Verdant Minerals Pty Ltd

Ammaroo Phosphate Project - EIS Supplementary Report

August 2018

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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.	Timeframe 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. WRD conceptual design 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. Rehabilitation and closure 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.	Surface TSF Closure 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). Surface TSF and ANCOLD design objectives 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. Certifying Engineer 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.	<u>Discharge from sediment dams</u> 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. <u>Process water</u> 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.	<u>Closure</u> 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

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					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.

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					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.

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		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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					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.	<u>Conceptual design</u> 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. <u>Settlement</u> 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. <u>Capping</u> 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.	<u>Closure Plan</u> 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. <u>Tailings</u> 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.

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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.	Risk 97 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*. Section numbering Noted. References 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. Section 6.7.4 All references to Section 6.7.4 should be replaced by reference to Section 6.8.4. Appendix O 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			NTES 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	<u>Greater Bilby</u> 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. <u>Gas pipeline trench</u> 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. <u>Weed Management Plan</u> 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)
<u>Historic records</u>
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><u>Victorian Mining PEM</u>
The PM_{10} 60 µg/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.

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				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.	<u>Tailings test work</u> 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

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				(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.

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				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.	Leachate test work 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. Leachate quantities Impacts to groundwater as a result of seepage from the in-pit TSF are discussed in Section 3.1. Monitoring 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 if 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 Mainr	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 CO_2 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 CO_2 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.

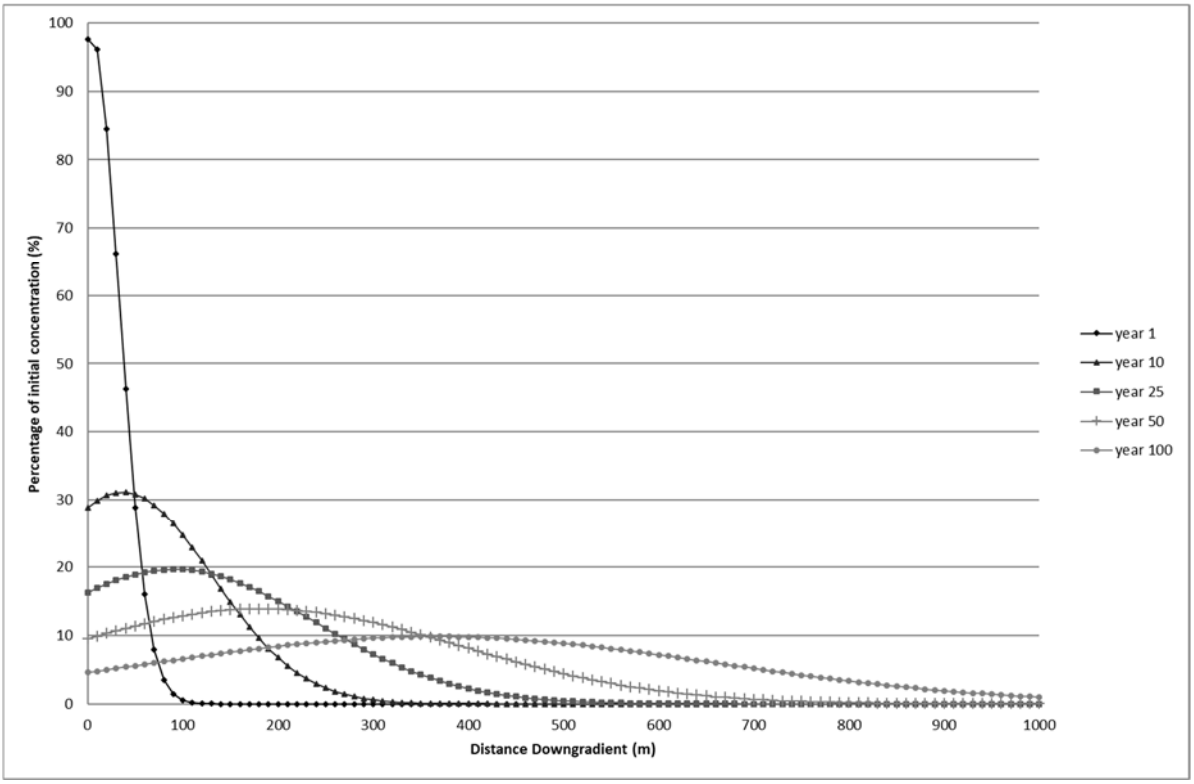


Figure 3-1 Down-gradient concentration of a plume

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

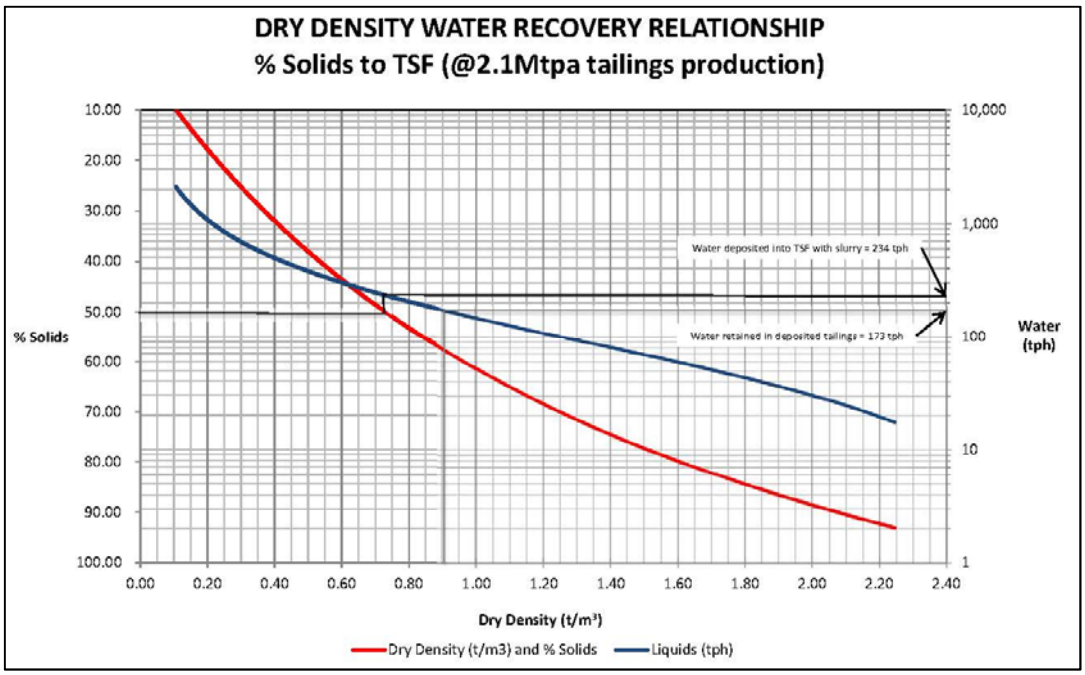


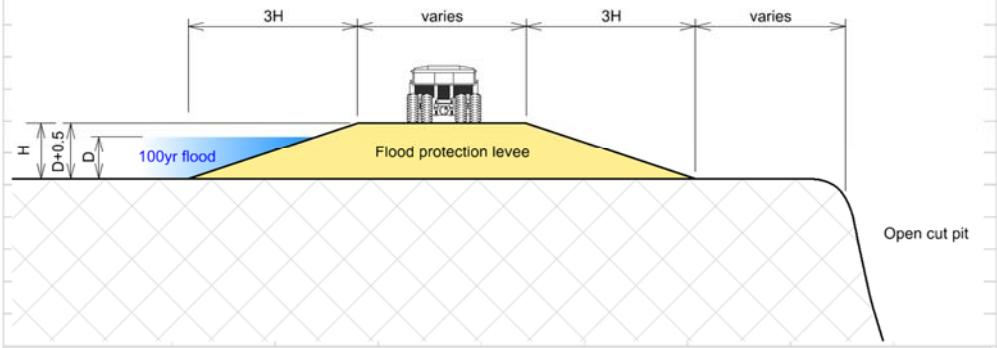
Figure 3-2 Tailings dry density – moisture content relationship

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	58000	(m^3)



