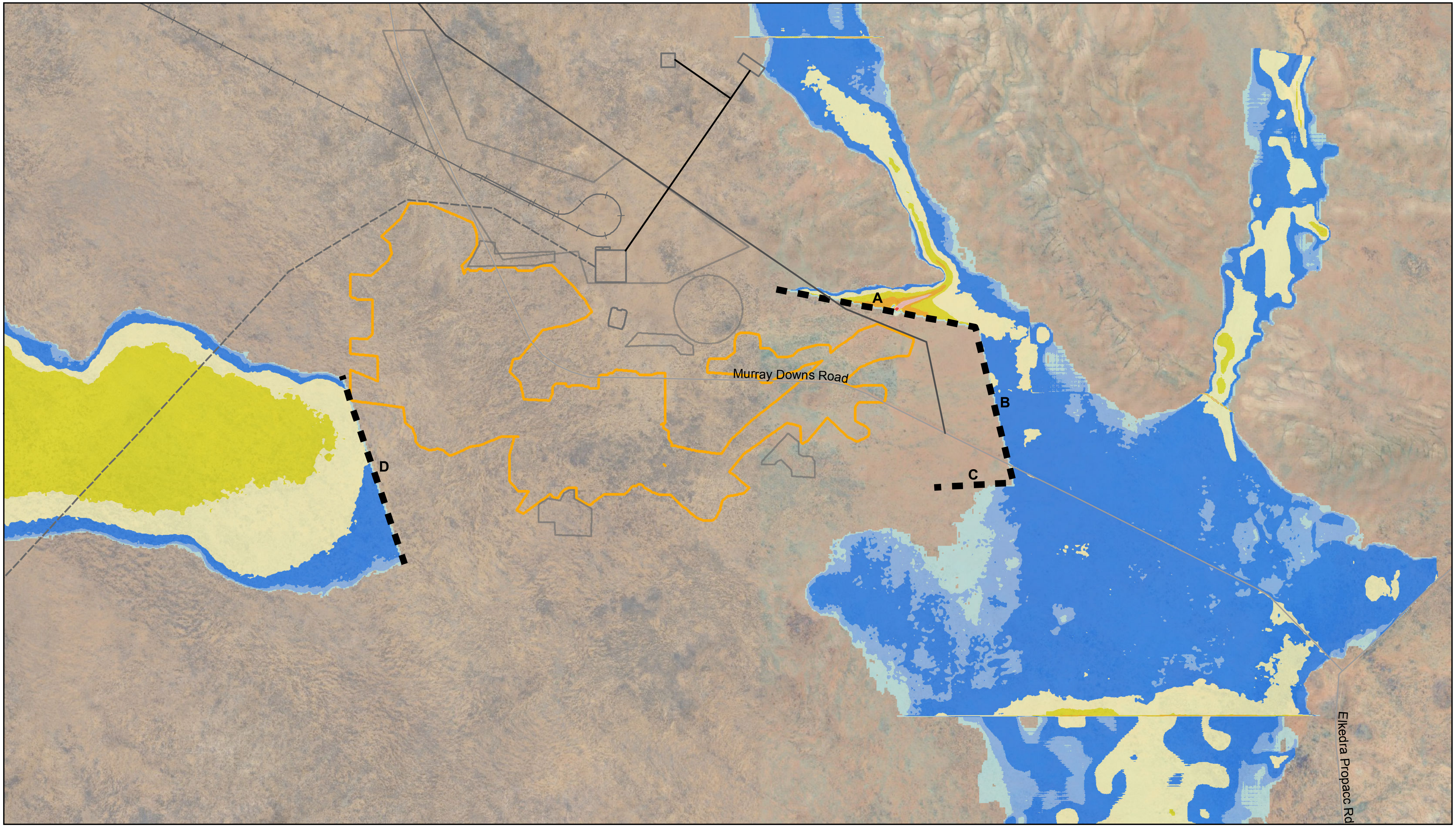
Level 5, 66 Smith Street Darwin NT 0800 Australia T 61 8 8982 0100 F 61 8 8981 1075 E drwmail@ghd.com W www.ghd.com

Data source: GA - Roads, Places, Hillshade (2015). VML - Pit Footprint, Access corridor, mine facilities (2017). GHD - Flood Model Data (2017). Created by: CM



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0 0.5 1 1.5 2

Kilometres

Map Projection: Universal Transverse Mercator
Horizontal Datum: GDA 1994
Grid: GDA 1994 MGA Zone 53

N

LEGEND

- Flood Protection Levees
- Pit Footprint

Flood Extent and Depth (m)

- 0.00 - 0.05
- 0.05 - 0.15
- 0.15 - 0.50
- 0.50 - 1.00
- 1.00 - 1.50
- 1.50 - 2.00
- 2.00 - 3.00
- 3.00 - 4.00

Verdant Minerals Ltd
Ammaroo Phosphate Project

Job Number	43-22544
Revision	0
Date	16 Feb 2018

Maximum modelled 1% AEP flood depths, proposed conditions

Figure 3-2

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Level 5, 66 Smith Street Darwin NT 0800 Australia T 61 8 8982 0100 F 61 8 8981 1075 E drwmail@ghd.com W www.ghd.com

Data source: GA - Roads, Places, Hillshade (2015). VML - Pit Footprint (2017). GHD - Flood Model Data (2017). Created by: CM

Raw water system

Raw water will be sourced from the borefield, and transferred to site via a dedicated pipeline. The raw water is filtered in sand filters and sent to be treated water storage tank. Treated water will be supplied to the power station, processing plant and reverse osmosis (RO) plant.

Potable water would be treated to meet Australian Drinking Water Guidelines (NRMMC 2011).

Dirty water management system

The dirty water management system would be constructed to manage sediment laden runoff generated from disturbed catchment areas which are located outside of the processing plant and tailings storage facilities.

The dirty water management system would generally consist of:

- **Catch drains** to intercept runoff generated from disturbed catchment areas; and
- **Sediment dams** where required to temporarily store sediment-laden runoff.

Catch drains are typically designed to safely convey the peak runoff generated by the catchment during the 20 year ARI critical duration design storm event. Ideally, flow velocities would be below about 1.5 metres per second to minimise scouring and avoid the need to place scour protection measures within the catch drains.

Sediment dams would be sized to safely manage runoff generated by the 100 year 72-hour design storm event (IECA 2008), and maintained in a generally drawn-down state. Water captured within the sediment dams may be transferred (by pump) to other storages on site for reuse, or treated if needed and discharged off-site. During large rainfall events or periods of extended wet weather, the sediment dams would overtop and discharge (via a constructed spillway). Wherever possible, overflows would be directed towards either the open cut pit or TSF to minimise the risk of discharge into the downstream environment.

Process water management system

The process water system manages water that is used in (and recaptured from) the process water system, including the tailings storage facilities, processing plant, process water storage and RO plant.

Water storage ponds will be designed similarly to turkey’s nest dams (i.e. have no external catchment) in order to minimise intercepted external water volumes. All process water storages will be lined with HDPE liner. The water storage ponds will be managed to maintain a minimum freeboard equivalent to the total inflows expected during a 100 year ARI 72 hour design storm event. Where a process water storage is used as a receiving point for a number of other storages across the site, additional freeboard storage may be required.

Tailings liquor will be recovered from the tailings storage facilities and recycled through the process facility. Recovered tailings liquor will be directed to the water storage ponds.

Runoff from the processing plant will be directed towards sumps or dams prior to being pumped to the process water dam for reuse on site. Runoff generated within the tailings storage facilities would be collected and managed with recovered tailings water for reuse within the processing plant.

No discharge of process water would occur to the environment. During extreme flood events, process water would be transferred from the water storage ponds into the open cut pits, if necessary.

3.2.3 Water balance

A copy of the water balance is provided in Appendix A.

3.3 Preliminary conceptual site model

3.3.1 Introduction

A Conceptual Site Model (CSM) is a representation of site-related information regarding potential surface and groundwater impacts, receptors and potential exposure pathways.

The development of a preliminary CSM provides the framework of identifying potential source-pathway-receptor linkages and associated monitoring techniques. Once detailed site specific information (monitoring data) is evaluated, the CSM will be refined and used as a decision tool to identify requirements for contingency management measures.

3.3.2 Key aspects

Surface watercourses

Watercourses are generally dry and do not exhibit flows for the majority of the year. Flows only occur during exceptional rainfall events and can flood existing watercourse banks.

Nil discharge

The Site has been designed, as far as practical, to be a no discharge site with respect to process and dirty water, however during heavy rainfall events (i.e. rainfall events exceeding the 100 year ARI design rainfall event) and under exceptional circumstances (i.e. widespread flooding) there may be some discharging of dirty water. Wherever possible, this discharge water will be directed towards the open cut pit and TSF. Contamination potential is considered low and during these events the considerable dilution within adjacent drainage lines will substantially reduce potential contaminant concentrations.

Regular water quality sampling will be undertaken, with additional sampling being undertaken when discharges occur. The sampling data will be used to assess if any additional management measures are required.

Tailings Storage Facilities

The recovery of water from the tailings and the tailings facility will vary throughout the life of the mine. The greatest recovery of water will be possible when the facility is well established and the beaching and decant system operating efficiently. Over the life of the facility it is expected that average recoveries in the region of 17% of the deposited slurry water will be achievable (ranging from 9% to 33%), depending upon the maturity of the beaching/decanting process, the tailings composition and weather conditions.

The design of the surface tailing facility has been optimised to aid water recovery and will use a circumferential distribution system of spigots around the TFS, with a central decant tower with a submersible pump located within the tower to recover water. The management of spigot distributors will aid the formation of segment beaches within the TSF and enhance earlier water recovery from the decant tower. In-pit TSF design will also use a spigot distribution system along the walls of the TSF to enhance local beach formation at the toe of the pit wall and hence water recovery using a floating pontoon pump. The recovered water will be pumped from the TSF to the water storage ponds and used within the process plant.

3.4 Potential impacts

3.4.1 Alteration of hydrological regime

Mine

It is expected that the flood protection berms will be implemented as required as the mine progresses. The maximum-modelled flood depths and extents for the 1% AEP (100 year ARI) critical duration design storm events for the proposed conditions are included in Figure 3-2. The modelling indicates that the proposed flood protection berms would be sufficient to protect the open cut pit from flood inrush during the 1% AEP event (Figure 3-2); however, flood depths and extents north of the project site are expected to increase. This area includes Woody's Dam.

Figure 3-2 shows that the proposed flood protection berms result in increased flooding east of the proposed open-cut pit, with local flood levels generally increased by about 300 millimetres (and up to about 1.5 metres within the vicinity of the proposed flood protection berm A. The modelling also indicates decreases in flood depths south of the open-cut pit of about 200 millimetres (up to about 400 millimetres immediately south of the open cut pit) (Figure 3-2). A summary of the change in maximum-modelled flood levels at selected locations is summarised below in Figure 3-2. These results indicate that the proposed flood protection berms would push flood flows eastwards, with flows being concentrated within a slightly narrower floodplain.

Infrastructure corridor

The rail spur will include a constructed embankment (or formation) which is to be designed so that it is above the local flood level for events up to the 25 year ARI (about the 4% annual exceedance probability) flood event.

The construction of the rail spur will affect upstream and downstream flood depths and extents. The railway embankment may act as a type of levee bank across the floodplain, concentrating flows through the proposed culverts. Culverts will be sized, located and installed to manage surface flows, and may increase downstream flow velocities, thereby increasing localised erosion and scouring within the watercourses in the immediate vicinity of the culverts.

A hydraulic model has been used to estimate the indicative scour protection for each watercourse crossing along the access corridor. Scour protection associated with any built culvert would consist of placed rock (rip-rap) of a specified median diameter.

3.4.2 Surface water contamination from spills and discharge

Contamination from sediment laden water

Discharges from the sediment dams will still occur following rainfall that exceeds the design rainfall depth (i.e. the 100 year ARI 72-hour design storm event). During these periods of higher rainfall, the wider area is expected to be flooded with sediment-laden runoff. As a result, the discharges from the sediment basins would be mixed with similarly sediment-laden flood waters, resulting in an unappreciable change to water quality. This is considered to be an insignificant consequence.

Contamination from process water

Process water will typically include elevated levels of phosphate, dissolved metals, elevated salinity, high or low pH, and suspended solids. The accidental, uncontrolled discharge of this water has the greatest potential to impact downstream areas.

The proposed process water storage ponds will be lined. The design of the ponds includes a freeboard storage capacity equivalent to the 100 year ARI critical duration runoff. This freeboard is intended to minimise the chance of uncontrolled discharges occurring. In addition, during extreme rainfall events excess process water will be directed towards the open cut mine pit in order to further minimise the risk of uncontrolled discharge of process water. If these management measures are followed, it is considered that the potential impacts to downstream water quality as a result of uncontrolled discharges of process water is low.

Contamination from tailings storage failure or overflow

The surface tailings facility will be used for the first three years of operation. The tailings produced after year 3 will then be deposited into the mined out pit void and will be progressively rehabilitated. The tailings geochemical analysis has concluded that the tailings material can be managed as non-acid-forming, non-saline, non-metalliferous and non-radioactive waste. As an in-pit facility the risk to surface water from a 'failure of the TSF' is considered low.

Contamination from spill of hazardous material or chemical

Project activities will involve the transport and storage of fuels and other chemicals. They will also involve the generation, transport and storage of chemical wastes. Due to their potential impacts on humans and the environment, both of these activities are well regulated, and therefore the potential for the accidental release of chemicals to impact upon surface water, is low.

3.4.3 Potential operation source-pathway-receptor linkages

Preliminary source, pathway and receptor linkages has been developed to establish potential linkages and is detailed below. A summary of potential source, pathway and receptor linkages is provided in Table 3-1. Monitoring will be undertaken to assess potential linkages and to inform additional management measures. The monitoring plan is provided in Section 3.5.

Table 3-1 Conceptual site model summary

Source	Pathway	Receptor	Possible Link and Associated Management Measure(s)	Monitoring
ROM Pad Ore Stockpile	Overland flow from stockpile bases entering creeks.		Unlikely The ROM Pad and Stockpile Pad will be constructed with impermeable bases ($1x10^{-8}$ m/s) with surface drainage captured within stormwater retention ponds.	Surface water sampling within watercourses during flow events. Sampling of discharges in accordance with the Emergency Overflow Procedure.
TSF	Overflow from structure and entering creeks		Unlikely Out of pit TSF constructed with capacity to capture a 100 year 72 hour ARI. Contingency measures will be available to transfer excess water to alternative storage/pit.	Surface water sampling within watercourses during flow events. Sampling of discharges in accordance with the Emergency Overflow Procedure.
Fuel Farm	Vertical migration through unsaturated zone into saturated zone and horizontal migration.		Improbable Fuel stored in self-bunded Above Ground Storage Tanks (ASTs) and Fuel Inventory (Loss Management) monitoring in accordance with the Hazardous Substances Management Plan.	Spills or sabotage will be managed in accordance with the Emergency Response Management Plan (ERMP) including the Environmental Investigation Procedure.

Note: Scales of Likelihood include improbable, unlikely, possible and probable.

3.5 Monitoring program

3.5.1 Multiple before-after control-impact

Monitoring will be undertaken in accordance with the Multiple Before-After Control-Impact (MBACI) approach due to the large scale and potential for permanent and/or long term water related environmental impacts. The monitoring program has been designed to include:

- Control Sites: upstream / up gradient monitoring sites which monitor background concentrations. Multiple control sites will be utilised.
- Adjacent: monitoring points situated adjacent to potential point sources of contamination (i.e. locations storing process water and dirty water), often called 'point of discharge'.
- Impact Site: downstream / down gradient monitoring sites. Multiple impact sites will be utilised.

No watercourses (i.e. channels with creek banks and obvious flow paths) within the Project site or across the access corridor. There no or very limited opportunities to sample up-gradient of the Mine. Two locations down-gradient of the mine will be monitored. Woody's Dam will also be monitored as the only permanent source of water in the vicinity.

3.5.2 Monitoring summary

The monitoring program has been designed to capture both baseline conditions and assess potential impacts from the operation. Monitoring will ultimately be utilised to assess if the Project is impacting the surrounding environment and to inform rehabilitation goals. A summary of monitoring program is provided in Table 3-2 and Table 3-3.

The locations of the minimum proposed monitoring points is included in Figure 3-3 with further detail provided in Appendix B.

The number and location of the monitoring points, sampling frequency and analyte suite will be finalised following the detailed design.

Table 3-2 Baseline monitoring

Monitoring	Number of Locations	Matrix	Frequency / Date	
			Field Measurements	Field and Laboratory
Mine Site				
Surface Water	3	Water	-	Early flows and late flows
Sediment	3	Sediment	-	Annually
Photopoint Monitoring	3	n/a	Six Monthly	-

Table 3-3 Operational monitoring

Monitoring	Number of Locations	Matrix	Frequency / Date	
			Field Measurements	Field and Laboratory
Mine Site				
Surface Water	3	Water	-	Early flows and late flows
Sediment	3	Sediment	-	Annually

Stormwater Retention Ponds	tbc	Water	Monthly	Annually
Open Pit	2	Water	Monthly	Quarterly
Surface Tailings Storage Facility	2	Water	Monthly	Quarterly
Photopoint Monitoring	tbc	n/a	Annual	-

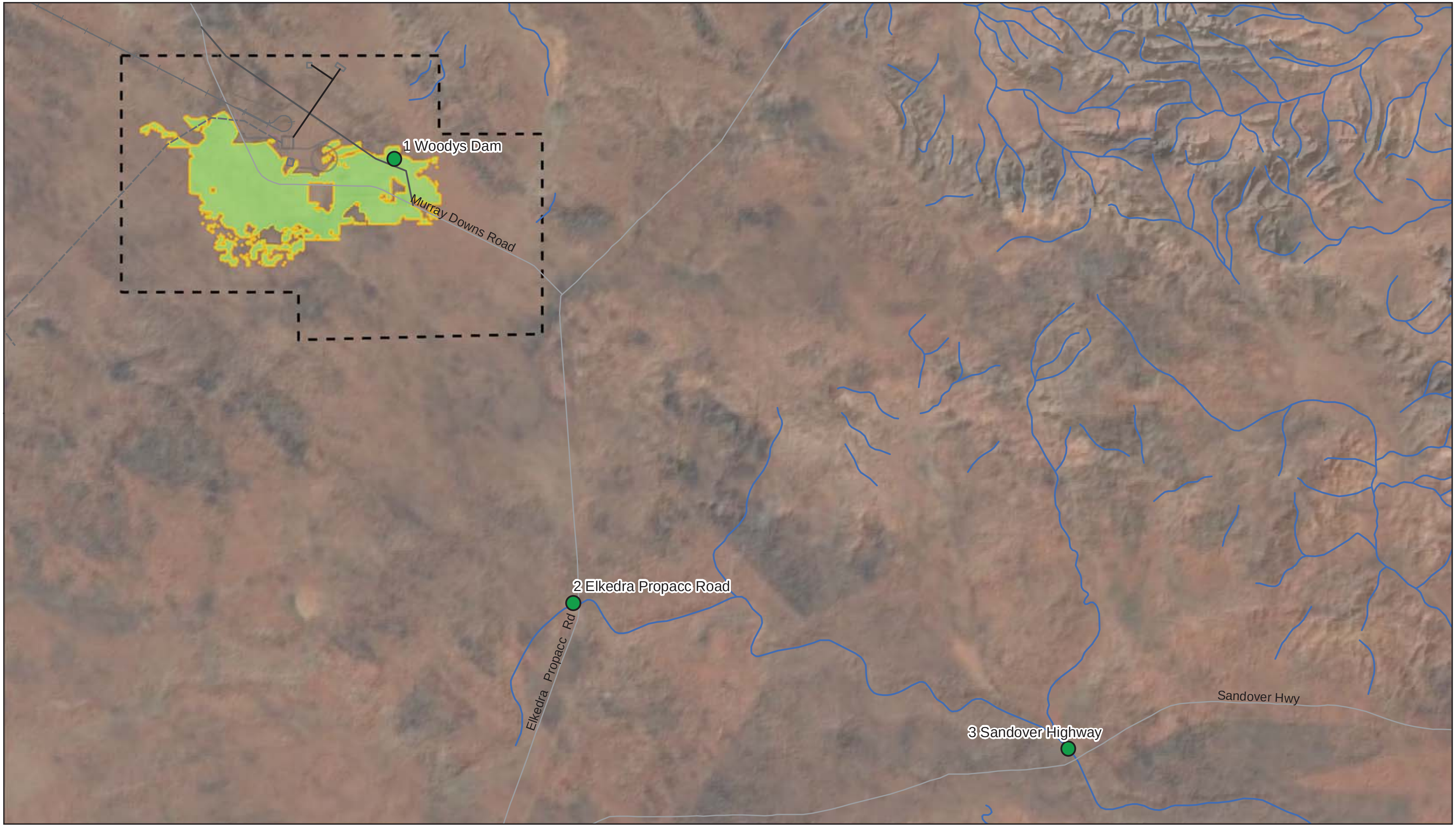
3.5.1 Sampling periods

Water quality monitoring combines surface water and sediment which will occur upstream/up gradient, adjacent and downstream / down gradient of the Project. The construction period will be used as the baseline period to capture a robust surface water (where available) and sediment dataset.

The basis of each phase of monitoring is provided in Table 3-4.

Table 3-4 Sampling period and basis

Sampling Period	Duration	Basis
Baseline	30 month	Establish existing conditions at the Project for surface water and sediment. Baseline period monitoring will be used to establish a definitive dataset from which potential impacts can be assessed during operation, care and maintenance and/or rehabilitation.
Operation	Life of mine	Assess monitoring data against baseline to determine if an impact has or is occurring. If significant differences between baseline and operation monitoring periods occur further management measures will be investigated and implemented as required.
Care and Maintenance	-	Assess Project impact to the surrounding environment through care and maintenance activities (i.e. minimal activities and/or management occurring). If significant differences between baseline and care and maintenance monitoring periods occur further management measures will be investigated and implemented as required.
Rehabilitation	-	Utilise baseline sampling data as the ultimate rehabilitation goal for surface water and sediment.



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Kilometres

Map Projection: Universal Transverse Mercator
Horizontal Datum: GDA 1994
Grid: GDA 1994 MGA Zone 53

N

LEGEND

- Monitoring locations
- Watercourses
- Mineral lease
- 30 yr pit shape
- Pit Footprint

Verdant Minerals Ltd
Ammaroo Phosphate Project

Job Number | 43-22544
Revision | 0
Date | 05 Mar 2018

Surface water monitoring locations

Figure 3-3

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Level 5, 66 Smith Street Darwin NT 0800 Australia T 61 8 8982 0100 F 61 8 8981 1075 E drwmail@ghd.com W www.ghd.com

Data source: GA - Roads, Places, Hillshade, watercourses (2015). VML - Pit Footprint (2017). Created by: AW

3.6 Trigger levels and mitigation measures

3.6.1 Alteration to hydrological system

Photo monitoring and surface water quality monitoring will be undertaken at 3 locations to detect potential changes to channel formation and water quality.

Trigger Levels comprise:

- Water quality declining from baseline (or default trigger values).
- Evidence of scouring or erosion within drainage lines.

Mitigation measures will be implemented sequentially as follows.

Stage 1. Assess the impact of water quality decline. The impact of surface water decline if detected should be assessed to against the default water quality trigger values included in the ANZECC guidelines. Assess the impact of erosion and sedimentation.

Stage 2. If hydrological changes causes unacceptable impacts (impacts to the riparian environment) then design and implement management measures:

- Review and change (as required) dirty water systems to reduce contaminated water being directed offsite.
- Identify and rectify source of erosion/sediment (e.g. civil formations, dirty water system, culvert crossings).

3.6.2 Surface water contamination from spills

Surface water 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.

4. Groundwater

4.1 Current conditions

4.1.1 Hydrogeological setting

The hydrogeological setting is described in detail in the project EIS and EIS Appendix H. This WMP should be read in conjunction with those documents.

The mine site exhibits an un-saturated orebody, elevated above the water table. The underlying fractured rock aquifer is very low yielding and hosts water suitable for pastoral use only.

The project water supply is extracted from the regionally extensive Georgina Basin Carbonate Aquifer via a planned borefield comprising 3 bores located approximately 10km south of the mine site. Water in the Georgina Basin Carbonate aquifer at the borefield site is suitable for pastoral use only.

Regionally the groundwater system recharges via direct infiltration particularly where fractured rock aquifers are exposed, and through infiltration at stream flood-outs. Groundwater seeps to the highly transmissive Georgina Basin Carbonate aquifer and moves via the basin toward the north-east for eventual discharge many hundreds of kilometres from the project site.

4.1.2 Environmental Values

There are no identified groundwater dependant ecosystems within 60 km of the proposal. The depth of water of the water table in proximity to the proposal is too deep to support groundwater dependent ecosystems.

A desktop review of stygofauna was undertaken. This study concluded that stygofauna are unlikely to be a factor for this project due to the limited impact on a very extensive possible habitat.

4.1.3 Declaration of beneficial uses

The beneficial use of groundwater at the mine site is summarized in Table 4-1. Groundwater at the mine site and borefield site is suitable for pastoral use. Raw data are provided in the project EIS Appendix H.

Table 4-1 Groundwater Beneficial Use

Site	Aquifer	Groundwater Beneficial Use	Water Quality constraints
Mine	Fractured Rock	Pastoral	Nitrate exceeds drinking water guidelines
Borefield	Georgina Basin Carbonate	Pastoral	Salinity exceeds drinking water guidelines

Groundwater is currently used for:

- stock watering with the nearest stock bore located 15 km from the borefield,
- community water supply with the nearest bores at Ampilwatja community 22 km from the borefield, and
- pastoral stations with the nearest bore at Ammaroo Station, approximately 30 km from the borefield.

4.2 Regulation

The primary tool for managing and protecting the Territory's water resources is the Northern Territory (NT) *Water Act*. The Water Act provide for the investigation, allocation, use, control, protection, management and administration of water resources. Mining is exempt from licencing under the Water Act. However, extraction and dewatering activities are governed under the MM Act, administered by the Department of Primary Industry and Resources (DPIR) who have a memorandum of understanding with the DENR to manage activities so they do not affect other water users.It is acknowledged that the Water Act is currently being reformed and under the reform specific requirements of the Act may be made applicable to mining activities.

The key requirements of the Water Act that may be applicable to the Project after the reform has taken place include:

4.2.1 Water Allocation Plans

The access corridor passes through the Western Davenport Water Control District (WDWCD). Water Control District s are proclaimed areas where the Department of Environment and Natural Resources (DENR) have identified a need to manage water resources (surface and groundwater) to avoid stressing groundwater reserves, river flows or wetlands.

The mine site is not located within the WDWCD; however, should water be sourced from the WDWCD then a review of the current allocation to mining in the Water Allocation Plan may be required.

4.2.2 Water Extraction Licence

A water extraction licence is required when extracting surface water or groundwater in a Water Control District or when extracting groundwater more than 15L/sec outside of a Water Control District. A water extraction licence would be required for the construction bores located within the WDWCD and would be required for the borefield.

All bores will have water meters comply with the Department of Environment and Natural Resources 'Non-Urban water metering policy' and 'Non-urban water metering code of practice for water extraction'.

Measures will be in place to quantify, record and report monthly the volume of water extracted from groundwater resources.

4.3 Groundwater management

4.3.1 Overview

Water will be managed at the Project in accordance with ANZECC/ARMCANZ (2013). Management of groundwater across the Project will be aligned with the six underlying principles:

1. **Protection of specified environmental value:** The current and future land use of the area is considered to be pastoral (cattle). Application of stock water ANZECC values will be used as groundwater trigger values.
2. **Polluter pays principle:** The site will be constructed, operated and rehabilitated in accordance with the *Mining Management Act* (MM Act). The MM Act requires the Proponent to report environmental data to assess and understand potential impacts from the Project to the Department of Mines and Energy (DME). In accordance with the MM Act, a security bond will be provided as part of the initial grant and maintaining Mine Authorisation. The security bond reinforces the polluter pays principle whereby the bond will be returned to the Proponent following successful rehabilitation or utilised by DME to complete rehabilitation (if the Proponent is not able to due to unforeseen circumstances).
3. **Intergenerational equity:** Currently the predominate use for groundwater in the immediate vicinity of the mine site and processing site is for pastoral use (i.e. stock drinking water). The development of the Project will be undertaken with consideration of current and potential future generations of pastoralists.
4. **Precautionary principle:** Hydrogeological modelling has been undertaken to assess the potential impact of the Project on surrounding groundwater resources. In accordance with the risk-based approach and implications of the polluter pays principle, the site will be operated under a precautionary principle.
5. **Ecologically sustainable development:** The Project will be managed in accordance with the above principles to promote ecologically sustainable development.

The Groundwater management plan comprising Monitoring, Trigger Levels and Mitigation measures for the risks identified in the EIS is summarised in Table 4-2. Details are provided in the sections that follow.

Table 4-2 Groundwater Management and Monitoring Plan Overview

Impact / Source	Pathway	Receptor	Probability / Risk	Monitoring	Triggers	Mitigation
Water table drawdown from borefield pumping	Georgina Basin Carbonate Aquifer	Other Groundwater users: • Stock • Community • Pastoral Stations	Low. Modelling predicts drawdown up to 3 m at other users. However, groundwater availability will not be reduced.	Monitoring of water levels and quality at a network of observation bores. Monitoring of volumes and water quality pumped.	Drawdown at observation bores exceeds drawdown predicted by modelling.	Re-calibration of model and re-assessment of predicted drawdown at receptors. Make-good measures at receptors to ensure water availability. For example, deepening bores. Increased water efficiency to be studied and implemented if practicable. Modified Pumping regimes.
Water table drawdown from construction supply pumping	Georgina Basin Carbonate Aquifer	none	Negligible Drawdown is negligible and does not extend more than 850m from bores. There are no receptors within that distance	None	None	None
Tailings leachate seepage from ex-pit and in-pit tailings.	Fractured Rock Aquifer, discharging to Georgina Basin Carbonate aquifer	Other Groundwater users: • Pastoral • Community	Negligible. Water table is at approximately 50m depth, surface expression of seepage very unlikely.	Monitoring Down Gradient of Ex-pit TSF for groundwater levels and quality. Monitoring Downgradient of In-pit TSF for	Groundwater levels rise above baseline Groundwater quality changes from baseline to reduce beneficial use.	Risk assessment of seepage on receptors. Seepage management if required, for instance • pump and treat, or pump and re-use.

Impact / Source	Pathway	Receptor	Probability / Risk	Monitoring	Triggers	Mitigation
			Tailing leachate quality is comparable to baseline groundwater quality. The distance to down gradient receptors exceeds 20km. Dilution down gradient will mitigate any impact even though there is no expected impact.	groundwater levels and quality.		• Implement underdrainage from TSF
Groundwater contamination from spills at the mine site and along the infrastructure corridor	Vertical Seepage via unsaturated zone, then lateral migration in aquifer.	Other Groundwater users: • Pastoral • Community	Low. Risk managed by appropriate transport and storage of hazardous materials	Detailed reporting of all spills and clean-up	Event based	Spills will be managed in accordance with the Emergency Response Management Plan (ERMP) including the Environmental Investigation Procedure.

4.4 Potential impacts

The project comprises an open pit mine with ex-pit and in-pit tailings storage. The project water supply comprises borefield pumping of between 3.6 GL/year for a 2 MTPA operation. During construction water bores spaced 20km apart on the infrastructure corridor will pump up to 5L/s from each bore for a period of approximately 1 year.

Potential Groundwater Impacts are detailed in Table 4-3.

Table 4-3: Potential Groundwater Impacts

Groundwater Impact	
1	Water table drawdown from borefield pumping
2	Water table drawdown from construction supply pumping
3	Tailings Leachate Seepage from ex-pit and in-pit tailings
4	Groundwater contamination from spills at the mine site and along the infrastructure corridor

4.4.1 Water table drawdown from borefield pumping

Groundwater modelling was undertaken to predict impacts of groundwater pumping on receptors. Note that the groundwater use implemented in the groundwater modelling was 4.4 GL/yr. The optimised project water balance requires 3.6 GL/yr. Drawdown varies linearly with water use, and the drawdown estimates from the model have been scaled according to the optimised water balance

The results from the drawdown analysis suggest that, for the 25 years scheduled life of mine, it is probable (5th-95th percentile) that a maximum drawdown of 1.2 - 3.0 metres can be expected at the closest pastoral bore Hagen's Bore (RN010717) and drawdown of 0.5 – 2.2 metres will be observed at the Ampilatwatja Community borefield (RN011454 & RN011455).

This level of drawdown does not reduce the availability of water for these users since the depth of the bores is much greater than 3.0 m below the water table (Refer Figure 20 of EIS Appendix H for context).

Drawdown at the end of mining is predicted to extend less than 25 km from the borefield to the 0.5m drawdown contour.

4.4.2 Water table drawdown from construction bore pumping

Water table drawdown from construction bore will be negligible due to the low rate and short duration of pumping. The maximum probable drawdown extent from each bore is approximately 850 m. There are no receptors within this distance.

4.4.3 Tailings leachate seepage from ex-pit and in-pit tailings

Tailing seepage will not be acidic, metalliferous, or saline. Neutral seepage is expected to exhibit low enrichment of metals and other contaminants. Notably the tailing seepage is expected to exhibit a higher quality of water than the receiving groundwater.

Downgradient transport and dispersion of leachate has been calculated. Downgradient seepage is slow due to the low inferred permeability of the fractured rock aquifer. After 100 years, a plume of leachate will have travelled approximately 350 m downgradient, and be diluted to a concentration of 20% leachate, and 80% natural groundwater.

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

4.4.4 Groundwater contamination from spills at the mine site and along the infrastructure corridor

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.

4.5 Monitoring program

4.5.1 Design

Borefield

Groundwater monitoring to measure the impact of borefield pumping is detailed in Table 4-4 and Figure 4-1. The monitoring network comprises 14 observation bores extending out from the borefield in all directions.

Observation bores located adjacent pastoral bores will be located approximately 200 m from the pastoral bore to assess drawdown without being overly impacted by intermittent low rate pumping from the pastoral bore. The bore extraction rate/volumes from the pastoral bores will be estimated on an annual basis to assist with the interpretation of potential variations in water levels.

Additional observation bores will be installed beyond the current predicted zone of drawdown if measured drawdown exceeds predicted drawdown.

Tailings

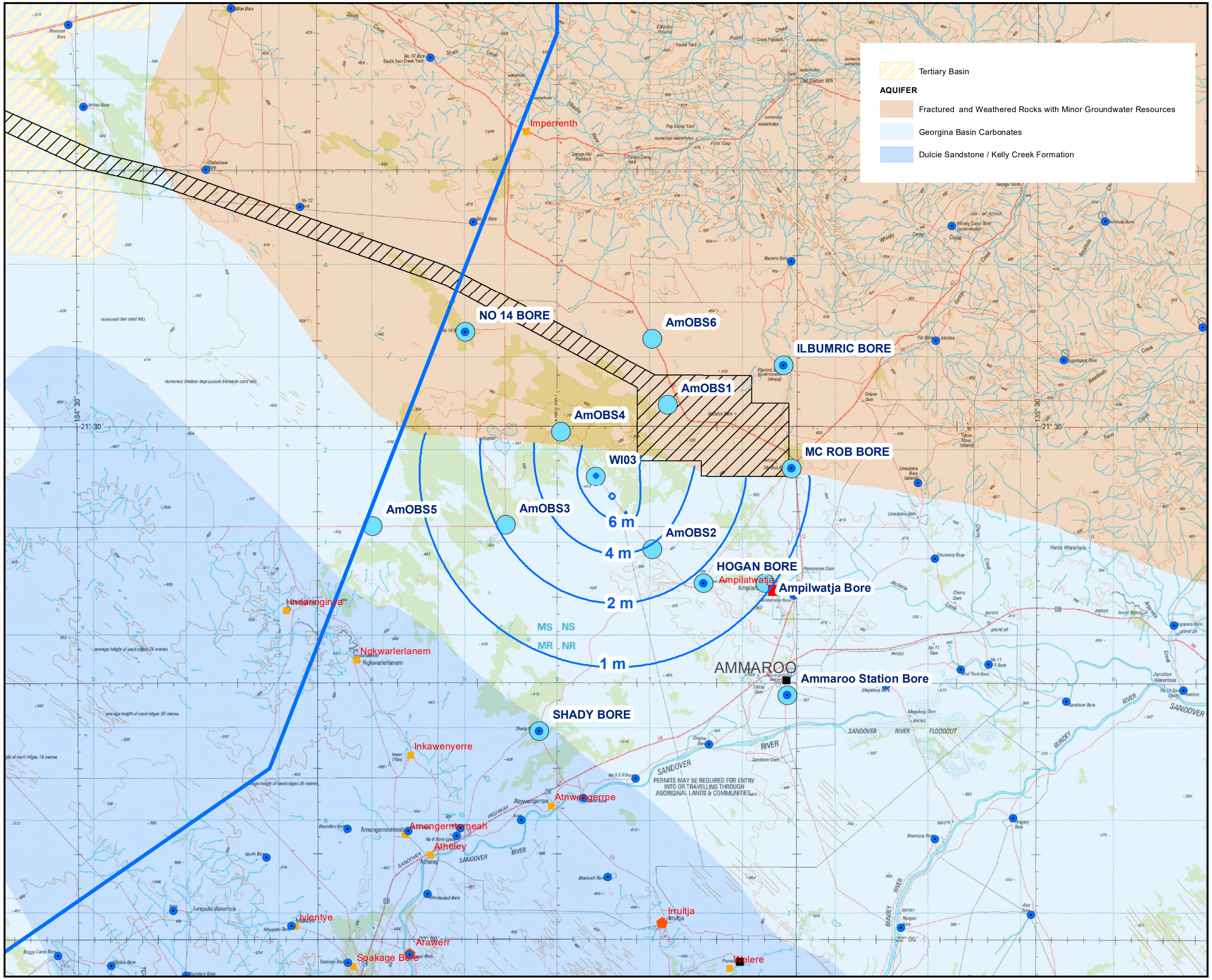
Groundwater Monitoring to measure the impact of tailings seepage is detailed in Table 4-4 and Figure 4-2. Two bores will be located down-gradient of the Ex-pit TSF, and two bores will be located down-gradient of the in-pit tailing storage. The existing bore AMObs1 is located upgradient of the pits and provides baseline data.

Bore Design

Bores will be constructed in accordance with the Minimum Construction Requirements for Water Bores in Australia. The nominal bore design comprises 100mmDN Class18 UPVC Bore casing with slotted production zone. Bores will be drilled to approximately 30m below the first water yielding interval. The bore casing will be slotted against water producing intervals. The screen annulus will be gravel packed, and the casing annulus grout sealed to prevent surface water ingress. A steel lockable cover will be installed to protect the PVC from damage and to secure logging equipment.

All monitoring and production bores are surveyed to a common datum (mAHD) to ±0.1m vertical accuracy to allow for accurate characterisation of groundwater flow directions.