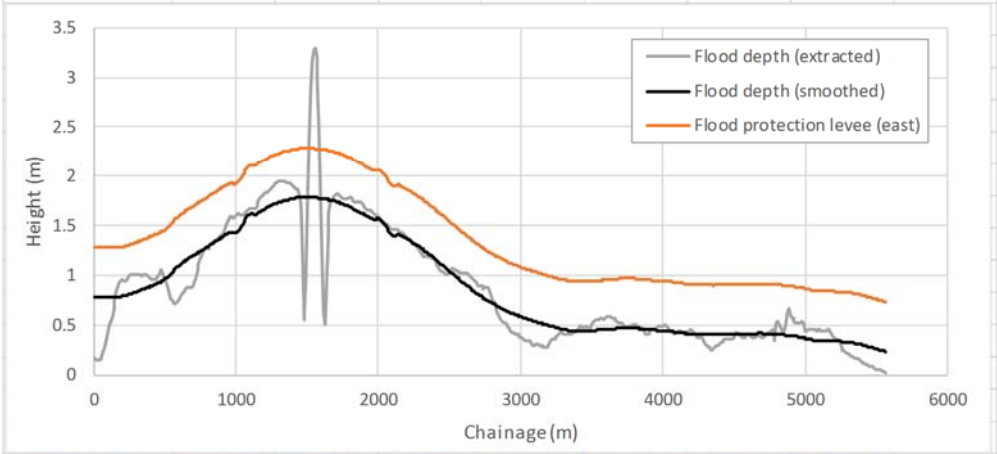
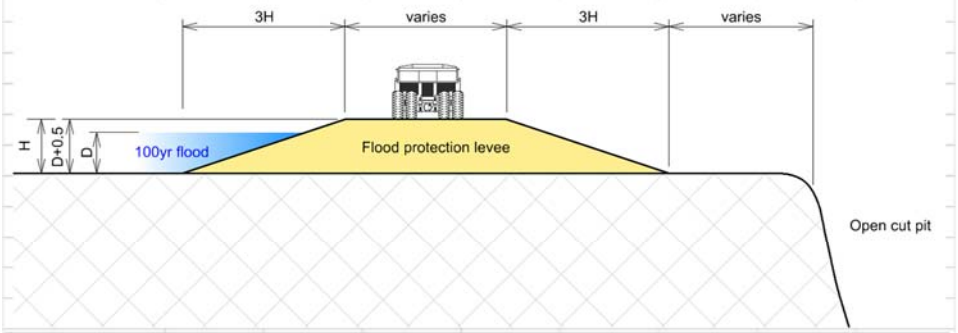
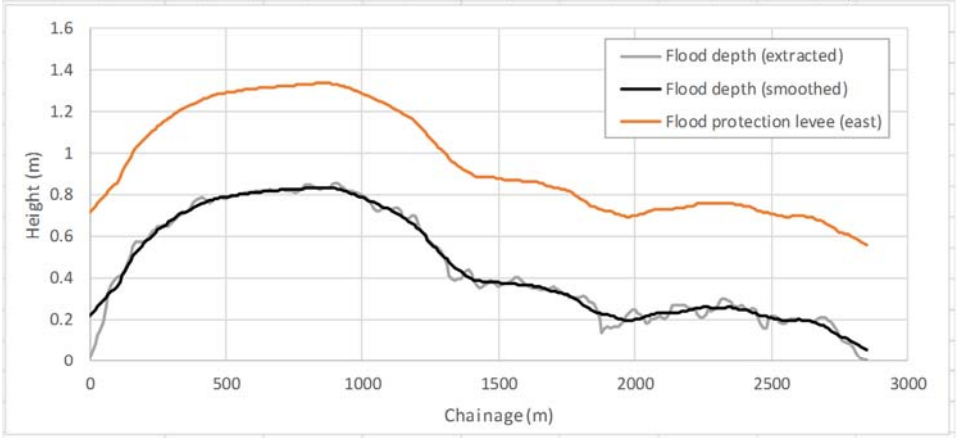


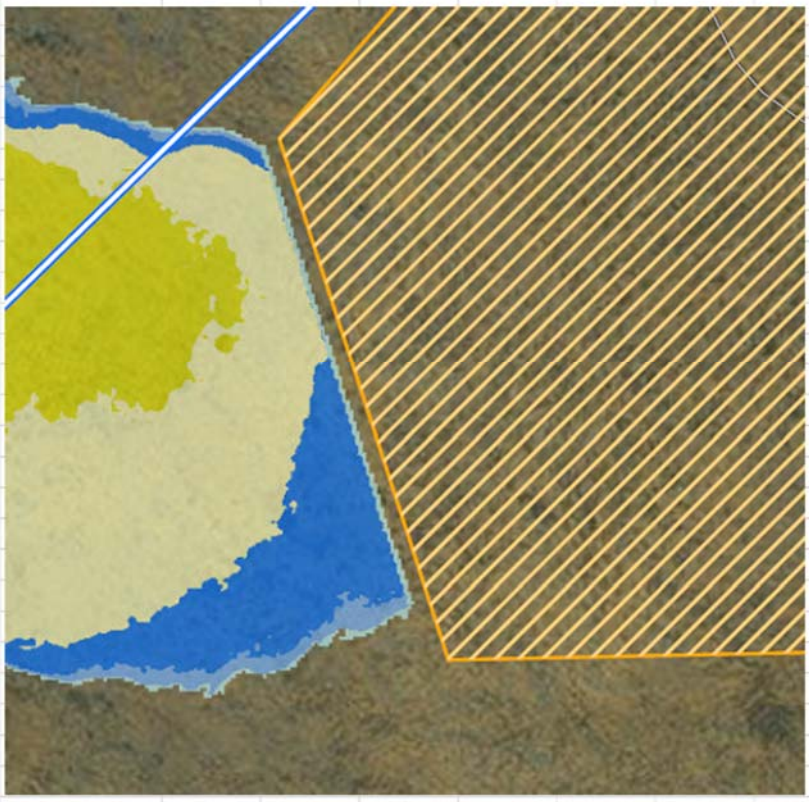
Table 3-12 Summary of results – west berm

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

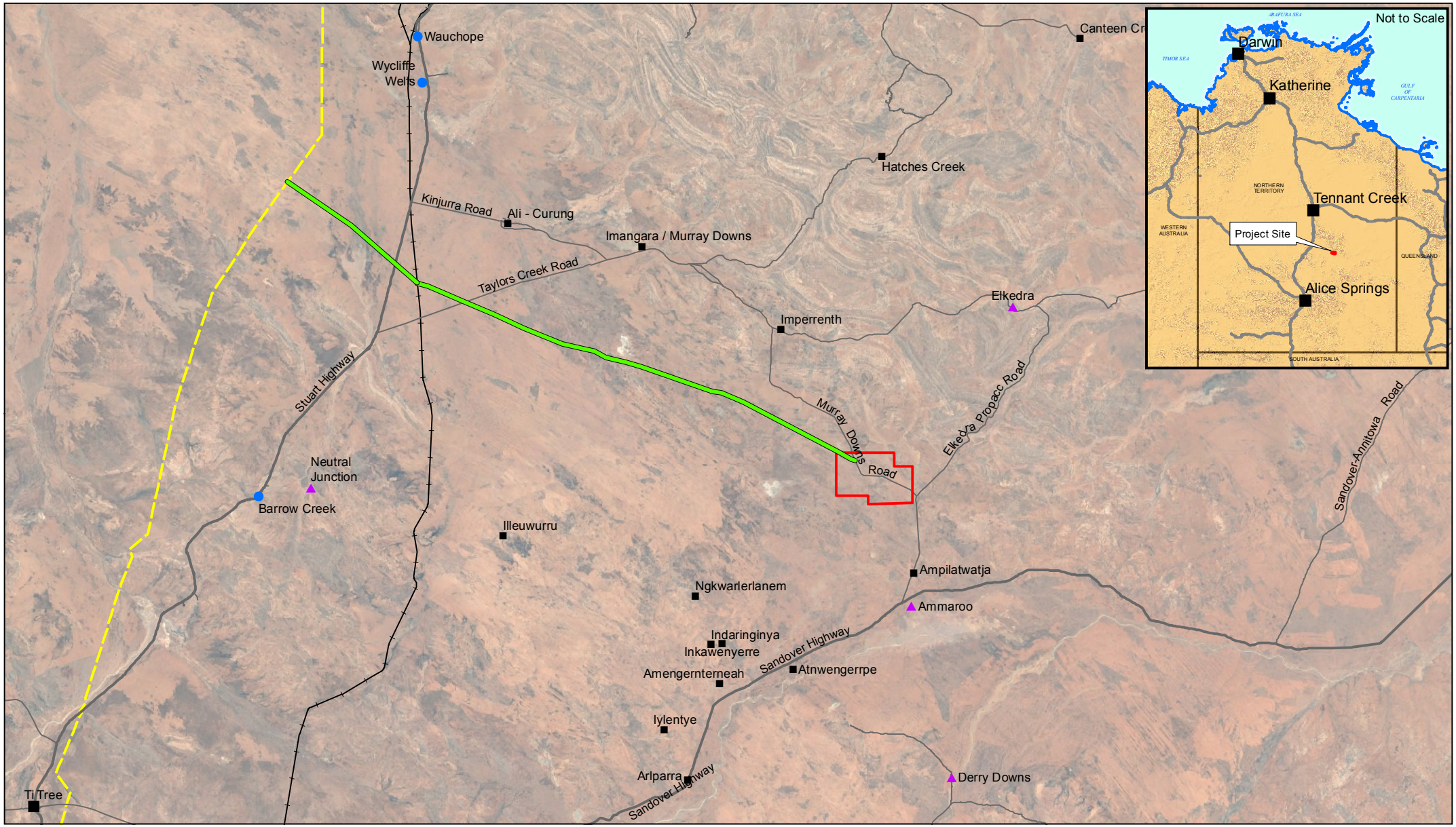
Table 3-16 Community information

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**

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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, 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.

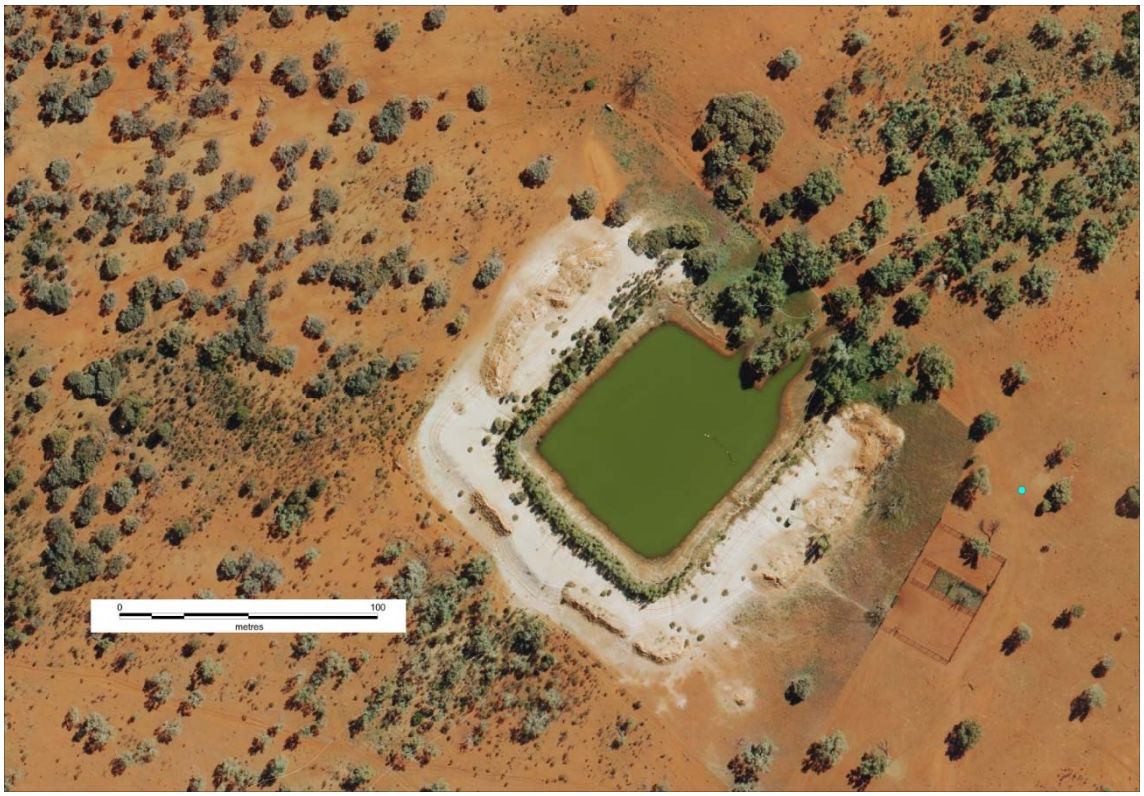


Figure 3-4 Woodys Dam aerial photo taken 16/07/2016.

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.

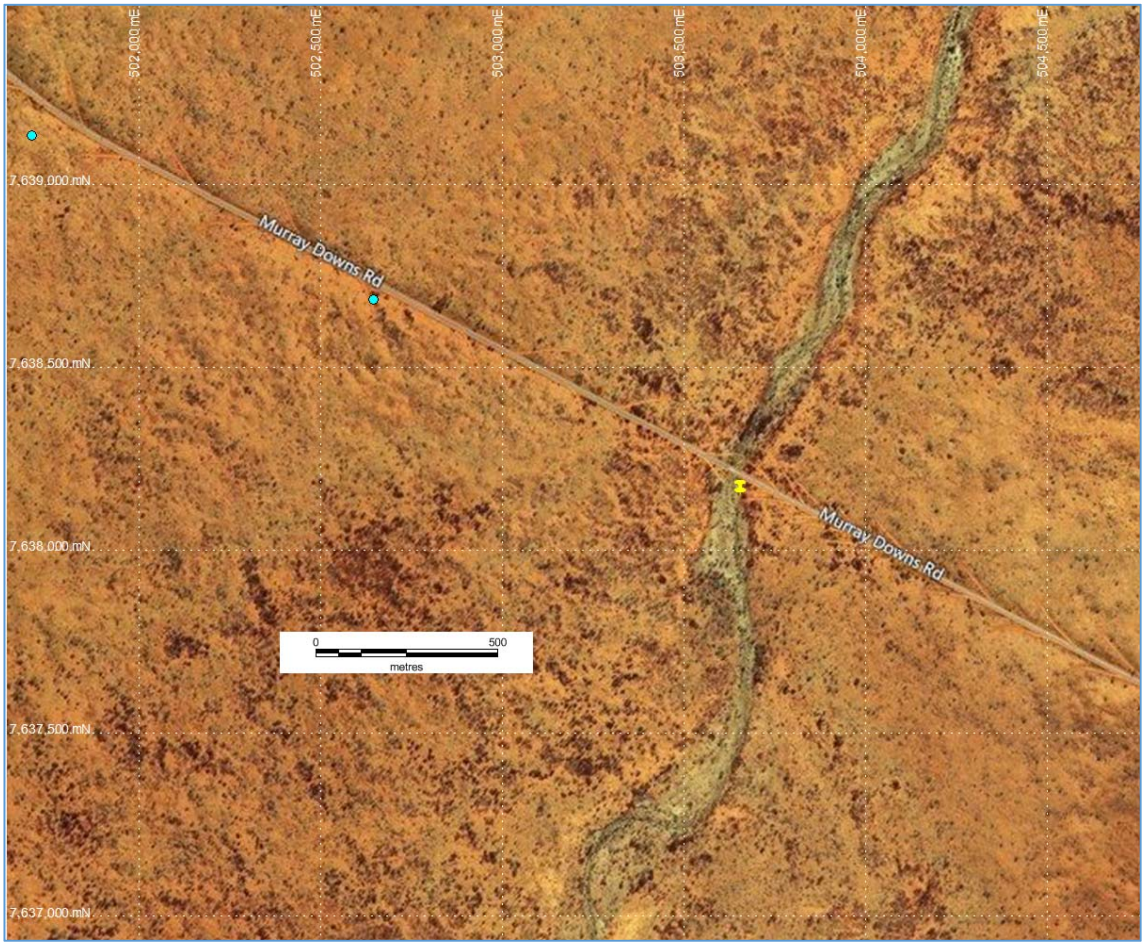


Figure 3-5 Location of sampling site EC1.

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.

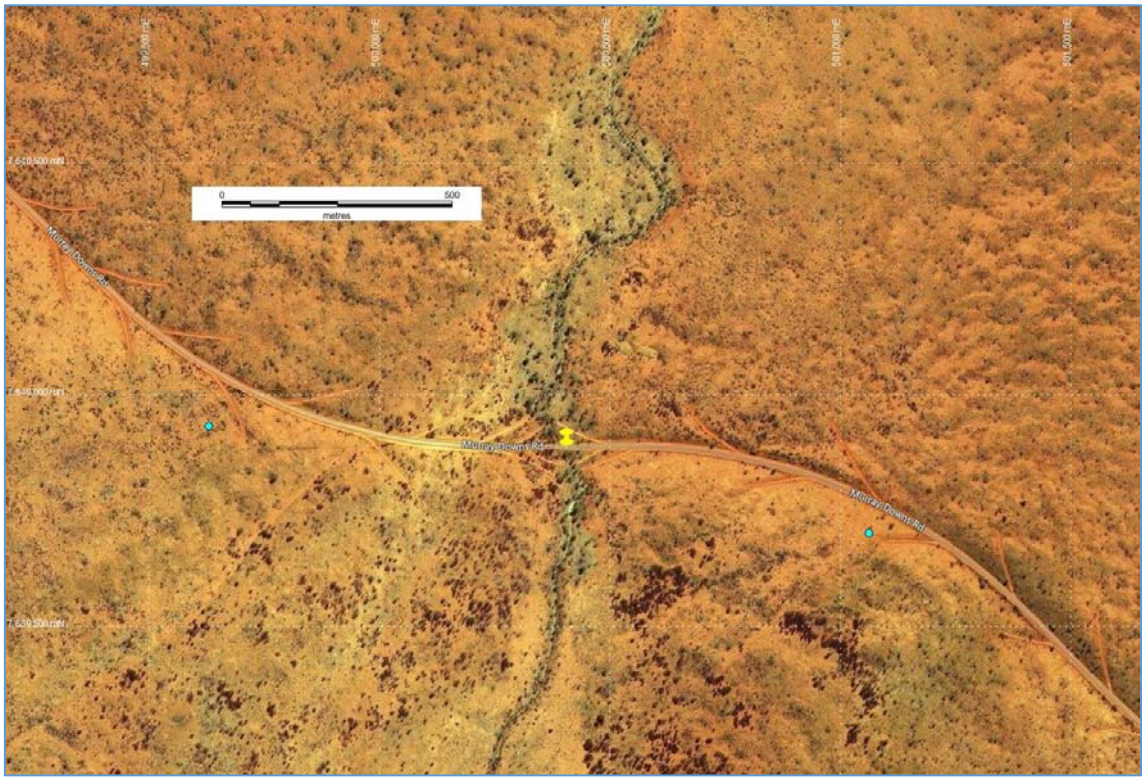


Figure 3-7 Location of sampling site EC2.