All bores will be registered with DENR and allocated an RN number.



GROUNDWATER SCIENCE

Job Number: RJR-16-3

Client: Verdant Minerals

Version: 1 Date: 11/03/2018

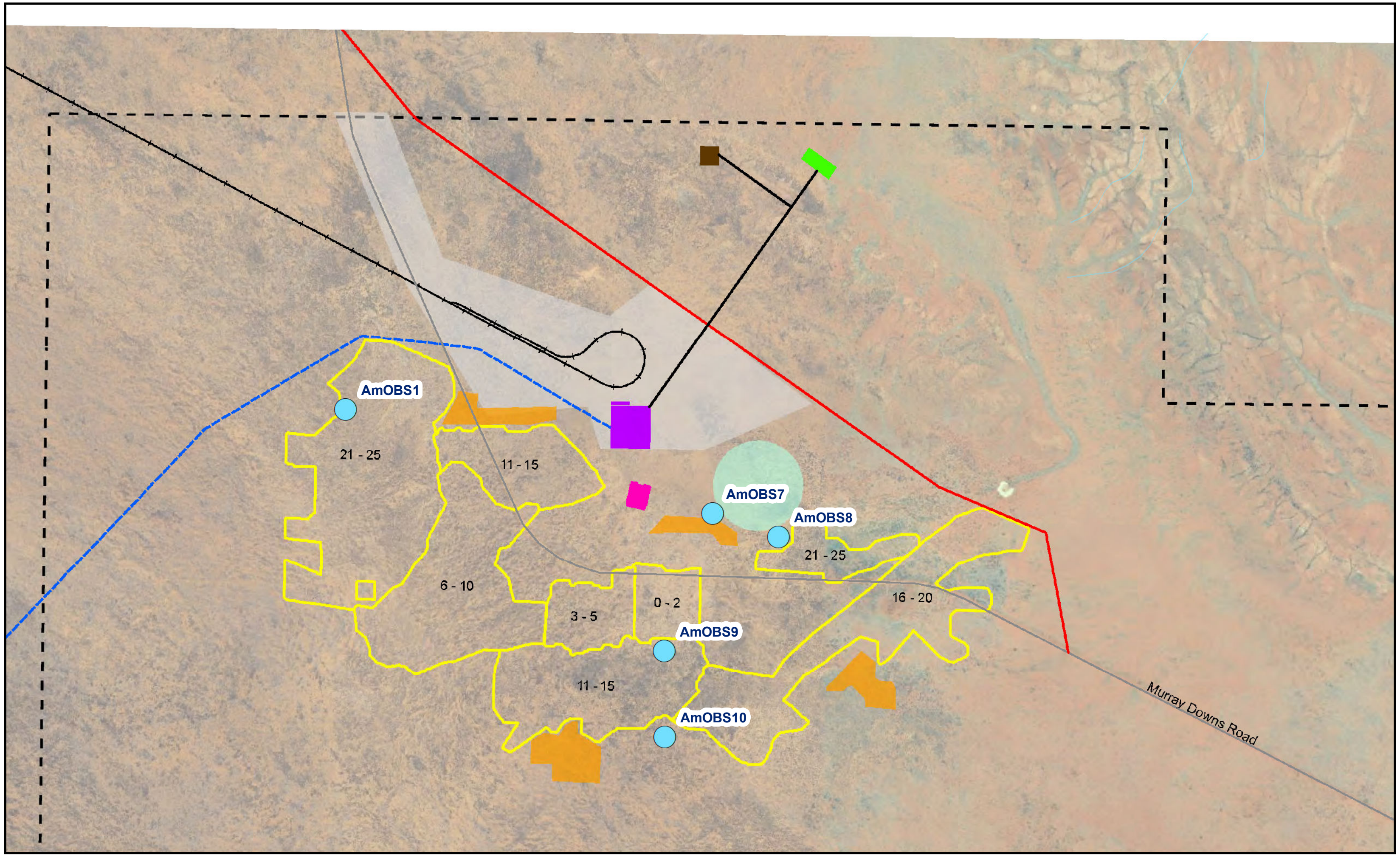
Drawn by: BJ

Coordinate System: GDA 1994 MGA Zone 53

Groundwater Monitoring Plan
Borefield Drawdown Monitoring

Figure xx.xx

Document Path: C:\Users\Ben Jeuken\Dropbox (Groundwater Science)\Groundwater Science Team Folder\Project Files\RJR\RJR-16-3 Ammaroo EIS_BFS\EIS\GIS\Supplementary\RJR-16-3 Borefield Monitoring.mxd
Document Name: RJR-16-3 Borefield Monitoring



LEGEND

- Existing roads
- Road realignment
- Access road
- Water supply pipeline
- Access corridor
- Accommodation camp
- Landfill
- ROM
- Mineral lease
- Pit extent (years)
- Construction area
- Beneficiation plant
- Surface tailings storage facility
- Temporary waste stockpiles

Groundwater_Monitoring_Points

GROUNDWATER SCIENCE

Job Number: RJR-16-3

Client: Verdant Minerals

Version: 4 Date: 17/04/2018

Drawn by: BJ

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Kilometers

Coordinate System: GDA 1994 MGA Zone 53

Groundwater Monitoring Plan
Mine Site Monitoring

Figure 4-2

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Document Name: RJR-16-3 Minesite Monitoring

Table 4-4: Groundwater Monitoring Well Network

Bore Name	Aquifer Monitored	X	Y	Purpose	Monitoring		
					Water Level Measurement	Water Quality Analysis	Volume Pumped
ILBUMRIC BORE (Twinned Obs)	TCB	524424	7629115	Third Party Impact Assessment	Daily (logger) Downloaded Quarterly. Quarterly (manual).	Annually	N/A
HOGAN BORE (Twinned Obs)	GBC	515779	7605608	Third Party Impact Assessment		Annually	N/A
SHADY BORE (Twinned Obs)	GBC	498094	7589676	Natural Recharge Processes / Third Party Impact Assessment		Annually	N/A
MC ROB BORE (Twinned Obs)	TCB	525285	7617999	Third Party Impact Assessment		Annually	N/A
NO 14 BORE (Twinned Obs)	TCB	490114	7632728	Third Party Impact Assessment		Annually	N/A
Ammaroo Station Bore (Twinned Obs)	GBC	524859	7593518	Natural Recharge Processes / Third Party Impact Assessment		Annually	N/A
Ampilwatja Bore (Twinned Obs)	GBC	522447	7605625	Third Party Impact Assessment		Annually	From PWC
AmOBS2	GBC	510258	7609283	Drawdown Validation – Ampilwatja and Ammaroo Leading Indicator		Annually	N/A
AmOBS3	GBC	494479	7611928	Drawdown Validation - WCD leading indicator		Annually	N/A
AmOBS4	TCB	500431	7621943	Drawdown Validation		Annually	N/A
AmOBS5	GCB	480118	7611739	Drawdown Validation - WCD boundary / Natural Recharge Processes		Annually	N/A
AmOBS6	TCB	510258	7631959	Drawdown Validation – Tenant Creek Block		Annually	N/A
AmOBS1	TCB	511958	7624872	Tailing Seepage Assessment		Quarterly	N/A
AmOBS7	TCB	515965	7623742	Ex-Pit TSF Seepage		Quarterly	N/A
AmOBS8	TCB	516685	7623488	Ex-Pit TSF Seepage		Quarterly	N/A
AmOBS9	TCB	515499	7622192	In-Pit TSF Seepage		Quarterly	N/A
AmOBS10	TCB	515413	7621163	In-Pit TSF Seepage		Quarterly	N/A
WI03	GBC	504179	7617158	Borefield Performance		Annually	N/A
Production Bores	GBC			Borefield Performance		Quarterly	Monthly
Additional bores beyond the predicted radius of drawdown.		Not defined		Contingency if drawdown exceeds prediction		Annually	N/A

*TBC = Tennant Creek Block Fractured Rock Aquifer. GBC = Georgina Basin Carbonate Aquifer.

4.5.2 Implementation schedule

Currently 3 observation bores are in place. One at the borefield site (WI03), one at the mine site (AMObs1) and a third up-gradient of the mine site (AMObs6). Monitoring of these bores has commenced in order to provide an ongoing baseline data set.

Water level monitoring in AMOBS6 should commence two years prior to mining.

The remaining observation bores will be installed at the beginning of the construction phase. This will enable collection of one year of pre-mining baseline data.

Additional observation bores will be installed beyond the current predicted zone of drawdown if measured drawdown exceeds predicted drawdown. The timing of these bores will be dependent on monitoring results.

Table 4-5: Groundwater Monitoring Schedule

Mine Stage	Bores
Pre-construction (Baseline) Currently In progress	WI03, AMObs1, AMObs6
Construction (pre-mining baseline)	ILBUMRIC BORE (Twinned Obs) HOGAN BORE (Twinned Obs) SHADY BORE (Twinned Obs) MC ROB BORE (Twinned Obs) NO 14 BORE (Twinned Obs) Ammaroo Station Bore (Twinned Obs) Ampilwatja Bore (Twinned Obs) AmOBS2 AmOBS3 AmOBS4 AmOBS5 AmOBS7 AmOBS8 AmOBS9 AmOBS10
Contingency	Additional bores beyond the predicted radius of drawdown.

4.5.3 Monitoring suite and frequency

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

Water quality will be monitored annually at all observation bores, and quarterly at pumping bores and TSF Seepage monitoring bores. A full suite of analytes per Table 4-6 will be analyses at all bores. The monitoring suite and frequency will be reviewed and optimised following two years data collection. Water quality sampling and analysis and QA/QC will be undertaken in accordance with guidelines (GA, 2009).

Volumes pumped will be recorded monthly for VRM production bores. Flow meters will comply with DENR Requirements. Groundwater use data from Ampilwatja Water supply will be requested from Power Water Corporation at the frequency that is available.

Table 4-6: Groundwater Monitoring Analytical Suite

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

4.5.4 Monitoring program review and optimisation

The monitoring suite and frequency will be reviewed and optimised following two years data collection and every two years thereafter. If stated purpose of the monitoring is not met then additional bores will be installed.

4.6 Trigger levels and mitigation measures

4.6.1 Water table drawdown from borefield pumping.

Water table drawdown from borefield pumping will be measured at observation bores 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 borefield.

A trigger value is defined as: measured drawdown at observation bores exceeds the range of drawdown predicted by modelling.

Mitigation measures will be implemented sequentially as follows:

Stage 1. Development of a Class 2 Groundwater flow model will be undertaken in accordance with the Australian Groundwater Modelling Guidelines (NWI, 2012). Volumes pumped from the borefield and Ampilwatja community water supply will be used to define hydraulic stress for the model. Water level drawdown measured at the monitoring bores will be used to provide a calibration data set. Aquifer parameters applied in the model will be adjusted such that the model drawdown matches the measured drawdown. The Approach is illustrated in Figure 4.3.

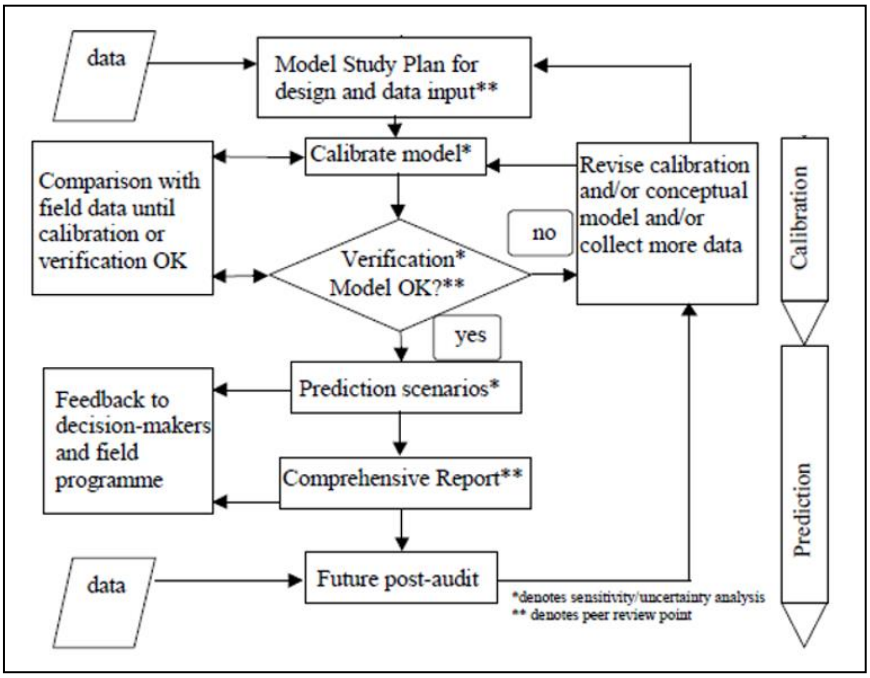

Figure 4.3: Model Revision Methodology (After MDBC, 2000)

The recalibrated model will be run to predict drawdown impacts on other users. If these impacts will reduce water availability to other users, then subsequent mitigation will be implemented.

The model set-up may require modification to better meet the model objective which is to predict the aquifer response to borefield pumping and borefield closure. Possible changes include: model development in 3 dimensions, definition of parameters zones to simulate varied geology, and modification of boundary conditions and the storage depletion approach.

Future models will be assessed as part of ongoing authorisation under the MM Act.

A recalibrated model will be delivered within one year of the trigger value being exceeded.

Stage 2. Make-good measures at other users to ensure water availability. For example, deepening bores and upgrading pumps.

Stage 3. Increased process water efficiency to be studied and implemented if practicable.

Stage 4. Modified pumping regimes to be implemented if significant impacts associated with groundwater drawdown are identified.

4.6.2 Water table drawdown from construction bore pumping

No monitoring, trigger levels or mitigation measures are proposed for this negligible impact activity.

4.6.3 Tailing leachate seepage from ex-pit and in-pit tailings

Groundwater levels and water quality downgradient of tailing storage will be monitored at 4 observation bores to detect seepage if it occurs.

Trigger Levels comprise:

- Water level rise beyond seasonal variation.
- Water quality declining from baseline.

Mitigation measures will be implemented sequentially as follows:

Stage 1: Assess the impact of water table rise. Water level rise can impact the environment if water levels rise to the root zones of plants, nominally higher than 15m below ground surface. Or if water tables rise to ground surface and cause soil waterlogging and/or salinization.

Assess the impact of water quality decline. The current beneficial use of groundwater beneath the mine is pastoral use. The impact of tailings leachate seepage if detected should be assessed to determine if the beneficial use category of groundwater will change. i.e. tailing seepage causes the groundwater to longer be suitable for pastoral use.

Stage 2: If tailing seepage causes unacceptable impacts (Water table rise to near surface or change in beneficial use) then design and implement seepage management measures:

- Pump and treat seepage from beneath the TSFs for subsequent re-use in the process plant.
- Implement underdrainage in subsequent in-pit storage cells to reduce seepage.

4.6.4 Groundwater contamination from spills at the mine site and along the infrastructure corridor

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

Monitoring, reporting and responses are defined in the ERMP.

5. Quality assurance and quality control

Quality Assurance (QA) involves all of the actions, procedures, checks and decisions, undertaken to ensure the representativeness and integrity of samples and accuracy and reliability of analytical results (NEPC 1999). Quality Control (QC) involves protocols to monitor and measure the effectiveness of QA procedures.

The QA/QC procedures will be based on AS 5567.1 – 1998 and will be implemented during sampling.

5.1.1 Data quality indicators

To minimise the potential for unrepresentative data, the following Data Quality Indicators (DQIs) will be used to evaluate sampling techniques and laboratory analysis of collected samples:

- **Data representativeness** - The degree to which the sample data accurately and precisely represents a characteristic of a population or an environmental condition. Representativeness is achieved by collecting samples in an appropriate pattern across the Project, and by using an adequate number of sample locations to characterise the site. Consistent and repeatable sampling techniques and methods are utilised throughout the sampling program.
- **Completeness** - The percentage of measurements made which are judged to be valid measurements. If there is insufficient valid data, then additional data are required to be collected.
- **Comparability** - The confidence with which one data set can be compared with another. This is achieved through maintaining a level of consistency in sample collection and laboratory analysis methods and reporting.
- **Precision** - The reproducibility of measurements under a given set of conditions. The precision of the data is assessed by calculating the Relative Percent Difference (RPD) between duplicate sample pairs:

$$\mathrm{RPD}(\%) = \frac{|C_o - C_d|}{C_o + C_d} \times 200$$

Where Co = Analyte concentration of the original sample

Cd = Analyte concentration of the duplicate sample

A nominal acceptance criteria of 30% RPD for field duplicates and splits for inorganics is recommended. It is noted that this will not always be achieved, particularly at low analyte concentrations.

- **Accuracy** - Measures the bias in a measurement system. Accuracy is assessed by reference to the analytical results of laboratory control samples, laboratory spikes, laboratory blanks and analyses against reference standards. The nominal “acceptance limits” on laboratory control samples are defined as follows:
  - Laboratory spikes – 70-130% for metals/inorganics, 60-140% for organics;
  - Laboratory duplicates – <30% for metals/inorganics, <50% for organics; and
  - Laboratory blanks – <practical quantitation limit.

Accuracy of field works is assessed by examining the level of contamination detected in field and equipment blanks. Blanks should return concentrations of all organic analytes as being less than the practical quantitation limit of the testing laboratory.

The individual testing laboratories will conduct an internal assessment of the laboratory QC program; however the results will also be independently reviewed and assessed.

5.1.2 Summary of data quality acceptance criteria

Data quality acceptance criteria adopted for this Project are set out in Table 5-1. These are generally based on the minimum requirements detailed in the Australian Standard AS4482.1-2005.

Table 5-1 Data quality acceptance criteria

Measurement	Sediment	Water	Frequency	Acceptance Criteria	
				RPD (%)	Recovery (%)
Quality control samples to be prepared or taken on site (field)					
Blind field duplicate (BFD) samples (primary laboratory)	Yes	Yes	1 in 20 samples collected or 1 per batch	30 or 50	-
Quality control samples to be prepared by laboratory					
Laboratory blanks	Yes	Yes	1 per batch	-	-
Laboratory duplicates	Yes		1 in 10 samples collected or 1 per batch (whichever is smaller)	30	-
Matrix spike recoveries	Yes		1 per batch	-	70 to 130
Laboratory control sample spike recoveries	Yes		1 per batch	-	70 to 130
Surrogate spikes	Yes	Yes	Each analysis done by GC-MS (all organics except TPH $_{C>10}$)		

Note: water includes surface and groundwater.

5.1.3 Field program

All field work will be conducted with reference to the advisory note of the Department of Resources (2009) for the sampling of surface waters and groundwaters. Key requirements of these procedures are as follows:

- Decontamination procedures - including the use of new disposable gloves for the collection of each sample, decontamination of all multiple use sampling equipment between each sampling location (using a phosphate free detergent and potable water) and the use of dedicated sampling containers provided by the laboratory;
- Sample identification procedures - collected samples will be immediately transferred to sample containers of appropriate composition and preservation for the required laboratory analysis. All sample containers to be clearly labelled with a sample number, sample location, sample depth (for groundwater) and sample date. The sample containers are then transferred to an ice filled cooler for sample preservation prior to and during shipment to the testing laboratory;
- Chain of custody protocols - a chain-of-custody form is to be completed and forwarded to the testing laboratory with each discrete batch of samples; and
- Sample duplicate frequency - field duplicates (blind) to be collected and analysed at a rate not less than ten per cent (i.e. not less than one duplicate per ten primary samples).

Field quality control

Field quality control procedures will include the collection and analysis of the following:

- **Blind field duplicates (BFDs):** Comprise a single sample that is divided into two separate sampling containers. Both samples are sent anonymously to the primary Project laboratory. Blind duplicates provide an indication of the analytical precision of the laboratory, but are inherently influenced by other factors such as sampling techniques and sample media heterogeneity.

6. References

ANZECC / ARMCANZ (2000a) *Australian and New Zealand guidelines for fresh and marine water quality, Volume 1, the guidelines*. National Water Quality Management Strategy Paper No. 4, Australian and New Zealand Environment and Conservation Council & Agriculture and Resource Management Council of Australia and New Zealand, Canberra.

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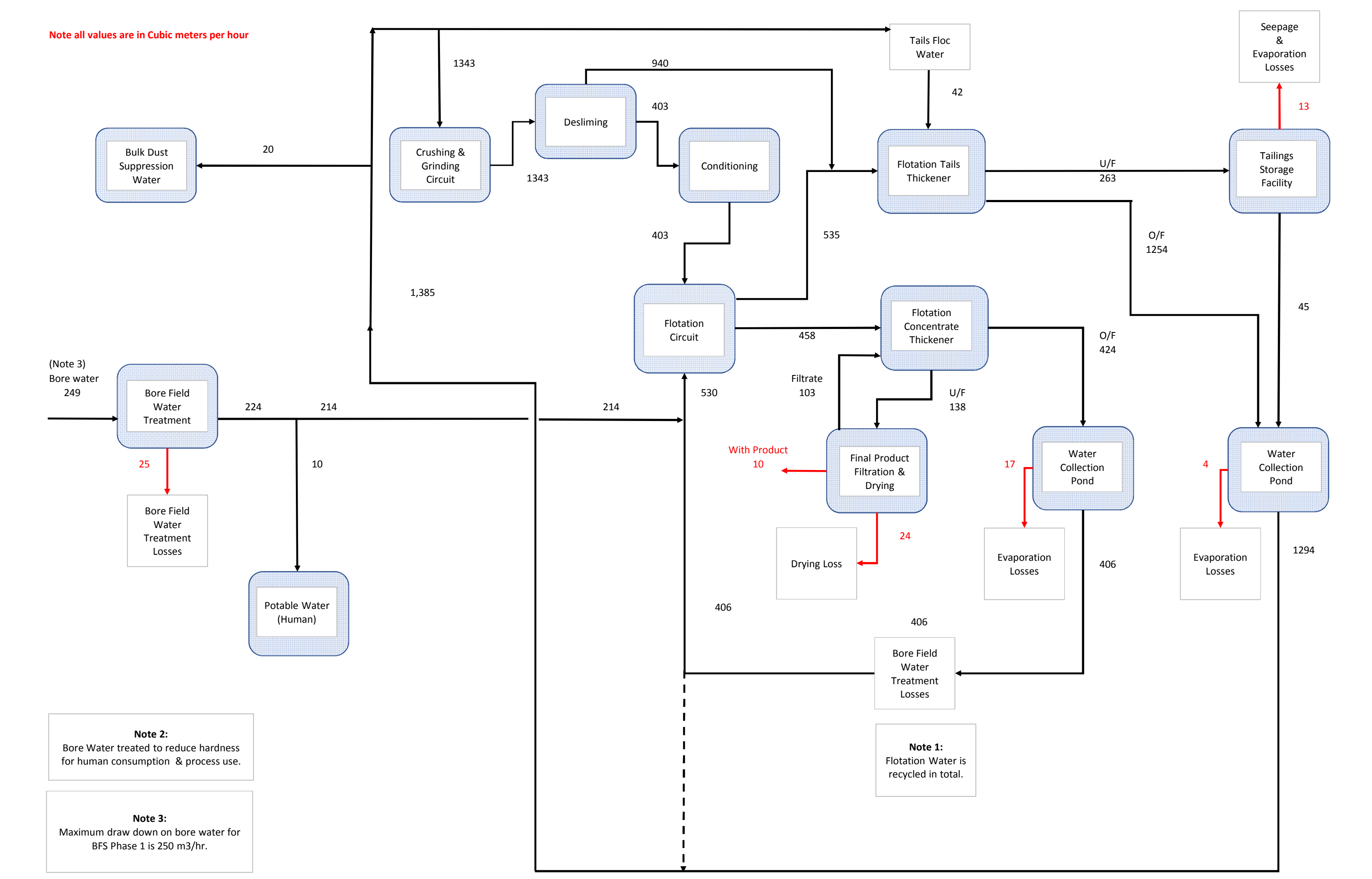
Appendices

Appendix A – Water Balance



Doc Desc:	PHASE 1 BENEFICIATION WATER BALANCE		Doc No.	201010-00710-00-PR-DSK-2001	
Project	AMMAROO PHOSPHATE PROJECT BFS	Revision	A	B	
Project No.	201010-00710	Description	For Review	Updated	
Location	Ammaroo, Australia	PREP. BY/DATE	E Wingate	E Wingate	
Client:	VERDANT MINERALS	CHKD. BY/DATE	R Atmuri	R Atmuri	
		APPD BY/DATE	M Burfield	M Burfield	

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Appendix B – Monitoring Program

Surface Water Monitoring Program

Table 1: Surface water monitoring sites

Name	Easting	Northing	Frequency	Purpose
Woody's Dam	519268.90	7624017.09	Early flows and late flows	Upstream
Elkedra Propacc Road	503631.00	7638172.00		Downstream
Sandover Highway	500450.00	7639870.00		Downstream

Table 2: Surface Water Monitoring Analytical Suite

Analytical Suite	
EC	Co
TSS	Cr
NH3_N	Cu
Total N	Hg
Total P	Mn
As	Ni
Ba	Pb
Be	V
Cd	Zn

Sediment Monitoring Program

Table 1: Sediment Monitoring Sites

Name	Easting	Northing	Frequency	Purpose
Woody's Dam	519268.90	7624017.09	Annually	Upstream
Elkedra Propacc Road	503631	7638172		Downstream
Sandover Highway	500450	7639870		Downstream
Sediment dams	TBC	TBC		Downstream

Table 2: Sediment Monitoring Analytical Suite

Analytical Suite	
TBC	

<u>Photopoint Monitoring Program</u>

Table 1: Photopoint monitoring sites

Name	Easting	Northing	Frequency	Purpose
Woody's Dam	519268.90	7624017.09	Early flows and late flows	Upstream
Elkedra Propacc Road	503631.00	7638172.00		Downstream
Sandover Highway	500450.00	7639870.00		Downstream

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Document Status

Revision	Author	Reviewer		Approved for Issue		
		Name	Signature	Name	Signature	Date
1	K. Marmion	A. Wyatt		N. Conroy		01/10/2017
2	K. Marmion B. Jeuken	A. Wyatt B. Jeuken		N. Conroy	[signature]	04/04/2018

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Appendix 7 – Peer Review of the Groundwater Monitoring Program

INDEPENDENT PEER REVIEW STATEMENT

Ammaroo Phosphate Project Groundwater Monitoring Plan

ATTENTION	Ben Jeuken, Principle Hydrogeologist, Groundwater Science Pty, Ltd
FROM	Simon Fulton, Independent Hydrogeological Consultant
DATE	16 April, 2018

This memo summarises the findings of an independent peer review of the groundwater monitoring plan proposed for the Verdant Minerals Ammaroo Phosphate Project. The work has been commissioned by Verdant Minerals through Groundwater Science in response to the following request from the EPA-NT

"*Provide an independent peer review to confirm the groundwater monitoring program proposed would be adequate to obtain the appropriate level of baseline information, inform recharge and discharge processes and be capable of detecting changes over time in the groundwater system that may indicate impacts from mining operations."*

The groundwater monitoring program is contained within the Draft Water Management Plan (GHD, 2018). This forms the principal document for the review, the following additional documents were provided for context:

- Ammaroo Phosphate Project - Draft Environmental Impact Statement (EIS)
- EIS Appendix H - Groundwater Study and Impact assessment.
- Ammaroo Phosphate Project – Draft EIS Supplementary Report

The Terms of Reference for the review are defined as follows:

- The review only covers groundwater elements of the water management plan.
- The review is of the monitoring program only not the baseline hydrogeological characterisation and impact assessment modelling.
- The review is an adequacy assessment. Any deficiencies that make the monitoring program inadequate against the assessment criteria should be identified in the review.

The assessment criteria for the review are defined as whether the proposed groundwater management plan is adequate to:

- Obtain the appropriate level of baseline information.
- Inform recharge and discharge processes.
- Is capable of detecting changes over time in the groundwater system that may indicate impacts from mining operations.

The review is presented in the following table which breaks monitoring activities into bore field related impacts in the Georgina Basin Carbonate Aquifer (GBCA) and tailings seepage impacts around the mine site in the Tennant Creek Block aquifer. The table provides a summary of the proposed groundwater monitoring activities, a commentary of the adequacy on the monitoring and recommended actions where the proposed monitoring is not considered adequate. The review is intended to be read alongside and draft EIS and the groundwater study and impact assessment (Appendix H EIS)

Aquifer/Area	Potential Groundwater Impact	Proposed Groundwater Monitoring Activity	Adequacy against EPA Assessment Criteria	Recommended Amendments
GBCA/Bore field aquifer	Drawdown impacts on existing pastoral bore (Hagen's Bore) and water supply (Ampilatwatja community)	The proposed bore field monitoring network consists of 13 dedicated monitoring bores extending out from the bore field in all directions, in addition to monitoring of the bore field production bores. Twinned bores (duplicate monitoring bores) are proposed at all existing groundwater receptors within the modelled area of influence and at the boundary with the Western Davenport Water Control District (WCD). Two bores are located are located between the borefield and the key receptors (Hagen's Bore, Ampilatwatja Community) and the WCD boundary respectively and will operate as leading indicators of drawdown impacts. The monitoring plan does not explicitly nominate the target aquifer/formation for the recommended monitoring bores.	The number and distribution of monitoring bores is considered adequate to allow the appropriate collection of baseline data. It provides a good spatial representation across the target aquifer (GBCA), and includes multiple bores between the bore field and key receptors. These bores will provide a measure of actual versus modelled drawdown before any drawdown response is observed near the key receptors. The monitoring plan should explicitly identify the target aquifers for each recommended monitoring bore.	It is recommended that the plan explicitly identify the target aquifers/formations at each of the proposed monitoring locations
			The monitoring program does not include background bores outside the radius of influence of the bore field to inform natural (as opposed to mine induced) recharge processes to the GBCA. The plan does include several bores (Shady Bore, Ammaroo Station Bore, AMOBS5) located over 30 km from the borefield at the outer extent (0.5 m) of the predicted drawdown cone. Analytical modelling (Theis, 1935) based on the range of aquifer parameters applied in the numerical model suggests that a measureable drawdown response (0.5 m) will take over ten years to propagate to these monitoring points. Collection of water level data at these bores during the intervening period is considered adequate to characterise natural recharge to the system assuming measurements are collected at an appropriate frequency (see below).	The plan should identify that water level observations from Shady bore, Ammaroo Station Bore and AMOBS5 will be used to identify natural recharge processes
		The plan proposes to monitor water levels in monitoring bores at monthly increments "typically" using water level loggers with an annual download frequency. Annual water quality	The monitoring plan should explicitly nominate the water level collection method for each monitoring bore including the monitoring interval for manual/logger measurements. The proposed	It is recommended that the monitoring plan explicitly defines the water level monitoring method and

Aquifer/Area	Potential Groundwater Impact	Proposed Groundwater Monitoring Activity	Adequacy against EPA Assessment Criteria	Recommended Amendments
		analysis is proposed for all monitoring bores with a quarterly frequency for borefield production bores. Water quality analytes include field parameters, major ions, nitrate, phosphorous, fluoride and a metals suite.	monthly water level frequency using loggers is not considered adequate to inform recharge processes. In line with Sundaram et al (2009) it is recommended that water levels are collected at a daily interval for bores (Shady Bore, Ammaroo Station Bore, AMOBS5) used to define recharge processes and rainfall response. Monthly water level measurements are considered appropriate for the remaining GBCA monitoring bores. The annual frequency of downloading loggers is not considered adequate to ensure that baseline data is reliably collected, as in the instance of logger failure this may result in the loss of up to 12 months data before the problem is identified. At a minimum it is recommended that manual water levels are collected and loggers downloaded and data reviewed on a quarterly basis. The proposed water quality suite and sample frequency is appropriate considering the risks and likely impacts from the bore field extraction	measurement interval for each monitoring bore. It is recommended that installed loggers measure at a minimum of daily frequency (in line with recommendations for recharge characterisation in Sundaram et al, 2009). This logging interval should be supported with quarterly manual readings and downloads. Downloaded data should be reviewed quarterly to ensure loggers have not failed
			The groundwater management plan does not incorporate monitoring of natural discharge processes, however, this is considered appropriate given the watertable depth in the GBCA precludes GDEs and groundwater discharge in the impact zone of the bore field. Surveying of bores to a common height datum (mAHD) will help refine the baseline understanding of groundwater flow directions within the GBCA.	It is recommended that pastoral bore extraction rates/volumes are estimated on an annual basis to assist with interpretation of potential variations in water level responses and to comply with the requirement to monitor discharge process.
		Baseline monitoring is currently being undertaken in bore WI03 and AMOBS6. The remaining 11 bores are proposed to be installed during the construction phase of the mine allowing for 12 months of pre-mining baseline data.	The level of baseline water level and quality data collected prior to mine operation is adequate considering the regional scale of the aquifer, the location of receptors and the anticipated impacts. This assessment is conditional on the assumption that the borefield will not be operating to support	

Aquifer/Area	Potential Groundwater Impact	Proposed Groundwater Monitoring Activity	Adequacy against EPA Assessment Criteria	Recommended Amendments
			construction activities during the pre-mine construction period.	
		The monitoring plan does not propose to survey monitoring bores to a common reference height datum	Current understanding of regional and local flow directions within the GBCA is based on historical bore records and elevations from the 1-second DEM, inherent errors in these sets acknowledged in Appendix H of the EIS. This data set is used to characterise groundwater flow and interactions with the Western Davenport WCD. It is recommended that completed monitoring and production bores are surveyed to a common height datum (mAHD) to allow a more accurate representation of groundwater flow processes in the GBCA.	All monitoring and production bores are surveyed to a common datum (mAHD) to ±0.1m vertical accuracy to allow for accurate characterisation of groundwater flow directions.
Tennant Creek Block Fractured Rock Aquifer/Mine Site	Tailings leachate seepage from ex-pit and in-pit tailings changes groundwater quality from baseline to reduce beneficial use, impact on receptors	The proposed monitoring network comprises five bores: two bores (AMOBS7, AMOBS8) situated down gradient of the ex-pit TFS, two bores (AMOBS9, AMOBS10) situated down gradient of the in-pit tailing storage and an up gradient bore (AMOBS1). The monitoring plan does not indicate whether monitoring bores will be surveyed. Trigger levels for the mine component of the groundwater monitoring plan comprise: water level rise above seasonal variation, water quality declining from baseline.	The rationale behind the location of the proposed monitoring bores is sound, however, with only one groundwater bore currently on the mine site there is insufficient data to establish local groundwater gradients and flow directions with adequate certainty. Consequently the designation of bores as up-gradient or down-gradient of the ex-pit and in-pit tailings disposal areas cannot be reasonably confirmed. It is recommended that post construction the bores are surveyed to a common height datum (mAHD) and groundwater gradients established across the mine site. The monitoring plan should subsequently be reviewed to ensure that the location of the monitoring bores meets their stated objective in the monitoring plan (i.e. up-gradient, down-gradient of TSF). If the monitoring bore coverage is inadequate additional bores should be installed at locations informed by the groundwater flow surface.	All monitoring and production bores are surveyed to a common datum (mAHD) to ±0.1m vertical accuracy to allow for accurate groundwater flow determination. The monitoring plan should be reviewed after establishing local groundwater flow directions to ensure the bores are adequately located to fulfil their monitoring objective. If stated objective is not met additional bores should be installed.
			Recommended bores AMOBS09 and AMOBS10 are positioned to monitor down gradient water level and	In order to collect baseline water quality and level data on

Aquifer/Area	Potential Groundwater Impact	Proposed Groundwater Monitoring Activity	Adequacy against EPA Assessment Criteria	Recommended Amendments
			quality impacts from seepage of tailings from in-pit disposal. The recommended location of these bores is around 1 km from the designated pit area for years 0-2 of mining. Applying the same model (Hantush, 1967) used to assess potential watertable rise in the supplementary EIS report (see section 3.1.2) under the low K and seepage scenario results suggest these bores are located too far away from the pits to detect a measurable water level change (0.5 m) within the 25 year lifespan of the project. In order to collect adequate early time data on potential seepage from in-pit tailings disposal it is recommended that monitoring bore AMOBS09 is relocated to a position immediately adjacent to the down gradient side of the 0-2 year pit. Water levels in this bore should be collected daily and water quality samples collected quarterly.	seepage from the in-pit tailings disposal in the early stage of the mine development monitoring bore AMOBS09 should be relocated to a position immediately adjacent to the down gradient side of the 0-2 year pit.
		Monthly water level monitoring is proposed for all five bores, the plan is equivocal regarding the method of water measurement (i.e. manual versus loggers) for each bore. Water quality samples will be collected on a quarterly basis from all bores. Water quality analytes include field parameters, major ions, nitrate, phosphorous, fluoride and a metals suite.	The monthly water level monitoring frequency for ex-pit and in-pit TSF seepage is not considered adequate to distinguish between water level changes from seepage and natural recharge processes. The monitoring plan should adopt a daily water level monitoring frequency for all seepage bores, in line with recommendations from Sundaram et al (2009) for monitoring groundwater where there is a risk of groundwater quality impact. Where loggers are deployed these should be downloaded at a minimum quarterly frequency and accompanying manual water levels collected. Quarterly water quality sampling frequency is considered appropriate for monitoring seepage impacts from the in-pit and ex-pit seepage. The recommended water quality analytes are considered adequate subject to the proponent confirming the analytical suite captures all chemicals	It is recommended that bores monitoring seepage around the in-pit and ex-pit TSF adopt a daily time step for water level monitoring. Where loggers are deployed these should be downloaded with a quarterly frequency and accompanied by manual water level measurements.

Aquifer/Area	Potential Groundwater Impact	Proposed Groundwater Monitoring Activity	Adequacy against EPA Assessment Criteria	Recommended Amendments
			(e.g. surfactants) used in the ore processing which are likely to be present in the leachate water.	
		The plan indicates that baseline monitoring has commenced in AMOBS1/AMOBS6 but does not provide detail on the level of baseline collected to date. The remaining bores (AMOBS7, AMOBS8, AMOBS9, AMOBS10) will be drilled at the start of construction allowing for 12 months of baseline data collection prior to mine operation.	The proposed groundwater quality baseline (four samples in 12 months before mine operation) is considered adequate provisional to these samples being collected before stripping of cover as this could affect local recharge. The proposed water level baseline (12 months) is considered adequate for the seepage monitoring bores with the exception of AMOBS6, which should be used as a background bore to determine seasonal fluctuation in the Tennant Creek Block aquifer. Monitoring in this bore should commence two years prior to mining activities.	Water level monitoring in AMOBS6 should commence 2 years prior to mining. This bore should be used to establish the seasonal variation in groundwater levels in the Tennant Creek Block aquifer, which is a reference for the water level trigger action in the seepage monitoring bores.