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:

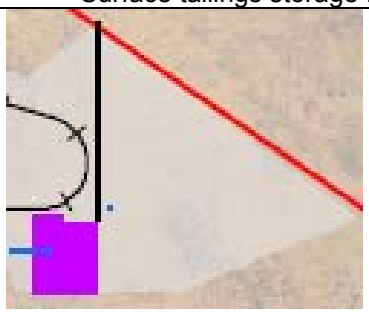
- Material with an ALSP concentration less than or equal 10 times the 2011 ADWG (or other more appropriate receptor guideline) is suitable for containment in un-lined waste rock dumps and tailings ponds, subject to normal sediment and erosion control and retention and testing of runoff. The base of the 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						CALCULATED INDICES				METALS												HARDNESS CORRECTED 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	Cation/Anion Balance	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	Cr	Cu	Pb	Zn	F	NO_2 as N	NO_3 as N	NO_x (NO_2 + NO_3) 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)	(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**		**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**	**0.0001**	**0.0004**	**0.0001**	**0.0023**	**1.28**	**0.009**	**7.8**	**7.80**	**0.25**	**0.02**
ANZECC (2000) FAE 95%																	**0.06**	**0.013**			**0.001**		**0.003**	**1.900**			**0.008**	**0.001**	**0.0014**	**0.003**	**0.008**		**0.700**				
ANZECC (2000) Livestock	**6 to 8.5**					**1,000**					**1,000**					**2**	**5.00**	**0.500**	**1.000**	**1.0000**	**0.500**			**0.100**	**0.200**		**20.000**					**2**	#####	**30**			
ANZECC (2000) Irrigation LTV	**6 to 8.5**			**<115-460**						**<175-700**			**<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**					**1**				**5**	**0.05**
ANZECC (2000) Irrigation STV	**6 to 8.5**		**5,000**							**700**					**60-350**	**2**	**20.00**	**2.000**	**1.0**	**0.10**	**5.000**	**10**	**5.000**	**10.000**	**0.100**	**0.5**	**5.000**					**4**				**25**	**0.8**
ADWG(2011) Health											**500**						**NA**	**0.010**	**0.05**		**2.000**	**NA**	**0.010**	**0.500**	**0.017**		**NA**		**2.0000**	**0.010**		**1.500**	**0.910**	**11.3**			
ADWG(2011) Aesthetic				**180**						**250**	**250**				**200**		**0.20**	**NA**	**NA**		**1.000**	**0.3**	**NA**	**0.100**	**NA**		**3.000**		**1.0000**		**3.000**						
Min	7.10	52	62	3	5	1	1	26	0.5	4	4	-47.67	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	0.010	0.0002	0.000	0.002	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	-38.67	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	0.029	0.0005	0.000	0.006	1	0.050	1	1.05	1.05	0.5
Mean	7.79	309	231	24	12	9	6	73	0.5	81	44	-30.64	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	0.044	0.0024	0.009	0.018	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	-32.68	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	0.034	0.0012	0.003	0.008	2	0.050	1	2.00	2	0.5
99%UCL	0.10	56	55	7	2	2	1	11	#NUM!	31	28	3.90	0	1	11	0	3.44	0.000	0.0	0.01	0.002	1.5	0.004	#NUM!	#NUM!	#NUM!	0.014	0.010	0.0012	0.010	0.009	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	-25.29	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	0.045	0.0026	0.008	0.021	3	0.800	2	3.01	3.0125	0.5
Max	8.15	746	859	85	30	46	24	150	0.5	400	570	0.27	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	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_2 + 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)	(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																												
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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_3 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.

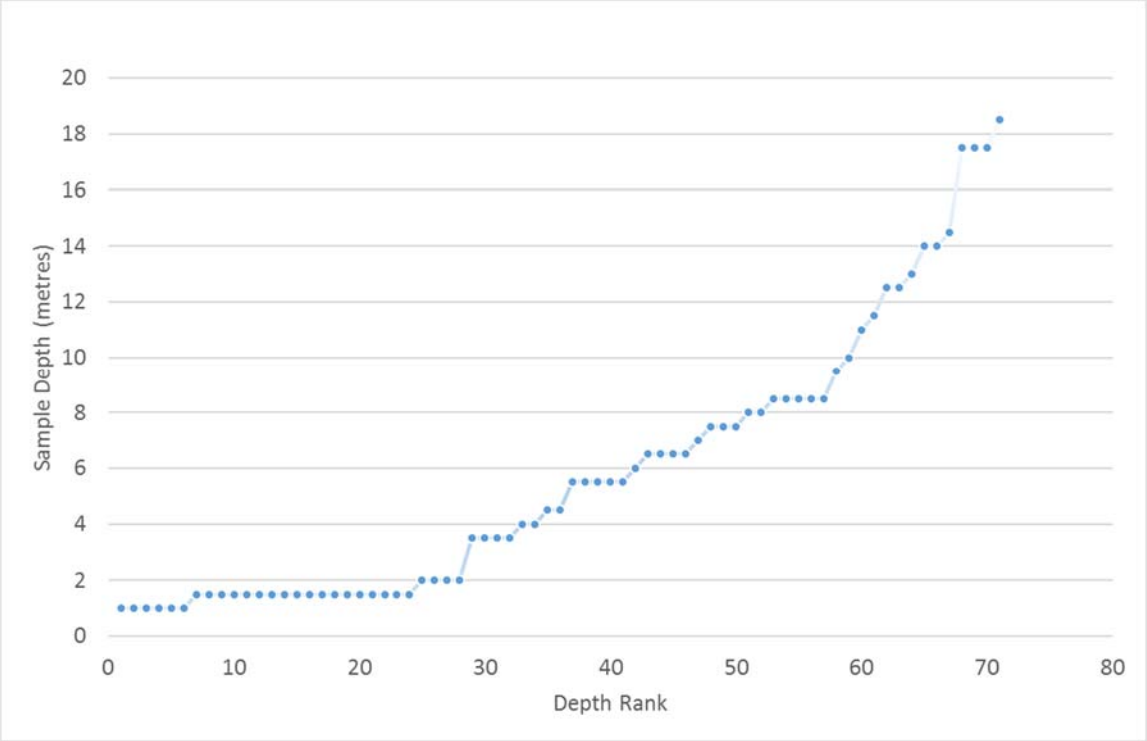


Figure 3-9 Secondary AMD sample depth distribution

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	736				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	-52.7	-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	257	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	-5.0	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	46.7	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.

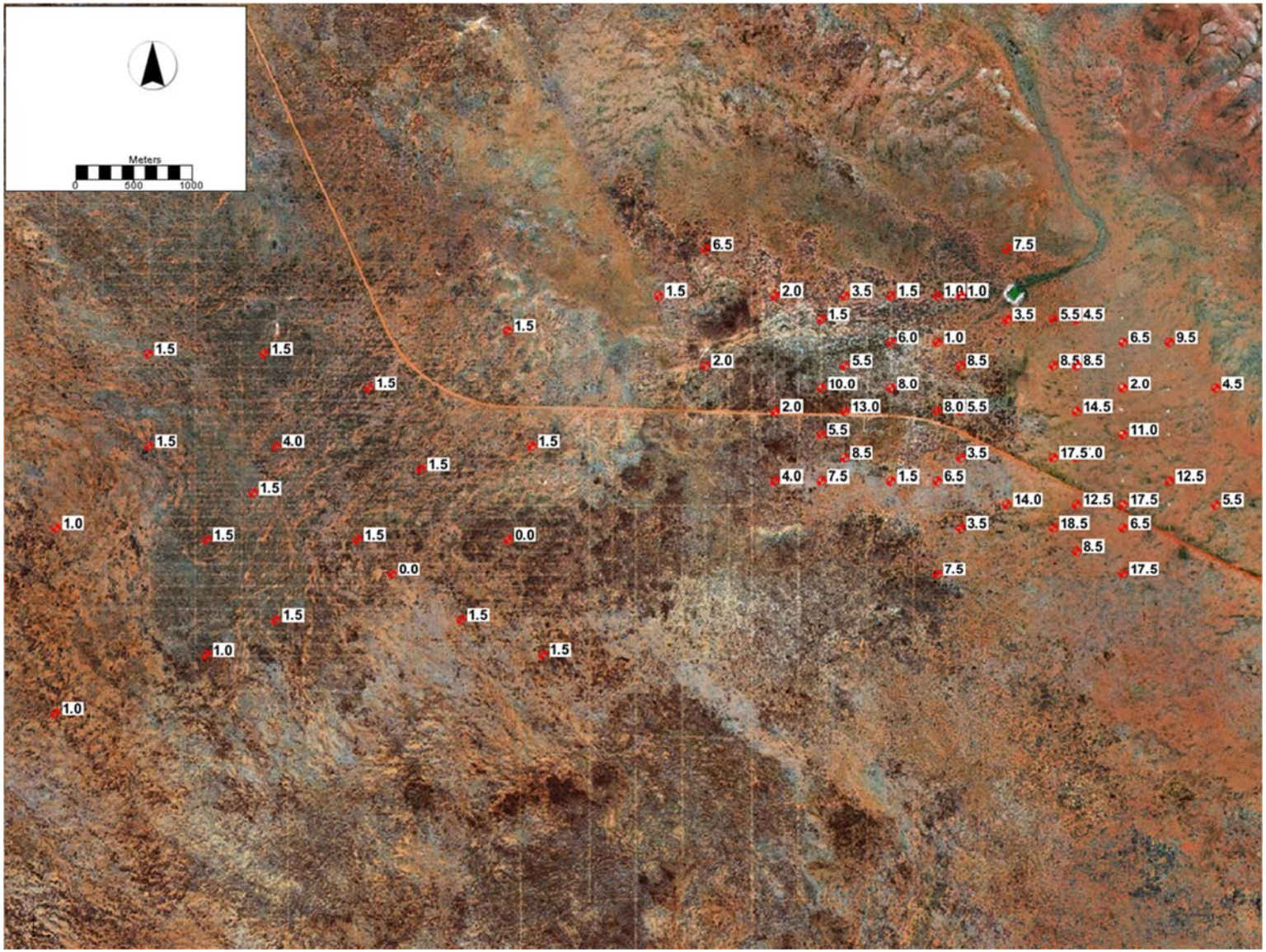


Figure 3-10 Sample depth below surface (m)

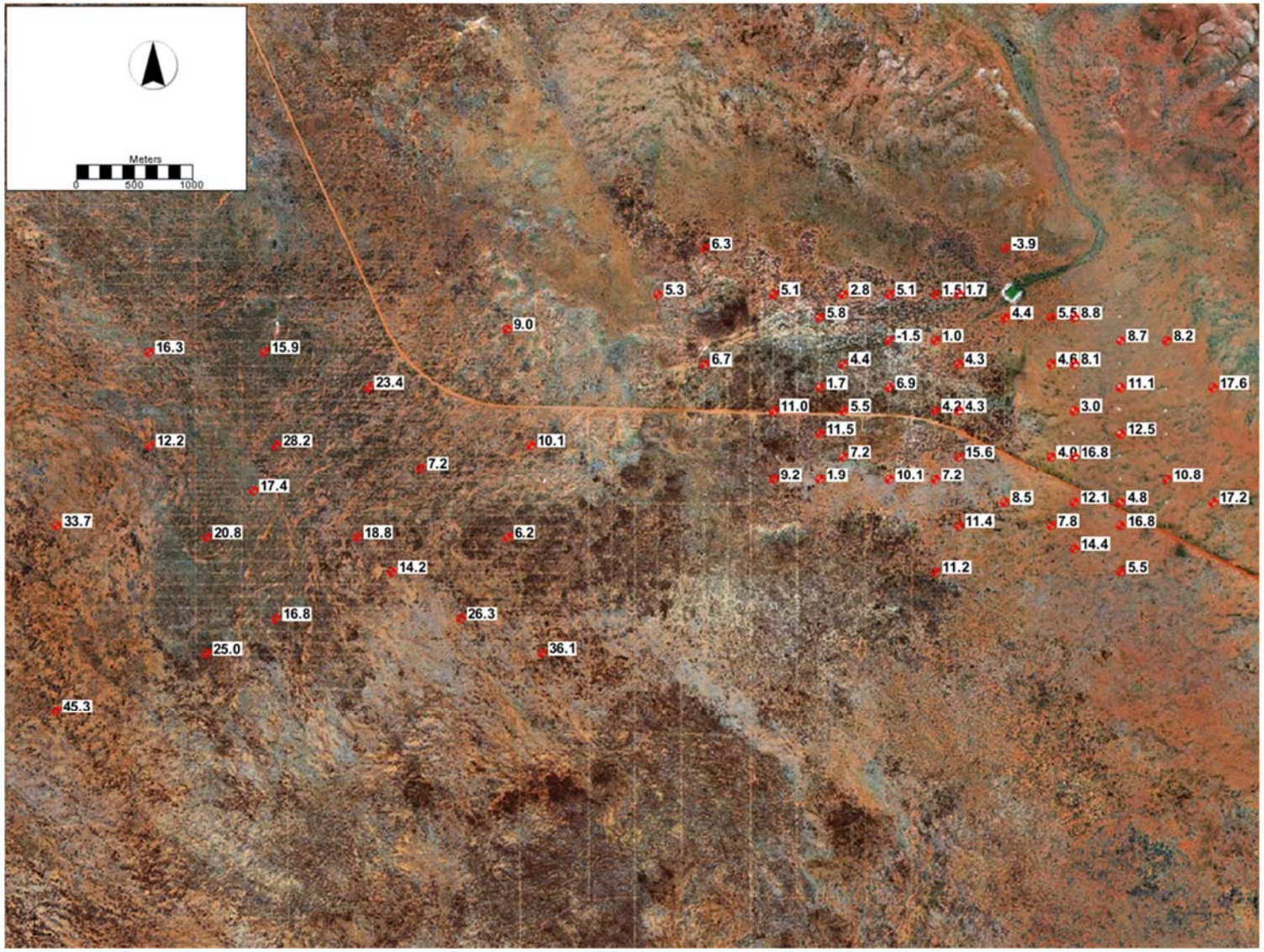


Figure 3-11 Sample height above top of ore (m)