Declaration: Simon is a hydrogeologist with over fifteen years experience working in the government and private sectors, and ten years specifically working in Northern Territory groundwater environments. He is familiar with designing and implementing groundwater monitoring programs for impact assessment and water resource planning in the NT. Simon developed the NT Great Artesian Basin groundwater monitoring plan which underpins the NT GAB Water Control District. He has been involved in the design and implementation of numerous groundwater monitoring programs for both government agencies and industry clients. Simon has demonstrated experience working in the Georgina Basin environment, including supervising drilling programs, undertaking desktop hydrogeological reviews and groundwater impact assessments. Simon has not undertaken any work for Verdant Minerals, Groundwater Science or GHD associated with the Ammaroo Phosphate Project. There is no conflict of interest in relation to this review task.

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Appendix 8 – Tailings Characterisation Report (SGS Minerals Services, 2017)

An Investigation into

Environmental Characterization of Phosphate Beneficiation Residue

AUSTRALIAN PHOSPHATE DEPOSIT

prepared for

WORLEY PARSONS INC.

Project 16400-001 – Final Report
December 15, 2017

NOTES

ACCREDITATION: SGS Minerals Services Lakefield is accredited to the requirements of ISO/IEC 17025 for specific tests as listed on our scope of accreditation, including geochemical, mineralogical, and trade mineral tests. To view a list of the accredited methods, please visit the following website and search SGS Lakefield: *http://palcan.scc.ca/SpecsSearch/GLSearchForm.do*.

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Table of Contents

List of Tables

List of Figures

Introduction

SGS was contracted by Worley Parsons to complete environmental characterization of a final tailing product from a phosphate beneficiation project. The samples tested were provided by COREM (Ville de Québec, Québec) under SGS sample receipt 0215-SEP17. The purpose of the environmental test program, entitled "Environmental Characterization of Phosphate Beneficiation Residue", was to assess the geochemical acid rock drainage (ARD), and contaminant mobility potential associated with the products tested.

The following report provides a summary of the environmental testwork completed and the results thereof.

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Environmental Metallurgist, Environmental Testing - Metallurgical Operations

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Testwork completed by David French
Report preparation by: R. Caldwell
Reviewed by: B. Bowman, C. Mina

Scope of Work

The scope of testwork completed on the phosphate beneficiation sample included:

- Total recoverable metals inductively coupled plasma-optical emission spectroscopy/mass spectroscopy (ICP-OES/MS) elemental analysis.
- Standard acid base accounting (ABA).
- Net acid generation testing (NAG).
- Toxicity characteristic leaching procedure (TCLP) – US EPA Method 1311.
- Modified TCLP – CO_2 saturated deionized water extraction.
- Modified TCLP – deionized water extraction.

Sample Descriptions, Preparation, and Test Methods

The following sections provide brief overviews of the samples received, sample preparation, and test methods included in the environmental characterization program.

1. Sample Descriptions

Description of the tailings sample received from the COREM phosphate beneficiation test program (SGS Sample Receipt 0215-SEP17) are presented in Table 1.

Table 1: Samples Received

Sample Identifier	Description	Sample Type	Sample Mass
Final Tails	Lot 20/60/20 Final Tails	Filter Cake	3 kg

2. Sample Preparation

Upon receipt of the *Final Tails* sample, the sample was homogenized and representative portions of the filter cake solids were submitted for analysis at SGS facilities in Lakefield.

Samples were prepared for the proposed testwork and analyses according to SGS Standard Operating Procedures and the individual test method protocols.

3. Test Methods

The following sections provide a brief overview of the test methods included in the environmental characterization program.

3.1. ICP-OES/MS Elemental Analyses – Recoverable Metals

The *Final Tails* solids were digested using the US EPA 200.2 total recoverable metals method to obtain the environmentally available concentration of the parameters being analyzed. ICP-OES/MS trace metal scans were performed to provide quantitative analyses of the elemental components of the sample material (Ag, Al, As, B, Ba, Be, Bi, Ca, Cd, Co, Cr, Cu, Fe, K, Li, Mg, Mn, Mo, Na, Ni, P, Pb, Sb, Se, Si, Sn, Sr, Th, Ti, Tl, U, V, W, Y, Zn, and Hg). Mercury analyses were completed by cold vapour atomic absorption spectroscopy (CVAAS).

3.2. Paste pH and Conductivity (1:5 Liquid/Solid)

Paste pH and conductivity were measured on a slurry made of one part deionized water and five parts *Final Tails* by weight. The pH was measured using a Thermo Orion 230A+ meter and a temperature corrected Thermo Orion Triode pH probe calibrated between pH 7 and 10. Electrical conductivity was measured using a Thermo Orion 135A conductivity meter and a 2-electrode epoxy/graphite conductivity cell (cell constant of 1.0 cm^{-1}.

3.3. Standard Acid Base Accounting

The standard ABA test provided quantification of the total sulphur, sulphide sulphur, and sulphate concentrations present and the maximum potential acidity (MPA) related to the oxidation of the sulphur concentration. The test method determined the acid neutralization capacity (ANC) of the sample by initiating a reaction with excess hydrochloric acid and then identified the quantity of acid neutralized by the samples' ANC by back-titrating to pH 7.0 with sodium hydroxide. The balance between the MPA and ANC assists in defining the potential of the sample to generate acid drainage upon exposure to oxygen and water.

3.4. Net Acid Generation

NAG testing was conducted to determine the balance between the acid consuming and acid producing components of the samples. The NAG test initiated a reaction between the sample and concentrated hydrogen peroxide (H_2O_2) in order to force complete oxidation and reaction of the acidity produced with the neutralizing minerals present within the sample. After the reaction ceased, the pH of the solution was measured (NAG pH). The acid remaining after the reaction was titrated with standardized sodium hydroxide to pH 4.5 and the net acid generated by the reaction was calculated and expressed in units of kg H_2SO_4 equivalent per tonne. The $NAG_{4.5}$ value is indicative of the contribution from free acid, aluminium, and iron. Titration from pH 4.5 to pH 7.0 can provide additional information for sample characterization as, under certain conditions, the $NAG_{7.0}$ is indicative of the presence of metallic ions that consume alkalinity over this pH range, such as copper and zinc.

3.5. Toxicity Characteristic Leaching Procedure (TCLP) – US EPA Method 1311

The objective of the TCLP extraction was to determine the mobility of inorganic analytes present in the solids and if the resultant leachates generated would classify the material as acceptable to a Class II landfill, or whether the waste materials would be considered hazardous due to toxicity. In the case of the *Final Tails* sample, the leachant was adjusted to pH 4.93 ± 0.05 (extraction fluid #1) through the addition of acetic acid and sodium hydroxide to deionized (DI) water. The leachant was added to the sample in a 20:1 ratio and the sample container was rotated end over end at 29±2 rpm for 18 hours. The resultant slurry was then filtered through a 0.7 µm glass fibre filter and analyzed for bicarbonate, carbonate, fluoride, sulphate, and total metals utilizing the previously noted analytical suite of metal parameters.

3.6. Modified TCLP – Deionized Water Saturated with CO_2

The objective of the modified TCLP extraction with leachant composed of deionized water saturated with CO_2 to a target pH of 5.3, was to determine the mobility of inorganic analytes present in the solids under the environmental conditions imposed by the addition of a weak carbonic acid solution. The leachant was added to the sample in a 20:1 ratio and the sample container was rotated end over end at 29±2 rpm for 18 hours in the same manner as the previously discussed extraction method. The resultant slurry was then filtered through a 0.7 µm glass fibre filter and analyzed for suite of parameters discussed in the TCLP section.

3.7. Modified TCLP – Deionized Water

The objective of the modified TCLP extraction with deionized water leachant was to determine the mobility of inorganic analytes present in the solids under the environmental conditions imposed by the residue itself. The deionized water leachant was added to the sample in a 20:1 ratio and the sample container was rotated end over end at 29±2 rpm for 18 hours. The resultant slurry was then filtered through a 0.7 µm glass fibre filter and analyzed for suite of parameters discussed in the TCLP section.

Test Results

Results of the testwork completed on the *Final Tails* sample are shown in the following sections. Analytical Certificates of Analysis are appended to this report (Appendix A).

1. ICP-OES/MS Elemental Analyses – Recoverable Metals

Table 2 shows results of the elemental analyses conducted on the *Final Tails* solids. Digestion of the solid sample was completed using the US EPA 200.2 method.

Table 2: ICP-OES/MS Elemental Analyses

Parameter	Unit	Final Tails
LIMS		15144-OCT17
Si	%	29.4
Hg	µg/g	0.13
Ag	µg/g	0.10
Al	µg/g	25000
As	µg/g	5.6
Ba	µg/g	110
Be	µg/g	3.4
B	µg/g	12
Bi	µg/g	0.15
Ca	µg/g	57000
Cd	µg/g	0.79
Co	µg/g	4.2
Cr	µg/g	44
Cu	µg/g	18
Fe	µg/g	13000
K	µg/g	1700
Li	µg/g	10
Mg	µg/g	3800
Mn	µg/g	200
Mo	µg/g	1.0
Na	µg/g	550
Ni	µg/g	19
Pb	µg/g	150
P	µg/g	24000
Se	µg/g	< 0.7
Sb	µg/g	< 0.8
Sn	µg/g	1.8
Sr	µg/g	120
Th	µg/g	8.0
Tl	µg/g	0.09
Ti	µg/g	87
U	µg/g	7.1
V	µg/g	39
W	µg/g	0.15
Y	µg/g	58
Zn	µg/g	75

2. Standard Acid Base Accounting & Net Acid Generation

Results of the standard ABA and NAG tests completed on the *Final Tails* solids are presented in Table 3 and Table 4, respectively.

Table 3: Standard Acid Base Accounting

Parameter	Unit	Final Tails
LIMS		15142-Oct17 and 15143-Oct17
Paste pH (1:5)	no unit	9.11
Paste Conductivity (1:5)	µS/cm	112
Paste pH (2:1)	no unit	8.36
Fizz Rate	---	3
Sample weight	g	2.02
HCl_added	mL	40.00
HCl	normality	0.50
NaOH	normality	0.50
NaOH to pH=7.0	mL	34.97
Final pH	no unit	1.04
ANC	kg H_2SO_4/tonne	103
MPA	kg H_2SO_4/tonne	0.18
NAPP	kg H_2SO_4/tonne	-103.24
ANC/MPA	ratio	563
S	%	0.006
Sulphide - S	%	< 0.02
Sulphate - S	%	< 0.1
C	%	0.104
CO_3	%	0.26
CO_3 ANC[1]	kg H_2SO_4/tonne	4.23
CO_3 NAPP	kg H_2SO_4/tonne	-4.05
CO_3 ANC/MPA	ratio	23.5

[1] CO_3 ANC calculated based on carbonate content of sample

Table 4: Net Acid Generation

Parameter	Unit	Final Tails
LIMS		15141-Oct17
Sample weight	g	1.51
Vol H_2O_2	mL	150
Final pH	no unit	7.66
NaOH	normality	0.10
Vol NaOH to pH 4.5	mL	0.00
Vol NaOH to pH 7.0	mL	0.00
NAG (pH 4.5)	kg H_2SO_4/tonne	0
NAG (pH 7.0)	kg H_2SO_4/tonne	0

3. Toxicity Characteristic Leaching Procedure Extractions

Results of the TCLP extractions (US EPA Method 1311 regulatory and modified leachants) are shown in Table 5 in comparison to the Australian drinking water quality guidelines based on health (aesthetic limits based on taste were ignored). Values exceeding the guideline values are highlighted with bold italicized font.

Table 5: Toxicity Characteristic Leaching Procedure Analyses

Parameter	Unit	Australian DWQG Health Limits	Final Tails	Final Tails	Final Tails
LIMS			15145-OCT17	15169-OCT17	15146-OCT17
Sample weight	g	--	100	100	100
Ext Fluid	#1 or #2	--	#1	DI Water to pH 5.3 with CO_2	DI Water
Ext Volume	mL	--	2000	2000	2000
Final pH	no unit	6.5 - 8.5	***5.04***	***10.20***	***10.24***
HCO_3	mg/L as $CaCO_3$		1300	18	16
CO_3	mg/L as $CaCO_3$		< 2	26	29
F	mg/L	1.5	0.68	0.90	0.89
SO_4	mg/L		< 2	< 2	< 2
Hg	mg/L	0.001	< 0.00001	< 0.00001	< 0.00001
Al	mg/L		0.464	2.22	2.33
As	mg/L	0.01	0.0079	0.0019	0.0016
Ag	mg/L	0.1	< 0.0005	< 0.0005	< 0.0005
Ba	mg/L	2	0.300	0.0132	0.0108
Be	mg/L	0.06	0.000960	0.000412	0.000259
B	mg/L	4	0.312	0.105	0.041
Bi	mg/L		< 0.00007	0.000029	0.000029
Ca	mg/L		62.9	7.25	3.53
Cd	mg/L	0.002	0.000439	0.000151	0.000033
Co	mg/L		0.000982	0.000354	0.000288
Cr	mg/L	0.05 as Cr(VI)	0.00367	0.00409	0.00326
Cu	mg/L	2	0.00609	0.00226	0.00189
Fe	mg/L		0.120	1.12	1.02
K	mg/L		2.80	0.712	1.44
Li	mg/L		0.0011	0.0012	0.0014
Mg	mg/L		12.7	0.767	0.699
Mn	mg/L	0.5	0.141	0.0140	0.00452
Mo	mg/L	0.05	0.00069	0.00101	0.00057
Na	mg/L		1050	14.8	16.8
Ni	mg/L	0.02	***0.0219***	0.0022	0.0016
P	mg/L		5.83	2.46	0.698
Pb	mg/L	0.01	0.00276	***0.0142***	0.00777
Sb	mg/L	0.003	< 0.002	0.0004	0.0003
Si	mg/L		5.89	13.9	11.9
Se	mg/L	0.01	0.00053	0.00009	0.00006
Sn	mg/L		0.00037	0.00092	0.00034
Sr	mg/L		0.487	0.0209	0.0129
Th	mg/L		< 0.001	0.0007	0.0011
Ti	mg/L		0.00965	0.0254	0.0738
Tl	mg/L		< 0.00005	0.000017	0.000014
U	mg/L	0.017	0.00207	0.00107	0.000636
V	mg/L		0.00182	0.0170	0.0147
W	mg/L		0.00166	0.00106	0.00017
Y	mg/L		0.00118	0.00678	0.00291
Zn	mg/L		0.021	0.010	0.006

Australian Drinking Water Guidelines (Version 3.4 Updated October 2017).

Discussion

Solids elemental analyses (US EPA 200.2 total recoverable metals) for the *Final Tails* solids determined that the recoverable portion of the sample was comprised primarily of silicates (~30%) with moderate to minor amounts of calcium (5.7%), aluminium (2.5%), phosphorous (2.4%), and iron (1.3%). All other parameters reported at trace levels (<1%).

Standard ABA test results clearly identified the *Final Tails* as not potentially acid generating (NPAG) with a sulphide concentration below detection (< 0.02%), and significant acid neutralization capacity (ANC of 103 kg H_2SO_4/t) resulting in an ANC/MPA ratio of 563. The carbonate (CO_3) assay indicated that most of the total ANC reported was from less reactive (non-carbonate) sources suggesting increased uncertainty with regards to the availability and reactivity of total ANC reported, however, with a CO_3 ANC/MPA ratio of 23.5 the carbonate alone provides more than sufficient ANC.

The NAG test completed on the sample resulted in a NAG pH of 7.66. This indicates that no acid was generated on aggressive oxidation through hydrogen peroxide addition and confirms the NPAG designation based on the standard ABA test. Results of the ABA test are illustrated in Figure 1.

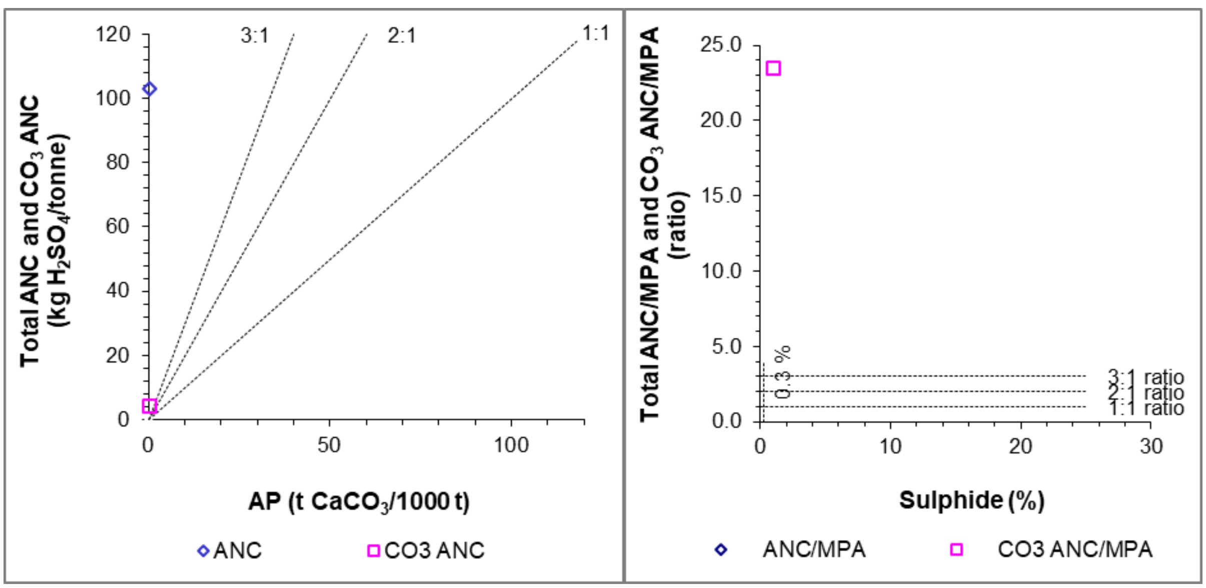

Figure 1: Standard Acid Base Accounting Results

The TCLP extraction was designed by the US EPA to determine the mobility of contaminants present in the sample material and if the resultant leachate would classify the material as acceptable to a Class II landfill, or whether the waste material would be considered hazardous due to toxicity. It should be noted that since the TCLP is a highly aggressive extraction procedure, the limits applicable to this test procedure are generally higher than those used for process water analyses, or drinking water. In the case of this test program the TCLP was completed following the US EPA SW 846 method 1311[1], as well as with two modified procedures. The modified procedures followed the TCLP method precisely apart from the extraction fluids used. The first modified procedure used deionized water saturated with carbon dioxide gas in order to depress the pH (through formation of carbonic acid) to a pH of 5.3, while the second modified procedure used deionized water as the leachant. In this way, the *Final Tails* sample was extracted using a range of pH environments (pH=5 buffered[2] extraction, a pH 5.3 unbuffered extraction, and deionized water).

Analysis of the TCLP and modified TCLP leachates reported all typically controlled parameters, with few exceptions, below the Australian drinking water quality guidelines (DWQG, given in Table 5 of this report for reference purposes). The TCLP extract analysis resulted in a nickel concentration (0.0219 mg/L) marginally above the DWQG of 0.02 mg/L, while the CO_2 saturated DI water extraction resulted in a lead concentration (0.0142 mg/L) marginally above the guideline of 0.01 mg/L. The pH of all of the extraction fluids were outside the health-related guidelines for drinking water. The low pH value reported by the TCLP leachate (5.04) was expected as the method target pH for this test is 5.0. Similarly, the very high sodium concentration measured in the TCLP leachate (1,050 mg/L) is directly related to the use of sodium acetate as a buffer in the extraction fluid (extraction fluid #1) and does not reflect the sodium content of the sample tested.

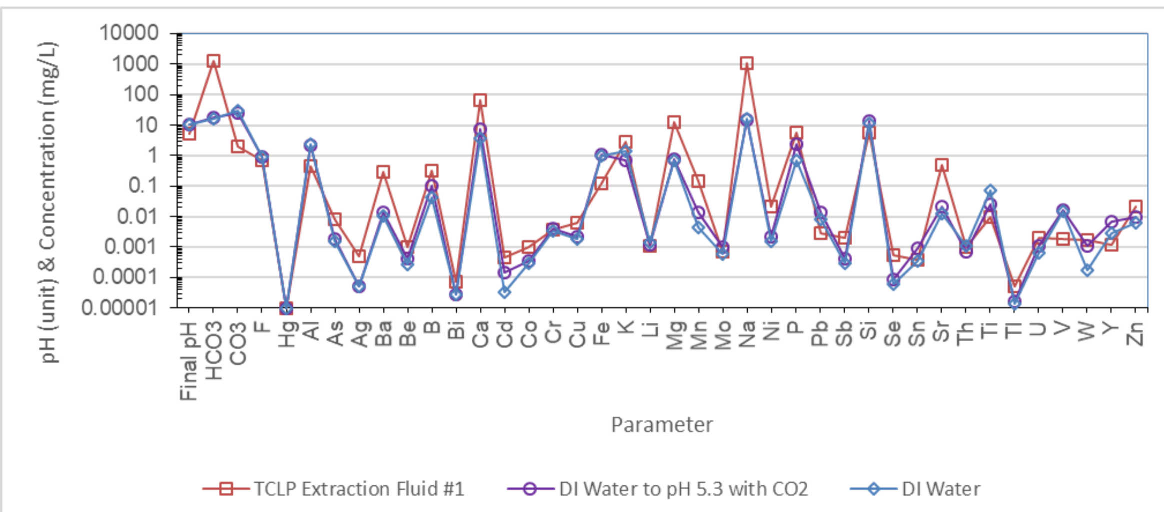

Figure 2: Toxicity Characteristic Leaching Procedure Results

Overall, the TCLP leachates typically reported significant concentrations (>1 mg/L) of bicarbonate, carbonate, aluminium, calcium, potassium, magnesium, sodium (as noted), and silicon in solution. Figure

[1] https://www.epa.gov/sites/production/files/2015-12/documents/1311.pdf

[2] *Sodium acetate (NaOAc) buffered to pH 5.0, providing a maximum of 2 eq/kg of acid.*

2 illustrates the results of the TCLP extractions. It is apparent that the lower pH of the TCLP extract typically results in higher concentrations of contaminants than the modified extractions except where a higher pH was favoured (carbonate, aluminium, iron, silicon as silica, titanium, and yttrium).

Conclusions

This report has been provided to summarize the results of geochemical testwork completed to characterize the *Final Tails* sample from a phosphate beneficiation program. In conclusion:

- Analysis of the recoverable portion of the sample determined that it was comprised primarily of silicates with moderate to minor amounts of calcium, aluminium, phosphorus, and iron.

- Standard acid base accounting demonstrated that the sample is not potentially acid generating due to a lack of acid generating sulphur content and an excess of acid neutralization capacity.

- The net acid generation test corroborated the acid base accounting result as no acid was generated upon aggressive oxidation.

- TCLP extraction results indicated that the sample would not be considered hazardous or potentially toxic as the extract passed the Australian drinking water quality (DWQ) guidelines for all parameters except pH (prescribed by the test method) and a marginally higher nickel concentration.

- CO_2 saturated deionized water extraction results indicated that the sample would be considered to have low toxicity as the extract passed the Australian DWQ guidelines for all parameters except the alkaline pH and a marginally higher lead concentration.

- Deionized water extraction results also indicated lox toxicity as the alkaline pH was the only parameter found to be outside the Australian DWQ guidelines.

- TCLP extract concentrations were higher than modified TCLP extracts in all cases except where a higher pH was favoured (carbonate, aluminium, iron, silicon as silica, titanium, and yttrium).

Appendix A – Analytical Certificates of Analysis

SGS Canada Inc.
P.O. Box 4300 - 185 Concession St.
Lakefield - Ontario - KOL 2HO
Phone: 705-652-2000 FAX: 705-652-6365

Project : CALR-16400-001

15-December-2017

Environmental Met
Attn : Barb Bowman

Date Rec. : 06 October 2017
LR Report: **CA15144-OCT17**
Reference: 16400-001-01

Copy: #2

CERTIFICATE OF ANALYSIS

Final Report - Revised

Analysis	1: Analysis Start Date	2: Analysis Start Time	3: Analysis Completed Date	4: Analysis Completed Time	5: QC - Blank	6: QC - STD % Recovery	7: QC - DUP % RPD	9: Final Tails
Sample Date & Time								N/A
Silica [%]	---	---	---	---	---	---	---	29.4
Mercury [µg/g]	13-Oct-17	11:24	13-Oct-17	14:16	< 0.05	98%	ND	0.13
Silver [ug/g]	13-Oct-17	15:00	15-Dec-17	10:55	< 0.01	103%	7%	0.10
Aluminum [ug/g]	13-Oct-17	15:00	13-Oct-17	16:45	< 1	100%	2%	25000
Arsenic [µg/g]	13-Oct-17	15:00	13-Oct-17	16:45	< 0.5	102%	3%	5.6
Barium [µg/g]	13-Oct-17	15:00	13-Oct-17	16:45	< 0.01	102%	6%	110
Beryllium [µg/g]	13-Oct-17	15:00	13-Oct-17	16:45	< 0.02	98%	5%	3.4
Boron [µg/g]	13-Oct-17	15:00	13-Oct-17	16:45	< 1	109%	5%	12
Bismuth [ug/g]	13-Oct-17	15:00	13-Oct-17	16:45	< 0.09	100%	ND	0.15
Calcium [µg/g]	13-Oct-17	15:00	16-Oct-17	15:59	< 1	103%	4%	57000
Cadmium [µg/g]	13-Oct-17	15:00	13-Oct-17	16:45	< 0.02	105%	12%	0.79
Cobalt [µg/g]	13-Oct-17	15:00	13-Oct-17	16:45	< 0.01	99%	ND	4.2
Chromium [µg/g]	13-Oct-17	15:00	13-Oct-17	16:45	< 0.5	103%	2%	44
Copper [µg/g]	13-Oct-17	15:00	13-Oct-17	16:45	< 0.1	103%	3%	18
Iron [ug/g]	13-Oct-17	15:00	16-Oct-17	15:59	< 1	98%	8%	13000
Potassium [µg/g]	13-Oct-17	15:00	16-Oct-17	15:59	< 1	100%	5%	1700
Lithium [ug/g]	13-Oct-17	15:00	13-Oct-17	16:46	< 2	105%	10%	10
Magnesium [ug/g]	13-Oct-17	15:00	16-Oct-17	15:58	< 0.1	106%	2%	3800
Manganese [µg/g]	13-Oct-17	15:00	13-Oct-17	16:46	< 0.1	104%	6%	200
Molybdenum [µg/g]	13-Oct-17	15:00	13-Oct-17	16:46	< 0.1	103%	2%	1.0
Sodium [µg/g]	13-Oct-17	15:00	16-Oct-17	15:58	< 1	105%	3%	550
Nickel [µg/g]	13-Oct-17	15:00	13-Oct-17	16:46	< 0.1	101%	4%	19
Lead [µg/g]	13-Oct-17	15:00	13-Oct-17	16:46	< 0.1	96%	ND	150
Phosphorus [µg/g]	13-Oct-17	15:00	16-Oct-17	15:58	< 1	99%	8%	24000
Selenium [µg/g]	13-Oct-17	15:00	13-Oct-17	16:46	< 0.7	108%	ND	< 0.7
Antimony [µg/g]	13-Oct-17	15:00	13-Oct-17	16:46	< 0.8	108%	ND	< 0.8
Tin [µg/g]	13-Oct-17	15:00	13-Oct-17	16:46	< 0.5	108%	11%	1.8
Strontium [µg/g]	13-Oct-17	15:00	13-Oct-17	16:46	< 0.01	100%	1%	120
Thorium [ug/g]	13-Oct-17	15:00	17-Oct-17	14:25	<0.005	102%	103%	8.0
Thallium [µg/g]	13-Oct-17	15:00	13-Oct-17	16:46	< 0.02	98%	9%	0.09

SGS Canada Inc.
P.O. Box 4300 - 185 Concession St.
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Phone: 705-652-2000 FAX: 705-652-6365

Project : CALR-16400-001

LR Report : **CA15144-OCT17**

Analysis	1: Analysis Start Date	2: Analysis Start Time	3: Analysis Completed Date	4: Analysis Completed Time	5: QC - Blank	6: QC - STD % Recovery	7: QC - DUP % RPD	9: Final Tails
Titanium [µg/g]	13-Oct-17	15:00	13-Oct-17	16:46	< 0.1	104%	5%	87
Uranium [ug/g]	13-Oct-17	15:00	13-Oct-17	16:46	< 0.002	96%	5%	7.1
Vanadium [µg/g]	13-Oct-17	15:00	13-Oct-17	16:46	< 3	99%	3%	39
Tungsten [ug/g]	13-Oct-17	15:00	13-Oct-17	16:46	< 0.04	99%	ND	0.15
Yttrium [ug/g]	13-Oct-17	15:00	13-Oct-17	16:46	< 0.004	105%	1%	58
Zinc [µg/g]	13-Oct-17	15:00	13-Oct-17	16:46	< 0.7	101%	4%	75

ND - Not Detected

Report revised to include results for Silver as requested on Chain of Custody.

Patti Stark
Project Specialist Environmental Services, Analytical

OnLine LIMS

0001232674

SGS Canada Inc.
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Phone: 705-652-2000 FAX: 705-652-6365

Liquid/solid ratio: 1:5

Project : CALR-16400-001

23-October-2017

Environmental Met
Attn : Barb Bowman

Date Rec. : 06 October 2017
LR Report: **CA15142-OCT17**
Reference: 16400-001-01

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CERTIFICATE OF ANALYSIS

Final Report

Sample ID	Sample Date & Time	Paste pH	Conductivity uS/cm
1: Analysis Start Date		12-Oct-17	12-Oct-17
2: Analysis Start Time		09:40	10:24
3: Analysis Completed Date		16-Oct-17	16-Oct-17
4: Analysis Completed Time		09:56	08:46
5: QC - Blank			0.002
6: QC - STD % Recovery			99%
7: QC - DUP % RPD			0%
8: QC - Spike Rep			NA
9: Final Tails	N/A	9.11	112

NA - Not applicable

Patti Stark
Project Specialist Environmental Services, Analytical

OnLine LIMS

0001176189

SGS Canada Inc.
P.O. Box 4300 - 185 Concession St.
Lakefield - Ontario - KOL 2HO
Phone: 705-652-2000 FAX: 705-652-6365

Standard ABA Siderite NP (ANC Method)
16

Project : CALR-16400-001

15-December-2017

Environmental Met
Attn : Barb Bowman

Date Rec. : 06 October 2017
LR Report: **CA15143-OCT17**
Reference: 16400-001-01

Copy: #1

CERTIFICATE OF ANALYSIS

Final Report

Analysis	1: Analysis Start Date	2: Analysis Start Time	3: Analysis Approval Date	4: Analysis Approval Time	5: QC - Blank	6: QC - STD % Recovery	7: QC - DUP % RPD	8: QC - Spike Rep	9: Final Tails
Sample Date & Time									N/A
Paste pH	02-Nov-17	08:00	02-Nov-17	12:19					8.36
Fizz Rate [---]	02-Nov-17	08:00	02-Nov-17	12:19					3
Sample weight [g]	02-Nov-17	08:00	02-Nov-17	12:19					2.02
HCl Added [mL]	02-Nov-17	08:00	02-Nov-17	12:19					40.00
HCl [Normality]	02-Nov-17	08:00	02-Nov-17	12:19					0.50
NaOH [Normality]	02-Nov-17	08:00	02-Nov-17	12:19					0.50
NaOH to pH=7.0 [mL]	02-Nov-17	08:00	02-Nov-17	12:19					34.97
Final pH	02-Nov-17	08:00	02-Nov-17	12:19					1.04
ANC [kg H2SO4/t]	02-Nov-17	08:00	02-Nov-17	12:19					103
MPA [kg H2SO4/t]	---	---	---	---					0.18
NAPP [kg H2SO4/t]	---	---	---	---					-103.24
ANC/MPA [ratio]	---	---	---	---					563
Sulphur (total) [%]	23-Oct-17	12:44	23-Oct-17	14:56	< 0.005	102%	7%		0.006
Sulphide [%]	23-Oct-17	13:13	23-Oct-17	14:45	< 0.02	113%	ND		< 0.02
Sulphate [%]	24-Oct-17	17:07	25-Oct-17	11:07	< 0.1	94%	ND	99%	< 0.1
Carbon (total) [%]	23-Oct-17	12:44	23-Oct-17	14:56	< 0.005	104%	4%		0.104
Carbonate [%]	23-Oct-17	13:47	23-Oct-17	14:48	< 0.005	95%	5%		0.260

Patti Stark
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0001231950

SGS Canada Inc.
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Phone: 705-652-2000 FAX: 705-652-6365

NAG Test

Project : CALR-16400-001

30-October-2017

Environmental Met
Attn : Barb Bowman

Date Rec. : 06 October 2017
LR Report: **CA15141-OCT17**
Reference: 16400-001-01

Copy: #1

CERTIFICATE OF ANALYSIS

Final Report

Analysis	1: Analysis Start Date	2: Analysis Start Time	3: Analysis Completed Date	4: Analysis Completed Time	7: QC - DUP % RPD	9: Final Tails
Sample Date & Time						N/A
Sample weight [g]	27-Oct-17	06:21	30-Oct-17	08:57		1.51
Vol H2O2 [mL]	27-Oct-17	06:21	30-Oct-17	08:57		150
Final pH	27-Oct-17	06:21	30-Oct-17	08:57		7.66
NaOH [Normality]	27-Oct-17	06:21	30-Oct-17	08:57		0.10
Vol NaOH to PH 4.5 [mL]	27-Oct-17	06:21	30-Oct-17	08:57		0.00
Vol NaOH to PH 7.0 [mL]	27-Oct-17	06:21	30-Oct-17	08:57		0.00
NAG (pH 4.5) [kg H2SO4/tonne]	27-Oct-17	06:21	30-Oct-17	08:57	1%	0
NAG (pH 7.0) [kg H2SO4/tonne]	27-Oct-17	06:21	30-Oct-17	08:57	1%	0

```
NAG = (49 x Vol. of base x N of base)/sample weight
kg H2SO4/tonne
```

Patti Stark
Project Specialist Environmental Services, Analytical

OnLine LIMS

0001183383

SGS Canada Inc.
P.O. Box 4300 - 185 Concession St.
Lakefield - Ontario - KOL 2HO
Phone: 705-652-2000 FAX: 705-652-6365

TCLP1311

Project : CALR-16400-001

Environmental Met
Attn : Barb Bowman

23-October-2017

Date Rec. : 06 October 2017
LR Report: **CA15145-OCT17**
Reference: 16400-001-01

Copy: #1

CERTIFICATE OF ANALYSIS

Final Report

Analysis	1: Analysis Start Date	2: Analysis Start Time	3: Analysis Completed Date	4: Analysis Completed Time	5: QC - Blank	6: QC - STD % Recovery	7: QC - DUP % RPD	8: QC - Spike Rep	9: Schedule 4 Limits	10: Final Tails
Sample Date & Time										N/A
Sample weight [g]	16-Oct-17	14:52	17-Oct-17	10:27						100
Ext Fluid [#1 or #2]	16-Oct-17	14:52	17-Oct-17	10:27						1
Ext Volume [mL]	16-Oct-17	14:52	17-Oct-17	10:27						2000
Final pH	17-Oct-17	14:52	17-Oct-17	10:27						5.04
Bicarbonate [mg/L as CaCO3]	17-Oct-17	11:04	18-Oct-17	11:54	< 2	NA	0%	NA		1300
Carbonate [mg/L as CaCO3]	17-Oct-17	11:04	18-Oct-17	11:54	< 2	NA	ND	NA		< 2
Fluoride [mg/L]	17-Oct-17	11:15	18-Oct-17	07:38	< 0.06	96%	0%	44%	150	0.68
Sulphate [mg/L]	17-Oct-17	03:59	19-Oct-17	07:29	< 0.2	95%	0%	94%		< 2
Mercury [mg/L]	18-Oct-17	12:00	18-Oct-17	17:31	< 0.00001	110%	ND	120%	0.1	< 0.00001
Aluminum [mg/L]	19-Oct-17	11:00	20-Oct-17	10:01	< 0.001	96%	4%	NV	--	0.464
Arsenic [mg/L]	19-Oct-17	11:00	20-Oct-17	10:01	< 0.0002	100%	5%	116%	2.5	0.0079
Silver [mg/L]	19-Oct-17	11:00	20-Oct-17	10:01	< 0.00005	103%	ND	101%	5	< 0.0005
Barium [mg/L]	19-Oct-17	11:00	20-Oct-17	10:01	< 0.00002	99%	1%	NV	100	0.300
Beryllium [mg/L]	19-Oct-17	11:00	20-Oct-17	10:01	< 0.000007	101%	ND	78%	--	0.000960
Boron [mg/L]	19-Oct-17	11:00	20-Oct-17	10:01	< 0.002	103%	0%	NV	500	0.312
Bismuth [mg/L]	19-Oct-17	11:00	20-Oct-17	10:01	< 0.000007	97%	13%	80%	--	< 0.00007
Calcium [mg/L]	19-Oct-17	11:00	20-Oct-17	10:01	< 0.01	97%	7%	NV		62.9

SGS Canada Inc.
P.O. Box 4300 - 185 Concession St.
Lakefield - Ontario - KOL 2HO
Phone: 705-652-2000 FAX: 705-652-6365

Analysis	1: Analysis Start Date	2: Analysis Start Time	3: Analysis Completed Date	4: Analysis Completed Time	5: QC - Blank	6: QC - STD % Recovery	7: QC - DUP % RPD	8: QC - Spike Rep	9: Schedule 4 Limits	10: Final Tails
Cadmium [mg/L]	19-Oct-17	11:00	20-Oct-17	10:01	< 0.000003	101%	ND	117%	0.5	0.000439
Cobalt [mg/L]	19-Oct-17	11:00	20-Oct-17	10:01	< 0.000004	100%	2%	105%	--	0.000982
Chromium [mg/L]	19-Oct-17	11:00	20-Oct-17	10:01	< 0.00003	101%	4%	111%	5	0.00367
Copper [mg/L]	19-Oct-17	11:00	20-Oct-17	10:01	< 0.00002	99%	0%	101%	--	0.00609
Iron [mg/L]	19-Oct-17	11:00	20-Oct-17	10:01	< 0.007	101%	2%	NV		0.120
Potassium [mg/L]	19-Oct-17	11:00	20-Oct-17	10:01	< 0.003	98%	9%	NV		2.80
Lithium [mg/L]	19-Oct-17	11:00	20-Oct-17	10:01	< 0.0001	100%	2%	NV	--	0.0011
Magnesium [mg/L]	19-Oct-17	11:00	20-Oct-17	10:01	< 0.001	102%	6%	NV		12.7
Manganese [mg/L]	19-Oct-17	11:00	20-Oct-17	10:01	< 0.00001	99%	2%	NV		0.141
Molybdenum [mg/L]	19-Oct-17	11:00	20-Oct-17	10:01	3.3e-005	105%	14%	111%	--	0.00069
Sodium [mg/L]	19-Oct-17	11:00	20-Oct-17	10:01	< 0.01	98%	4%	NV		1050
Nickel [mg/L]	19-Oct-17	11:00	20-Oct-17	10:01	< 0.0001	100%	5%	99%	--	0.0219
Phosphorus [mg/L]	19-Oct-17	11:00	20-Oct-17	10:01	< 0.003	101%	2%	NV		5.83
Lead [mg/L]	19-Oct-17	11:00	20-Oct-17	10:01	< 0.00001	98%	8%	80%	5	0.00276
Antimony [mg/L]	19-Oct-17	11:00	20-Oct-17	10:01	< 0.0002	102%	1%	NV	--	< 0.002
Silicon [mg/L]	19-Oct-17	11:00	20-Oct-17	10:01	< 0.02	95%	16%	NV		5.89
Selenium [mg/L]	19-Oct-17	11:00	20-Oct-17	10:01	< 0.00004	99%	13%	93%	1	0.00053
Tin [mg/L]	19-Oct-17	11:00	20-Oct-17	10:01	7.1e-005	101%	0%	NV	--	0.00037
Strontium [mg/L]	19-Oct-17	11:00	20-Oct-17	10:01	< 0.00002	99%	3%	NV	--	0.487
Thorium [mg/L]	19-Oct-17	11:00	20-Oct-17	10:01	< 0.00001	100%	3%	NV		< 0.001
Titanium [mg/L]	19-Oct-17	11:00	20-Oct-17	10:01	< 0.00005	104%	ND	NV	--	0.00965
Thallium [mg/L]	19-Oct-17	11:00	20-Oct-17	10:01	< 0.000005	95%	ND	83%	--	< 0.00005
Uranium [mg/L]	19-Oct-17	11:00	20-Oct-17	10:01	< 0.000002	95%	18%	85%	10	0.00207
Vanadium [mg/L]	19-Oct-17	11:00	20-Oct-17	10:01	< 0.00001	101%	14%	116%	--	0.00182
Tungsten [mg/L]	19-Oct-17	11:00	20-Oct-17	10:01	6.2e-005	104%	ND	NV	--	0.00166
Yttrium [mg/L]	19-Oct-17	11:00	20-Oct-17	10:01	< 0.000002	99%	13%	NV	--	0.00118
Zinc [mg/L]	19-Oct-17	11:00	20-Oct-17	10:01	< 0.002	101%	2%	NV	--	0.021

Extraction Fluid #1 - pH 4.93 ± 0.05
= 5.7mLs of acetic acid plus 64.3 mLs of 1.0N NaOH bulked to 1L with deionized water.