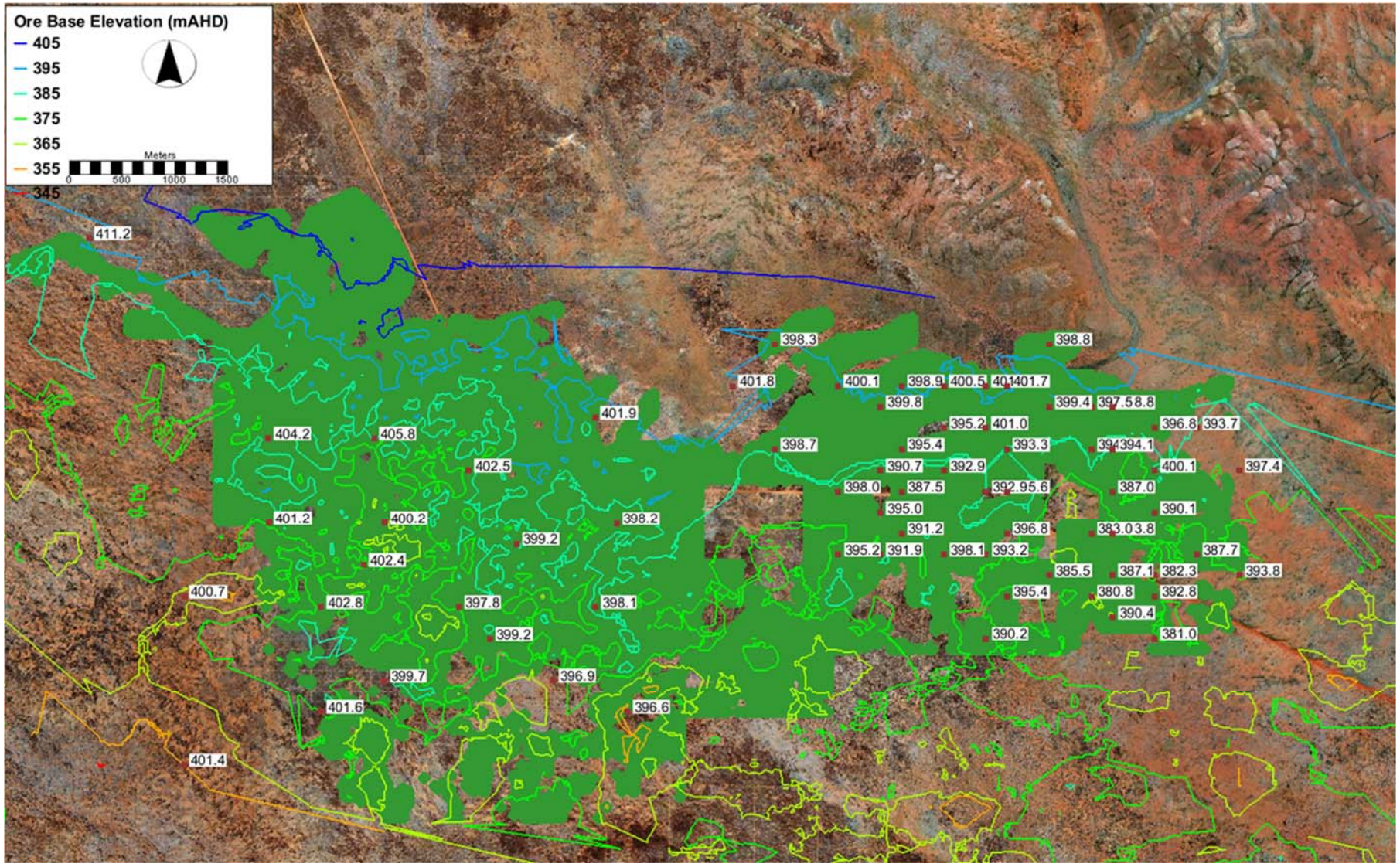


Figure 3-12 Sample elevation and ore base elevation contours (mAHD) showing approximate life of mine pit limits.

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.

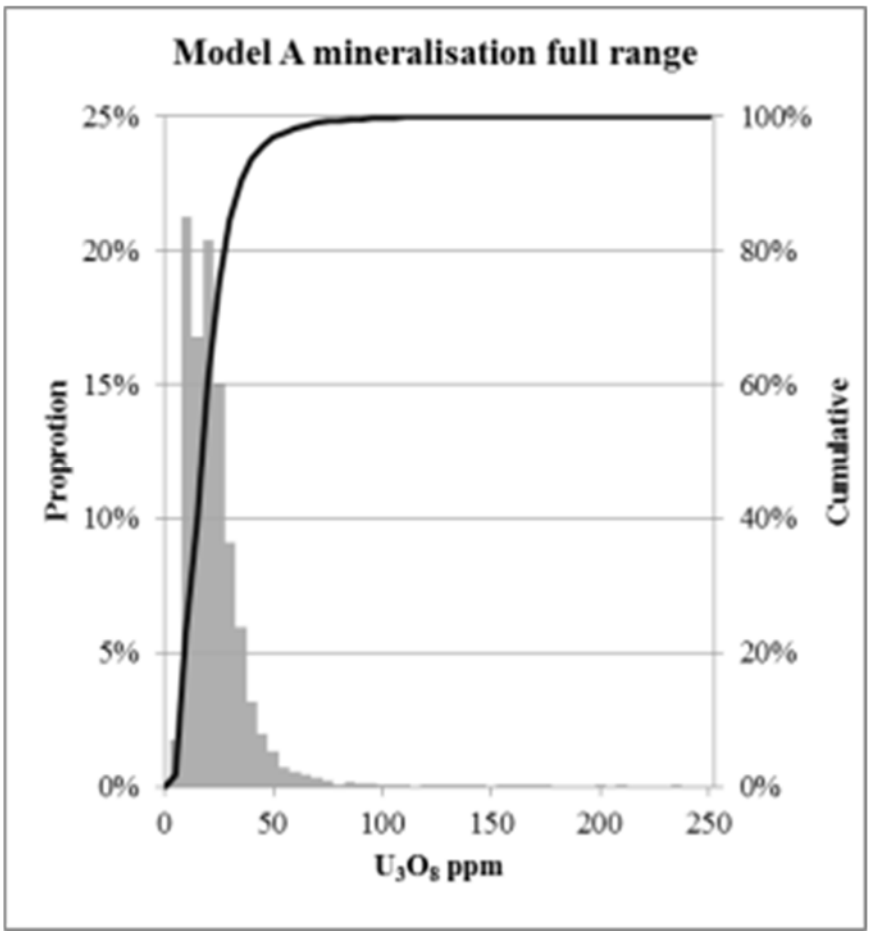


Figure 3-13 Histogram of uranium concentration in ore. There is a maximum outlier of 236 ppm U

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

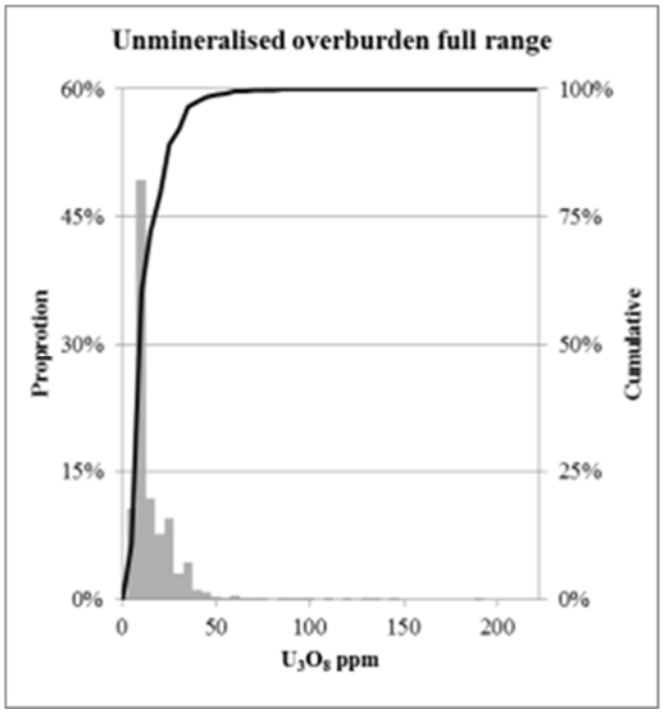


Figure 3-14 Histogram of uranium concentration in overburden.

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.

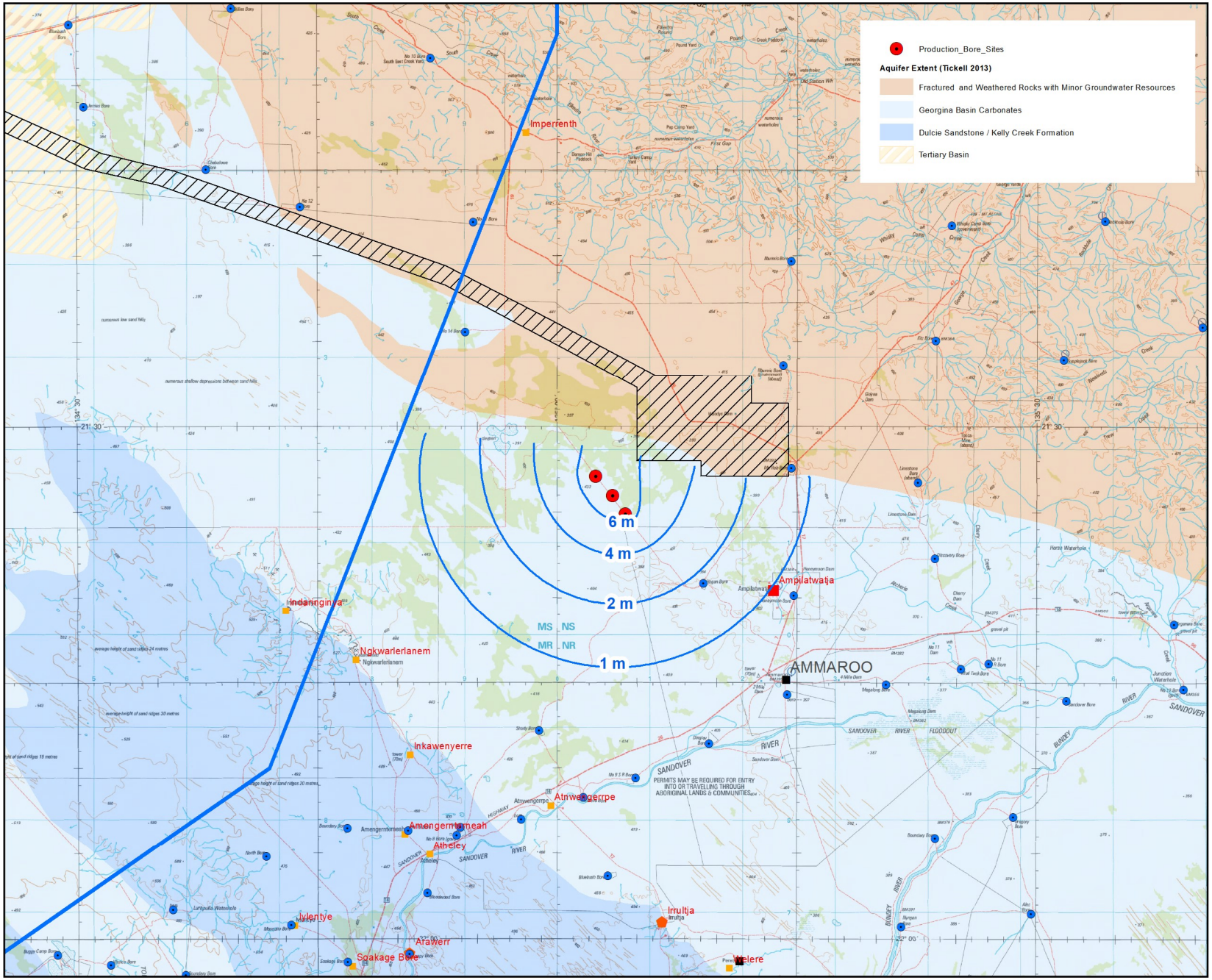
The closest margin of the Tertiary aquifers are located approximately 65 km to the northwest of the borefield.