ND - Not Detected
NV - No Value

OnLine LIMS

0001176197

SGS Canada Inc.
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Patti Stark
Project Specialist Environmental Services, Analytical

OnLine LIMS

0001176197

SGS

SGS Canada Inc.
P.O. Box 4300 - 185 Concession St.
Lakefield - Ontario - KOL 2HO
Phone: 705-652-2000 FAX: 705-652-6365

TCLP using deionized water saturated with CO2 to pH 5.3 21

Project : CALR-16400-001

23-October-2017

Environmental Met
Attn : Barb Bowman

Date Rec. : 06 October 2017
LR Report: **CA15169-OCT17**
Reference: 16400-001-01

Copy: #1

CERTIFICATE OF ANALYSIS

Final Report

Analysis	3: Analysis Completed Date	4: Analysis Completed Time	5: QC - Blank	6: QC - STD % Recovery	7: QC - DUP % RPD	8: QC - Spike Rep	10: Final Tails
Sample Date & Time							N/A
Sample weight [g]	17-Oct-17	11:23					100
Ext Volume [mL]	17-Oct-17	11:23					2000
Final pH	17-Oct-17	11:23					10.20
Bicarbonate [mg/L as CaCO3]	18-Oct-17	15:24	< 2	NA	0%	NA	18
Carbonate [mg/L as CaCO3]	18-Oct-17	15:24	< 2	NA	ND	NA	26
Fluoride [mg/L]	19-Oct-17	08:31	< 0.06	97%	ND	99%	0.90
Sulphate [mg/L]	19-Oct-17	07:29	< 0.2	95%	0%	94%	< 2
Mercury [mg/L]	18-Oct-17	17:31	< 0.00001	110%	ND	120%	< 0.00001
Aluminum [mg/L]	20-Oct-17	10:02	< 0.001	96%	4%	NV	2.22
Arsenic [mg/L]	20-Oct-17	10:02	< 0.0002	100%	5%	116%	0.0019
Silver [mg/L]	20-Oct-17	10:02	< 0.00005	103%	ND	101%	< 0.00005
Barium [mg/L]	20-Oct-17	10:02	< 0.00002	99%	1%	NV	0.0132
Beryllium [mg/L]	20-Oct-17	10:02	< 0.000007	101%	ND	78%	0.000412
Boron [mg/L]	20-Oct-17	10:02	< 0.002	103%	0%	NV	0.105
Bismuth [mg/L]	20-Oct-17	10:02	< 0.000007	97%	13%	80%	0.000029
Calcium [mg/L]	20-Oct-17	10:02	< 0.01	97%	7%	NV	7.25
Cadmium [mg/L]	20-Oct-17	10:02	< 0.000003	101%	ND	117%	0.000151
Cobalt [mg/L]	20-Oct-17	10:02	< 0.000004	100%	2%	105%	0.000354
Chromium [mg/L]	20-Oct-17	10:02	< 0.00003	101%	4%	111%	0.00409
Copper [mg/L]	20-Oct-17	10:02	< 0.00002	99%	0%	101%	0.00226
Iron [mg/L]	20-Oct-17	10:02	< 0.007	101%	2%	NV	1.12
Potassium [mg/L]	20-Oct-17	10:02	< 0.003	98%	9%	NV	0.712
Lithium [mg/L]	20-Oct-17	10:02	< 0.0001	100%	2%	NV	0.0012
Magnesium [mg/L]	20-Oct-17	10:02	< 0.001	102%	6%	NV	0.767
Manganese [mg/L]	20-Oct-17	10:02	< 0.00001	99%	2%	NV	0.0140
Molybdenum [mg/L]	20-Oct-17	10:02	3.3e-005	105%	14%	111%	0.00101
Sodium [mg/L]	20-Oct-17	10:02	< 0.01	98%	4%	NV	14.8
Nickel [mg/L]	20-Oct-17	10:02	< 0.0001	100%	5%	99%	0.0022
Phosphorus [mg/L]	20-Oct-17	10:02	< 0.003	101%	2%	NV	2.46
Lead [mg/L]	20-Oct-17	10:02	< 0.00001	98%	8%	80%	0.0142

OnLine LIMS

0001176214

SGS Canada Inc.
P.O. Box 4300 - 185 Concession St.
Lakefield - Ontario - KOL 2HO
Phone: 705-652-2000 FAX: 705-652-6365

Project : CALR-16400-001

LR Report : **CA15169-OCT17**

Analysis	3: Analysis Completed Date	4: Analysis Completed Time	5: QC - Blank	6: QC - STD % Recovery	7: QC - DUP % RPD	8: QC - Spike Rep	10: Final Tails
Antimony [mg/L]	20-Oct-17	10:02	< 0.0002	102%	1%	NV	0.0004
Silicon [mg/L]	20-Oct-17	10:02	< 0.02	95%	16%	NV	13.9
Selenium [mg/L]	20-Oct-17	10:02	< 0.00004	99%	13%	93%	0.00009
Tin [mg/L]	20-Oct-17	10:02	7.1e-005	101%	0%	NV	0.00092
Strontium [mg/L]	20-Oct-17	10:02	< 0.00002	99%	3%	NV	0.0209
Thorium [mg/L]	20-Oct-17	10:02	< 0.00001	100%	3%	NV	0.0007
Titanium [mg/L]	20-Oct-17	10:02	< 0.00005	104%	ND	NV	0.0254
Thallium [mg/L]	20-Oct-17	10:02	< 0.000005	95%	ND	83%	0.000017
Uranium [mg/L]	20-Oct-17	10:02	< 0.000002	95%	18%	85%	0.00107
Vanadium [mg/L]	20-Oct-17	10:02	< 0.00001	101%	14%	116%	0.0170
Tungsten [mg/L]	20-Oct-17	10:02	6.2e-005	104%	ND	NV	0.00106
Yttrium [mg/L]	20-Oct-17	10:02	< 0.000002	99%	13%	NV	0.00678
Zinc [mg/L]	20-Oct-17	10:02	< 0.002	101%	2%	NV	0.010

Patti Stark
Project Specialist Environmental Services, Analytical

OnLine LIMS

0001176214

SGS Canada Inc.
P.O. Box 4300 - 185 Concession St.
Lakefield - Ontario - KOL 2HO
Phone: 705-652-2000 FAX: 705-652-6365

TCLP using deionized water

Project : CALR-16400-001

23-October-2017

Environmental Met
Attn : Barb Bowman

Date Rec. : 06 October 2017
LR Report: **CA15146-OCT17**

Copy: #1

CERTIFICATE OF ANALYSIS

Final Report

Analysis	3: Analysis Completed Date	4: Analysis Completed Time	5: QC - Blank	6: QC - STD % Recovery	7: QC - DUP % RPD	8: QC - Spike Rep	10: Final Tails
Sample Date & Time							N/A
Sample weight [g]	17-Oct-17	11:22					100
Ext Volume [mL]	17-Oct-17	11:22					2000
Final pH	17-Oct-17	11:22					10.24
Bicarbonate [mg/L as CaCO3]	18-Oct-17	15:23	< 2	NA	0%	NA	16
Carbonate [mg/L as CaCO3]	18-Oct-17	15:23	< 2	NA	ND	NA	29
Fluoride [mg/L]	19-Oct-17	08:31	< 0.06	96%	0%	44%	0.89
Sulphate [mg/L]	19-Oct-17	07:29	< 0.2	95%	0%	94%	< 2
Mercury [mg/L]	18-Oct-17	17:31	< 0.00001	110%	ND	120%	< 0.00001
Aluminum [mg/L]	20-Oct-17	09:08	< 0.001	93%	3%	NV	2.33
Arsenic [mg/L]	20-Oct-17	09:08	< 0.0002	100%	ND	115%	0.0016
Silver [mg/L]	20-Oct-17	09:08	< 0.00005	100%	ND	NV	< 0.00005
Barium [mg/L]	20-Oct-17	09:08	< 0.00002	99%	2%	NV	0.0108
Beryllium [mg/L]	20-Oct-17	09:08	< 0.000007	95%	12%	99%	0.000259
Boron [mg/L]	20-Oct-17	09:08	< 0.002	97%	7%	NV	0.041
Bismuth [mg/L]	20-Oct-17	09:08	< 0.000007	104%	ND	NV	0.000029
Calcium [mg/L]	20-Oct-17	09:08	< 0.01	102%	5%	101%	3.53
Cadmium [mg/L]	20-Oct-17	09:08	< 0.000003	100%	4%	116%	0.000033
Cobalt [mg/L]	20-Oct-17	09:08	< 0.000004	98%	4%	92%	0.000288
Chromium [mg/L]	20-Oct-17	09:08	< 0.00003	98%	0%	96%	0.00326
Copper [mg/L]	20-Oct-17	09:08	< 0.00002	96%	3%	NV	0.00189
Iron [mg/L]	20-Oct-17	09:08	< 0.007	103%	1%	102%	1.02
Potassium [mg/L]	20-Oct-17	09:08	< 0.003	104%	3%	96%	1.44
Lithium [mg/L]	20-Oct-17	09:08	< 0.0001	95%	10%	98%	0.0014
Magnesium [mg/L]	20-Oct-17	09:08	< 0.001	103%	4%	81%	0.699
Manganese [mg/L]	20-Oct-17	09:08	< 0.00001	95%	3%	NV	0.00452
Molybdenum [mg/L]	20-Oct-17	09:08	< 0.00001	99%	105%	97%	0.00057
Sodium [mg/L]	20-Oct-17	09:08	< 0.01	101%	6%	100%	16.8
Nickel [mg/L]	20-Oct-17	09:08	< 0.0001	100%	2%	92%	0.0016
Phosphorus [mg/L]	20-Oct-17	09:08	< 0.003	103%	ND	NV	0.698
Lead [mg/L]	20-Oct-17	09:08	< 0.00001	103%	17%	98%	0.00777
Antimony [mg/L]	20-Oct-17	09:08	< 0.0002	98%	ND	95%	0.0003
Silicon [mg/L]	20-Oct-17	09:08	< 0.02	109%	3%	NV	11.9
Selenium [mg/L]	20-Oct-17	09:08	< 0.00004	102%	12%	72%	0.00006
Tin [mg/L]	20-Oct-17	09:08	< 0.00001	97%	18%	NV	0.00034
Strontium [mg/L]	20-Oct-17	09:08	< 0.00002	97%	2%	101%	0.0129
Thorium [mg/L]	20-Oct-17	09:08	< 0.00001	96%	ND	NV	0.0011

OnLine LIMS

0001176208

SGS Canada Inc.
P.O. Box 4300 - 185 Concession St.
Lakefield - Ontario - KOL 2HO
Phone: 705-652-2000 FAX: 705-652-6365

Project : CALR-16400-001
LR Report : **CA15146-OCT17**

Analysis	3: Analysis Completed Date	4: Analysis Completed Time	5: QC - Blank	6: QC - STD % Recovery	7: QC - DUP % RPD	8: QC - Spike Rep	10: Final Tails
Titanium [mg/L]	20-Oct-17	09:08	< 0.00005	94%	13%	NV	0.0738
Thallium [mg/L]	20-Oct-17	09:08	< 0.000005	100%	0%	89%	0.000014
Uranium [mg/L]	20-Oct-17	09:08	< 0.000002	102%	ND	90%	0.000636
Vanadium [mg/L]	20-Oct-17	09:08	< 0.00001	99%	ND	103%	0.0147
Tungsten [mg/L]	20-Oct-17	09:08	< 0.00002	100%	ND	NV	0.00017
Yttrium [mg/L]	20-Oct-17	09:08	< 0.000002	100%	2%	NV	0.00291
Zinc [mg/L]	20-Oct-17	09:08	< 0.002	98%	ND	NV	0.006

ND - Not Detected
NV - No Value

Patti Stark
Project Specialist Environmental Services, Analytical

OnLine LIMS

0001176208

Appendix B – Chain of Custody Forms

SGS
Environmental Services

Request for Laboratory Services and Chain of Custody Form

No.: 16400-001-01

P.O. Box 4300, 185 Concession St., Lakefield, ON. K0L 2H0, Phone (705) 652-2038, Fax (705) 652-6441

Report Results to:	**Name:** Barb Bowman	LRL LIMS No.: ~~10/6/17~~ Oct 15141
	Company: SGS Lakefield Research Ltd	Received by (Date & Time): 10/6/17
	Address:	Logged in by (Date): -46.
	City	Lab Batch ID: +15169
	Province, Postal Code	**Project No.:** 16400-001
	Telephone Number: 2148 **Fax:**	**Plant No.:**
Send Invoice to:	Name: Rob Caldwell	**Quote No.:**
	Company:	**Purchase Order No.:**
	Address:	TAT (Turnaround Time) * Some exceptions apply, please contact lab
	City	Standard [X] RUSH [ ] Specify Date:
	Province, Postal Code	Time:
	Telephone Number: 2043 Fax:	PLEASE CONTACT LAB PRIOR TO SUBMITTING RUSH PROJECTS
Chain of Custody	**Sampled by:**	Sample condition upon receipt:
	Packed and Shipped by: **Date /Time:**	19x1
	Shipment Method and WB#: **Date /Time:**	Temperature upon receipt: ____ °C

Please specify any guideline or regulation that these samples may apply(I.e. ODWS, PWQO, Reg 558, GCSO, MISA, MMER, CBWA).

Guideline: ______ **Regulation:** ______ **initial:** ______

Recoverable Metals suite to include: Ag, Al, As, B, Ba, Be, Bi, Ca, Cd, Co, Cr, Cu, Fe, K, Li, Mg, Mn, Mo, Na, Ni, P, Pb, Sb, Se, Si, Sn, Sr, Th, Ti, Tl, U, V, W, Y, Zn and Hg.
TCLP suite to include: Ag, Al, As, B, Ba, Be, Bi, Ca, Cd, Co, Cr, Cu, Fe, K, Li, Mg, Mn, Mo, Na, Ni, P, Pb, Sb, Se, Si, Sn, Sr, Th, Ti, Tl, U, V, W, Y, Zn and Hg.
Plus Anions (SO4 CO3 HCO3 and F).

Analysis Requested (X) as Required
(Enter an "X" in the boxes to indicate which request(s) apply to each sample)

	Sample Matrix*	Sample Identifier	No. Bottles	Date Sampled	Time Sampled	NAG	Paste pH and Conductivity (1:5 L/S)	MPA, ANC, NAPP with sulphate-S	US EPA 200.2 Total Recoverable Metals Analysis	TCLP US EPA Method 1311	Modified TCLP Using deionized water	Modified TCLP Using deionized water saturated with CO2 to pH 5.3
1		Final Tails				X	X	X	X	X	X	X
2												
3												
4												
5												
6												
7												
8												
9												
10		**** Report QA/QC on C of A's****										

* **Matrix Codes: GW**-ground water, **SW**-surface water, **RES**-Residential Water, **EFF**-Effluent, **PROC**-Process Water, **SOIL**-Soil, **SED**-Sediment, **SWAB**-Swabs, **FILT**-Filters

* **Regulated Water Codes: GRW**-ground raw water, **SRW**-surface raw water, **TDW**-Treated Drinking Water, **DDW**-Distribution Drinking Water

Work Authorized by(Client or representative signature must accompany request): [signature] **Date:** 2-Oct-17

Part No. CofC-2(Email/Fax Copy)

Appendix 9 – Process Water Test Work

Memorandum

30 July 2018

To	Verdant Minerals Limited		
Copy to	Nicole Conroy		
From	Rob Virtue	Tel	+61 3 6210 0726
Subject	Ammaroo Project - Tailings Process Water Analysis	Job no.	4322544

1 Introduction

To assess likely Ammaroo tailings decant water quality, Verdant Minerals Limited (Verdant) arranged for the process water from tailings beneficiation trials to be analysed for a range of metals, metalloids and major ions.

2 Sampling and analysis

2.1 Sample source

The tailings were generated as part of beneficiation trials carried out by Worley Parsons in Canada. The water samples were composites from solutions decanted from drums of trial tailings. The samples comprised the following:

- Sample A (Lab ID 110364) composite of drums #85-46-100-142-135
- Sample B (Lab ID110362 composite of drums #130-50-115-9-5
- Sample C (Lab ID 110363) composite of drums #38-23-41-63-67
- Tap Water

The synthetic tailings samples were produced using potable Quebec City municipal water supply, hence the analyses only assess the contribution from the processed tailings and do not take into account input from site water sources, such as groundwater. However, as the intent is to treat the ground water prior to use in the beneficiation circuit, it is not expected that the resultant process water will be materially different to the samples produced in recent trials. A sample of the water used to produce the tailings was also analysed and compared against the adopted guidelines described below.

GHD ABN 39 008 488 373
Level 7, 24 Mitchell Street Darwin NT 0800 PO Box 351 Darwin NT 0801 Australia
T 61 8 8982 0100 **F** 61 8 8981 1075 **E** drwmail@ghd.com **W** www.ghd.com

2.2 Sample Analysis

Samples were analysed by Corem, Quebec, and laboratory certificates are attached.

2.3 Analytical results and guidelines

Summary tables are attached including the results compared to the guidelines below, colour-shaded according to the extent to which they exceed available guidelines. Guidelines used are:

- Australian Drinking Water Guidelines (ADWG) (NHMRC, NRMMC, 2011) health-based guidelines;
- Australian Drinking Water Guidelines (ADWG) (NHMRC, NRMMC, 2011) aesthetics-based guidelines;
- Livestock drinking water guidelines (ANZECC & ARMCANZ, 2000);
- Long-term irrigation values (LTV) (ANZECC & ARMCANZ, 2000);
- Guidelines for the protection of slightly to moderately disturbed freshwater aquatic ecosystems at the 95% of species level (FAE95%) (ANZECC & ARMCANZ, 2000); and
- Average Ammaroo groundwater concentrations.

2.3.1 Drinking water - health

The tap water sample did not exceed any of the drinking water guidelines. All analytes from the tailings were within drinking water guidelines with the exception of fluoride, which was approximately 4-5 times the guideline, based on the risk of dental fluorosis, of 1.5 mg/L in all samples. It is likely that around 0.5-1 mg/L of the 6.3 to 7.2 mg/L is derived from the potable water used for the processing trials.

2.3.2 Drinking water aesthetic

All analytes were within drinking water guidelines with the exception of sodium, which was approximately 1-2 times the guideline of 180 mg/L, based on taste, in all samples, although total dissolved solids were within the guidelines.

2.3.3 Livestock drinking water

All analytes, apart from the tap water sample, were within livestock drinking water guidelines with the exception of fluoride, which was approximately 3-4 times the guideline of 2 mg/L, based on the risk of fluorosis, in all samples, and one sample returned a pH of 8.51, which is slightly above the upper limit of 8.5. As noted above, some of the fluoride may be from the raw water used for the trials.

2.3.4 Long-term irrigation

All three tailings samples exceeded the long-term irrigation values for sodium and sodium adsorption ratio (SAR) indicating a risk of damage to clayey soil structure and dispersion of clays from long-term use. This result indicates water may require treatment to increase calcium content, if used for long-term dust suppression in clay soils. The risk is low for the sandy soils that dominate the project area or for clayey soils if used for short-term watering, such as initial revegetation planting watering.

GHD ABN 39 008 488 373
Level 7, 24 Mitchell Street Darwin NT 0800 PO Box 351 Darwin NT 0801 Australia
T 61 8 8982 0100 **F** 61 8 8981 1075 **E** drwmail@ghd.com **W** www.ghd.com

Alternatively, if calcium-based neutralising agents such as lime or hydrated lime are used in the process instead of sodium-based products, this would remove the sodicity risk, although it may present issues with scaling.

The molybdenum guideline of 0.01 mg/L was exceeded by a factor of up to 3. This guideline is based on the impact on crop yields, and given that the concentrations are within the short-term value of 0.05 mg/L, the concentrations would not impact on use for dust suppression or short term rehabilitation irrigation.

Fluoride concentrations were approximately 6-7 times the guideline, based on the risk to crop yields and runoff quality, of 1 mg/L in all samples.

Total phosphorus concentrations exceeded the long-term guideline of 0.05 mg/L by up to 40 times, based on the risk to excessive phosphorus accumulation in soils and to runoff quality. As the risk to vegetation can vary significantly according to soil and vegetation types, and the area is likely to have naturally high soil phosphate concentrations, a site-specific assessment should be carried out if it is required to use untreated process water for irrigation of rehabilitated areas.

Notwithstanding the above irrigation quality issues, the water would be suitable for in-pit dust suppression where all runoff is captured and soil exposure to the water would be short-term.

2.3.5 Freshwater aquatic ecosystems

Although there are no permanent surface water bodies at the site, water quality has been assessed against these guidelines to address the risk to downstream, ephemeral drainage lines that may receive flood flows.

All tailings decant samples exceeded the default guideline of 500 µS/cm for tropical upland rivers, however, as the project is in an arid area, it is likely that local, ephemeral, surface water bodies are relatively saline. See also surface water sample analysis in Section 3.9 of the Supplementary report.

Guidelines for total nitrogen in the tailings samples and total and reactive phosphorus in all samples exceed the guidelines based on the risk of nuisance algal growth, although this risk is reduced by the likely high turbidity of ephemeral water bodies. The exceedance factors ranged from around 3 for total nitrogen to 200 for total phosphorus. Given the likelihood of naturally high phosphorus concentrations in local waterways and potential for algal growth to be nitrogen limited, concentrations should be compared to site-specific guidelines when these are developed. Zinc slightly exceeded the guideline value in the tap water, however it was below the laboratory limit of reporting in the tailings samples. It is likely that the elevated zinc levels in the tap water is a result of the municipal water delivery system.

Based on the above analyses, process water release to surface waters should only be allowed to occur where there is sufficient upstream runoff to dilute the water to a suitable quality. As process water discharge to surface water bodies is only likely after extreme rainfall events (if at all) sufficient dilution is unlikely to be a problem.

GHD ABN 39 008 488 373
Level 7, 24 Mitchell Street Darwin NT 0800 PO Box 351 Darwin NT 0801 Australia
T 61 8 8982 0100 **F** 61 8 8981 1075 **E** drwmail@ghd.com **W** www.ghd.com

2.3.6 *Average groundwater*

Most concentrations in the process water were lower than the average Ammaroo groundwater concentrations, with the following exceptions.

- Salinity (TDI), sodicity (sodium and SAR) and alkalinity (bi-carbonate and carbonate) were higher than the average groundwater levels. Arsenic, barium and manganese exceeded groundwater averages in one or more samples.
- Phosphate, sodium and fluoride also exceeded the average groundwater concentrations in each of the samples.

Local groundwater also exceeds drinking water, stock, irrigation and aquatic ecosystems guidelines, by similar or higher factors.

3 Conclusions and recommendations

Based on the above assessment, process water used on-site for dust suppression does not pose a significant risk to underlying groundwater quality. The water is suitable for dust suppression within the pit catchment but should not be used for long-term irrigation and use outside of the pit should be managed to prevent runoff entering surface water bodies. The following are recommended to be done prior to on-site use of process water, other than for mineral processing:

- Process water is likely to have elevated sodicity and use for dust suppression should be confined to within the pit;
- If process water is to be used for irrigation outside of the pit catchment, a management plan, taking into account the local soil and vegetation types will be prepared to manage the risks from elevated nutrients and sodicity.
- To minimise the risk on groundwater quality and to prevent loss of process water, the process water storage ponds will be lined and water content of tailings discharged to the mine void recycled.
- Process water storage ponds will be designed to prevent release of water unless there is sufficient dilution to meet site-specific guidelines.

GHD ABN 39 008 488 373
Level 7, 24 Mitchell Street Darwin NT 0800 PO Box 351 Darwin NT 0801 Australia
T 61 8 8982 0100 **F** 61 8 8981 1075 **E** drwmail@ghd.com **W** www.ghd.com

Memorandum

4 Reference

ANZECC & ARMCANZ. (2000). *Australian and New Zealand Guidelines for Fresh and Marine Water Quality.* Canberra: Australian and New Zealand Environment and Conservation Council (ANZECC) and Agriculture and Resource Management Council of Australia and New Zealand (ARMCANZ.

NHMRC, NRMMC. (2011). *Australian Drinking Water Guidelines Paper 6 National Water Quality Management Strategy.* Canberra: National Health and Medical Research Council, National Resource Management Ministerial Council,.

Regards

Rob Virtue
Principal Hydrogeologist

GHD ABN 39 008 488 373
Level 7, 24 Mitchell Street Darwin NT 0800 PO Box 351 Darwin NT 0801 Australia
T 61 8 8982 0100 **F** 61 8 8981 1075 **E** drwmail@ghd.com **W** www.ghd.com

Memorandum

Attachment 1 – Laboratory Certificates

GHD ABN 39 008 488 373
Level 7, 24 Mitchell Street Darwin NT 0800 PO Box 351 Darwin NT 0801 Australia
T 61 8 8982 0100 **F** 61 8 8981 1075 **E** drwmail@ghd.com **W** www.ghd.com

COREM

CHRISTINE CROTEAU
1180, RUE DE LA MINÉRALOGIE

QUÉBEC,QC
G1N 1X7

RAPPORT D´ANALYSE version 2

CHRISTINE CROTEAU
COREM

Date de réception : **2018-04-04**
Certificat émis le .: **2018-04-16**

Numéro COREM :	110362- 1
Nature :	LIQUIDES
Désignation :	38-23-41-63-67

L12-	2	Analyse	2018-04-11
L12-	2	Cl (mg/L)	2.4 mg/L
L19-	2	Analyse	2018-04-11
L19-	2	F (mg/L)	6.30 mg/L
L35-	2	Analyse	2018-04-13
L35-	2	SO4 (mg/L)	28 mg/L
L78-	4	Analyse	2018-04-12
L78-	4	Be	< 0.03 mg/L
L78-	4	Na	230 mg/L
L78-	4	Mg	1.65 mg/L
L78-	4	Al	< 0.03 mg/L
L78-	4	Si	5.3 mg/L
L78-	4	P	< 0.8 mg/L
L78-	4	K	0.96 mg/L
L78-	4	Ca	3.2 mg/L
L78-	4	Sc	< 0.002 mg/L
L78-	4	Ti	< 0.005 mg/L
L78-	4	V	< 0.003 mg/L
L78-	4	Cr	< 0.003 mg/L
L78-	4	Mn	0.021 mg/L
L78-	4	Fe	< 0.02 mg/L
L78-	4	Co	< 0.003 mg/L
L78-	4	Ni	< 0.003 mg/L
L78-	4	Cu	< 0.003 mg/L
L78-	4	Zn	< 0.02 mg/L
L78-	4	Ga	< 0.005 mg/L
L78-	4	Ge	< 0.8 mg/L
L78-	4	As	< 0.003 mg/L
L78-	4	Se	< 0.5 mg/L
L78-	4	Sr	0.0309 mg/L
L78-	4	Zr	< 0.002 mg/L
L78-	4	Mo	0.010 mg/L
L78-	4	Ag	< 0.003 mg/L
L78-	4	Cd	< 0.003 mg/L
L78-	4	Sb	< 0.003 mg/L
L78-	4	Ba	0.0054 mg/L
L78-	4	Tl	< 0.2 mg/L
L78-	4	Pb	< 0.003 mg/L
L78-	4	Bi	< 0.1 mg/L
L78-	4	Th	< 0.0005 mg/L
L84-ICP-	1	Analyse	2018-04-12

COREM
1180, rue de la Minéralogie, Québec (Québec) Canada G1N 1X7
Téléphone : (418) 527-8211 Télécopieur : (418) 527-9188

RAPPORT D´ANALYSE version 2

Votre référence ...: **T0002124**

CHRISTINE CROTEAU
COREM

Date de réception : **2018-04-04**
Certificat émis le .: **2018-04-16**

Numéro COREM :	110362- 1
Nature :	LIQUIDES
Désignation :	38-23-41-63-67
L84-ICP- 1 U	< 0.003 mg/L
SEXT.*- 1 Analyse	2018-04-13
SEXT.*- 1 Anal.ext.	Voir annexe

110362- 1 L84-ICP- 1/U : Version 2 - Ajout Uranium (U)
110362- 1 SEXT.*- 1/Anal.ext. : # Rapport Maxxam B811564

Approuvé par : Alain Perron, chimiste, M.Sc.

CHIMISTE Alain Perron 2003-052 QUÉBEC

COREM

COREM

CHRISTINE CROTEAU
1180, RUE DE LA MINÉRALOGIE

QUÉBEC,QC
G1N 1X7

RAPPORT D´ANALYSE version 2

CHRISTINE CROTEAU
COREM

Date de réception : **2018-04-04**
Certificat émis le .: **2018-04-16**

Numéro COREM :	110363- 1
Nature :	LIQUIDES
Désignation :	85-46-100-142-135

L12-	2	Analyse	2018-04-11
L12-	2	Cl (mg/L)	3.1 mg/L
L19-	2	Analyse	2018-04-11
L19-	2	F (mg/L)	6.57 mg/L
L35-	2	Analyse	2018-04-13
L35-	2	SO4 (mg/L)	36 mg/L
L78-	4	Analyse	2018-04-12
L78-	4	Be	< 0.05 mg/L
L78-	4	Na	274 mg/L
L78-	4	Mg	2.77 mg/L
L78-	4	Al	< 0.05 mg/L
L78-	4	Si	9.0 mg/L
L78-	4	P	< 2 mg/L
L78-	4	K	0.8 mg/L
L78-	4	Ca	5.4 mg/L
L78-	4	Sc	< 0.004 mg/L
L78-	4	Ti	< 0.01 mg/L
L78-	4	V	< 0.005 mg/L
L78-	4	Cr	< 0.005 mg/L
L78-	4	Mn	0.016 mg/L
L78-	4	Fe	< 0.03 mg/L
L78-	4	Co	< 0.005 mg/L
L78-	4	Ni	< 0.005 mg/L
L78-	4	Cu	< 0.005 mg/L
L78-	4	Zn	< 0.03 mg/L
L78-	4	Ga	< 0.01 mg/L
L78-	4	Ge	< 2 mg/L
L78-	4	As	0.005 mg/L
L78-	4	Se	< 1 mg/L
L78-	4	Sr	0.058 mg/L
L78-	4	Zr	< 0.004 mg/L
L78-	4	Mo	0.025 mg/L
L78-	4	Ag	< 0.005 mg/L
L78-	4	Cd	< 0.005 mg/L
L78-	4	Sb	< 0.005 mg/L
L78-	4	Ba	0.048 mg/L
L78-	4	Tl	< 0.4 mg/L
L78-	4	Pb	< 0.005 mg/L
L78-	4	Bi	< 0.2 mg/L
L78-	4	Th	< 0.001 mg/L
L84-ICP-	1	Analyse	2018-04-11

COREM
1180, rue de la Minéralogie, Québec (Québec) Canada G1N 1X7
Téléphone : (418) 527-8211 Télécopieur : (418) 527-9188

RAPPORT D´ANALYSE version 2

Votre référence ...: **T0002124**
Frigo-Équip-78

Date de réception : **2018-04-04**
Certificat émis le .: **2018-04-16**

CHRISTINE CROTEAU
COREM

```
     Numéro COREM :          110363-  1
     Nature       :          LIQUIDES
     Désignation  :          85-46-100-142-135

L84-ICP-  1  U               < 0.003 mg/L

SEXT.*-  1  Analyse          2018-04-13
SEXT.*-  1  Anal.ext.        Voir annexe

110363-  1  L84-ICP-  1/U              : Version 2 - Ajout Uranium (U)
110363-  1  SEXT.*-  1/Anal.ext.       : # Rapport Maxxam B811557
```

Approuvé par : Alain Perron, chimiste, M.Sc.

CHIMISTE Alain Perron 2003-052 QUÉBEC

COREM

CHRISTINE CROTEAU
1180, RUE DE LA MINÉRALOGIE

QUÉBEC,QC
G1N 1X7

CHRISTINE CROTEAU
COREM

Numéro COREM :	110364- 1
Nature :	LIQUIDES
Désignation :	130-50-115-9-5

L12-	2	Analyse	2018-04-11
L12-	2	Cl (mg/L)	3.0 mg/L
L19-	2	Analyse	2018-04-11
L19-	2	F (mg/L)	7.12 mg/L
L35-	2	Analyse	2018-04-13
L35-	2	SO4 (mg/L)	67 mg/L
L78-	4	Analyse	2018-04-12
L78-	4	Be	< 0.05 mg/L
L78-	4	Na	300 mg/L
L78-	4	Mg	1.90 mg/L
L78-	4	Al	< 0.05 mg/L
L78-	4	Si	10.4 mg/L
L78-	4	P	< 2 mg/L
L78-	4	K	0.8 mg/L
L78-	4	Ca	3.2 mg/L
L78-	4	Sc	< 0.004 mg/L
L78-	4	Ti	< 0.01 mg/L
L78-	4	V	< 0.005 mg/L
L78-	4	Cr	< 0.005 mg/L
L78-	4	Mn	0.035 mg/L
L78-	4	Fe	< 0.03 mg/L
L78-	4	Co	< 0.005 mg/L
L78-	4	Ni	< 0.005 mg/L
L78-	4	Cu	0.028 mg/L
L78-	4	Zn	< 0.03 mg/L
L78-	4	Ga	< 0.01 mg/L
L78-	4	Ge	< 2 mg/L
L78-	4	As	0.008 mg/L
L78-	4	Se	< 1 mg/L
L78-	4	Sr	0.037 mg/L
L78-	4	Zr	< 0.004 mg/L
L78-	4	Mo	0.024 mg/L
L78-	4	Ag	< 0.005 mg/L
L78-	4	Cd	< 0.005 mg/L
L78-	4	Sb	< 0.005 mg/L
L78-	4	Ba	0.015 mg/L
L78-	4	Tl	< 0.4 mg/L
L78-	4	Pb	< 0.005 mg/L
L78-	4	Bi	< 0.2 mg/L
L78-	4	Th	< 0.001 mg/L
L84-ICP-	1	Analyse	2018-04-12

RAPPORT D´ANALYSE version 2

Votre référence ...: **T0002124**
Frigo-LSA-Équip-78
Date de réception :
Certificat émis le .: **2018-04-16**

CHRISTINE CROTEAU
COREM

```
     Numéro COREM :          110364-  1
     Nature       :          LIQUIDES
     Désignation  :          130-50-115-9-5

L84-ICP-  1  U               < 0.003 mg/L

SEXT.*-  1  Analyse          2018-04-13
SEXT.*-  1  Anal.ext.        Voir annexe

110364-  1  L84-ICP-  1/U              : Version 2 - Ajout Uranium (U)
110364-  1  SEXT.*-  1/Anal.ext.       : # Rapport Maxxam B811562
```

Approuvé par : Alain Perron, chimiste, M.Sc.

CHIMISTE Alain Perron 2003-052 QUÉBEC

COREM
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Téléphone : (418) 527-8211 Télécopieur : (418) 527-9188

Memorandum

Attachment 2 – Summary Tables

GHD ABN 39 008 488 373
Level 7, 24 Mitchell Street Darwin NT 0800 PO Box 351 Darwin NT 0801 Australia
T 61 8 8982 0100 **F** 61 8 8981 1075 **E** drwmail@ghd.com **W** www.ghd.com

Sample ID	TDI Calc from Major Ions	SO_4	Sb	As	Ba	Be	Cd	Cr	Cu	Pb	Mn	Hg	Mo	Ni	Se	Ag	U	F	NO_2 as N	NO_3 as N
Units	(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)	mg/L	(mg/L)	(mg/L)	(mg/L)
ADWG(2011) Health	**1,000**	**500**	**0.003**	**0.010**	**2.000**	**0.06**	**0.002**	**0.05**	**2.0000**	**0.010**	**0.500**	**0.001**	**0.0500**	**0.0200**	**0.010**	**0.1**	**0.017**	**1.5**	**0.910**	**11.29**
110362	565	28	<0.003	<0.003	0.005	<0.03	<0.003	<0.003	<0.003	<0.003	0.021	<0.0001	0.0100	<0.003	<0.5	<0.003	<0.003	6.3	<0.20	<0.20
110363	676	36	<0.005	0.005	0.048	<0.05	<0.005	<0.005	<0.005	<0.005	0.016	<0.0001	0.0250	<0.005	<1	<0.005	<0.003	6.57	<0.20	<0.20
110364	738	67	<0.05	0.008	0.015	<0.05	<0.005	<0.005	<0.005	<0.005	0.035	<0.0001	0.0240	<0.005	<1	<0.005	<0.003	7.12	<0.20	<0.20

1-10 x Guideline
10-100 x Guideline
100-1000 x Guideline
>1000 x Guideline

Sample ID	Na	Cl	SO_4	Calc Hardness	Al	Cu	Fe	Mn	Zn	Total NH_3 as N (@pH 6.0 to 9.0)
Units	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(mg/L)
ADWG(2011) Aesthetic	**180**	**250**	**250**	**200**	**0.200**	**1.0000**	**0.3**	**0.100**	**3.000**	**0.500**
110362	230	2	28	15	<0.03	<0.003	<0.02	0.021	<0.02	<0.020
110363	274	3	36	25	<0.05	<0.005	<0.03	0.016	<0.03	<0.020
110364	300	3	67	16	<0.05	<0.005	<0.03	0.035	<0.03	<0.020

1-10 x Guideline
10-100 x Guideline
100-1000 x Guideline
>1000 x Guideline

Sample ID	Lab pH	TDI Calc from Major Ions	Ca	SO_4	Al	As	Cd	Cr	Co	Cu	Pb	Hg	Mo	Ni	Se	U	Zn	F	NO_2 as N	NO_3 as N
Units		(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)	(mg/L)	(mg/L)	(mg/L)
ANZECC (2000) Livestock	**6 to 8.5**	**2,000**	**1,000**	**1,000**	**5**	**0.5**	**0.01**	**1**	**1**	**0.5**	**0.1**	**0.002**	**0.05**	**1**	**0.02**	**0.2**	**20**	**2**	**30**	**400**
110362	8.42	565	3	2	<0.03	<0.003	<0.003	<0.003	<0.003	<0.003	<0.003	<0.0001	0.0100	<0.003	<0.5	<0.003	<0.02	6.30	<0.20	<0.20
110363	8.50	676	5	3	<0.05	0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.0001	0.0250	<0.005	<1	<0.003	<0.03	6.57	<0.20	<0.20
110364	8.51	738	3	3	<0.05	0.008	<0.005	<0.005	<0.005	<0.005	<0.005	<0.0001	0.0240	<0.005	<1	<0.003	<0.03	7.12	<0.20	<0.20

1-10 x Guideline
10-100 x Guideline
100-1000 x Guideline
>1000 x Guideline

Sample ID	Lab pH	Na	Cl	SAR	Al	As	Be	Cd	Cr	Co	Cu	Pb	Mn	Hg	Mo	Ni	Se	U	V	Zn	F	Total N	Total P
Units		(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	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(mg/L)
ANZECC (2000) Irrigation LTV	**6 to 8.5**	**115**	**175**	**2**	**5**	**0.1**	**0.1**	**0.01**	**0.1**	**0.05**	**0.2**	**2**	**0.200**	**0.002**	**0.0**	**0.2**	**0.02**	**0.01**	**0.1**	**2**	**1**	**5**	**0.05**
110362	8.42	230	2	26	<0.03	<0.003	<0.03	<0.003	<0.003	<0.003	<0.003	<0.003	0.021	<0.0001	0.0100	<0.003	<0.5	<0.003	<0.003	<0.02	6.3	0.42	1.4
110363	8.50	274	3	24	<0.05	0.005	<0.05	<0.005	<0.005	<0.005	<0.005	<0.005	0.016	<0.0001	0.0250	<0.005	<1	<0.003	<0.005	<0.03	6.57	<0.40	2
110364	8.51	300	3	33	<0.05	0.008	<0.05	<0.005	<0.005	<0.005	<0.005	<0.005	0.035	<0.0001	0.0240	<0.005	<1	<0.003	<0.005	<0.03	7.12	0.43	0.68

1-10 x Guideline
10-100 x Guideline
100-1000 x Guideline
>1000 x Guideline

Sample ID	Lab pH	EC	Al	As	Cd	Cr	Cu	Fe	Pb	Mn	Hg	Ni	Se	Ag	Zn	NO_2 as N	Total NH_3 as N (@pH 6.0 to 9.0)	Total N	Reactive P	Total P
Units		uS/cm	(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)	(mg/L)	(mg/L)
ANZECC (2000) FAE 95%	**6.5-8.5**	**500**	**0.055**	**0.013**	**0.0002**	**0.074**	**0.0014**	**0.3**	**0.0034**	**1.900**	**0.0006**	**0.0110**	**0.011**	**0.00005**	**0.008**	**0.700**	**0.900**	**0.15**	**0.005**	**0.01**
110362	8.42	860	<0.03	<0.003	<0.003	<0.003	<0.003	<0.02	<0.003	0.021	<0.0001	<0.003	<0.5	<0.003	<0.02	<0.20	<0.020	0.42	0.011	1.4
110363	8.50	1100	<0.05	0.005	<0.005	<0.005	<0.005	<0.03	<0.005	0.016	<0.0001	<0.005	<1	<0.005	<0.03	<0.20	<0.020	<0.40	0.012	2
110364	8.51	1200	<0.05	0.008	<0.005	<0.005	<0.005	<0.03	<0.005	0.035	<0.0001	<0.005	<1	<0.005	<0.03	<0.20	<0.020	0.43	0.036	0.68

1-10 x Guideline
10-100 x Guideline
100-1000 x Guideline
>1000 x Guideline

Sample ID	Lab pH	EC	TDI Calc from Major Ions	Na	K	Ca	Mg	Bi-carbonate as $Ca(HCO_3)_2$	Carbonate as $CaCO_3$	Cl	SO_4	SAR	Calc Hardness	Al	Sb	As	Ba	Be	Cd	Cr	Co	Cu	Fe	Pb
Units		uS/cm	(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)	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(mg/L)
Average GW	**7.93**	**1530**	**655**	**124**	**23**	**93**	**53**	**358**	**0.5**	**188**	**206**	**3**	**450**	**0.041**	**0.001**	**0.002**	**0.028**	**0.0005**	**0.000057**	**0.001**	**0.0008**	**0.003**	**0.544**	**0.0033**
110362	8.42	860	565	230	1	3.2	1.65	390	9.2	2	28	26	15	<0.03	<0.003	<0.003	0.005	<0.03	<0.003	<0.003	<0.003	<0.003	<0.02	<0.003
110363	8.50	1100	676	274	1	5.4	2.77	450	26	3	36	24	25	<0.05	<0.005	0.005	0.048	<0.05	<0.005	<0.005	<0.005	<0.005	<0.03	<0.005
110364	8.51	1200	738	300	1	3.2	1.9	460	26	3	67	33	16	<0.05	<0.05	0.008	0.015	<0.05	<0.005	<0.005	<0.005	<0.005	<0.03	<0.005

1-10 x Guideline
10-100 x Guideline
100-1000 x Guideline
>1000 x Guideline

Sample ID	Mn	Hg	Mo	Ni	Se	Ag	U	V	Zn	F	NO_2 as N	NO_3 as N	NO_x (NO_3 + NO_2) as N	Total N	Total P
Units	(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)
Average GW	**0.022**	**0.00005**	**0.0256**	**0.0014**	**0.005**	**0.0014**	**0.014**	**0.005**	**0.024**	**1.3**	**0.009**	**7.80**	**7.80**	**6.75**	**0.215**
110362	0.021	<0.0001	0.0100	<0.003	<0.5	<0.003	<0.003	<0.003	<0.02	6.3	<0.20	<0.20	<0.4	0.42	1.4
110363	0.016	<0.0001	0.0250	<0.005	<1	<0.005	<0.003	<0.005	<0.03	6.57	<0.20	<0.20	<0.4	<0.40	2
110364	0.035	<0.0001	0.0240	<0.005	<1	<0.005	<0.003	<0.005	<0.03	7.12	<0.20	<0.20	<0.4	0.43	0.68

1-10 x Guideline
10-100 x Guideline
100-1000 x Guideline
>1000 x Guideline

Appendix 10 – Geochemical Assessment of Phosphate Flotation Tailings (EGI 2014)

Prepared by:

ENVIRONMENTAL GEOCHEMISTRY
INTERNATIONAL PTY LTD
ABN 12 003 793 486

81A College Street, Balmain, NSW Australia 2041
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For:

Rum Jungle Resources Limited

&

Worley Parsons Services Pty Ltd

Document No. 5204 / 1110

Ammaroo Phosphate Project

Geochemical Assessment of Phosphate Flotation Tailings

July 2014

Contents

Tables (within text)

Figures (within text)

1.0 Introduction

Environmental Geochemistry International Pty Ltd (EGi) was commissioned by Rum Jungle Resources Limited (RJR) in collaboration with Worley Parson Services Pty Ltd to carry out a geochemical assessment of a sample representing tailings that will be produced at the Ammaroo Phosphate Project. The assessment was undertaken as part of feasibility studies for the mining and processing of phosphate rock from the Ammaroo deposit located approximately 200 km north of Alice Springs in the Northern Territory.

The tailings sample was produced during the metallurgical testing program carried out at the Bureau Veritas Minerals Laboratory in Adelaide, South Australia. The sample was provided as a slurry which was sealed within a 25 litre plastic bucket labelled *N5718-FL14 MGBF Tailings Composite #1*. For the purposes of this report the sample is hereafter referred to as *Ammaroo Phosphate Tailings*.

The main objectives of the assessment were to define the geochemical characteristics of Ammaroo phosphate tailings in relation to:

- The potential for acidification of the tailings solids,
- The quality of the flotation tailings liquor discharged to the tailings storage facility, and
- The potential for mobilisation of environmentally important elements that could adversely impact drainage quality.

This report presents the results and findings of the geochemical assessment.

2.0 Sample Preparation

Upon receipt, the tailings sample was allowed to stand for 24 hours then a 1 litre sub-sample of the tailings liquor was removed for analysis. Most of the remaining liquor was then decanted into a separate container. The remaining wet tailings were thoroughly mixed and a sub-sample comprising approximately 1 kg of solids was removed and vacuum filtered to remove excess liquor. The wet solids were then slowly dried in a fan-forced oven at approximately 70 ^{o}C for 24 hours. The dried filter cake was initially broken-up and screened through a 1 mm mesh screen then gently milled by mortar and pestle. All analysis of solids were carried out using dried material.

The decanted liquor was then returned to the remaining wet tailings solids and the reconstituted tailings slurry placed in storage pending any future requirements.

3.0 Geochemical Assessment Methodology

3.1 Laboratory Program

The following geochemical characteristics were determined:

Tailings Liquor

- pH
- Electrical conductivity (EC)
- Alkalinity
- Elemental composition

Tailings Solids

- Sulphur forms
- ANC
- MPA
- NAPP
- NAG pH and capacity
- Elemental composition of solids
- Batch sequential extraction test

3.2 Analytical Methods

Analysis of Tailings Liquor

A one-litre subsample of tailings liquor was decanted from the "as-received" tailings slurry and filtered through 0.45 micron membrane filters. Sub-samples of the filtrate were taken for analysis as follows:

- 250 mL (preserved H_2SO_4) - Phosphorus and nitrogen species (by discrete analyser)
- 250 mL (unpreserved) - Major elements (by ICP-AES)
- 100 mL (preserved HNO_3) - Minor elements(by ICP-MS)
- residual - pH, alkalinity and EC

The measurements of pH, alkalinity and EC were made by EGi. All other assays were carried out by ALS using methods accredited by NATA. The full elemental suite included Ag, Al, As, B, Ba, Be, Ca, Cd, Cl, Cr, Co, Cu, F, Fe, Hg, K, Mg, Mn, Mo, Na, Ni, Pb, Sb, Se, Si, Sn, SO_4, Sr, Th, U, Zn, total-N, NO_2-N, NO_3-N, NH_3-N, total-P, reactive-P.

Sulphur Forms

Sulphur forms were determined by Australian Laboratory Services (ALS) and included the following:

- Total-S - Measured using a Leco sulphur analyser
- Sulphate-S - Samples were leached with hot HCl to remove acid-soluble sulphates. The amount of sulphate within the leachate was then determined by inductively coupled plasma atomic emission spectrometry (ICPAES).
- Sulphide-S - Calculated as the difference between Total-S and Sulphate-S values.

Acid Neutralising Capacity

The ANC of a sample was determined using a modified Sobek Method. This method provides a direct measurement of the amount of acid that can be consumed by carbonate and other gangue minerals within a sample. A fizz test was initially carried out to provide a qualitative indication of the magnitude of neutralisation capacity. The fizz test involved addition of a few drops of acid to a small sub-sample of sample. A fizz rating was then assigned on the basis of the degree of fizzing, and based on the fizz rating, a known amount of acid was added to a known weight of pulverised material to produce a suspension with a pH in the range 1 to 2. The suspension was allowed to react for approximately 1 to 2 hours and then it is gently heated to complete the reaction. The amount of acid remaining after the reaction stage was determined by back-titration with sodium hydroxide. The amount of acid consumed by the sample (expressed in terms of kg H_2SO_4/t) was then determined by difference.

Maximum Potential Acidity

The MPA is the amount of acid that theoretically can be generated by a sample if all the sulphur occurs as reactive pyrite and there is complete oxidation of the pyrite according to the following reaction:

$$FeS_2 + 15/4\ O_2 + 7/2\ H_2O \Rightarrow Fe(OH)_3 + 2\ H_2SO_4$$

MPA is expressed in units of kg H_2SO_4/t. For the test samples the MPA values were calculated using the total sulphur contents as follows:

MPA (kg H_2SO_4/t) = Sulphur-%S x 30.6

Net Acid Producing Potential

The NAPP is the amount of acid that potentially can be produced by a sample after allowance for any ANC that the samples may also have. The NAPPs were calculated by subtracting the ANC values from the MPA values, with the results expressed in units of kg H_2SO_4/t.

Net Acid Generation (NAG) Test

The NAG test is a direct oxidation procedure for estimating the acid forming potential of a sample. The NAG test involved reaction of a 2.5 g sub-sample of pulverised material with 250 mL of 15% hydrogen peroxide, which acted as an oxidant to any sulphides present. The samples were allowed to react overnight to provide sufficient time for oxidation to occur. The reaction flasks were then gently heated for approximately 1 hour to decompose any residual peroxide. After cooling, the liquor pHs were recorded As both acid generation and acid neutralisation can occur simultaneously during a NAG test, the end result represents a direct measurement of the net amount of acid that a sample can generate. A sample is considered to be acid forming if the pH after reaction is less than pH 4.5. For such samples, the actual amount of acidity generated (expressed as kg H_2SO_4/t) is also determined by back-titration of the mixture to a pH 7 end-point.

Multi-Element Analysis of Solids

Elemental analysis of solids was carried out by ALS using methods accredited by NATA. Samples were digested by multi-acid addition (*i.e.* hydrofluoric, nitric, perchloric and hydrochloric acids) and the digests were analysed using inductively coupled plasma mass spectrometry (ICPMS) for the following suite of elements: Al, As, Ba, Be, Bi, Ca, Cd, Co, Cr, Cu, Fe, Hg, K, Li, Mg, Mn, Mo, Na, Ni, P, Pb, S, Sb, Se, Sn, Sr, Th, U, and Zn. Mercury was also assayed but an aqua regia digestion was used to ensure minimal volatilisation followed by analysis using ICPMS.

Batch Sequential Water Extraction Test

The water-soluble components within the phosphate tailings solids were determined by EGi by batch extraction using deionised water. A series of five extractions were carried out sequentially on the same sample of tailings solids. The initial extraction involved 500 g of dried tailings solids in 1000 g of deionised water, contained within a 2 litre capacity Teflon screw top bottle. The bottle was initially rotated on an end-over-end shaker for one hour, then periodically hand shaken throughout the remainder of the 24 hour extraction period. The extract was then filtered through 0.45 micron membrane filters, and sub-samples of filtrates were taken for analysis as per the tailings liquor as reported above. The solids were recovered from the filter and returned to the extraction bottle, then extracted a second time with another 2000 g of deionised water. This cycle was repeated another three times.

4.0 Geochemical Characteristics

4.1 Acid Forming Characteristics

The acid forming characteristics of the Ammaroo Phosphate tailings solids are given in Table 1. In addition, an acid-base account plot for the tailings sample is given in Figure 1, and an ARD classification plot is given in Figure 2. The main findings were as follows:

- The sulphur content of the tailings solids was negligible at only 0.04 %S.
- Correspondingly, the MPA was negligible (*i.e.* less than 1 kg H_2SO_4/t), signifying that the tailings solids had little, if any, capacity for acid generation.
- There was a modest ANC of 27 kg H_2SO_4/t, probably associated with the presence of some carbonate mineralisation. As the MPA was close to zero, the NAPP was essentially the inverse of the ANC result.
- Based on the sulphur and ANC results the tailings had a negative NAPP, and when the solids were oxidised with peroxide in the NAG test the pH remained circum-neutral.
- Therefore, based on the NAPP and NAG test results, the sample of Ammaroo Phosphate was classified as *non-acid forming* (NAF).

TABLE 1: *Acid forming characteristics of Ammaroo Phosphate tailings solids*

Parameter	Unit	Ammaroo Phosphate Tailings
Sulphur		
- Total Sulphur	%S	0.04
- Sulphate Sulphur	%S	0.02
- Sulphide Sulphur	%S	0.02
Neutalising Characteristics		
- Acid Neutralising Capacity (ANC)	kg H2SO4/t	27
Acid Generating Characteristics		
- Maximum Potential Acidity (MPA)	kg H2SO4/t	<1
- Net Acid Producing Potential (NAPP)	kg H2SO4/t	-26
- Net Acid Generation (NAG)	kg H2SO4/t	0
- NAG pH	-	6.9
ARD Classification		Non-Acid Forming (NAF)

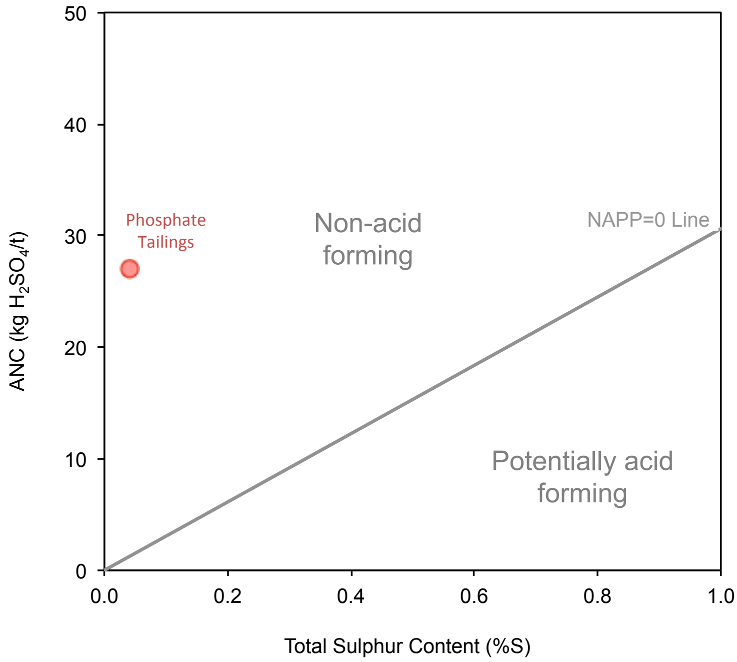


***FIGURE 1:** Acid-base account plot for Ammaroo Phosphate tailings*

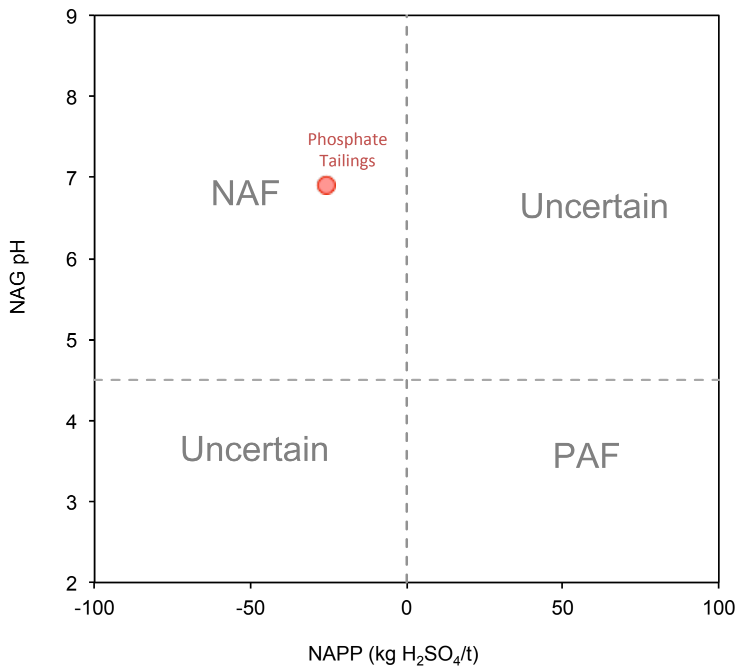


***FIGURE 2**: ARD classification plot for Ammaroo Phosphate tailings*

4.2 Elemental Composition

The elemental composition of the Ammaroo Phosphate tailings solids is given in Table 2. The data are also shown graphically in Figure 3. The composition of the tailings was compared to median concentrations reported for soil from non-mineralised areas to identify any elements that might be markedly enriched, and potentially of environmental significance for the project. The comparison is expressed as a Geochemical Abundance Index (GAI), which relates enrichment to the median soil abundance value based on the following formula:

$GAI = \log_2 [C / (1.5*S)]$

where C is the concentration of the element in the sample and S is the median soil[1] content for that element. GAIs are truncated to integer increments (0 through to 6, respectively) where a GAI of 0 indicates the element is present at a concentration similar to, or less than, median soil abundance and a GAI of 6 indicates approximately a 100-fold, or greater, enrichment above median soil abundance. The enrichment ranges for the GAI are as follows:

Little or No Enrichment
GAI = 0 < 3 times median soil

Minor Enrichment
GAI = 1 (3 to <6 times) or GAI=2 (6 to <12 times)

Significant Enrichment
GAI = 3 (12 to <24 times), 4 (24 to <48 times), 5 (48 to <96 times) or 6 (≥ 96 times)

The median soil data are included in Figure 3 for comparison purposes, and the GAIs for the tailings sample are included in Table 2.

As might be expected, the phosphorus content (>1 %)[2] of the tailings solids was significantly greater than the median concentration reported for soil from non-mineralised areas. The only other element that was significantly enriched relative to median soil (*i.e.* GAI≥3) was molybdenum (31 mg/kg). There was also minor enrichment of the tailings relative to median soil (*i.e.* GAI = 1 or 2) with chromium (253 mg/kg), nickel (169 mg/kg), lead (291 mg/kg) and uranium (16 mg/kg). The occurrence of these elements is not unusual, as U-Mo-Ni-Pb is a common elemental association for phosphorites. Typical concentrations reported for phosphorites are given in Table 2.

[1] References for median soil data were:
(1) Bowen, H.J.M. (1997) Environmental Chemistry of the Elements. Academic Press, London.
(2) Berkman, D.A. (1976) Field Geologists' Manual, The Australian Institute of Mining and Metallurgy, Australia

[2] The actual concentration of phosphorus exceeded the upper analytical limit of 1 %P.

TABLE 2:

Elemental composition and geochemical abundance indices for Ammaroo Phosphate tailings solids and comparison with published data for median soil and phosphorites

Element	Unit	Ammaroo Phosphate Tailings	*Median Soil Content	*Phosphorites	Geochemical Abundance Indices
Al	%	5.0	7.1	0.9	0
Ca	%	3.6	1.5	31.4	0
Fe	%	1.5	4.0	0.8	0
K	%	0.6	1.4	0.4	0
Mg	%	0.4	0.5	0.2	0
Na	%	0.07	0.5	0.5	0
S	%	0.04	0.07	0.7	0
As	mg/kg	10	6	30	0
Ba	mg/kg	310	500	100	0
Be	mg/kg	5	6	0.5	0
Bi	mg/kg	0	0.2	<0.05-0.4	0
Cd	mg/kg	1	0.4	0.01-25	0
Co	mg/kg	9	8	<3-5	0
Cr	mg/kg	253	70	2-1000	1
Cu	mg/kg	35	30	100	0
Hg	mg/kg	0.006	0.06	0.2	0
Mn	mg/kg	491	1000	30	0
Mo	mg/kg	31	2	30	3
Ni	mg/kg	169	50	<2-1000	1
P	mg/kg	>10000	800	138,000	6
Pb	mg/kg	291	35	2-14	2
Sb	mg/kg	0.2	1	0.2-7	0
Se	mg/kg	1	0.4	1-300	0
Sn	mg/kg	1	4	0.18	0
Sr	mg/kg	471	250	1000	0
U	mg/kg	16	2	90	2
Zn	mg/kg	112	90	300	0

* Median soil and Phosphorite data from:

Bowen, H.J.M. (1979) Environmental Chemistry of the Elements. Academic Press, London.

Berkman, D.A. (1976) Field Geologists' Manual, The Australian Institute of Mining and Metallurgy,Victoria, Australia.

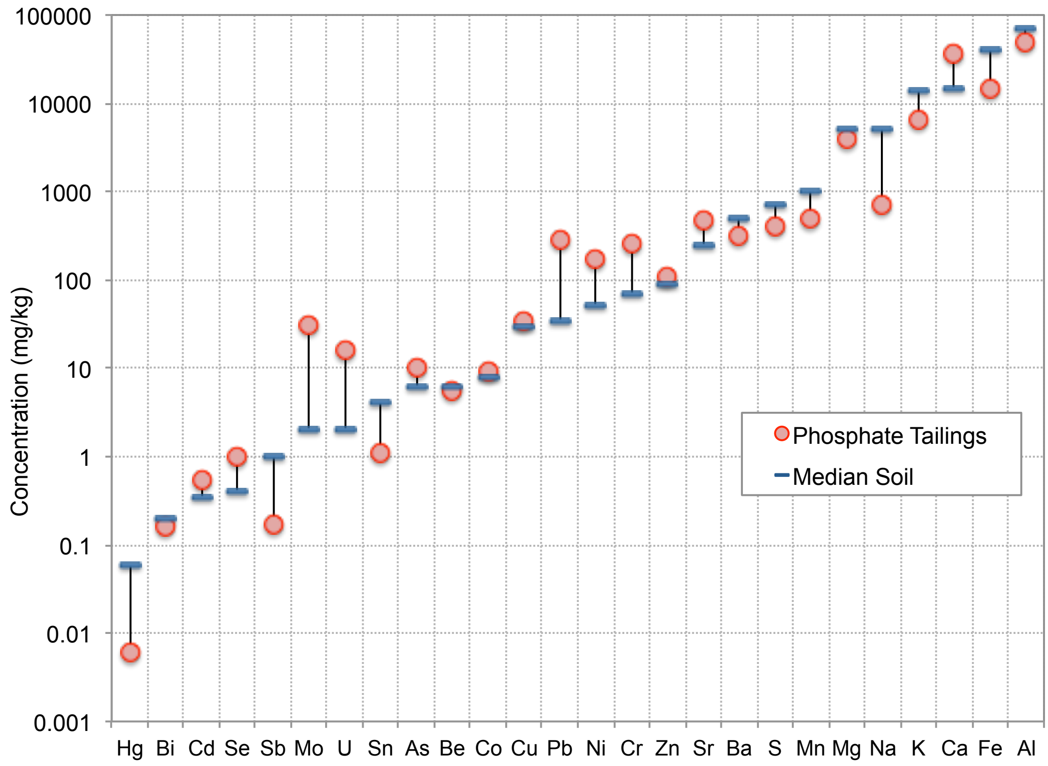


***FIGURE 3**: Box plot of elemental concentrations for Ammaroo Phosphate tailings and comparison with median soil data*

4.3 Tailings Liquor and Sequential Extraction Test

The composition of the tailings liquor and the results of the sequential batch extraction test involving tailings solids are given in Table 3.

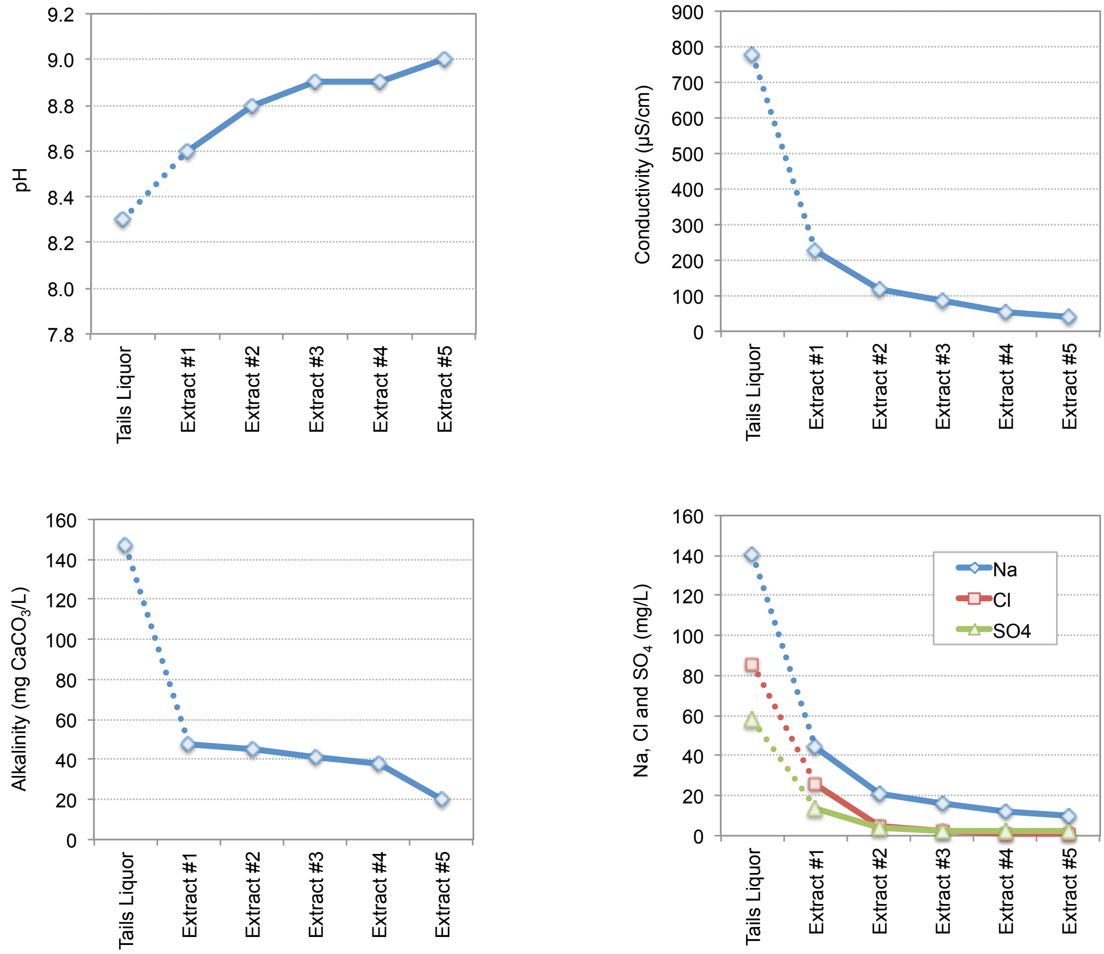
The tailings liquor can generally be described as moderately alkaline and slightly saline. It had a pH of 8.3, alkalinity of 147 mg $CaCO_3$/L, and a conductivity of 779 µS/cm. The salinity was mostly due to sodium (141 mg/L), chloride (86 mg/L) and sulphate (58 mg/L). The concentrations of calcium, magnesium and potassium were less than 10 mg/L, and the concentration of dissolved phosphorus was only 0.03 mg/L. Concentrations of dissolved metals were typically at, or close to the limits of analytical detection.

The objective of the extraction test was to provide data on chemical reactions that may occur for phosphate tailings solids exposed within the tailings storage facility to atmospheric conditions. The test was carried out over a five day period, with each extraction step extending for approximately 24 hours. Figure 4 shows the trends in pH, alkalinity, conductivity, and concentrations of major solutes in the tailings extracts during the five stage test.

TABLE 3: *Compositions of tailings liquor and water extracts of Ammaroo Phosphate tailings*

Element	Unit	Detection Limit	Composite Tailings #1 Liquor	Sequential Water Extracts				
				Extract #1	Extract #2	Extract #3	Extract #4	Extract #5
pH	-		8.3	8.6	8.8	8.9	8.9	9.0
EC	μS/cm		779	226	116	86	56	39
Alkalinity	mg/L $CaCO_3$		147	48	45	41	38	20
Nutrients								
Total-P	mg/l	0.01	0.03	0.35	0.43	0.43	0.59	0.53
Reactive-P	mg/l	0.01	0.03	0.10	0.19	0.24	0.30	0.33
Total-N	mg/l	0.1	0.1	0.1	0.2	<0.1	<0.1	<0.1
Kjeldahl-N	mg/l	0.1	0.1	0.1	0.2	<0.1	<0.1	<0.1
Ammoniia-N	mg/l	0.01	<0.01	0.05	0.01	0.02	0.02	0.02
Nitrite-N	mg/l	0.01	<0.01	0.02	0.01	<0.01	<0.01	<0.01
Nitrate-N	mg/l	0.01	<0.01	0.01	<0.01	<0.01	<0.01	<0.01
Nitrite+Nitrate	mg/l	0.01	<0.01	0.03	0.01	<0.01	<0.01	<0.01
Major Anions								
Cl	mg/l	1	86	26	5	2	1	<1
SO4	mg/l	1	58	14	4	2	2	2
Major Cations								
Ca	mg/l	1	9	1	<1	<1	<1	<1
K	mg/l	1	4	1	<1	<1	<1	<1
Mg	mg/l	1	5	<1	<1	<1	<1	<1
Na	mg/l	1	141	44	21	16	12	10
Trace Elements								
Ag	mg/l	0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Al	mg/l	0.01	0.02	0.7	0.4	0.2	0.09	0.12
As	mg/l	0.001	0.004	0.01	0.008	0.007	0.005	0.004
B	mg/l	0.05	0.4	0.2	0.1	0.08	0.07	0.05
Ba	mg/l	0.001	0.008	0.3	0.07	0.06	0.04	0.05
Be	mg/l	0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Cd	mg/l	0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001
Co	mg/l	0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Cu	mg/l	0.001	0.003	0.005	0.003	0.002	0.003	0.002
F	mg/l	0.1	3	4	3	2	1	1
Fe	mg/l	0.05	<0.05	0.4	0.2	0.1	<0.05	<0.05
Hg	mg/l	0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001
Mn	mg/l	0.001	0.04	0.006	0.005	0.003	0.007	0.004
Mo	mg/l	0.001	0.02	0.01	0.003	0.001	<0.001	<0.001
Ni	mg/l	0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Pb	mg/l	0.001	<0.001	0.003	0.002	0.002	0.001	0.001
Sb	mg/l	0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Se	mg/l	0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Si	mg/l	0.1	23	20	15	15	12	11
Sn	mg/l	0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Sr	mg/l	0.001	0.094	0.009	0.005	0.003	0.002	0.003
Th	mg/l	0.001	<0.001	<0.001	<0.001	<0.001	<0.001	0.002
U	mg/l	0.001	0.01	<0.001	<0.001	<0.001	<0.001	<0.001
Zn	mg/l	0.005	<0.005	0.015	0.009	0.005	0.005	0.006

< indicates concentration below analytical detection limit



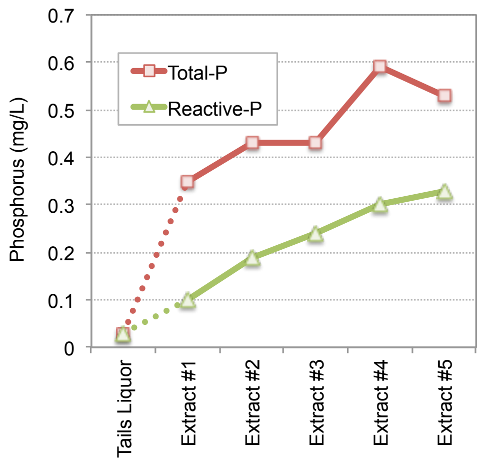


FIGURE 4:

Results of sequential extraction of Ammaroo Phosphate tailings solids with deionised water

Over the course of the five extractions, the pH increased slightly from 8.6 to 9.0 while at the same time alkalinity decreased from 48 mg $CaCO_3$/L down to 20 mg $CaCO_3$/L. The concentrations of dissolved salts in the extracts also progressively decreased with successive extractions, and the results for the fifth extraction suggest that virtually all soluble salts had been flushed by that stage.

The results indicate that the release of phosphorus from the tailings was relatively small, but in contrast to soluble salts such as sodium and chloride, there was an upward trend in the concentrations of total phosphorus with successive extractions. Total phosphorus concentrations ranged from 0.3 to 0.6 mg/L, with approximately half present as reactive-phosphorus. There was no evidence of leaching of nitrogen, with concentrations of ammonia, nitrite and nitrate typically close to, or below the analytical detection limits.

There were minor concentrations of fluorine (1 to 4 mg/L), aluminium (0.09 to 0.7 mg/L), barium (0.04 to 0.3 mg/L) and boron (0.05 to 0.2 mg/L) in the extracts but the concentrations of other environmentally important elements were low, and in most cases close to, or below, the analytical detection limits as indicated below:

- ≤ 0.0001 mg/L Hg, Cd
- ≤ 0.001 mg/L Be, Co, Ni, Sb, Sn, U
- ≤ 0.005 mg/L Cu, Pb,
- ≤ 0.01 mg/L As, Mo, Mn, Se, Sr
- ≤0.02 mg/L Zn

5.0 Summary

This report presents the results of geochemical testing of a laboratory generated sample representing tailings that will produced at the Ammaroo Phosphate Project in the Northern Territory. The main aims of the geochemical testing program were to assess the acid forming characteristics of the tailings solids, the elemental composition, and whether there is potential for release of environmentally important elements from tailings if exposed to atmospheric conditions within a TSF. The geochemical characteristics of the tailings sample were determined using standard static testing procedures. The main findings were as follows:

- The tailings sample was classified as NAF based on negative NAPP and NAG results. The sulphur content was negligible (*i.e.* 0.04 %S), hence the MPA was correspondingly small, and the negative NAPP (-26 kg H_2SO_4/t) s was essentially the inverse of the ANC value.
- Apart from phosphorus, only molybdenum was significantly (GAI≥3) enriched in the tailings solids relative to concentrations typically reported for soils in non-mineralised areas was molybdenum.
- There was also minor enrichment of the solids with chromium, nickel, lead and uranium, but there was no evidence of mobilisation of these elements when the tailings solids were sequentially extracted with deionised water.
- Phosphorus was slightly soluble. Total phosphorus concentrations in water extracts ranged from 0.3 to 0.6 mg/L, with approximately half present as reactive-phosphorus.

Appendix 11 - Declaration – Peer review of AMD Report and Management Plan

13 June 2018
Chris Tziolis
Managing Director
Verdant Minerals Ltd
Unit 20, 90 Frances Bay Drive
NT 0820 Australia

RE: Peer Review of AMD Report and Management Plan for the Ammaroo Phosphate Project

Dear Chris,

In my capacity as Director/Principal Geochemist of RGS Environmental Pty Ltd as Trustee for the RGS Environmental Family Trust (ABN 25 924 595 681), I completed a Peer Review of the AMD Report and Management Plan prepared by GHD Pty Ltd (GHD) associated with the Ammaroo Phosphate Project in April 2018. I was requested to complete the Peer Review based on my PhD qualification in Pure and Applied Chemistry and 25 years of experience in completing similar geochemical assessment projects in Australia and other parts of the world. I hereby state that the Peer Review was conducted independent from the proponent (Verdant Minerals Ltd) and GHD.