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).



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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

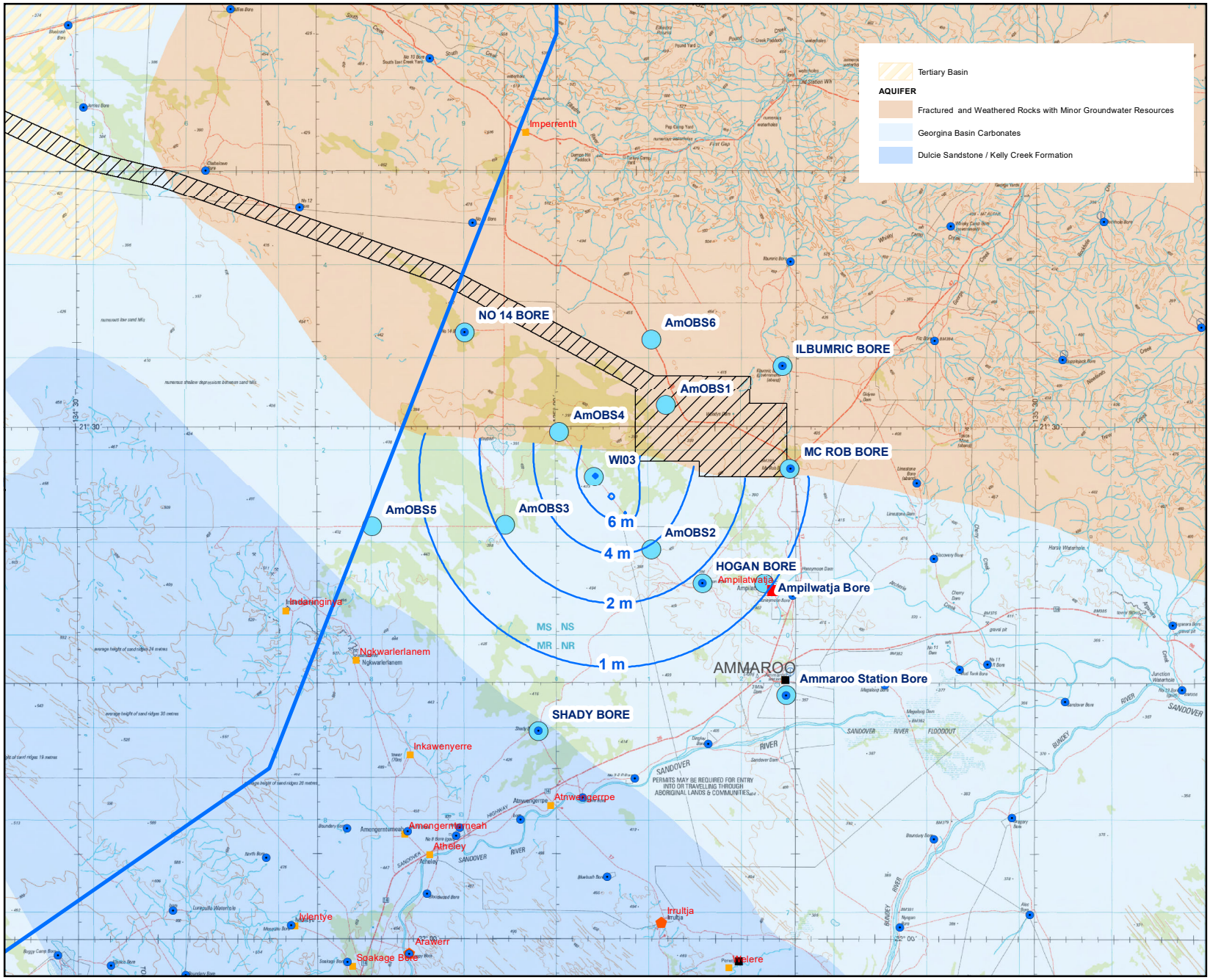
Groundwater Monitoring to measure the impact of tailings seepage is detailed in Table 3-35 and Figure 3-17. Two bores will be located down-gradient of the Ex-pit TSF, and two bores will be located down-gradient of the in-pit tailing storage. The existing bore AMObs1 is located upgradient of the pits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



Water Table Drawdown (m)

Third Party Water Bores

Western Davenport Water Control District

NT_Aboriginal_Communities

MAJOR

MINOR

TOWN CAMP

FAMILY

Stations

Groundwater_Monitoring_Points

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

Groundwater Monitoring Plan
Borefield Drawdown Monitoring
Figure 3-16

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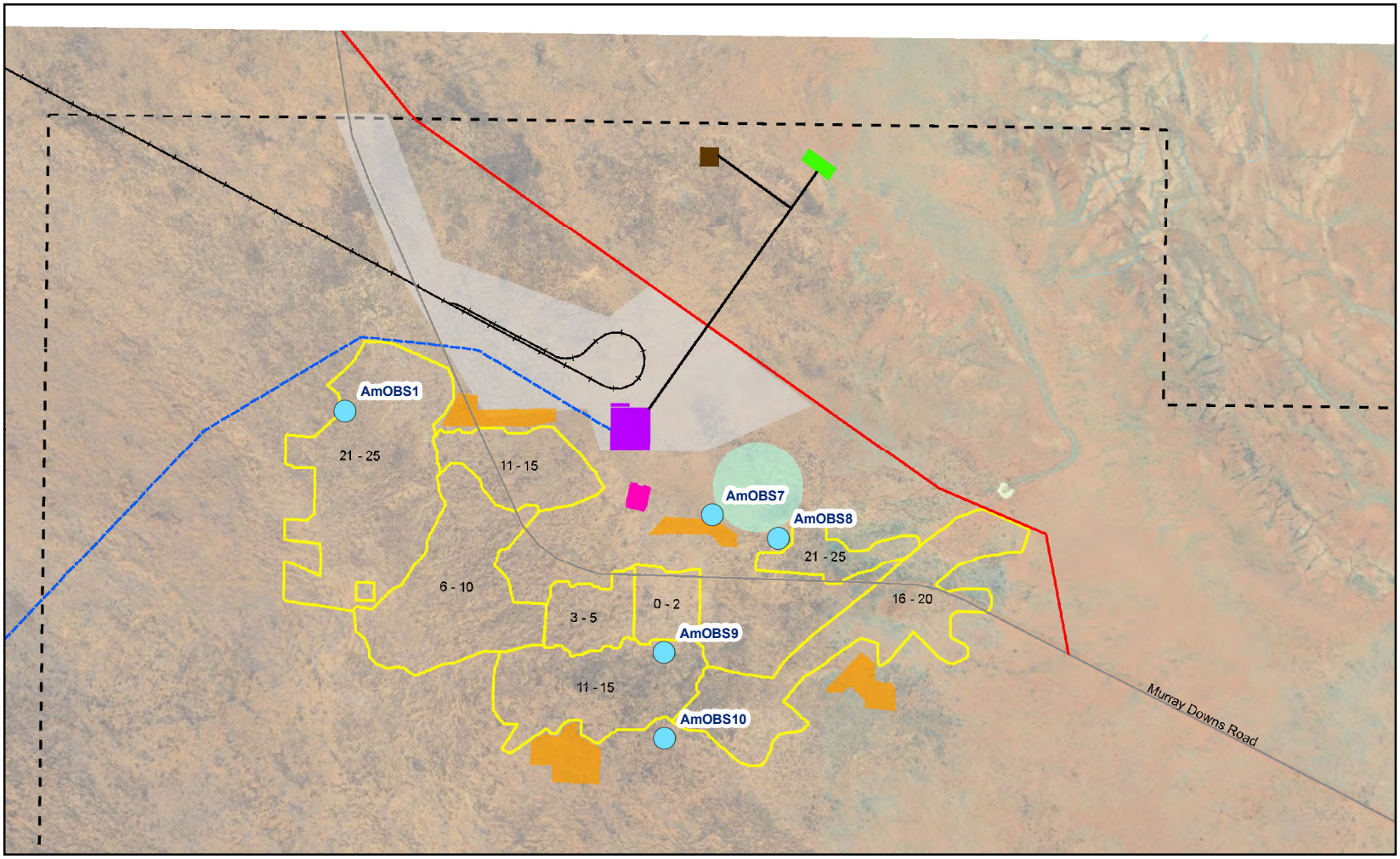

LEGEND

- 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

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.