The Peer Review included some minor comments and recommendations on the AMD Report and Management Plan; and concluded that the document effectively covers the key requirements of a geochemical assessment process for the proposed phosphate mining operation in Northern Territory (NT EPA, 2013[1]; Team NT, 2004[2]). The Geochemical Assessment Report also met the requirements of Australian (DIIS, 2016[3]) and International (INAP, 2009[4]) guidelines associated with geochemical assessments at proposed mining operations.

Based on the information presented in the AMD Report and Management Plan, I endorse the document conclusions and management recommendations, as presented.

Yours sincerely,

Alan M Robertson

Dr. Alan M Robertson

Director/ Principal Geochemist – RGS Environmental Pty Ltd ATF RGS Environmental Family Trust

[1] NT EPA (2013). *Environmental Assessment Guidelines. Acid and Metalliferous Drainage. Version 2.0. November.*
[2] Team NT (2004). Northern Territory Minerals Council (Inc.) and the Mines and Petroleum Management Division of the Northern Territory Government, 2004, *TEAM NT: Technologies for Environmental Advancement of Mining in the Northern Territory: Toolkit*, D.R. Jones and M. Fawcett, principal authors. Posted on the Northern Territory Minerals Council web page at: http://ntminerals.org.au/VisionEdit/files/TEAMNT.pdf
[3] DIIS (2016) [Department of Industry, Innovation and Science]. Leading Practice Sustainable Development Program for the Mining Industry. *Preventing Acid and Metalliferous Drainage*. September, Commonwealth of Australia, Canberra ACT.
[4] INAP (2009). Global Acid Rock Drainage Guide (GARD Guide). Document prepared by Golder Associates on behalf of the International Network on Acid Prevention (INAP). June (http://www.inap.com.au/).

Appendix 12 - Barrel leachate results, July 2018

Verdant Minerals Limited

Ammaroo Phosphate Project

Preliminary Barrel Leach Test Results

July 2018

Table of contents

Table index

Figure index

Appendices

1. Introduction

1.1 Overview

As part of the assessment of the risk of acid, saline or metalliferous drainage (collectively referred to as AMD) Verdant Minerals Limited (VML) established field leachate testing barrels to assess the release of soluble metals, metalloids and other environmentally significant solutes. These are referred to as barrel leach tests. Three leachate cycles have been completed and the leachate analysed.

1.2 Purpose of this report

This report will provide a preliminary discussion of barrel leach testing used to simulate the AMD risk associated with long-term effects of rain percolation through stockpiles of the various materials on site including the presence of soluble potential deleterious elements, which may be mobile through the environment.

1.3 Scope and limitations

The scope of works for this study was to characterise the waste rock in terms of potential to develop acid, metalliferous or saline drainage (AMD)

This report has been prepared by GHD for Verdant Minerals Limited and may only be used and relied on by Verdant Resources Limited for the purpose agreed between GHD and the Verdant Minerals Limited as set out in section 1.1 of this report.

GHD otherwise disclaims responsibility to any person other than Verdant Minerals Limited arising in connection with this report. GHD also excludes implied warranties and conditions, to the extent legally permissible.

The services undertaken by GHD in connection with preparing this report were limited to those specifically detailed in the report and are subject to the scope limitations set out in the report.

The opinions, conclusions and any recommendations in this report are based on conditions encountered and information reviewed at the date of preparation of the report. GHD has no responsibility or obligation to update this report to account for events or changes occurring subsequent to the date that the report was prepared.

GHD has prepared this report on the basis of information provided by Verdant Minerals Limited and others who provided information to GHD (including Government authorities), which GHD has not independently verified or checked beyond the agreed scope of work. GHD does not accept liability in connection with such unverified information, including errors and omissions in the report which were caused by errors or omissions in that information.

1.4 Assumptions

GHD has assumed the samples provided by VML are representative of the materials as described, the testing was carried out according to the procedure outlined below and the laboratory analytical methods and results are appropriate for the materials tested.

1.5 Data sources

GHD provided a draft barrel leach testing procedure which was modified by VML to suite local conditions and availability of equipment. The procedure below is based on VML's modified procedure. This report is based on laboratory results provided by VML's contracting laboratory.

1.6 Project summary

The Ammaroo Phosphate Mine Site is located 270 km north east of Alice Springs, 120 km east of Barrow Creek (latitude 21° 39' 52" longitude 135° 16' 48"). The project is located on the western side of the Georgina Basin. The site is north of the Sandover Highway. The phosphate ore is hosted in an oxidised sedimentary sequence, located above the regional water table. The ore is to be mined by open cut methods, with waste rock and tailings returned to the pit. Ore is processed by grinding and flotation to produce a phosphate concentrate. More detail on the geology, hydrogeology and mining process is provided in the EIS documents (GHD 2018).

2. Geochemical assessment

2.1 Methods

The long-term effects of percolation of rainwater through waste rock at the proposed Ammaroo Phosphate Mine is being determined through barrel leach tests that simulate conditions on the site. The detailed description of this methodology is provided in Appendix A. The assessment includes the construction of five 100 L barrels with 120 kg of sample in each (Figure 2-1), which are representative of stockpiles of:

- Ore (OR)
- Overburden with low ironstone (BO)
- Overburden with high ironstone (BF1)
- A second overburden with high ironstone (BF2)
- Top soil and surface sand (TS)

Samples with high ironstone content were included, as ironstone was felt to be the lithology most likely to leach metals. The first four barrels used drill core, broken to represent the likely size of the material in the stockpiles. The fifth sample is representative of the surface soil/sand that would be stockpiled for rehabilitation use. Sub-samples (1 kg) were taken from each barrel for whole rock analyses (using 4 acid digest) and Australian Standard Leachate Procedure (ASLP) using deionised water in accordance with AS4439-1997.

Given the low rainfall on site, it would be impractical to simulate the actual annual rainfall or even the most intense events. Instead, the rainfall is greatly accelerated by the addition of a large quantity of water to each sample each month. Each week the liquid leachate is tested for pH, electrical conductivity (EC) and oxidation/reduction potential (ORP) with a calibrated meter. In addition, after each monthly leachate cycle, a set amount of water is collected from the bottom drain tap and sent to the laboratory for analysis.

The tests are proposed to run for a minimum of 18 months. Blanks from the RO make-up water that was supplied, and rinse water from the sample transport containers, was analysed to test if contamination was coming from the water or from the equipment. All results were converted to mg/L (liquids) or ppm (solids) to simplify comparison with the guidelines.

Figure 2-1 leach barrels with A - Ore. B - Overburden with low ironstone. C - Overburden with high ironstone. D - Overburden with high ironstone. E - Top soil and surface sand. F - Set up of the five barrels.

2.2 Leachability – barrel leachate results

2.2.1 Time vs pH

There is a trend of pH increase over time for all five samples types (Figure 2-2). All samples except for top soil and surface sand (TS) have similar starting pH values with an average pH of 7.6 (standard deviation 0.1), TS begins with a pH of 5.8 (Figure 2-2). This is consistent with highly leached acidic soils, which have naturally lower pH values compared to carbonate-bearing overburden and ore. As the results of only three leachate cycles per sample are available, only a preliminary assessment is provided. A more detailed interpretation of the results should wait until further information is gathered.

2.2.2 Dispersion risk classification (SAR vs EC)

The soil dispersion risk classification is calculated by comparing the Sodium Adsorption Ratio (SAR) values to the electrical conductivity (EC). Presently, with three data points per sample, all samples plot in the stable soil zone (Figure 2-3). This means that clays in the soil will not be subject to significant dispersion and the leachate is unlikely to result in damage to soil structures. With all the overburden and ore samples having relatively high EC values (range = 2200 – 7720 µs/cm) it is unlikely that future samples will present problems for soil stability and based on these values alone, leachate or runoff from waste piles may be suitable for irrigation or dust control.

2.2.3 ANZECC & ARMCANZ (2000) FAE 95%

In the barrel leach results, Total N, Cd, Cu, Pb and Zn exceed the guidelines for protection of 95% of Freshwater Aquatic Ecosystems (FAE 95%). Copper and Zn may be attributed to the concentrations found in the applied reagent (reverse osmosis) water and transport containers (see section 2.3). Cadmium exceeded guidelines in all samples, however it exceeded the guidelines by less than a factor of 10. The UCL 95% for Cd also exceeded the guidelines, with Cd levels for overburden at 0.0009 mg/L and ore at 0.0018 mg/L.

All samples exceed the guideline triggers for total N, with all but three also exceeding the irrigation guidelines, most by more than a factor of 10 but none by a factor of 100. High total N can lead to eutrophication in still, clear, enclosed water systems, but are less likely to cause issues in turbid open water systems. Nitrate is naturally elevated in soils and groundwater in the region.

Lead only exceeded the guideline trigger in the initial measurement for BF2 and that value is still less than 2 times the guideline.

Given the high calcium and magnesium content of the water, the resultant hardness significantly reduces the bioavailability of copper, cadmium, lead nickel and zinc (Table 2-2 Initial values compared to hardness corrected values against ANZECC (2000) FAE 95% guidelines.). Nickel and lead are no longer above guidelines once corrected for hardness. Corrected copper, cadmium and zinc only exceed the guidelines in one measurement for top soil compared to nearly all measurements before correction.

2.2.4 ANZECC & ARMCANZ (2000) Livestock

Only the initial measurement of the top soil/surface sand has values above the livestock guidelines for nitrate (NO_3), with the average value for TS being below the guidelines of 30 mg/L (average = 19.98 mg/L). This indicates the initial high value may be a first flush effect and the subsequent lower values may reflect more realistic results, ongoing analysis will determine this.

The ore exceeds the mercury (Hg) guideline concentrations but by less than a factor of 2. The ore UCL 95% for Hg is above the guidelines at 0.0046. Further, samples that had salinity concentrations greater than the linear working range (>LWR) of the ICPMS were reanalysed by ICPOES, hence mercury data is indicative only.

2.2.5 ANZECC & ARMCANZ (2000) Irrigation LTV

The irrigation guidelines are exceeded for total N, total P, F, Na, Cl and B (Table 2-1) in at least one sample. All samples exceeded the guidelines for total N, with BF2 and TS having samples that exceed total N guidelines by more than a factor of 10. Total N has a UCL 95% value for overburden of 29 mg/L which is greater than the guideline trigger of 5 mg/L. All overburden samples exceed total P with the UCL 95% value for overburden at 0.16 mg/L compared to the guideline trigger of 0.05 mg/L. Fluoride only exceeds the irrigation guideline in the ore sample and is still below the health and livestock guidelines (Figure 2-6), its UCL 95% is 1.2 mg/L compared to the irrigation trigger of 1.1 mg/L, based on the initial data, fluoride is a low risk. Sodium values are significant as they contribute to the SAR values and subsequently the soil dispersion risk and structure problems. The sodium guideline triggers are exceeded by all samples except TS and have a UCL 95% value of 695 mg/L compared to a guideline trigger of <115 – 460. However, as the calcium concentrations are also elevated, the SAR (as noted above) is within the acceptable range. All overburden and ore samples exceed the irrigation LTV triggers for boron with the samples also exceeding the FAE 95% trigger. The overburden does not exceed 2 times the irrigation trigger, and the UCL 95% value is 0.72 mg/L compared to the guideline of 0.5 mg/L. The ore sample, however, is more than 2 times the guideline for irrigation and has a UCL 95% value of 1.68 mg/L. All samples except for TS exceed the guidelines for chloride.

2.2.6 ADWG (2011) Health

The leach results for NO_2, NO_3, SO_4, Mn, Ni, Sb, Se and U exceed the health guidelines (Table 2-1) in one or more samples. Only the high Fe overburden exceeds the health guidelines for NO_2 and only does so for the first measurement of each sample, the majority of samples are below the detection limit of the analysis. The nitrate (NO_3) concentrations exceed the health guidelines in the high Fe overburden and only initially in the TS. The overburden UCL 95% value exceeds the guidelines at 13.95 mg/L compared to 11.29 mg/L. The sulfate (SO_4) exceeds the guidelines in the ore and high Fe overburden samples with a UCL 95% values of 747.4 mg/L for overburden and a value of 859 mg/L for ore compared to a guideline of 500 mg/L. Manganese only exceeds the guidelines in the TS sample and has a UCL 95% value of 2 mg/L compared to the guideline of 0.5 mg/L. Nickel and selenium only exceed the guidelines in sample BF2, the overburden samples have a UCL 95% value of 0.018 mg/L and 0.0094 mg/L respectively which is below the health guidelines for both. Antimony exceeds the guidelines but the base levels of the green plastic transport container (sold as being suitable for drinking water) and the rinse water are four times the guideline. Uranium exceeds the guidelines for the OR and BF1 samples with both the ore and overburden's UCL 95% values exceeding the guidelines.

2.2.7 ADWG (2011) Aesthetic

The samples exceed the aesthetic guidelines for Cl, SO_4, Mn and Na. Samples that exceed Mn Cl and Na also exceed higher triggers such as livestock or health guidelines. All sulfate (SO_4) values exceed the aesthetic guidelines except for TS, the ore and high Fe overburden samples also exceed the health trigger, which is higher. The ironstone-free overburden (BO) exceeds just the aesthetic values but has an average concentration of 249 mg/L which is below the aesthetic trigger of 250 mg/L.

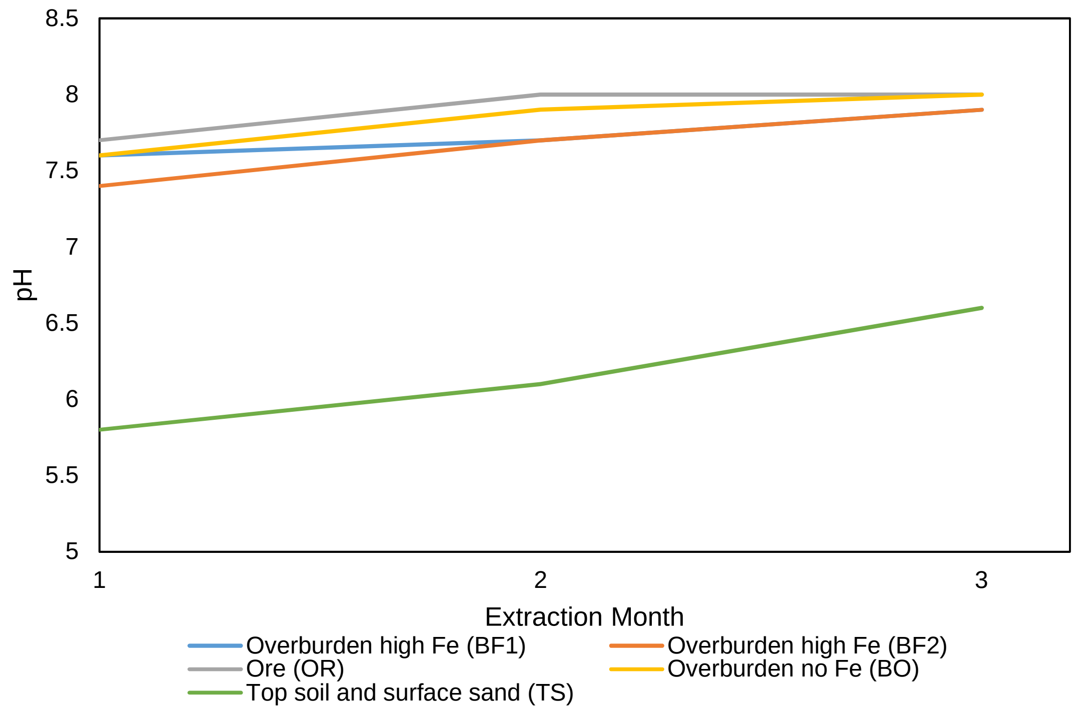


Figure 2-2 Extraction time vs pH for each barrel.

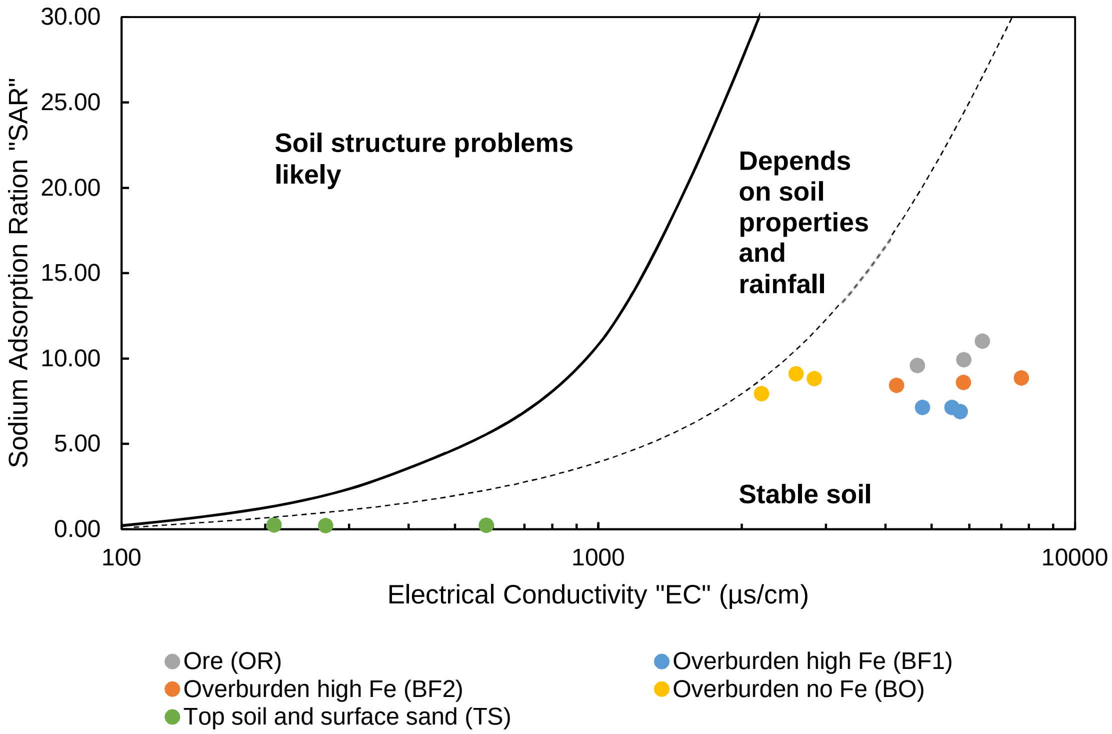


Figure 2-3 Sodium adsorption ratio (SAR) vs EC (dispersion risk classification).

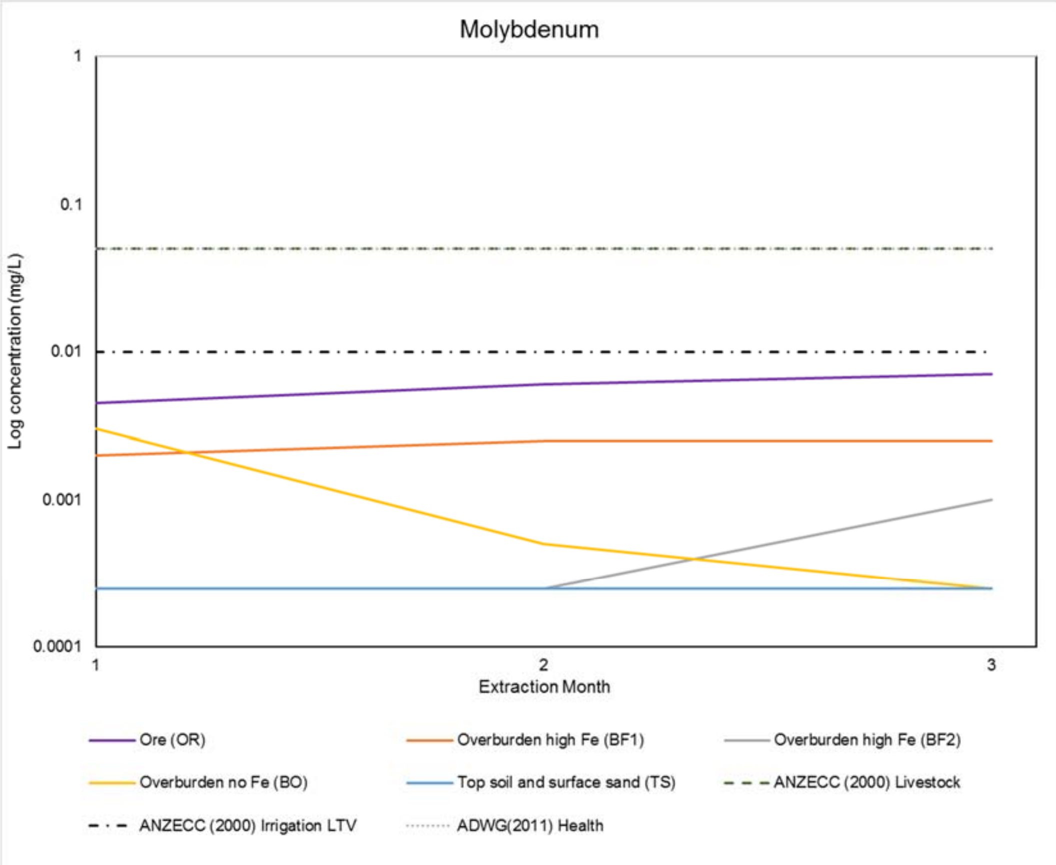


Figure 2-4 Molybdenum

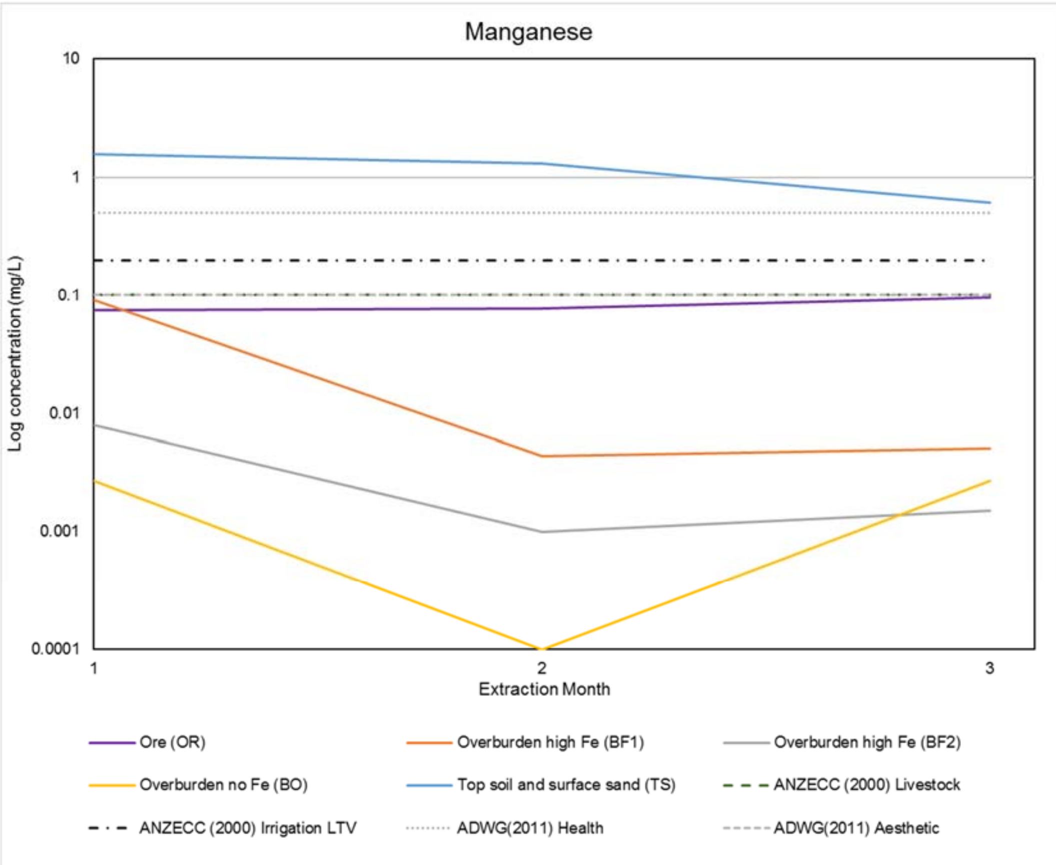


Figure 2-5 Manganese

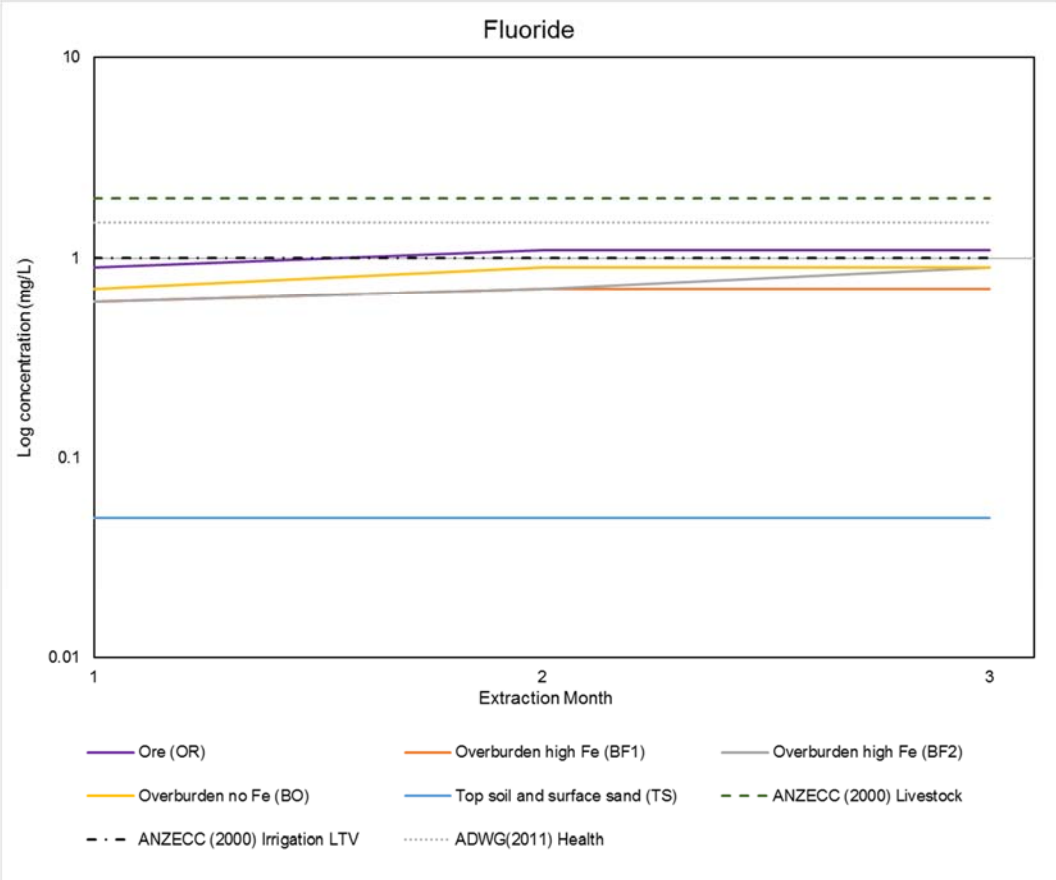


Figure 2-6 Fluoride

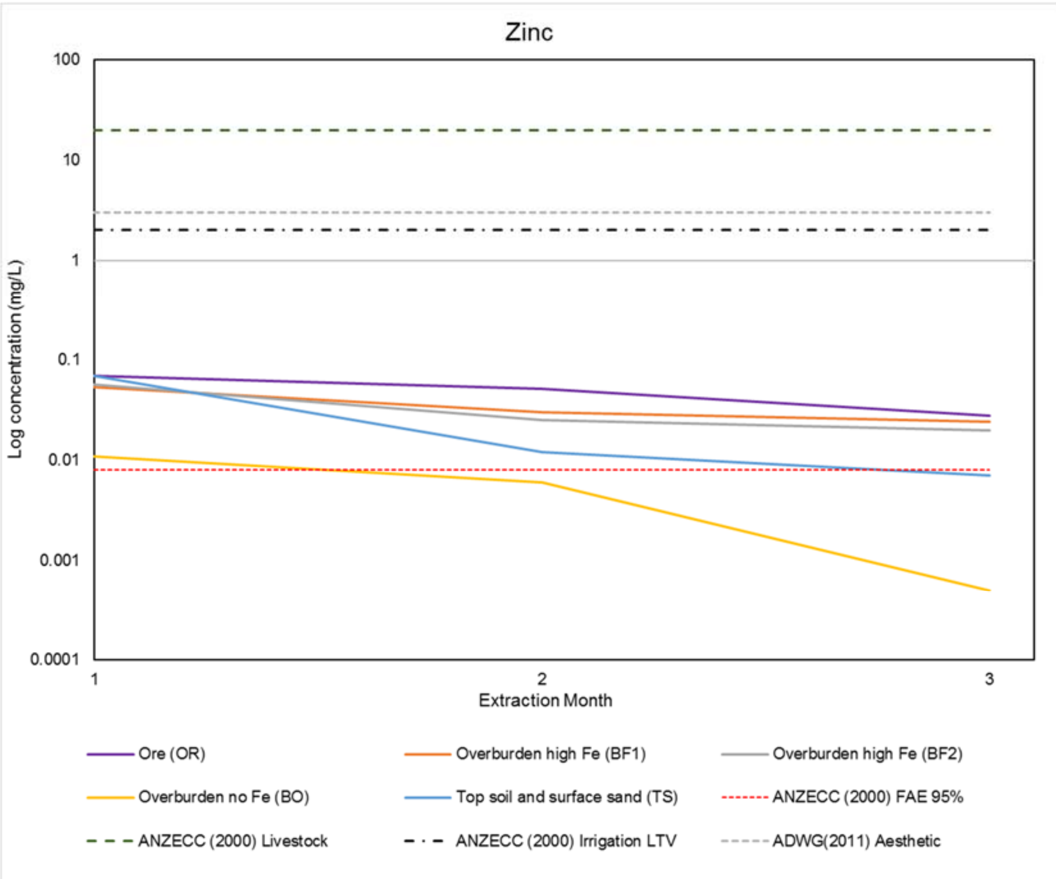


Figure 2-7 Zinc

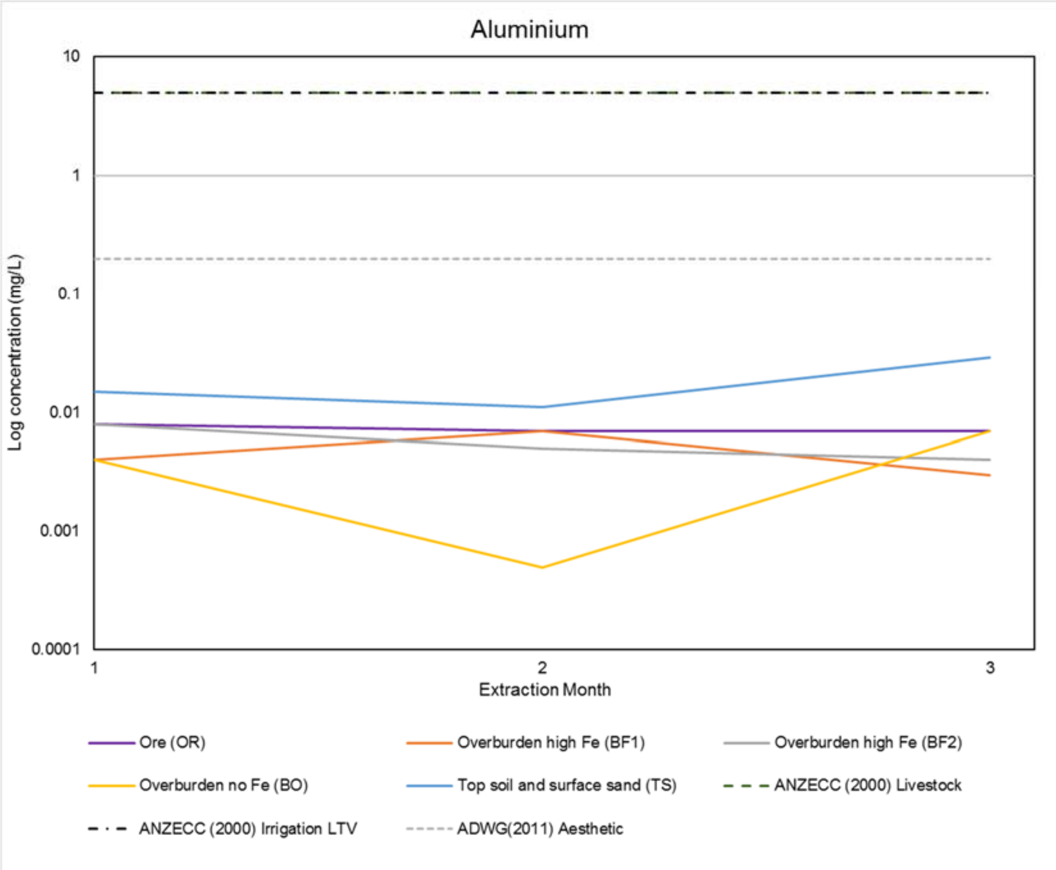


Figure 2-8 Aluminium

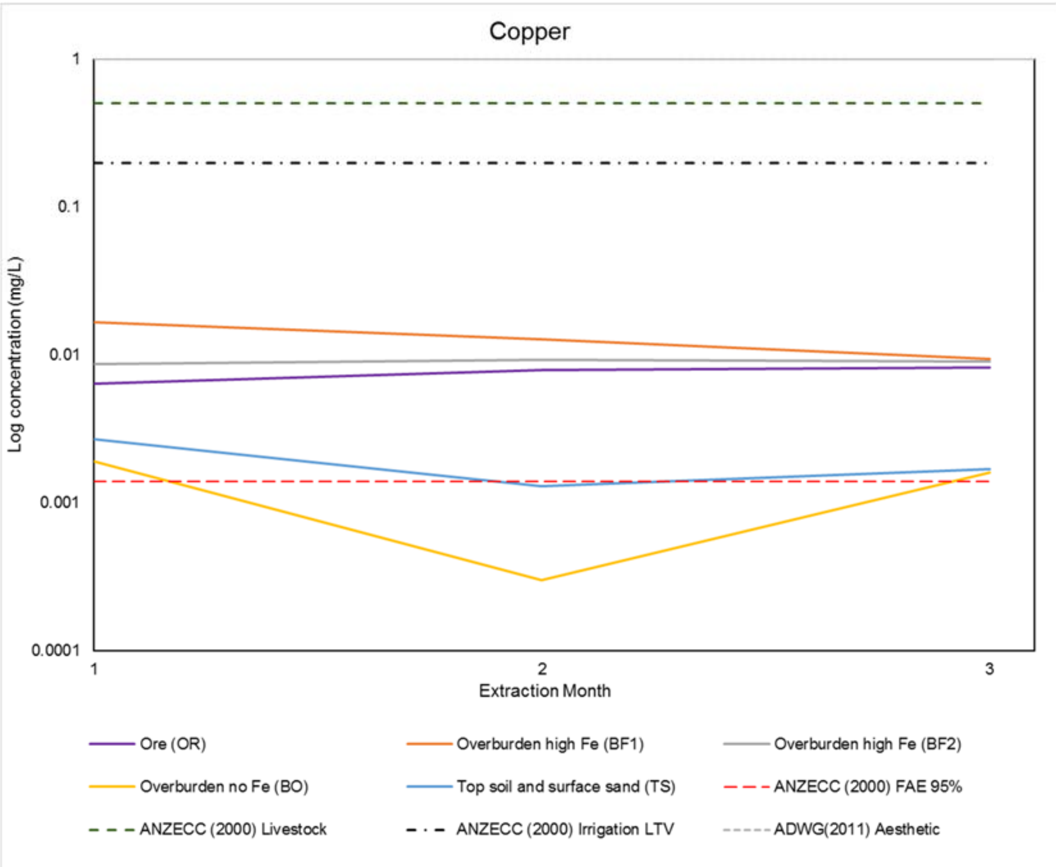


Figure 2-9 Copper

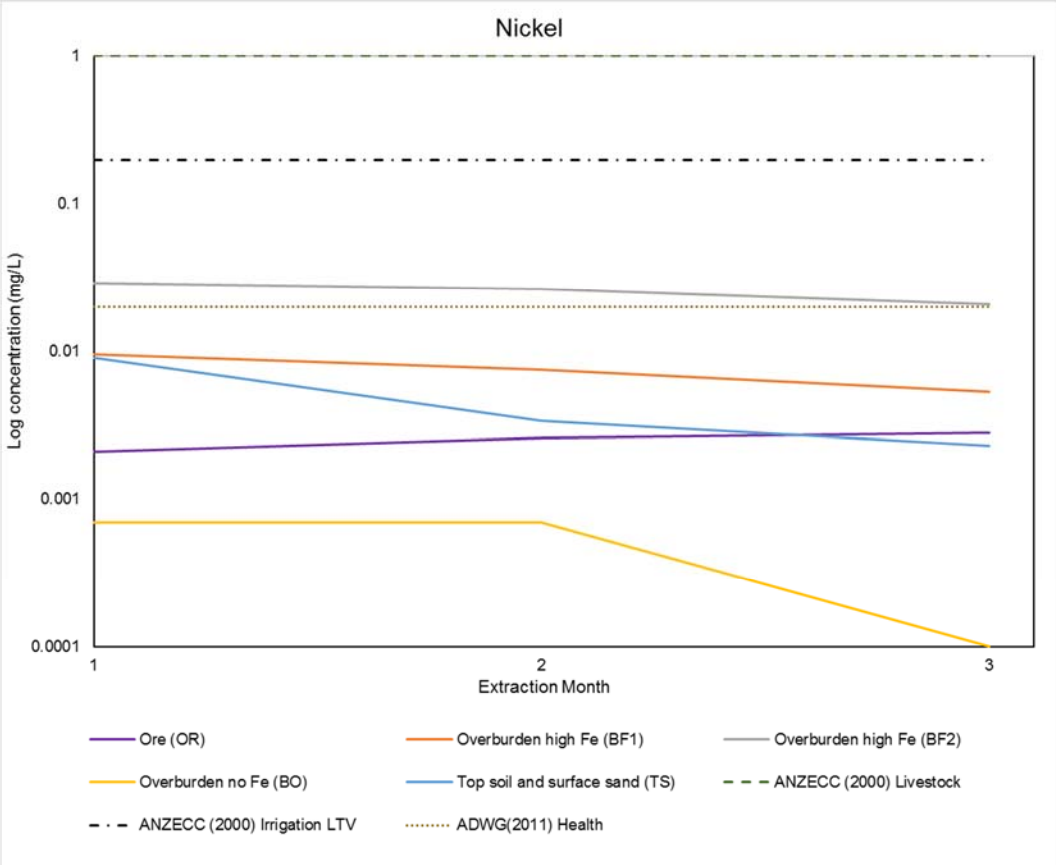


Figure 2-10 Nickel

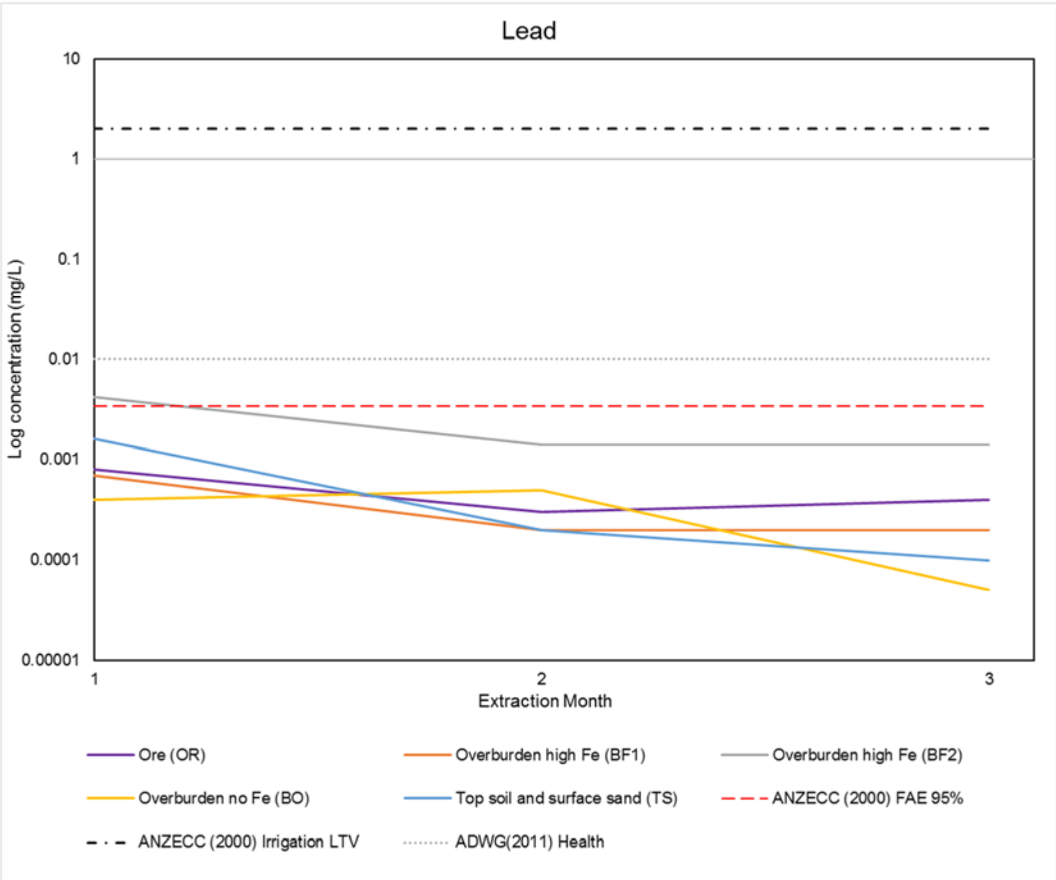


Figure 2-11 Lead

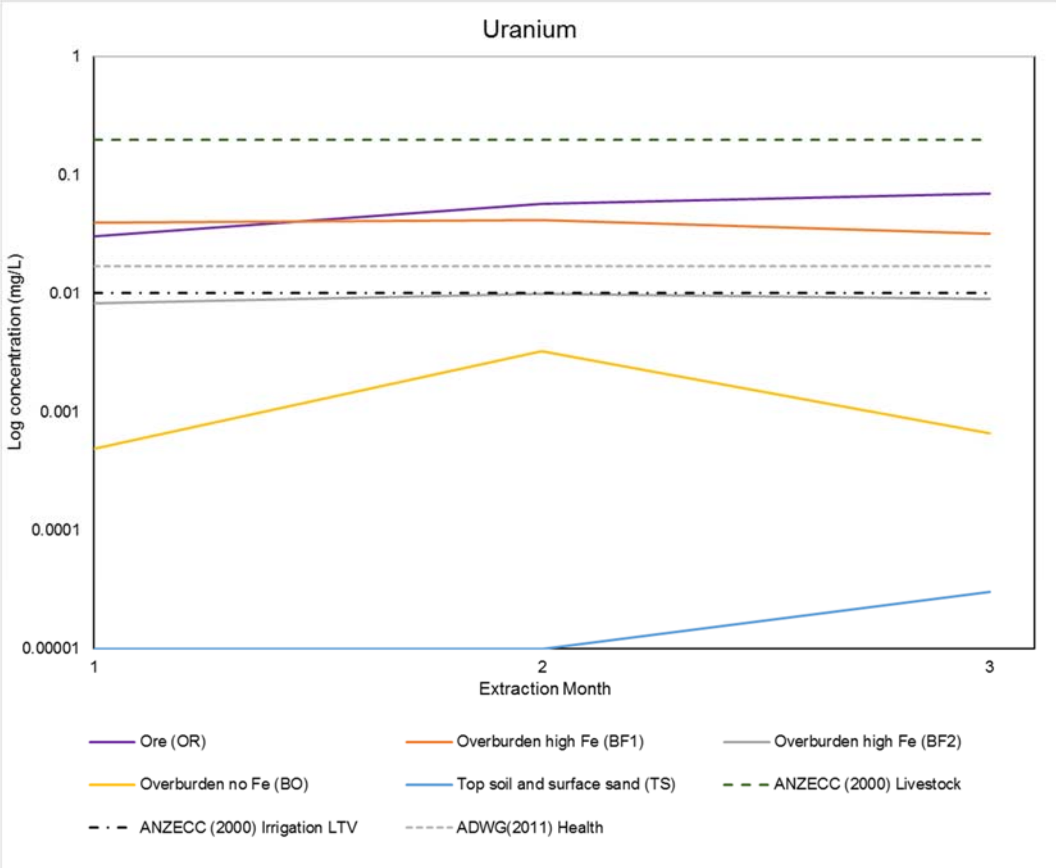


Figure 2-12 Uranium

Table 2-1 Barrel leach results compared to ANZECC (2000) and ADWG (2001) guidelines.

Leachate sample source	Leachate date	NO2 as N (mg/L)	NO3 as N (mg/L)	Cl (mg/L)	PO4_P mg/L	Total N (mg/L)	Total P (mg/L)	F (mg/L)	Ca (mg/L)	Mg (mg/L)	Na (mg/L)
ANZECC (2000) FAE 95%		**0.7**				**0.9**					
ANZECC (2000) Livestock		**400**	**30**					**2**	**1000**		
ANZECC (2000) Irrigation LTV				***<175-700***		**5**	**0.05**	**1**			***<115-460***
ADWG(2011) Health		**0.91**	**11.29**					**1.5**			
ADWG(2011) Aesthetic				**250**							**180**
Blue plastic (BP)	26/04/2018										
Green plastic (GP)	26/04/2018							***0.05***			
Rinse water (RW)	12/04/2018	***0.0025***	0.01	1.5	***0.0025***	0.08	0.005	***0.05***	0.5	***0.05***	1
Ore (OR)	1/05/2018	0.145	3.69	1180	***0.0025***	5.46	***0.05***	0.9	126	130	642
Ore (OR)	5/06/2018	0.295	3.27	1820	***0.0025***	4.81	0.015	1.1	179	182	788
Ore (OR)	3/07/2018	***0.0025***	7.47	1800	0.01	8.56	0.01	1.1	197	203	921
Overburden high Fe (BF1)	1/05/2018	6.34	12.4	1520	0.01	20.8	***0.125***	0.6	340	185	635
Overburden high Fe (BF1)	5/06/2018	***0.0025***	12.4	1390	0.015	14.3	0.025	0.7	325	176	642
Overburden high Fe (BF1)	3/07/2018	***0.0025***	16.2	1150	0.055	16.8	0.075	0.7	269	143	581
Overburden high Fe (BF2)	1/05/2018	1.51	14.8	2270	0.01	61.6	***0.125***	0.6	388	265	923
Overburden high Fe (BF2)	5/06/2018	***0.0025***	14.8	1470	0.02	14.8	0.025	0.7	255	179	731
Overburden high Fe (BF2)	3/07/2018	***0.0025***	13.9	991	0.02	14.4	0.025	0.9	158	112	566
Overburden no Fe (BO)	1/05/2018	0.005	4.47	518	0.035	13.3	0.32	0.7	40.1	50.4	320
Overburden no Fe (BO)	5/06/2018	***0.0025***	3.72	682	0.05	4.73	0.07	0.9	56.2	73.2	426
Overburden no Fe (BO)	3/07/2018	***0.0025***	5	621	0.06	5.18	0.095	0.9	48.6	63.3	408
Top soil and surface sand (TS)	1/05/2018	0.025	47.1	12.3	0.015	50.8	***0.05***	***0.05***	38.3	11.7	6.1
Top soil and surface sand (TS)	5/06/2018	0.355	10.3	5.1	0.035	11.1	0.05	***0.05***	14.5	4.7	3.4
Top soil and surface sand (TS)	3/07/2018	0.02	2.54	3.4	0.04	3.13	0.045	***0.05***	10.6	3.6	3.5

Half detection limit

Leachate sample source	Leachate date	SO4 (mg/L)	Ag (mg/L)	Al (mg/L)	As (mg/L)	B (mg/L)	Ba (mg/L)	Be (mg/L)	Cd (mg/L)	Co (mg/L)	Cu (mg/L)	Fe (mg/L)
ANZECC (2000) FAE 95%					**0.013**	**0.37**			**0.0002**		**0.0014**	
ANZECC (2000) Livestock		**1000**		**5**	**0.5**	**5**			**0.01**	**1**	**0.5**	
ANZECC (2000) Irrigation LTV				**5**	**0.1**	**0.5**		**0.1**	**0.01**	**0.05**	**0.2**	
ADWG(2011) Health		**500**	**0.1**		**0.01**	**4**	**2**	**0.06**	**0.002**		**2**	
ADWG(2011) Aesthetic		**250**	**NA**	**0.2**							**1**	**0.3**
Blue plastic (BP)	26/04/2018		***0.00025***	***0.0005***	***0.00025***	***0.00025***	***0.0001***	***0.00025***	***0.0001***	***0.00005***	0.0027	***0.01***
Green plastic (GP)	26/04/2018		***0.00025***	0.006	***0.00025***	***0.00025***	0.0028	***0.00025***	***0.0001***	***0.00005***	0.002	***0.01***
Rinse water (RW)	12/04/2018	0.3	***0.00025***	0.007	***0.00025***	***0.00025***	0.0022	***0.00025***	***0.0001***	***0.00005***	0.0016	***0.01***
Ore (OR)	1/05/2018	457	***0.00025***	0.008	0.0015	1.36	0.0574	***0.00025***	0.0006	0.0007	0.0064	***0.01***
Ore (OR)	5/06/2018	655	***0.00025***	0.007	0.0015	1.51	0.0584	***0.00025***	0.0014	0.0003	0.0079	***0.01***
Ore (OR)	3/07/2018	737	***0.00025***	0.007	0.0015	1.59	0.057	***0.00025***	0.0012	0.0003	0.0082	***0.01***
Overburden high Fe (BF1)	1/05/2018	794	***0.00025***	0.004	0.0025	0.75	0.111	***0.00025***	0.0012	0.0029	0.0165	***0.01***
Overburden high Fe (BF1)	5/06/2018	805	***0.00025***	0.007	0.0025	0.74	0.071	***0.00025***	0.0006	0.002	0.0127	***0.01***
Overburden high Fe (BF1)	3/07/2018	731	***0.00025***	0.003	0.002	0.65	0.058	***0.00025***	0.0008	0.0017	0.0094	***0.01***
Overburden high Fe (BF2)	1/05/2018	871	***0.00025***	0.008	0.0015	0.7	0.141	***0.00025***	0.0008	0.0069	0.0087	***0.01***
Overburden high Fe (BF2)	5/06/2018	738	***0.00025***	0.005	0.001	0.68	0.0704	***0.00025***	0.0004	0.0063	0.0092	***0.01***
Overburden high Fe (BF2)	3/07/2018	562	***0.00025***	0.004	0.001	0.555	0.0484	***0.00025***	0.001	0.0053	0.009	***0.01***
Overburden no Fe (BO)	1/05/2018	196	***0.00025***	0.004	0.001	0.515	0.0974	***0.00025***	0.0006	***0.00005***	0.0032	***0.01***
Overburden no Fe (BO)	5/06/2018	287	***0.00025***	0.004	0.001	0.655	0.0852	***0.00025***	0.0002	***0.00005***	0.0019	***0.01***
Overburden no Fe (BO)	3/07/2018	264	***0.00025***	***0.0005***	***0.00025***	0.12	0.0152	***0.00025***	***0.0001***	***0.00005***	0.0003	***0.01***
Top soil and surface sand (TS)	1/05/2018	21.3	***0.00025***	0.015	***0.00025***	0.135	0.529	***0.00025***	0.0004	0.0161	0.0027	***0.01***
Top soil and surface sand (TS)	5/06/2018	42.8	***0.00025***	0.011	***0.00025***	0.095	0.182	***0.00025***	***0.0001***	0.0185	0.0013	***0.01***
Top soil and surface sand (TS)	3/07/2018	37.4	***0.00025***	0.029	***0.00025***	0.07	0.124	***0.00025***	0.0006	0.0023	0.0017	***0.01***

Half detection limit

Leachate sample source	Leachate date	Hg (mg/L)	Mn (mg/L)	Mo (mg/L)	Ni (mg/L)	Pb (mg/L)	Sb (mg/L)	Se (mg/L)	U mg/L	Zn (mg/L)
ANZECC (2000) FAE 95%						**0.0034**				**0.008**
ANZECC (2000) Livestock		**0.002**	**0.1**	**0.05**	**1**			**0.02**	**0.2**	**20**
ANZECC (2000) Irrigation LTV		**0.002**	**0.2**	**0.01**	**0.2**	**2**		**0.02**	**0.01**	**2**
ADWG(2011) Health		**0.001**	**0.5**	**0.05**	**0.02**	**0.01**	**0.003**	**0.01**	**0.017**	**NA**
ADWG(2011) Aesthetic			**0.1**							**3**
Blue plastic (BP)	26/04/2018		***0.000025***	***0.00025***	***0.00005***	0.0003	***0.00025***	***0.001***	***0.000005***	0.003
Green plastic (GP)	26/04/2018		0.003	***0.00025***	0.0003	0.0007	0.012	***0.001***	***0.000005***	0.046
Rinse water (RW)	12/04/2018	***0.0001***	0.0027	***0.00025***	0.0003	0.0008	0.012	***0.001***	***0.000005***	0.046
Ore (OR)	1/05/2018		0.0744	0.0045	0.0021	0.0008	0.0055	0.004	0.0303	0.069
Ore (OR)	5/06/2018	0.00238	0.0773	0.006	0.0026	0.0003	0.0055	0.006	0.0573	0.052
Ore (OR)	3/07/2018	0.003	0.0961	0.007	0.0028	0.0004	0.006	0.006	0.0698	0.028
Overburden high Fe (BF1)	1/05/2018		0.0914	0.002	0.0095	0.0007	0.0045	0.008	0.0399	0.054
Overburden high Fe (BF1)	5/06/2018	***0.0001***	0.0044	0.0025	0.0075	0.0002	0.001	0.008	0.0418	0.03
Overburden high Fe (BF1)	3/07/2018	***0.00005***	0.0051	0.0025	0.0053	0.0002	0.002	0.006	0.0322	0.024
Overburden high Fe (BF2)	1/05/2018		0.008	***0.00025***	0.0291	0.0042	0.0025	0.014	0.00817	0.057
Overburden high Fe (BF2)	5/06/2018	***0.0001***	0.001	***0.00025***	0.0266	0.0014	0.0015	0.01	0.00994	0.025
Overburden high Fe (BF2)	3/07/2018	***0.00005***	0.0015	0.001	0.0208	0.0014	0.002	0.008	0.00896	0.02
Overburden no Fe (BO)	1/05/2018		0.0005	0.0025	0.0007	0.0004	0.012	0.004	0.00049	0.011
Overburden no Fe (BO)	5/06/2018	***0.00005***	0.0027	0.003	0.0007	0.0005	0.0035	0.004	0.00327	0.006
Overburden no Fe (BO)	3/07/2018	***0.00005***	0.0001	0.0005	0.0001	***0.00005***	0.0005	***0.001***	0.00066	***0.002***
Top soil and surface sand (TS)	1/05/2018		1.57	***0.00025***	0.009	0.0016	0.007	***0.001***	0.00001	0.069
Top soil and surface sand (TS)	5/06/2018	***0.00001***	1.32	***0.00025***	0.0034	0.0002	0.0015	***0.001***	0.00001	0.012
Top soil and surface sand (TS)	3/07/2018	***0.00001***	0.615	***0.00025***	0.0023	0.0001	0.0015	***0.001***	0.00003	0.007

Half detection limit

Table 2-2 Initial values compared to hardness corrected values against ANZECC (2000) FAE 95% guidelines.

Leachate sample source	**Month**	**Cd mg/L**	**Cu mg/L**	**Pb mg/L**	**Ni mg/L**	**Zn mg/L**	**Cd_HC (mg/L)**	**Cu_HC (mg/L)**	**Pb_HC (mg/L)**	**Ni_HC (mg/L)**	**Zn_HC (mg/L)**
ANZECC (2000) FAE 95%		*0.0002*	*0.001*	*0.0034*	*0.011*	*0.008*	*0.0002*	*0.001*	*0.0034*	*0.011*	*0.008*
Blue plastic (BP)	April	***0.0001***	0.003	0.0003	***0.00005***	0.003					
Green plastic (GP)	April	***0.0001***	0.002	0.0007	0.0003	0.046					
Rinse water (RW)	April	***0.0001***	0.002	0.0008	0.00030	0.046	0.0015	0.021	0.0374	0.004	0.603
Ore (OR)	May	0.0006	0.006	0.0008	0.00210	0.069	0.0000	0.000	0.0000	0.000	0.004
Ore (OR)	June	0.0014	0.008	0.0003	0.00260	0.052	0.0001	0.000	0.0000	0.000	0.002
Ore (OR)	July	0.0012	0.008	0.0004	0.00280	0.028	0.0000	0.000	0.0000	0.000	0.001
Overburden high Fe (BF1)	May	0.0012	0.017	0.0007	0.00950	0.054	0.0000	0.001	0.0000	0.000	0.002
Overburden high Fe (BF1)	June	0.0006	0.013	0.0002	0.00750	0.030	0.0000	0.000	0.0000	0.000	0.001
Overburden high Fe (BF1)	July	0.0008	0.009	0.0002	0.00530	0.024	0.0000	0.000	0.0000	0.000	0.001
Overburden high Fe (BF2)	May	0.0008	0.009	0.0042	0.02910	0.057	0.0000	0.000	0.0000	0.001	0.002
Overburden high Fe (BF2)	June	0.0004	0.009	0.0014	0.02660	0.025	0.0000	0.000	0.0000	0.001	0.001
Overburden high Fe (BF2)	July	0.0010	0.009	0.0014	0.02080	0.020	0.0001	0.001	0.0000	0.001	0.001
Overburden no Fe (BO)	May	0.0006	0.003	0.0004	0.00070	0.011	0.0001	0.000	0.0000	0.000	0.002
Overburden no Fe (BO)	June	0.0002	0.002	0.0005	0.00070	0.006	0.0000	0.000	0.0000	0.000	0.001
Overburden no Fe (BO)	July	***0.0001***	0.000	***0.0001***	0.00010	0.002	0.0000	0.000	0.0000	0.000	0.000
Top soil and surface sand (TS)	May	0.0004	0.003	0.0016	0.00900	0.069	0.0001	0.001	0.0002	0.002	0.018
Top soil and surface sand (TS)	June	***0.0001***	0.001	0.0002	0.00340	0.012	0.0001	0.001	0.0001	0.002	0.007
Top soil and surface sand (TS)	July	0.0006	0.002	0.0001	0.00230	0.007	0.0005	0.001	0.0001	0.002	0.005

ANZECC (2000) FAE 95%	
ANZECC (2000) FAE 95% x10	
ANZECC (2000) FAE 95% x100	

2.2.8 Comparison with Groundwater

The barrel leach EC is higher than the groundwater in all samples except for the Top Soil sample. There are several metals and metalloids from the barrel leach results that report below groundwater levels (e.g., Al, Cd, Fe and Mo). In the case of Al and Fe this is contrary to ASLP predictions. Most major and minor ions report above groundwater with F and total P as exceptions.

The carbonate exceeds the average groundwater by over 100x in all samples except the topsoil where it exceeds it by 10x. It is not released under the reported pHs in the leach so is not of great concern. Nitrogen dioxide (NO_2) exceeds the average groundwater by over 100x in the initial measurements for the high ironstone overburden but is below detection limits for subsequent measurements, indicating this may be the result of first flush effects.

Antimony is above groundwater levels with some samples up to 10x greater. This is likely due to the contamination from the transport container and rinse water as the values in those also exceed groundwater levels.

Barium, cobalt and manganese are at least 10x greater in concentration than groundwater levels but only in the Top Soil sample the remainder report below 10x or below groundwater levels. Initial results for Ba and Mn are highest with gradual decrease in concentration over time for both indicating high result may be due to first flush effects.

Nickle is 10x the groundwater level for the high ironstone overburden 2 (BF2) sample all other samples are below 10x the groundwater levels or less than those levels.

While the results report both above and below average groundwater concentrations for different elements, overall the concentrations are unlikely to impact on groundwater quality other than immediately below the pit.

2.2.9 Contamination in blanks

The reagent water and sample transport containers (e.g., drinking water grade blue and green HDPE bottles) and the rinse water from the apparatus (green HDPE drums) showed levels of Zn, Cu and Sb above guideline values, with Zn and Cu exceeding FAE 95% values and Sb exceeding ADWG health guidelines (Table 2-1). The blue plastic container only exceeded FAE 95% guidelines for Cu and the green plastic container and the rinse water exceeded the guidelines for Zn and Sb. Therefore, high levels of Cu, Zn and Sb in the samples could be partially due to the high levels in the transport containers. The blue and green plastic sample containers and the rinse water reported below all guidelines for all other elements.

2.2.10 Summary

The initial results for the barrel leach data are based only on three data points per sample. As such, care should be taken to avoid interpreting trends at this stage. As more data become available, a more thorough interpretation of results can be conducted. The plots from 2-2 to 2-13 will be added to and used as ongoing figures, and trends observed in these plots will determine the suitability of the runoff from the piles for irrigation, dust control or if necessary proper treatment and storage.

Table 2-3 Barrel leach results compared to average groundwater.

Leachate sample source	Leachate date	pH units	EC µS/cm	Na mg/L	K mg/L	Ca mg/L	mg/L mg/L	Bi-carbonate as $Ca(HCO_3)_2$ (0.5 = <LOR) mg/L	Carbonate as $CaCO_3$ (0.5 = <LOR) mg/L	Cl mg/L	SO4 mg/L
Average Groundwater		*7.9*	*1530*	*124*	*23*	*93*	*53*	*358*	*0.5*	*146*	*267*
Blue plastic (BP)	26/04/2018										
Green plastic (GP)	26/04/2018										
Rinse water (RW)	12/04/2018	6.5	12	1	***0***	0.5	***0***	5	1	2	0
Ore (OR)	1/05/2018	7.7	4670	642	47	126	130	306	126.5	1180	457
Ore (OR)	5/06/2018	8.0	5840	788	55	179	182	357	179.5	1820	655
Ore (OR)	3/07/2018	8.0	6390	921	63	197	203	371	197.5	1800	737
Overburden high Fe (BF1)	1/05/2018	7.6	5740	635	36	340	185	590	340.5	1520	794
Overburden high Fe (BF1)	5/06/2018	7.7	5520	642	35	325	176	561	325.5	1390	805
Overburden high Fe (BF1)	3/07/2018	7.9	4790	581	32	269	143	477	269.5	1150	731
Overburden high Fe (BF2)	1/05/2018	7.4	7720	923	86	388	265	544	388.5	2270	871
Overburden high Fe (BF2)	5/06/2018	7.7	5830	731	66	255	179	431	255.5	1470	738
Overburden high Fe (BF2)	3/07/2018	7.9	4220	566	54	158	112	334	158.5	991	562
Overburden no Fe (BO)	1/05/2018	7.6	2200	320	37	40.1	50	244	40.6	518	196
Overburden no Fe (BO)	5/06/2018	7.9	2840	426	44	56.2	73	400	56.7	682	287
Overburden no Fe (BO)	3/07/2018	8.0	2600	408	45	48.6	63	375	49.1	621	264
Top soil and surface sand (TS)	1/05/2018	5.8	582	6.1	49	38.3	12	50	38.8	12	21
Top soil and surface sand (TS)	5/06/2018	6.1	268	3.4	32	14.5	5	47	15	5	43
Top soil and surface sand (TS)	3/07/2018	6.6	209	3.5	30	10.6	4	79	11.1	3	37

Legend	
Average Groundwater	***Half Detection Limit***
Average Groundwater x10	
Average Groundwater x100	

Leachate sample source	Leachate date	SAR	Al mg/L	Sb mg/L	As mg/L	Ba mg/L	Be mg/L	B mg/L	Cd mg/L	Co mg/L	Cu mg/L
Average Groundwater		*3.0*	*0.041*	*0.001*	*0.002*	*0.028*	*0.0005*	*0.38*	*0.0055*	*0.0008*	*0.003*
Blue plastic (BP)	26/04/2018		***0.0005***	***0.00025***	***0.00025***	***0.0001***	***0.00025***	***0.00025***	***0.0001***	***0.00005***	0.003
Green plastic (GP)	26/04/2018		0.006	0.0120	***0.00025***	0.003	***0.00025***	***0.00025***	***0.0001***	***0.00005***	0.002
Rinse water (RW)	12/04/2018	0.4	0.007	0.0120	***0.00025***	0.002	***0.00025***	***0.00025***	***0.0001***	***0.00005***	0.002
Ore (OR)	1/05/2018	9.6	0.008	0.0055	0.002	0.057	***0.00025***	1.36	0.0006	0.0007	0.006
Ore (OR)	5/06/2018	9.9	0.007	0.0055	0.002	0.058	***0.00025***	1.51	0.0014	0.0003	0.008
Ore (OR)	3/07/2018	11.0	0.007	0.0060	0.002	0.057	***0.00025***	1.59	0.0012	0.0003	0.008
Overburden high Fe (BF1)	1/05/2018	6.9	0.004	0.0045	0.003	0.111	***0.00025***	0.75	0.0012	0.0029	0.017
Overburden high Fe (BF1)	5/06/2018	7.1	0.007	0.0010	0.003	0.071	***0.00025***	0.74	0.0006	0.0020	0.013
Overburden high Fe (BF1)	3/07/2018	7.1	0.003	0.0020	0.002	0.058	***0.00025***	0.65	0.0008	0.0017	0.009
Overburden high Fe (BF2)	1/05/2018	8.8	0.008	0.0025	0.002	0.141	***0.00025***	0.70	0.0008	0.0069	0.009
Overburden high Fe (BF2)	5/06/2018	8.6	0.005	0.0015	0.001	0.070	***0.00025***	0.68	0.0004	0.0063	0.009
Overburden high Fe (BF2)	3/07/2018	8.4	0.004	0.0020	0.001	0.048	***0.00025***	0.56	0.0010	0.0053	0.009
Overburden no Fe (BO)	1/05/2018	7.9	0.004	0.0120	0.001	0.097	***0.00025***	0.52	0.0006	***0.00005***	0.003
Overburden no Fe (BO)	5/06/2018	8.8	0.004	0.0035	0.001	0.085	***0.00025***	0.66	0.0002	***0.00005***	0.002
Overburden no Fe (BO)	3/07/2018	9.1	***0.0005***	0.0005	***0.00025***	0.015	***0.00025***	0.12	***0.0001***	***0.00005***	0.000
Top soil and surface sand (TS)	1/05/2018	0.2	0.015	0.0070	***0.00025***	0.529	***0.00025***	0.14	0.0004	0.0161	0.003
Top soil and surface sand (TS)	5/06/2018	0.2	0.011	0.0015	***0.00025***	0.182	***0.00025***	0.10	***0.0001***	0.0185	0.001
Top soil and surface sand (TS)	3/07/2018	0.2	0.029	0.0015	***0.00025***	0.124	***0.00025***	0.07	0.0006	0.0023	0.002

Average Groundwater	***Half Detection Limit***
Average Groundwater x10	
Average Groundwater x100	

Leachate sample source	Leachate date	Fe mg/L	Pb mg/L	Mn mg/L	Hg mg/L	Mo mg/L	Ni mg/L	Se mg/L	Ag mg/L	U mg/L	V mg/L
Average Groundwater		*0.544*	*0.0033*	*0.022*	*0.00005*	*0.256*	*0.0014*	*0.005*	*0.0014*	*0.014*	*0.005*
Blue plastic (BP)	26/04/2018	***0.01***	0.0003	***0.000025***		***0.00025***	***0.00005***	***0.001***	***0.00025***	***0.000005***	***0.00025***
Green plastic (GP)	26/04/2018	***0.01***	0.0007	0.003		***0.00025***	0.0003	***0.001***	***0.00025***	***0.000005***	***0.00025***
Rinse water (RW)	12/04/2018	***0.01***	0.0008	0.003	***0.0001***	***0.00025***	0.0003	***0.001***	***0.00025***	***0.000005***	***0.00025***
Ore (OR)	1/05/2018	***0.01***	0.0008	0.074		0.005	0.0021	0.004	***0.00025***	0.030	0.014
Ore (OR)	5/06/2018	***0.01***	0.0003	0.077	0.00238	0.006	0.0026	0.006	***0.00025***	0.057	0.017
Ore (OR)	3/07/2018	***0.01***	0.0004	0.096	0.00300	0.007	0.0028	0.006	***0.00025***	0.070	0.018
Overburden high Fe (BF1)	1/05/2018	***0.01***	0.0007	0.091		0.002	0.0095	0.008	***0.00025***	0.040	0.004
Overburden high Fe (BF1)	5/06/2018	***0.01***	0.0002	0.004	***0.0001***	0.003	0.0075	0.008	***0.00025***	0.042	0.005
Overburden high Fe (BF1)	3/07/2018	***0.01***	0.0002	0.005	***0.00005***	0.003	0.0053	0.006	***0.00025***	0.032	0.004
Overburden high Fe (BF2)	1/05/2018	***0.01***	0.0042	0.008		***0.00025***	0.0291	0.014	***0.00025***	0.008	0.003
Overburden high Fe (BF2)	5/06/2018	***0.01***	0.0014	0.001	***0.0001***	***0.00025***	0.0266	0.010	***0.00025***	0.010	0.005
Overburden high Fe (BF2)	3/07/2018	***0.01***	0.0014	0.002	***0.00005***	0.001	0.0208	0.008	***0.00025***	0.009	0.005
Overburden no Fe (BO)	1/05/2018	***0.01***	0.0004	0.001		0.003	0.0007	0.004	***0.00025***	0.000	0.016
Overburden no Fe (BO)	5/06/2018	***0.01***	0.0005	0.003	***0.00005***	0.003	0.0007	0.004	***0.00025***	0.003	0.021
Overburden no Fe (BO)	3/07/2018	***0.01***	***0.00005***	0.000	***0.00005***	0.001	0.0001	***0.001***	***0.00025***	0.001	0.004
Top soil and surface sand (TS)	1/05/2018	***0.01***	0.0016	1.570		***0.00025***	0.0090	***0.001***	***0.00025***	0.000	***0.00025***
Top soil and surface sand (TS)	5/06/2018	***0.01***	0.0002	1.320	***0.00001***	***0.00025***	0.0034	***0.001***	***0.00025***	0.000	***0.00025***
Top soil and surface sand (TS)	3/07/2018	***0.01***	0.0001	0.615	***0.00001***	***0.00025***	0.0023	***0.001***	***0.00025***	0.000	0.001

Average Groundwater	***Half Detection Limit***
Average Groundwater x10	
Average Groundwater x100	

Leachate sample source	Leachate date	Zn mg/L	F mg/L	NO2 mg/L	NO3 mg/L	Total N mg/L	Total P mg/L
Average Groundwater		*0.024*	*1.28*	*0.009*	*7.80*	*6.75*	*0.215*
Blue plastic (BP)	26/04/2018	0.003					
Green plastic (GP)	26/04/2018	0.046	***0.05***				
Rinse water (RW)	12/04/2018	0.046	***0.05***	***0.0025***	0.01	0.08	0.005
Ore (OR)	1/05/2018	0.069	0.90	0.145	3.69	5.46	***0.05***
Ore (OR)	5/06/2018	0.052	1.10	0.295	3.27	4.81	0.015
Ore (OR)	3/07/2018	0.028	1.10	***0.0025***	7.47	8.56	0.010
Overburden high Fe (BF1)	1/05/2018	0.054	0.60	6.340	12.40	20.80	***0.125***
Overburden high Fe (BF1)	5/06/2018	0.030	0.70	***0.0025***	12.40	14.30	0.025
Overburden high Fe (BF1)	3/07/2018	0.024	0.70	***0.0025***	16.20	16.80	0.075
Overburden high Fe (BF2)	1/05/2018	0.057	0.60	1.510	14.80	61.60	***0.125***
Overburden high Fe (BF2)	5/06/2018	0.025	0.70	***0.0025***	14.80	14.80	0.025
Overburden high Fe (BF2)	3/07/2018	0.020	0.90	***0.0025***	13.90	14.40	0.025
Overburden no Fe (BO)	1/05/2018	0.011	0.70	0.005	4.47	13.30	0.32
Overburden no Fe (BO)	5/06/2018	0.006	0.90	***0.0025***	3.72	4.73	0.070
Overburden no Fe (BO)	3/07/2018	0.002	0.90	***0.0025***	5.00	5.18	0.095
Top soil and surface sand (TS)	1/05/2018	0.069	***0.05***	0.025	47.10	50.80	***0.05***
Top soil and surface sand (TS)	5/06/2018	0.012	***0.05***	0.355	10.30	11.10	0.050
Top soil and surface sand (TS)	3/07/2018	0.007	***0.05***	0.020	2.54	3.13	0.045

Average Groundwater	***Half Detection Limit***
Average Groundwater x10	
Average Groundwater x100	

2.3 Barrel leach compared to ASLP

Leachate results that are above the guidelines do not definitively indicate unacceptable leachate will be generated, but they act as a screening tool and identify the need for additional testing that more closely mimics the storage environment to be carried out.

There are ASLP results for both the individual leach barrels (e.g., top soil, ore, low ironstone overburden, and high ironstone overburden 1 and 2) and the various waste rock piles combined. The combined waste rock ASLP values are based of several rock types and represent an average of the site's waste rock. The barrel leach values are calculated for separate materials at the site (e.g., ore, overburden, top soil). Therefore, a comparison between the values is not a direct comparison of the two techniques and this should be noted when observing combined results (Table 2-3). The ASLP results for individual leach barrels are comparable to the barrel leach results as both assessed the same suite of elements and used the same source material.

2.3.1 Barrel sample ASLP results

Barrel leach results are compared to ASLP results for each barrel, but as this study is in the early stages each barrel only has three measurements. The initial, final and average measurements for each barrel have been compared to the ASLP results, this will be updated as more measurements are collected.

The majority of elements report below that of the ASLP results or at the detection limit. Copper, Zn and Sb report over limits due to contamination from the rinse water and the transport containers. Other notable differences include the ASLP results overestimating Fe and Al in some cases by over 100x. Elevated aluminium is a common occurrence in ASLP tests due to the release of colloidal clays during the leachate test not being removed by filtration. Given that aluminium solubility is pH controlled, and pH is more neutral in barrel tests, it is unlikely that unacceptably high concentrations would occur in the circum-neutral leachate.

Lead was a concern in initial ASLP combined results as one of the samples exceeded the FAE 95%. However, Pb does not exceed any of the other guidelines and the barrel results show that while it initially reports at similar or higher levels to the ASLP results it reduces to below ASLP results by the third month.

The major ions (Na, K, Ca, Mg and SO_4) in the barrel leach are greater than the ASLP prediction (Table 2-3). These are likely higher as the leach test allows for evaporation, which concentrates the major ions in the samples, whereas the ASLP test is sealed and no evaporation occurs. Results for some of the major and minor ion (e.g., Cl, NO_2, NO_3, OH, CO_3, HCO_3 and F) are not yet available for comment.

Initial elements of concern for the combined ASLP were Al, F, Pb, Cu and Zn, based on the findings of the barrel sample ASLP results (awaiting F results) these metals are lower than the ASLP predicted or in the case of Cu and Zn contaminated by external sources.

Table 2-4 ASLP results compared to initial, final and average barrel leach results.