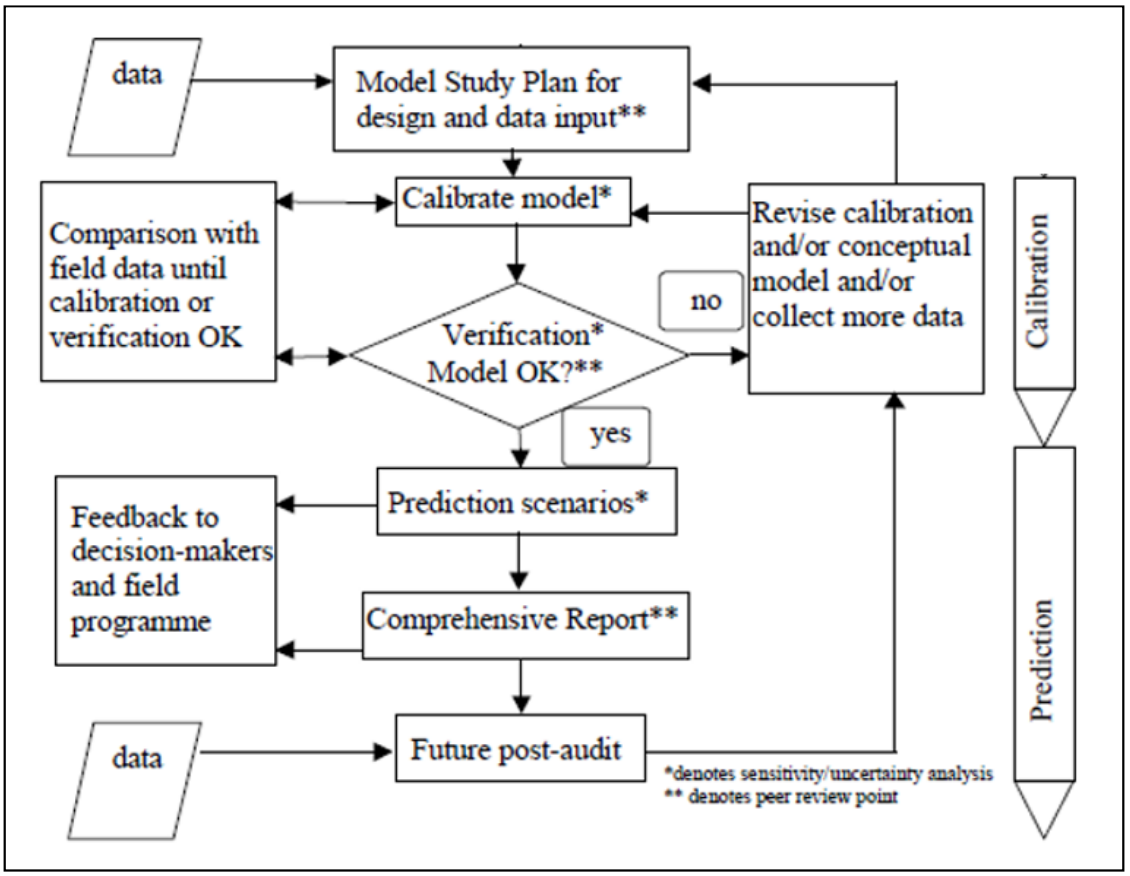


Figure 3-18 Model Revision Methodology (After MDBC, 2000)

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.

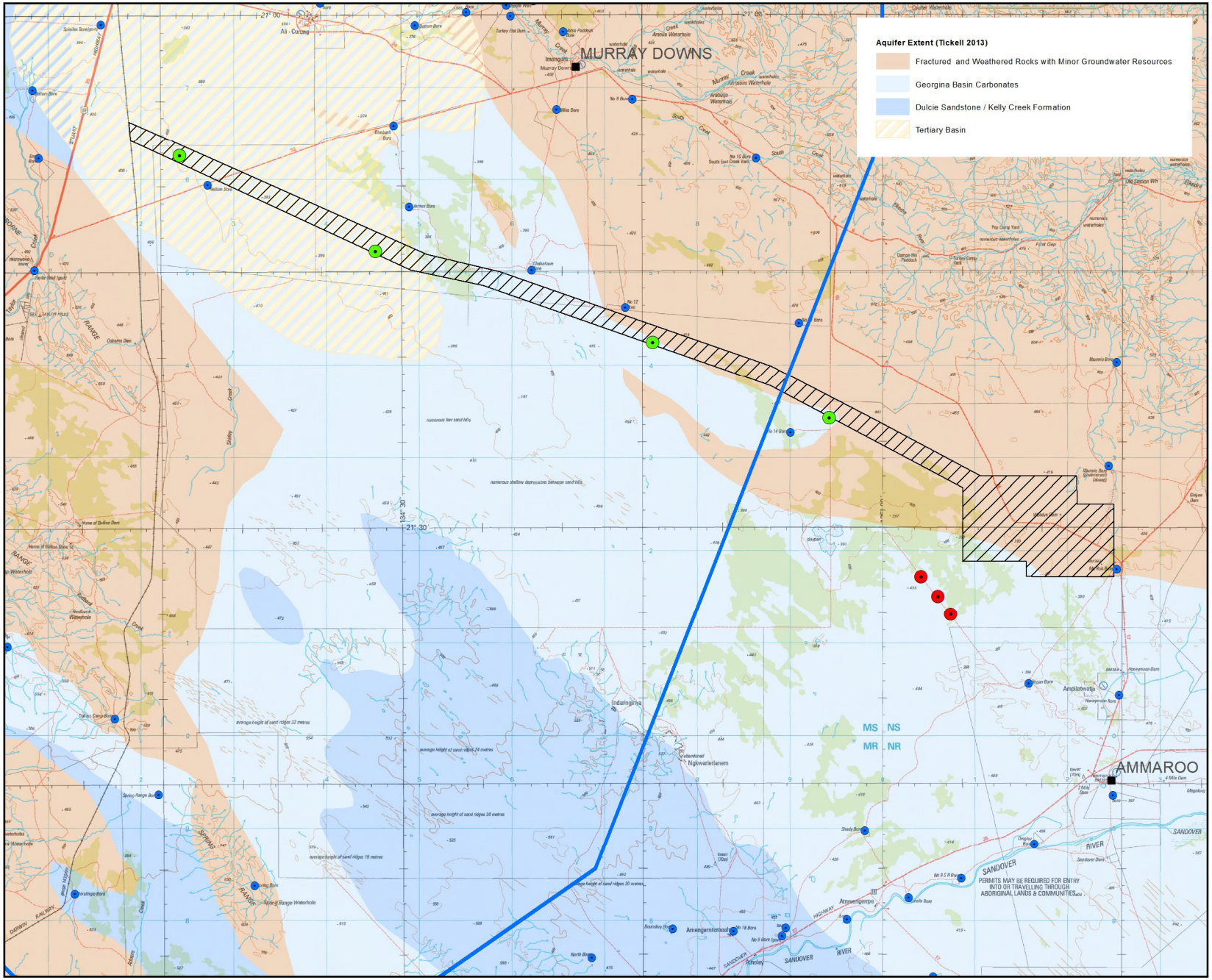
All bore construction and decommissioning will be undertaken by licensed drillers in accordance with the National Uniform Drillers Licensing Committee, 2011, Minimum Standards for Water Bore Construction in Australia, Third Edition, 2012.

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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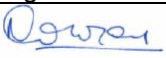
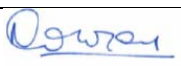
0	L. Kneen K. Marmion B. Jeuken R. Virtue T. Ewers-Reilly A. Wyatt D. Craggs	N. Conroy		N. Conroy		30/07/2018
1	L. Kneen K. Marmion B. Jeuken R. Virtue T. Ewers-Reilly A. Wyatt D. Craggs	N. Conroy		N. Conroy		02/08/2018

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