		ASLP					Barrel Leach Initial					Barrel Leach Final					Barrel Leach Average				
		Top soil and surface sand (TS)	Ore (OR)	Overburden no Fe (BO)	Overburden High Fe	Overburden High Fe	Top soil and surface sand (TS)	Ore (OR)	Overburden low Fe (BO)	Overburden high Fe (BF1)	Overburden high Fe (BF2)	Top soil and surface sand (TS)	Ore (OR)	Overburden no Fe (BO)	Overburden high Fe (BF1)	Overburden high Fe (BF2)	Top soil and surface sand (TS)	Ore (OR)	Overburden no Fe (BO)	Overburden high Fe (BF1)	Overburden high Fe (BF2)
Ag	mg/L	0.0005	0.0005	0.0005	0.0005	0.0005	0.0003	0.0003	0.0003	0.0003	0.0003	0.0003	0.0003	0.0003	0.0003	0.0003	0.0003	0.0003	0.0003	0.0003	0.0003
Al	mg/L	0.1900	0.3200	2.8700	0.0050	0.5900	0.0150	0.0080	0.0040	0.0040	0.0080	0.0290	0.0070	0.0005	0.0030	0.0040	0.0183	0.0073	0.0028	0.0047	0.0057
As	mg/L	0.0030	0.0005	0.0005	0.0005	0.0005	0.0003	0.0015	0.0010	0.0025	0.0015	0.0003	0.0015	0.0003	0.0020	0.0010	0.0003	0.0015	0.0008	0.0023	0.0012
Ba	mg/L	0.0045	0.0015	0.0105	0.0025	0.0060	0.5290	0.0574	0.0974	0.1110	0.1410	0.1240	0.0570	0.0152	0.0580	0.0484	0.2783	0.0576	0.0659	0.0800	0.0866
Be	mg/L	0.0005	0.0005	0.0005	0.0005	0.0005	0.0003	0.0003	0.0003	0.0003	0.0003	0.0003	0.0003	0.0003	0.0003	0.0003	0.0003	0.0003	0.0003	0.0003	0.0003
Bi	mg/L	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001
Ca	mg/L	0.50	3.20	1.10	2.70	1.60	38.30	126.00	40.10	340.00	388.00	10.60	197.00	48.60	269.00	158.00	21.13	167.33	48.30	311.33	267.00
Cd	mg/L	0.0003	0.0003	0.0003	0.0003	0.0003	0.0004	0.0006	0.0006	0.0012	0.0008	0.0006	0.0012	0.0001	0.0008	0.0010	0.0004	0.0011	0.0003	0.0009	0.0007
Ce	mg/L	0.0004	0.0001	0.0024	0.0001	0.0010	0.0006	0.0001	0.0001	0.0001	0.0001	0.0004	0.0001	0.0001	0.0001	0.0001	0.0005	0.0001	0.0001	0.0001	0.0001
Co	mg/L	0.0004	0.0002	0.0002	0.0001	0.0001	0.0161	0.0007	0.0001	0.0029	0.0069	0.0023	0.0003	0.0001	0.0017	0.0053	0.0123	0.0004	0.0001	0.0022	0.0062
Cr	mg/L	0.0015	0.0015	0.0015	0.0015	0.0015	0.0005	0.0005	0.0005	0.0005	0.0040	0.0005	0.0010	0.0005	0.0005	0.0010	0.0005	0.0007	0.0005	0.0005	0.0023
Cs	mg/L	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0002	0.0001	0.0004	0.0004	0.0001	0.0003	0.0001	0.0003	0.0003	0.0001	0.0003	0.0001	0.0003	0.0003
Cu*	mg/L	0.0030	0.0006	0.0016	0.0002	0.0006	0.0027	0.0064	0.0032	0.0165	0.0087	0.0017	0.0082	0.0003	0.0094	0.0090	0.0019	0.0075	0.0018	0.0129	0.0090
Dy	mg/L	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001
Er	mg/L	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001
Eu	mg/L	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001
Fe	mg/L	0.4200	0.2400	1.3400	0.0015	0.0800	0.0015	0.0015	0.0015	0.0015	0.0015	0.0015	0.0015	0.0015	0.0015	0.0015	0.0015	0.0015	0.0015	0.0015	0.0015
Ga	mg/L	0.0001	0.0001	0.0008	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001
Gd	mg/L	0.0001	0.0001	0.0002	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001
Hf	mg/L	0.0001	0.0001	0.0001	0.0002	0.0002	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0002	0.0001	0.0002	0.0003	0.0001	0.0001	0.0001	0.0001	0.0001
Ho	mg/L	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001
In	mg/L	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001
K	mg/L	3.60	3.80	3.70	3.20	4.10	48.80	46.90	37.40	36.30	86.30	29.60	63.20	44.50	31.50	54.20	36.80	55.13	41.83	34.27	68.97
La	mg/L	0.0001	0.0001	0.0012	0.0001	0.0006	0.0002	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001
Li	mg/L	0.0010	0.0010	0.0010	0.0005	0.0010	0.0300	0.0170	0.0110	0.0245	0.0260	0.0055	0.0240	0.0020	0.0230	0.0170	0.0155	0.0208	0.0082	0.0238	0.0215
Lu	mg/L	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001
Mg	mg/L	0.70	2.40	1.00	1.70	1.30	11.70	130.00	50.40	185.00	265.00	3.60	203.00	63.30	143.00	112.00	6.67	171.67	62.30	168.00	185.33

		ASLP					Barrel Leach Initial					Barrel Leach Final					Barrel Leach Average				
		Top soil and surface sand (TS)	Ore (OR)	Overburden no Fe (BO)	Overburden High Fe	Overburden High Fe	Top soil and surface sand (TS)	Ore (OR)	Overburden low Fe (BO)	Overburden high Fe (BF1)	Overburden high Fe (BF2)	Top soil and surface sand (TS)	Ore (OR)	Overburden no Fe (BO)	Overburden high Fe (BF1)	Overburden high Fe (BF2)	Top soil and surface sand (TS)	Ore (OR)	Overburden no Fe (BO)	Overburden high Fe (BF1)	Overburden high Fe (BF2)
Mn	**mg/L**	0.0040	0.0014	0.0074	***0.0001***	0.0002	1.5700	0.0744	0.0005	0.0914	0.0080	0.6150	0.0961	0.0001	0.0051	0.0015	1.1683	0.0826	0.0011	0.0336	0.0035
Mo	**mg/L**	0.0010	***0.0005***	***0.0005***	0.0010	***0.0005***	***0.0003***	0.0045	0.0025	0.0020	***0.0003***	***0.0003***	0.0070	0.0005	0.0025	0.0010	0.0003	0.0058	0.0020	0.0023	0.0005
Na	**mg/L**	0.60	23.80	14.20	25.50	18.00	6.10	642.00	320.00	635.00	923.00	3.50	921.00	408.00	581.00	566.00	4.33	783.67	384.67	619.33	740.00
Nb	**mg/L**	***0.0003***	***0.0003***	***0.0003***	***0.0003***	***0.0003***	***0.0001***	***0.0001***	***0.0001***	***0.0001***	***0.0001***	***0.0001***	***0.0001***	***0.0001***	***0.0001***	***0.0001***	0.0001	0.0001	0.0001	0.0001	0.0001
Nd	**mg/L**	0.0002	***0.0001***	0.0012	***0.0001***	0.0006	0.0004	***0.0001***	***0.0001***	***0.0001***	***0.0001***	0.0003	***0.0001***	***0.0001***	***0.0001***	***0.0001***	0.0003	0.0001	0.0001	0.0001	0.0001
Ni	**mg/L**	0.0012	0.0010	0.0010	***0.0001***	0.0002	0.0090	0.0021	0.0007	0.0095	0.0291	0.0023	0.0028	0.0001	0.0053	0.0208	0.0049	0.0025	0.0005	0.0074	0.0255
P	**mg/L**	0.4000	***0.0500***	***0.0500***	***0.0500***	***0.0500***	***0.0500***	***0.0500***	0.3200	***0.1500***	***0.1500***	0.0450	0.0100	0.0950	0.0750	0.0250	0.0483	0.0250	0.1617	0.0833	0.0667
Pb	**mg/L**	0.0024	0.0004	0.0020	***0.0001***	0.0018	0.0016	0.0008	0.0004	0.0007	0.0042	0.0001	0.0004	***0.0001***	0.0002	0.0014	0.0006	0.0005	0.0003	0.0004	0.0023
Pr	**mg/L**	***0.0001***	***0.0001***	0.0002	***0.0001***	***0.0001***	***0.0001***	***0.0001***	***0.0001***	***0.0001***	***0.0001***	***0.0001***	***0.0001***	***0.0001***	***0.0001***	***0.0001***	0.0001	0.0001	0.0001	0.0001	0.0001
Rb	**mg/L**	0.0028	0.0040	0.0036	0.0030	0.0028	0.0275	0.0252	0.0162	0.0284	0.0564	0.0162	0.0299	0.0036	0.0231	0.0375	0.0208	0.0283	0.0131	0.0255	0.0463
Re	**mg/L**	***0.0001***	***0.0001***	***0.0001***	***0.0001***	***0.0001***	***0.0001***	***0.0001***	***0.0001***	***0.0001***	***0.0001***	***0.0001***	***0.0001***	***0.0001***	***0.0001***	***0.0001***	0.0001	0.0001	0.0001	0.0001	0.0001
SO_4	**mg/L**	0.78	19.50	10.02	33.00	12.36	21.30	457.00	196.00	794.00	871.00	37.40	737.00	264.00	731.00	562.00	33.83	616.33	249.00	776.67	723.67
Sb*	**mg/L**	***0.0005***	***0.0005***	***0.0005***	***0.0005***	***0.0005***	0.0070	0.0055	0.0120	0.0045	0.0025	0.0015	0.0060	0.0005	0.0020	0.0020	0.0033	0.0057	0.0053	0.0025	0.0020
Sc	**mg/L**	***0.0005***	***0.0005***	***0.0005***	***0.0005***	***0.0005***	***0.0003***	***0.0003***	***0.0003***	***0.0003***	***0.0003***	***0.0003***	***0.0003***	***0.0003***	***0.0003***	***0.0003***	0.0003	0.0003	0.0003	0.0003	0.0003
Se	**mg/L**	***0.0025***	***0.0025***	***0.0025***	***0.0025***	***0.0025***	***0.0015***	0.0040	0.0040	0.0080	0.0140	***0.0015***	0.0060	***0.0015***	0.0060	0.0080	0.0015	0.0053	0.0032	0.0073	0.0107
Sm	**mg/L**	***0.0001***	***0.0001***	0.0002	***0.0001***	***0.0001***	***0.0001***	***0.0001***	***0.0001***	***0.0001***	***0.0001***	***0.0001***	***0.0001***	***0.0001***	***0.0001***	***0.0001***	0.0001	0.0001	0.0001	0.0001	0.0001
Sn	**mg/L**	***0.0015***	***0.0015***	***0.0015***	***0.0015***	***0.0015***	***0.0005***	***0.0005***	***0.0005***	***0.0005***	***0.0005***	***0.0005***	***0.0005***	***0.0005***	***0.0005***	***0.0005***	0.0005	0.0005	0.0005	0.0005	0.0005
Sr	**mg/L**	0.03	0.02	0.01	0.05	0.02	0.34	2.12	0.95	3.88	5.23	0.10	3.27	0.23	3.28	2.38	0.19	2.80	0.85	3.74	3.74
Ta	**TYPE**	***0.0001***	***0.0001***	***0.0001***	***0.0001***	***0.0001***	***0.0003***	***0.0003***	***0.0003***	***0.0003***	***0.0003***	***0.0003***	***0.0003***	***0.0003***	***0.0003***	***0.0003***	0.0003	0.0003	0.0003	0.0003	0.0003
Tb	**mg/L**	***0.0001***	***0.0001***	***0.0001***	***0.0001***	***0.0001***	***0.0001***	***0.0001***	***0.0001***	***0.0001***	***0.0001***	***0.0001***	***0.0001***	***0.0001***	***0.0001***	***0.0001***	0.0001	0.0001	0.0001	0.0001	0.0001
Te	**mg/L**	***0.0005***	***0.0005***	***0.0005***	***0.0005***	***0.0005***	***0.0005***	***0.0005***	***0.0005***	***0.0005***	***0.0005***	***0.0005***	***0.0005***	***0.0005***	***0.0005***	***0.0005***	0.0005	0.0005	0.0005	0.0005	0.0005
Th	**mg/L**	***0.0001***	***0.0001***	0.0004	***0.0001***	0.0002	***0.0001***	***0.0001***	***0.0001***	***0.0001***	***0.0001***	***0.0001***	***0.0001***	***0.0001***	***0.0001***	***0.0001***	0.0001	0.0001	0.0001	0.0001	0.0001
Ti	**mg/L**	***0.0015***	***0.0015***	0.0800	***0.0015***	***0.0015***	***0.0015***	***0.0015***	***0.0015***	***0.0015***	***0.0015***	***0.0015***	***0.0015***	***0.0015***	***0.0015***	***0.0015***	0.0015	0.0015	0.0015	0.0015	0.0015
Tl	**mg/L**	***0.0001***	***0.0001***	***0.0001***	***0.0001***	***0.0001***	0.0002	0.0001	***0.0001***	0.0002	0.0006	0.0001	0.0001	***0.0001***	0.0002	0.0003	0.0001	0.0001	0.0001	0.0002	0.0004
Tm	**mg/L**	***0.0001***	***0.0001***	***0.0001***	***0.0001***	***0.0001***	***0.0001***	***0.0001***	***0.0001***	***0.0001***	***0.0001***	***0.0001***	***0.0001***	***0.0001***	***0.0001***	***0.0001***	0.0001	0.0001	0.0001	0.0001	0.0001
U	**mg/L**	0.0002	0.0001	0.0001	0.0001	0.0002	0.0000	0.0303	0.0005	0.0399	0.0082	0.0000	0.0698	0.0007	0.0322	0.0090	0.0000	0.0525	0.0015	0.0380	0.0090
V	**mg/L**	0.0050	0.0030	0.0060	0.0040	0.0080	***0.0003***	0.0135	0.0155	0.0035	0.0030	0.0005	0.0175	0.0040	0.0040	0.0045	0.0003	0.0160	0.0133	0.0040	0.0042

		ASLP					Barrel Leach Initial					Barrel Leach Final					Barrel Leach Average				
		Top soil and surface sand (TS)	Ore (OR)	Overburden no Fe (BO)	Overburden High Fe	Overburden High Fe	Top soil and surface sand (TS)	Ore (OR)	Overburden low Fe (BO)	Overburden high Fe (BF1)	Overburden high Fe (BF2)	Top soil and surface sand (TS)	Ore (OR)	Overburden no Fe (BO)	Overburden high Fe (BF1)	Overburden high Fe (BF2)	Top soil and surface sand (TS)	Ore (OR)	Overburden no Fe (BO)	Overburden high Fe (BF1)	Overburden high Fe (BF2)
W	mg/L	0.0060	***0.0005***	***0.0005***	0.0070	0.0030	***0.0003***	0.1180	0.0050	0.0105	***0.0003***	***0.0003***	0.3170	0.0015	0.0090	0.0005	0.0003	0.2253	0.0042	0.0092	0.0003
Y	mg/L	0.0003	0.0002	0.0009	***0.0001***	0.0015	0.0005	***0.0001***	***0.0001***	***0.0001***	0.0001	0.0004	***0.0001***	***0.0001***	***0.0001***	***0.0001***	0.0004	0.0001	0.0001	0.0001	0.0001
Yb	mg/L	***0.0001***	***0.0001***	***0.0001***	***0.0001***	0.0001	***0.0001***	***0.0001***	***0.0001***	***0.0001***	***0.0001***	***0.0001***	***0.0001***	***0.0001***	***0.0001***	***0.0001***	0.0001	0.0001	0.0001	0.0001	0.0001
Zn*	mg/L	0.0110	0.0030	0.0030	***0.0005***	0.0020	0.0690	0.0690	0.0110	0.0540	0.0570	0.0070	0.0280	***0.0005***	0.0240	0.0200	0.0293	0.0497	0.0058	0.0360	0.0340
Zr	mg/L	0.0020	0.0010	0.0030	***0.0005***	0.0030	***0.0003***	***0.0003***	***0.0003***	***0.0003***	***0.0003***	***0.0003***	***0.0003***	***0.0003***	***0.0003***	***0.0003***	0.0003	0.0003	0.0003	0.0003	0.0003

Greater than ASLP values
10x Greater than ASLP values
100X Greater than ASLP values
Less than ASLP values
10x Less than ASLP values
100x Less than ASLP values

* The blank samples were above the guidelines for Zn, Cu and Sb and so these metals should not be considered.

2.3.2 Combined sample ASLP results

The pH and EC in the barrel leachate results is mostly greater than that reported in the ASLP results with the exception of the overburden pH, which is less than the ASLP. The higher EC is likely due to evaporation.

The major ions (Na, K, Ca, Mg, SAR, bicarbonate as $Ca(HCO_3)_2$, carbonate as $CaCO_3$ Cl and SO_4) in the barrel leach ore and overburden are greater than the ASLP prediction, with minimum values up to 100x greater than minimums from ASLP (Table 2-3). These are likely higher as the leach test allows for evaporation which condenses the major ions in the samples, the ASLP test is sealed and no evaporation occurs.

Non-metallic inorganics such as total N and nitrate (NO_3), are in higher concentrations in the barrel leach samples compared to the ASLP results. Fluoride is in lower concentrations and this is likely due to the ASLP method releasing F from the samples when crushed.

The high Cu and Zn values in the leachate compared to the ASLP are likely from the contamination caused by the plastic transport containers and for these metals the ASLP values are thought to be more accurate. All other metals (e.g., Al, As, Cr, Co, Fe, Pb, Mn, U and V) are lower in the barrel leach samples than in the ASLP, with Al and Fe 100x less than the ASLP results. The greater concentrations of metals in the ASLP results are caused by the method finely crushing (<2.4 mm) and agitating the samples for several hours which results in larger volumes of material leaching. This is not reflective of how the waste piles are stored on site and in this case, the barrel leach results have more accurate metal leach concentrations.

Table 2-5 Barrel leach results compared to combined sample ASLP results

		ASLP				Barrel Leach Ore			
		Average	Median	Max	Min	Average	Median	Max	Min
pH	units	7.79	7.89	8.15	7.10	7.90	8.00	8.00	7.60
EC	µS/cm	309	280	746	52	5633	5840	6390	4790
Na	mg/L	23.89	20.00	85.00	2.50	783.67	788.00	921.00	581.00
K	mg/L	12.21	10.00	30.00	5.00	55.13	55.30	63.20	31.50
Ca	mg/L	9.29	8.00	46.00	1.00	167.33	197.00	340.00	269.00
Mg	mg/L	6.10	6.00	24.00	1.00	171.67	185.00	203.00	143.00
Bi-carbonate as Ca(HCO3)2 (0.5 = <LOR)		73.04	52.00	150.00	26.00	344.67	371.00	590.00	477.00
Carbonate as CaCO3 (0.5 = <LOR)		0.50	0.50	0.50	0.50	167.83	197.50	340.50	269.50
Cl	mg/L	81.15	58.50	400.00	4.00	1600.000	1800.000	1800.000	1150.000
SO4	mg/L	43.56	29.00	570.00	4.00	616.333	737.000	805.000	731.000
SAR		1.57637	1.43	4.46	0.16	10.165	9.914	10.999	6.885
Al	mg/L	8.221	2.5	40	2.5	0.007	0.007	0.007	0.003
As	mg/L	0.002	0.002	0.005	0.0005	0.002	0.002	0.003	0.002
Cr	mg/L	0.050	0.050	0.050	0.050	0.001	0.001	0.001	0.001
CO	mg/L	0.012	0.002	0.148	0.001	0.000	0.000	0.003	0.002
Cu	mg/L	0.003	0.002	0.028	0.001	0.008	0.008	0.017	0.009
Fe	mg/L	4.231	2.500	20.000	2.500	0.010	0.010	0.010	0.010
Pb	mg/L	0.009	0.004	0.052	0.001	0.001	0.000	0.001	0.000
Mn	mg/L	0.500	0.500	0.500	0.500	0.083	0.091	0.096	0.004
U	mg/L	0.500	0.500	0.500	0.500	0.052	0.057	0.070	0.032
V	mg/L	0.500	0.500	0.500	0.500	0.016	0.017	0.018	0.004
Zn	mg/L	0.023	0.012	0.214	0.006	0.050	0.052	0.054	0.024
F	mg/L	2.688	2.000	12.000	0.100	1.033	1.100	1.100	0.600
NO2	mg/L	0.472	0.050	4.000	0.050	0.148	0.295	6.340	0.003
NO3	mg/L	1.937	1.000	7.000	0.400	4.810	7.470	12.400	12.400
Total N	mg/L	2.409	2.000	9.000	0.450	6.277	8.560	20.800	14.300
Total P	mg/L	0.569	0.500	2.000	0.500	0.025	0.015	0.125	0.025

Legend
Greater than ASLP
10x greater than ASLP
100x greater than ASLP
Less than ASLP
10x less than ASLP
100x less than ASLP

		ASLP				Barrel Leach Overburden			
		Average	Median	Max	Min	Average	Median	Max	Min
pH	units	7.79	7.89	8.15	7.10	7.74	7.70	8.00	5.80
EC	µS/cm	309	280	746	52	4607	4220	7720	209
Na	mg/L	23.89	20.00	85.00	2.50	581.33	566.00	923.00	3.40
K	mg/L	12.21	10.00	30.00	5.00	48.36	44.50	86.30	29.60
Ca	mg/L	9.29	8.00	46.00	1.00	208.88	158.00	388.00	10.60
Mg	mg/L	6.10	6.00	24.00	1.00	138.54	112.00	265.00	3.60
Bi-carbonate as Ca(HCO3)2 (0.5 = <LOR)		73.04	52.00	150.00	26.00	439.54	400.20	544.00	46.50
Carbonate as CaCO3 (0.5 = <LOR)		0.50	0.50	0.50	0.50	209.38	158.50	388.50	11.10
Cl	mg/L	81.15	58.50	400.00	4.00	1179.111	991.000	2270.000	3.400
SO4	mg/L	43.56	29.00	570.00	4.00	583.111	562.000	871.000	21.300
SAR		1.57637	1.43	4.46	0.16	8.092	8.420	9.084	0.198
Al	mg/L	8.221	2.5	40	2.5	0.004	0.004	0.015	0.001
As	mg/L	0.002	0.002	0.005	0.0005	0.001	0.001	0.002	0.000
Cr	mg/L	0.050	0.050	0.050	0.050	0.001	0.001	0.004	0.001
CO	mg/L	0.012	0.002	0.148	0.001	0.003	0.002	0.019	0.000
Cu	mg/L	0.003	0.002	0.028	0.001	0.008	0.009	0.009	0.000
Fe	mg/L	4.231	2.500	20.000	2.500	0.010	0.010	0.010	0.010
Pb	mg/L	0.009	0.004	0.052	0.001	0.001	0.001	0.004	0.000
Mn	mg/L	0.500	0.500	0.500	0.500	0.013	0.003	1.570	0.000
U	mg/L	0.500	0.500	0.500	0.500	0.016	0.008	0.032	0.000
V	mg/L	0.500	0.500	0.500	0.500	0.007	0.005	0.021	0.000
Zn	mg/L	0.023	0.012	0.214	0.006	0.025	0.024	0.069	0.002
F	mg/L	2.688	2.000	12.000	0.100	0.744	0.700	0.900	0.050
NO2	mg/L	0.472	0.050	4.000	0.050	0.874	0.003	1.510	0.003
NO3	mg/L	1.937	1.000	7.000	0.400	10.854	13.900	47.100	2.540
Total N	mg/L	2.409	2.000	9.000	0.450	18.434	14.400	61.600	3.130
Total P	mg/L	0.569	0.500	2.000	0.500	0.098	0.070	0.320	0.025

Greater than ASLP
10x greater than ASLP
100x greater than ASLP
Less than ASLP
10x less than ASLP
100x less than ASLP

3. Conclusions

The results of the barrel leach tests are ongoing but at this stage indicate that some of the material may produce leachate with moderately elevated metals relative to aquatic ecosystem or drinking water guidelines. On the whole the leachate was generally within levels suitable for Livestock and irrigation.

Salinity levels were classified as very low to medium (DME - Queensland Department of Mines and Energy, 1995) and Sodium Adsorption Ratios are lower than predicted and fall into the stable soil category with low risk of soil dispersion. Based on these values leachate and runoff may be suitable for dust control or irrigation.

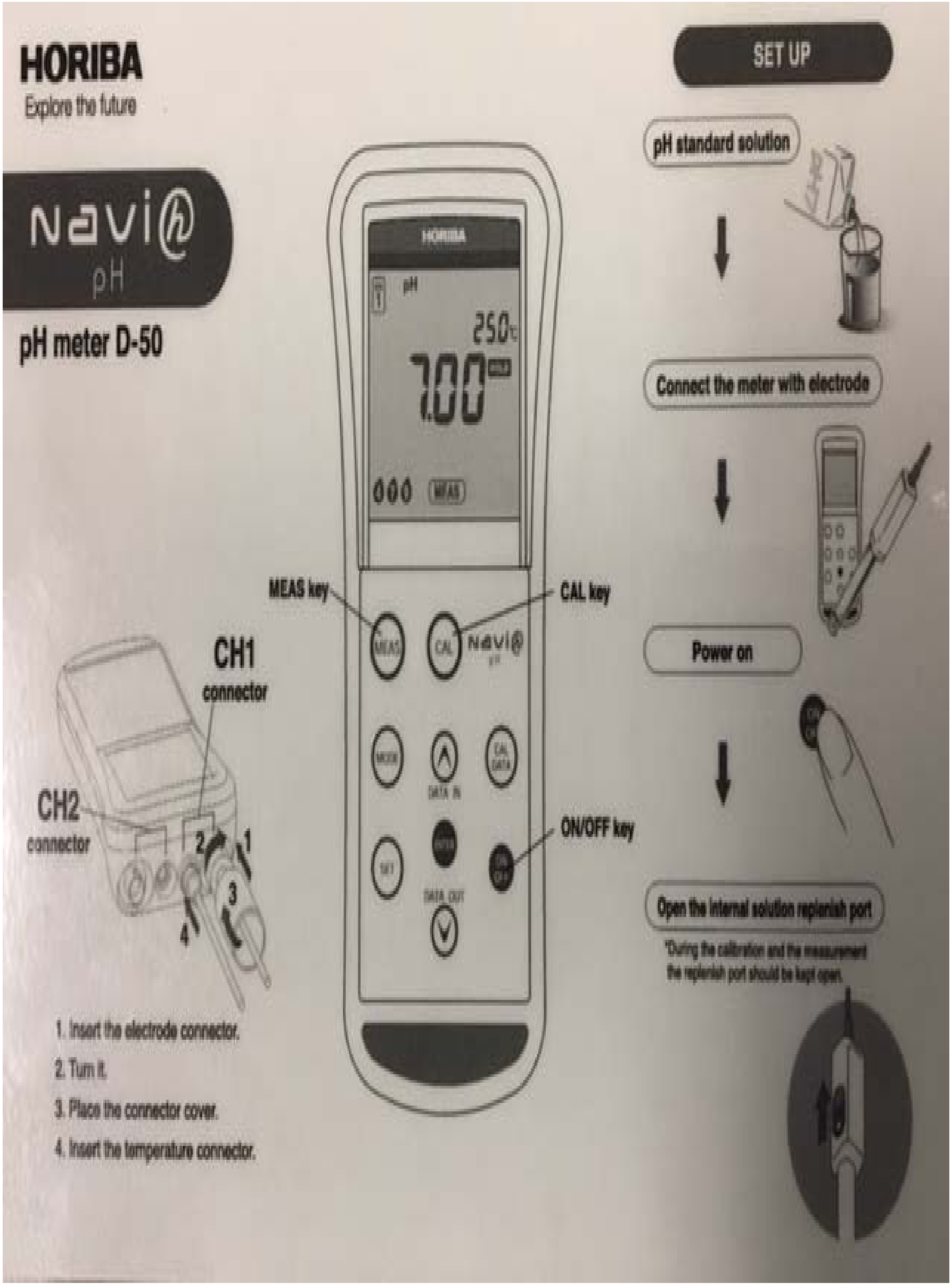
Overall, the preliminary barrel leach results show that ASLP concentrations significantly overestimate likely concentrations, even in the initial flush samples. The exception is major ions associated with moderately to highly soluble salts which can be leached and concentrated through sample evaporation.

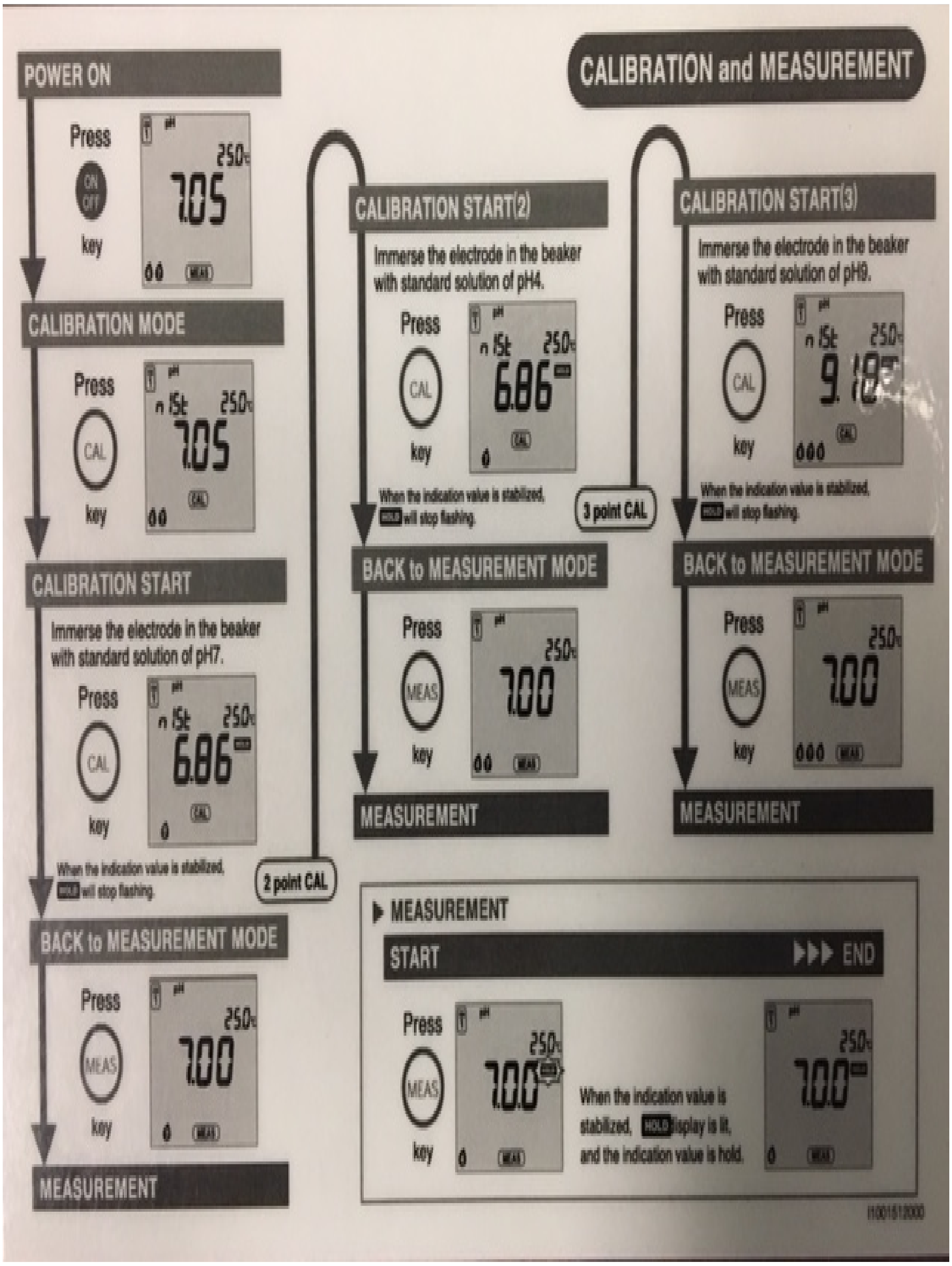
The preliminary findings support the previous assessments that leachate from excavated waste rock is unlikely to present a risk to nearby receptors providing normal sediment and erosion controls are in place and leachate or runoff are prevented from entering surface water bodies undiluted. The proposed management of in-pit waste rock storage and lack of nearby permanent waterbodies makes undiluted discharge to waterways very unlikely.

Appendices

Appendix A – Barrel leachate instructions

Notes to Set Up




CALIBRATION and MEASUREMENT
POWER ON
Press
ON OFF
key
25.0°C
7.05
MEAS
CALIBRATION MODE
Press
CAL
key
1St
25.0°C
7.05
CAL
CALIBRATION START
Immerse the electrode in the beaker with standard solution of pH7.
Press
CAL
key
1St
25.0°C
6.86
CAL
When the indication value is stabilized, HOLD will stop flashing.
2 point CAL
BACK to MEASUREMENT MODE
Press
MEAS
key
25.0°C
7.00
MEAS
MEASUREMENT
CALIBRATION START(2)
Immerse the electrode in the beaker with standard solution of pH4.
Press
CAL
key
1St
25.0°C
6.86
CAL
When the indication value is stabilized, HOLD will stop flashing.
3 point CAL
BACK to MEASUREMENT MODE
Press
MEAS
key
25.0°C
7.00
MEAS
MEASUREMENT
CALIBRATION START(3)
Immerse the electrode in the beaker with standard solution of pH9.
Press
CAL
key
1St
25.0°C
9.18
CAL
When the indication value is stabilized, HOLD will stop flashing.
BACK to MEASUREMENT MODE
Press
MEAS
key
25.0°C
7.00
MEAS
MEASUREMENT
MEASUREMENT
START
END
Press
MEAS
key
25.0°C
7.00
MEAS
When the indication value is stabilized, HOLD display is lit, and the indication value is hold.
25.0°C
7.00
MEAS

Maintenance after daily use

After taking measurements, wash the electrode using pure water (de-ionized water), wipe off the water from the electrode with filter paper or tissue paper, and store it with its cap on.

Extended storage

1. Remove the electrode from pH meter
2. Remove the protective cap from the electrode
3. Open the internal solution filler port and use a syringe to remove the internal solution
4. Fill the electrode with new internal solution, until it nears the opening.
5. Wash the tip of the electrode well with pure (de-ionized) water and wipe it with filter paper or tissue paper
6. If the liquid on the inside of the electrode cap dried, wash the inside of the electrode cap with pure (de-ionized) water, and then, after shaking out the water, fill the cap with enough pure water to soak the sponge.

Additional Notes and Hints

The conductivity electrode has to be immersed so that all three black rings are covered. To avoid excessive usage of the calibration standard, use a tall thin container like a measuring cylinder. This electrode retains its calibration for several months. It must be cleaned thoroughly after each use. Its Ok to wash it under a tap initially and then rinse with distilled water. It is stored between uses in distilled water. Do not let it dry out.

The pH electrode doesn't hold its calibration as long as the conductivity electrode. Best to re-calibrate it at least once a month. Be sure to check that the sliding/close cover at the top of the pH electrode is in the appropriate position i.e. open for measurement, closed for storage.

HORIBA D-54 pH/Cond. METER

pH standard solution setting.

The meter allows you to select the standard solution specifications used for calibration. Select either NIST or USA pH buffer values:

NIST Standard pH values	**USA** Standard pH values
1.68	1.68
4.00	4.00
6.86	7.00
9.18	10.00
12.45	12.45

OR

User defined standard solution (**CUST**). *Please refer instruction manual for further details.*

Most pH calibrations in Australia are carried out using the USA standard solutions. Please select the standard solution setting for the pH solutions you are using as follows.

Select Standard Solution Setting. (***You only have to set it once)***

Turn on meter.

Press SET key.

Press ENT key to toggle between NIST, USA or CUST. (Refer manual if CUST selected)

Press MEAS key to return to normal measuring mode.

PH CALIBRATION IS SIMPLE.

1) Turn on meter. Rinse probe in clean water and pat dry with a tissue.
2) Place probe in pH7.00 solution. Wait about 10 seconds for pH and temp readings to stabilise.
3) **Press CAL key twice.** The 'HOLD' message will flash and when it stops flashing, the meter is calibrated at pH7. The pH7 symbol will appear on display.
4) Rinse probe in clean water and pat dry with a tissue.
5) Place probe in pH4.00 or pH10 solution, wait about 10 seconds.
6) **Press CAL key.** The 'HOLD' message will flash. When it stops flashing the meter is calibrated and the second calibration symbol appears on the bottom of the screen and two point calibration is complete.
7) **Press MEAS key** to return to measuring mode.
   You can continue above steps if you wish to calibrate at a 3rd point.

(Press OFF key for two seconds to shut down meter.)

D-54 CONDUCTIVITY CALIBRATION IS SIMPLE

Conductivity calibration (calibration of cell constant) is summarised as follows:

Important. **Bring calibration solution to 25°C, +/- 0.5°C.** ***(the closer the better)***
Rinse probe with calibration solution.
Immerse probe in calibration solution, so electrodes (black rings) are covered, making sure no bubbles are trapped in the cell. Tap side of container with probe to release any air bubbles.

1. **Press MODE** key to select COND. measurement.
2. **Press CAL** key.
3. **Press MODE** key.
4. **Enter value** of standard soln at 25°C by pressing up or down arrows.
5. **Press CAL** key. When "HOLD" stops flashing calibration is complete.
6. **Press MEAS** key to return to normal measuring mode.suring mode.

If using a conductivity electrode with a cell constant other than k=1, please make sure the cell constant is changed. (refer manual page 51)

IMPORTANT NOTES for best performance of black platinum conductivity probes.

Always store electrode in plastic cap. Soak sponge in plastic cap with distilled or deionised water. If pure water is not available, use tap water for short term storage.

The black platinum rings on the conductivity electrode should be stored clean and moist. If they are left dry, the electrode performance will deteriorate.

Conductivity and automatic temperature conversion.

Since the conductivity of a solution varies depending on temperature, samples should be compared at the same temperature. For this reason conductivity meters have a built-in conversion factor (temperature co-efficient) to automatically convert readings to a value at a certain temperature (usually 25°C) in accordance with the temperature characteristic of the sample. The conductivity value which is displayed on the meter is the value at 25°C (known as the standard temperature). **During the calibration procedure, it is important to bring the conductivity standard to 25°C. Use the value of the standard solution at 25°C as the calibration value that is entered in the meter.**

To convert the actual conductivity reading to a value at 25°C, the meter uses a temperature coefficient of 2% for each 1 degree of temperature away from the standard temperature of 25°C. The closer the sample temperature is to 25°C for calibration and measurement purposes, then the smaller the margin of error. The temperature coefficient value may be changed (refer manual) if it is known for a particular sample. If not, we suggest you leave it at the set value of 2%/°C.

HORIBA D-54 pH/Cond meter (important notes)

Calibration of electrical conductivity (EC) function.

Conductivity on the D-54 meter can be calibrated in either of two ways.

1) **SETTING THE CELL CONSTANT**

What's the CELL CONST. (CC)?

When a conductivity probe is manufactured it is made to a certain cell constant value. Most general purpose EC probes have a CC value of approximately 1 (k=1)
Special EC probes are made with CC of 0.1 for very low conductivity samples or CC of 10 for very high conductivity samples.

When HORIBA EC probes are made, the CC value is accurately measured to 3 decimal places and this value is stamped on the side of the probe.

When the probe is brand new, the CC value (from side of probe) may be entered into the meter and it will measure conductivity quite accurately when this is done.

Procedure to set cell constant.
*Turn on meter
*Press **MODE** until you select COND mode.
*Press **CAL** and CELL x 1 will be displayed ***(if you press ENTER when in this screen you will change between x10, x0.1 and x1 but just leave it as x1 if using the standard conductivity probe 9382-10D)***
*Press **UP/DOWN** arrows to change CELL value to the value stamped on side of the EC probe. eg 1.045 or 1.051 etc
*Press **MEAS** to return to normal measuring mode.

Now the correct CC value is set for the probe and COND measurements may be taken.

2) **CALIBRATING THE CELL CONSTANT**

Over time, the actual CC value of the probe changes as the condition of the probe changes due to normal wear and tear and the CC value may be re-calibrated by placing the probe in a known EC calibration standard.

Procedure for re-calibration of cell constant using conductivity standard solution
*Press **MODE** key to select COND mode
*Place probe in EC standard soln eg 1.413mS/cm std soln
The closer to 25^{0}C the better.
*Press **CAL** key
*Press **MODE** key
*Use **UP/DOWN** keys to set value of the EC std soln at given temp
eg if using 1.413mS/cm std, set it at 1.413 if temp is 25^{0}C
OR set it at 1.332 if temp of soln is only 22^{0}C (see chart on side of bottle to confirm EC value for given temperature)
*When value is set, press **CAL** key
When HOLD stops flashing, calibration is complete and the temperature compensated value will be displayed ie 1.413 or close to it.

*Press **MEAS** to return to normal measuring mode

You can now check the new CELL CONST value which was calculated during the cal process. To do this, press **CAL** key and new CELL value will be displayed. Press **MEAS** key to return to normal measuring mode.

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